School of Pure and Applied Sciences

Course Structure and Syllabi

M. Sc. Courses

Academic Programmes

July, 2013
M.Sc. Biotechnology

Objectives of the course

To identify, formulate and solve biotechnology related problems in healthcare, agriculture, environment and energy sectors and to design experiments involving live organisms, perform and control such experiments and interpret results obtained.

To assess new biomaterials and bio-processing techniques for improving efficiency or reducing pollution and use Bioinformatics tools, improving communication efficiency and work harmoniously in multi-disciplinary and multi-cultural teams.

To understand professional and ethical responsibility, to transfer laboratory results for large scale commercial production; and improving the understanding of IPR and its implications on protecting local innovations, as well as the competitiveness of Indian biotechnological products and ensuring environmental safety.

It is expected that the knowledge gained through this course will make student competent to meet the challenges of academic and professional courses and entrepreneurship development.
## BIO-TECHNOLOGY

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<th>SEMESTER – I</th>
<th>Code</th>
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<td>MICROBIOLOGY</td>
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<td>S11003</td>
<td>IMMUNOLOGY</td>
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<td>S11004</td>
<td>MOLECULAR BIOLOGY and BIOTECHNIQUES</td>
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<td>S11005</td>
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BIOTECHNOLOGY

S11001: BIOCHEMISTRY-I  Credit(s):4

Chemical foundation of biology– pH, acids, bases, chemical bonding, properties of water, Gibbs free energy, High energy compounds, ATP Cycle
Carbohydrates– Classification and properties of carbohydrates, mono (glucose, galactose and fructose) di (lactose, maltose, and sucrose), poly (starch, glycogen, cellulose).
Classification, Structure and biological functions of fatty acids, triacylglycerols, phospholipids, steroids. Physico-chemical properties and analysis of fats and oils. Structure and functions of prostaglandins, leukotrienes, thromboxanes
Amino acids– Classification; Structure and physicochemical properties; Peptides Peptide bonds, Proteins– Classification. Isolation and purification of protein; Primary structure of proteins and its sequence determination.
Secondary (Ramachandran plot), tertiary and quaternary structural features of proteins; Primary structure Forces responsible for protein stability. Structural organization of globular (myoglobin, hemoglobin), fibrous proteins (collagen, keratins, silk fibroin). Denaturation and renaturation of proteins, Structure and functions of glycoproteins and lipoproteins.
Nucleic Acids– Structure of purines, pyrimidine, nucleosides, and nucleotides. Structure, properties and functions of nucleic acids (DNA, RNA), Different forms of DNA and RNA. Three dimensional structure of tRNA. Isolation of nucleic acids, Denaturation and renaturation of nucleic acids, cot curves. C value paradox.

Suggested Readings

8. Nucleic acid Biochemistry and Molecular Biology by Main Waring et al., (Blackwell).
Introduction to Microbiology: Historical background & scope, structure of peptidoglycan, Prokaryotic and Eukaryotic cell structures, Difference between prokaryotic and eukaryotic organisms, Microscopy - light, electron and laser optic system; micrometry.

Classification of microorganism- Classification of Bacteria: Basic principle and techniques used in bacterial classification. Phylogenetic polyphasic taxonomy and numerical taxonomy; Kingdom- protista, prokaryotic and eukaryotic microorganisms, the five-kingdom concept of classification, archaeobacteria, eubacteria and eukaryotes; New approaches to bacterial taxonomy classification including genetic methods, ribotyping and ribosomal RNA sequencing characteristic of primary domains. Morphology and fine structure of bacteria, General structure and features, Brief account of all group of bacteria and cyanobacteria, Rickettsia, Chlamydia and Mycoplasma, Archaea - archebacterial cell wall; fungal cell wall, Cyanobacteria: General account and their economic importance, extremophilic microbes – their biotechnological potentials.

Methods in Microbiology: Sterilization techniques- Physical and chemical methods; Preparation of culture media, Different types of media- simple, complex and defined, Pure culture techniques- isolation, cultivation, enumeration and preservation of microbes; microbial staining techniques- simple and differential staining, enrichment culture techniques for isolation of nutritional categories of microbes. Microbial genetics- recombination- transformation, transduction, conjugation, Plasmids and Transposons, regulation of gene expression

Nutritional requirements and nutritional classification of microorganisms: principle of microbial nutrient ion, Different carbon and nitrogen sources, different modes of nutrient ion in bacteria - Sulfate reduction, Nitrogen metabolism – nitrate reduction, nitrifying and denitrifying bacteria, Nitrogen fixation and Microbes used as bio fertilizer, transport of nutrient ion across the bacterial membrane; Metabolic diversity among microorganisms: Photosynthesis; Chemo lithotrophy; Hydrocarbon transformation, Hydrogen-iron nitrite- oxidizing bacteria; Nitrate and sulfate reduction; Methanogenesis and acetogenesis; Fermentations-diversity; Microbial Diversity: Bacteria: Purple and green bacteria, cyanobacteria, acetic acid bacteria, Pseudo monads, lactic and propionic acid bacteria, endospore forming rods and cocci; Mycobacteria and Mycoplasms. Archaea: Halophiles; Methanogens; Hyperthermophilic archaea; Thermoplasma. Eukarya: Algae, Fungi, Slime molds and Protozoa.

Microbial Growth: The definition of growth, mathematical expression of growth, growth curve, bacterial generation time, specific growth rate and measurement of growth and growth yields, Axenic culture, Monoauxic, Diauxic and Synchronous growth curve, Continuous culture; Growth as affected by environmental factors like temperature, acidity, alkalinity, water availability and oxygen, Different effects of physical and chemical factors on microbial growth. Culture collection and maintenance of cultures, Sporulation in
bacteria
Chemotherapeutic agents: Antimicrobial agents; Sulfa drugs; Antibiotics - Penicillin and Cephalosporin; Classification of Antibiotics, Broad and narrow spectrum antibiotics; Antibiotics from prokaryotes; Antifungal and antiviral antibiotics, mode of action of antibiotics; Resistance to antibiotics, origin of drug resistance, mechanism of drug resistance, antimicrobial susceptibility test.

Microbes in natural habitats- air, water & soil; Industrial application of microbes - Wine, Beer, Cheese, Yogurt; Primary and secondary metabolites and their applications; biosensors.

Viruses: Discovery, General characteristics, Morphology, Classification and structure of plant, animal and bacterial viruses, Types, Isolation, cultivation and identification of viruses, viroids, viroids and prions, viral replication.

Structure and morphology of bacteriophages- \( \phi X \) 174, lytic and lysogenic cycle; cyanophages and retroviruses.

DNA viruses- Life cycle and replication of SV 40, RNA viruses – Life cycle and replication of Retroviruses.

Plant viruses: TMV, Gemini, CMV, Human Viruses: Influenza (SARS), Herpes Simplex virus, Rubella.

Host-Parasite Relationships: Normal microflora of skin, oral cavity, gastrointestinal tract; Entry of pathogens into the host; colonization and factors predisposing to infection; types of toxins and their structure; Mode of actions; Virulence and Pathogenesis.


Viral pathogens- Influenza, Rabies, Enterovirus, Retrovirus, Oncogenic viruses. Control of microorganisms- physical and chemical methods - antibiotics and chemotherapeutic agents - antimicrobial susceptibility test.

Microbial Diseases: Disease reservoirs; Infectious disease transmission; Respiratory infections caused by bacteria and viruses; Tuberculosis; Sexually transmitted diseases including AIDS; Diseases transmitted by animals, insects and ticks, food and water borne diseases; Pathogenic fungi; Emerging and resurgent infectious diseases. Infectious and disease, types of infection, Mechanism of pathogenesis of bacterial and viral disease; Mycoplasma and diseases caused by them.


Suggested Readings

1. Alcamo’s Fundamental of Microbiology, (2004); Pommerville et al.
2. Microbiology (2004); Tortora, F.
3. Foundation in Microbiology (1996); Talaro & Talora.
4. Food Microbiology (2004); Adam, M.R.
5. Principles of Microbiology (1994); Atlas, R.M.
6. Pharmaceuticals Microbiology (2003); Purohit & Saluja.
7. Brock Biology of Microbiology, Martinko, M.T. & Parker, J.
S11003: IMMUNOLOGY  Credit(s): 4


Organs of the immune system: Primary and secondary lymphoid organs: Thymus, Bone marrow, lymphatic system, lymph nodes, spleen, Mucosal Associated Lymphoid Tissue (MALT), Cutaneous-Associated Lymphoid Tissues. Antigen: Immunogenicity vs antigenicity, factors affecting immunogenicity, nature of immunogen, biological system, epitopes, haptens and antigenicity, pattern recognition receptors, superantigens. Immunoglobulins: Structure of antibody, function and synthesis, antibody mediated effector functions, antibody classes and biological activities, antigenic determinants on immunoglobulins, immunoglobulins superfamilies. Production and applications of monoclonal antibodies (by hybridoma technology).

Antigen-Antibody interactions: Strength of interaction, cross reactivity, precipitate, reaction, agglutination reaction, radio immunoassay, Enzyme Linked Immunosorbent Assay, chemiluminescence, ELISPOT assay, western blot, immunoprecipitation, immunofluorescence, flow cytometry and fluorescence.

Major histocompatibility complex: General organization, MHC molecules: structure & genes, their mode of antigen presentation and interaction, cellular distribution of MHC, regulation of MHC expression and disease susceptibility. Antigen Processing and Presentation: role of antigen presenting cells, endogenous antigens: cytosolic pathway; exogenous antigens: endocytic pathway. T-Cell receptor complex, T-Cell accessory membrane molecules, activation of T-cells, organization and arrangement of T-receptor genes B-cell receptor complex, activation and proliferation of B-cells, regulation of B-cell development.

Cytokines: Structure and functions, cytokine receptors, signal transduction mediated by cytokine receptors, cytokine regulation of immune responses, cytokine related diseases and...


Transplantation immunology: immunologic basis of graft rejection, immune suppression and immune tolerance. Tumor immunology: cancer definition, malignant transformation of cells, oncogenes and cancer induction, tumor antigens, tumor evasion of the immune system, cancer immunotherapy.

Suggested Readings


13. Basic and Clinical Immunology, D.P. Stities and J.D. Stobo.
15. Immunology by Tizzard
17. Immunology by Abbas.

S11004: MOLECULAR BIOLOGY and BIOTECHNIQUES Credit(s): 4

Nuclear organization: Chromosomal DNA and particles, nucleosomes. Modern Concept of gene organization. Chromosomal replication, synthesis and processing (DNA replication, Enzymology of DNA replication), DNA repair.
Gene mutation: Types of mutations, Molecular mechanism of mutations Chromosomal mutations: changes in the structure of chromosome and changes in number of chromosomes, polyploidy.
Transcription and Translational control: Structure of bacterial RNA polymerase, Transcription events, and sigma factor cycle, Eukaryotic RNA polymerase, Promoter sequences, TATA box, Hogness Box, CAAT box, Enhancers, upstream activating sequences, Initiation and termination of transcription factor, RNA processing in Prokaryotes Vs Eukaryotes, Spliceosome.

Suggested Readings

2. Alberts et al: Molecular biology of the cell,
5. Jayraman: Laboratory Manual in Biochemistry

S11005: Laboratory Exercises Credit(s): 6

1. \( \lambda \text{max of Protein} \)
2. \( \lambda \text{max of DNA} \)
3. Separation of Amino acids using paper chromatography
4. Qualitative analysis of carbohydrates
5. Qualitative analysis of Fats and Oil
6. Qualitative analysis of Protein
7. Preparation of Buffers
8. Verification of Lambert and Beer law
9. Calibration of Spectrometer
10. Sterilization and preparation of media, Enumeration of bacteria and fungi from environmental samples - soil, water and air. Techniques for pure culture - streaking, pour plate and spread plate.
12. Isolation and maintenance of organisms by plating, streaking and serial dilution method, slant and stab cultures, storage of microorganisms.
13. Preparation of Liquid and Solid media for growth of microorganisms.
14. Stains and staining techniques, simple staining, negative staining, acid fast, spore, endospore staining, capsule staining & differential staining techniques.
18. Antimicrobial assay, phenol coefficient, agar plate sensitive method.
19. Culture ion and morphology of molds and yeast.
20. Assay of antimicrobials and demonstration of antibiotic resistance.
22. One step growth curve of coli phage.
23. Antimicrobial activity of certain plant extracts.
25. Cell counting and cell viability.
27. Lymphocyte subset identification and enumeration.
28. Separation of serum components by electrophoresis.
29. Immunodiffusion.
30. Radial immunodiffusion test.
31. Immunoelectrophoresis.
32. ELISA.
33. Differential WBC count.
34. The effect of hypertonic, hypotonic and isotonic environment on human RBC.
35. Ouchterlony technique.

Suggested Readings


8. Nucleic acid Biochemistry and Molecular Biology by Main Waring et al., (Blackwell).


11. Organic Chemistry, DJ Cram and GS Hammond

S12002: MOLECULAR THERAPEUTICS  
Credit(s): 4

Gene therapy: Background, Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Types of gene therapy (ex vivo & in vivo), choosing targets for gene therapy, vectors in gene therapy, Retro and adenovirus mediated gene transfer; Liposome and nano-particles mediated gene delivery

Cellular therapy: Stem cells: definition, properties and potency of stem cells; Sources: embryonic and adult stem cells; Concept of tissue engineering; Role of scaffolds; Role of growth factors; Role of adult and embryonic stem cells; Clinical applications; Ethical issues

Recombinant therapy: Clinical applications of recombinant technology; Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors

Immunotherapy: Monoclonal antibodies and their role in cancer; Role of recombinant interferons; Immunostimulants; Immunosuppressors in organ transplants; Role of cytokine therapy in cancers; Vaccines: types, recombinant vaccines and clinical applications Gene silencing technology; Antisense therapy; siRNA; Tissue and organ transplantation; Transgenics and their uses; Cloning; Ethical issues

Suggested Readings

S12003: GENETIC ENGINEERING  
Credit(s) 4

Concept and emergence of r-DNA technology, preparation and purification of total cell DNA, plasmid DNA and bacteriophage DNA; Basic techniques involved in rDNA technology; Enzymes involved in RDT( Klenow fragment, Taq DNA, Ribonucleases, Alkaline phosphatase, Nuclease, T4 DNA ligase) Restrict ion enzymes, Preparation of Desired Gene from genome, reverse transcription and gene machine. Generation of genomic and cDNA libraries; Methods of Ligation linkers, polylinker, adapter etc.
Vectors – Plasmids, cosmids, λ, phagemids, yeast artificial chromosomes. Introduction of DNA/RNA in bacteria, yeast, fungi and in other eukaryotic host systems; Select ion and screening of recombinant clones: Direct and indirect methods. Probe preparation (radio labelling and non-radio labelling) Methods based on Nucleic acid homology (Southern, northern, western, southern-western, subtractive, colony and plaque hybridization, in situ chromosomal hybridization, chromosomal walk, etc.)

Characterization of cloned DNA: Restriction mapping. DNA sequencing: Polymerase Chain Reaction and its variants. DNA fingerprinting, Molecular Markers (RAPD, SSR, VNR, RFLP, AFLP etc.)

Expression of cloned DNA: Expression vectors. Modification of cloned DNA (Site directed mutagenesis) Secretion of cloned product; Applications of recombinant DNA technology: Transgenic animals. Transgenic plants; Pharmaceutical products

Suggested Readings

1. Recombinant DNA: Watson
2. Genetic engineering: Sandya Mitra
5. Molecular Biology Lab fax I & II: T. A. Brown

S12004: INDUSTRIAL BIOTECHNOLOGY Credit(s): 4

Microorganisms involved in natural fermentation, Microbial succession.

Composition and nutrition of fermented products: Traditional fermented foods: Bread, cocoa, coffee, tea, sauerkraut, cheese, butter, yoghurt, meat, fish, etc. Alcoholic beverages: Beer, wine, and whisky. Value addition products: High fructose syrup, invert sugars, etc. Edible fungus: Mushrooms. Bioreactors in food fermentation; Packaging of fermented food products; Biosensors; Biological monitoring of foods, waste management and food processing; HACCP and hurdle technology. Protein engineering in food technology: methods, targets, and applications in foods.

Fermentation Technology- The component parts of a fermentation process range of fermentation processes, chronological development of fermentation industry. Isolation, Preservation and strain improvement of industrially-important microorganisms. Fermentation media for industrial fermentation. Design of Fermentor- Basic functions of a Fermentor for microbial culture, aseptic operation and containment, Aeration and Agitation, valves and steam traps; Types of fermentation, Types of fermentation vessels. Fermentation Processes- Batch, fed-batch and continuous fermentations. Solid-state fermentations, Dual or multiple fermentations; Recovery and purification of fermentation products (down-stream processing)- Recovery of microbial cells, cell disruption. Chromatography, membrane processes, drying and crystallization. Fermentation.


Suggested Readings

1. Microbial Biotechnology – Glazer and Nikaido 1995
5. Prescott and Dunn’s Industrial Microbiology – Reed (Ed).
6. Concepts in Biotechnology– Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman


8. Industrial Microbiology– Casida.

S12005: Laboratory Exercises

1. Estimation of carbohydrate by Anthrone reagent
2. Estimation of Glycogen
3. Estimation of Protein by Lowry’s, Barford and Biurate method
4. Saponification value of oil
5. Acid number of oil and fats
6. Iodine number
7. Estimation of DNA by DPA Method
8. Estimation of RNA by Orcinol Method
9. Restriction digestion
10. Ligation
11. Isolation of Bacterial DNA
12. Quantification of bacterial DNA using spectrophotometer
13. Isolation of RNA and quantification by a spectrophotometric method
14. Separation of plant protein by SDS PAGE and visualization
15. Demonstration of PCR technique
16. Isolation of genomic DNA from plant and bacteria
17. Isolation of plasmid
18. Agarose gel electrophoresis
19. Restriction Digestion DNA/plasmid
20. Isolation of RNA
21. Southern Blotting
22. Ligation
23. Conjugation
24. Transformation
25. PCR
26. Microbial analysis of food samples, methylene blue reduction test for milk.
27. Microbial production of food and beverages by fermentation–wine and yogurt
28. Isolation of industrially important microbes from the environment
29. Microbial Production of citric acid and antibiotics
30. Comparative studies of Ethanol production using different substrates
31. Production and assay of Alkaline Protease
32. Isolation of casein from milk
33. Microbial Production of antibiotics
34. Microbial Production of vitamin B12
35. Isolation of Ascorbic acid producing bacteria
36. Determination of TDP and TDT of microorganisms for design of a sterilizer
37. Microbial production of citric acid using Aspergillus niger.
38. Isolation and study of fungus responsible for food spoilage
39. Quality testing of milk by resazurin test
40. Determination of phosphatase activity in butter, whey, milk powder
41. Microbial logical analysis of food production
42. Analysis of mycotoxin in fungal contaminated food materials

S13001-ENVIRONMENTAL BIOTECHNOLOGY AND BIOSAFETY, BIOETHICS AND IPR
Credit(s): 4

Air pollution: Measurement of air pollution, Sources of air pollution, sampling, air pollution control through biotechnology. Biofuels and bio logical control of air pollution, plant derived fuels, biogas, landfill gas, bioethanol, biohydrogen; use of bio logical techniques in controlling air pollution; Removal of chlorinated hydrocarbons from air.

Water pollution and its control: Water as a scarce natural resource, Need for water management, Measurement of water pollution, Sources of water pollution.


Bio medical waste and its management

Degradation of Xenobiotic Compounds in Environment: Microbiology of degradation of xenobiotics in environment: Ecological considerations, decay behaviour & degradative plasmids; Hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides. Bioremediation: In-situ and ex-situ techniques, advantages and disadvantages of bioremediation, GEMs in environment, applications of genetically engineered microbes (GEM) in bioremediation; Slurry bioremediation; Bioremediation of contaminated groundwater, contaminated soils and waste land.

Phytoremediation: Types and its applications, phytoremediation of soil metals; Environmental monitoring: Bio indicators
Integrated pest management- An ecological approach; Biopesticides, role of biopesticides in
integrated pest management.

Biosafety definitions - biosafety levels - framework of biosafety regulation in India; Structure and functions of Committees; DBT guidelines on biosafety in conducting research in biology/biotechnology - Regulations of Genetically modified Organisms in India - Biosafety regulation for transgenic plants and animals - labeling of GM foods

IPR - Definitions - Different forms of IPR - Benefits of IPR system; WTO - Definitions, GATT - Definitions - Objectives - Structural format of WTO - Economic Impact of WTO - WTO Agreements - Benefits of WTO in relation to biotechnology.

Bioethics - Definitions - Bioethics of IPR - ethical criteria in biotechnology - animal ethics; Guidelines for use of lab animals in medical Colleges - Licensing of animal house Human cloning - Ethical issues - Ethical clearance norms for conducting studies on human subjects.

Suggested Readings


5. Waste water treatment for pollution control. 2nd ed. Arceivala.


11. Introduction to Biodeterioration, D Allsopp and K J Seal, ELBS/Edward Arnold. Cambridge
Concepts & basic techniques in tissue culture; Conventional breeding v/s tissue culture. Tissue culture media (composition & preparation), sterilization techniques, tissue culture as a technique to produce novel plants & hybrids, Greenhouse and Greenhouse technology; Initiation and maintenance of callus and suspension cultures, single cell clones, nurse culture technique, differentiation, organogenesis & somatic embryogenesis, Production and application of artificial seeds

Shoot tip culture for rapid clonal propagation & production of virus-free plants, stages of micropropagation, propagation by direct and indirect organogenesis, micrografting, physiological nature/abnormalities of micropropagated plants. Transfer and establishment of whole plants in soil, in situ and ex situ rooting & difference; Changes during hardening of micropropagated plants

Protoplast isolation, fusion & culture, somatic hybridization, selection of hybrid cells and regeneration of hybrid plants, symmetric and asymmetric hybrids, cybrids and role of protoplast culture and somatic hybridization in improvement of crop plants. Haploid production and its significance, anther, pollen culture, monoploid production through bulbosum method, Embryo culture/embryo rescue and ovary culture; Endosperm culture, production of triploids, Role of haploid, monoploid and triploid in agriculture

Basic concepts and genetic engineering for increasing crop productivity by manipulation of
Photosynthesis, nitrogen fixation, Nutrient uptake efficiency, biotic

Insects, fungi, bacteria, viruses, weeds, Abiotic stress- drought, flooding, salt and temperature and for quality improvement- Protein, lipids, carbohydrates, vitamins & mineral nutrients.

Plants as bioreactor or Molecular farming- value added crops, edible vaccines, industrial enzymes, antibodies, medicines. Cell cultures for secondary metabolites production.

Suggested Readings


2. TJ Fu, G Singh and WR Curtis (Eds): Plant Cell and Tissue Culture for the Production of


S13003: ANIMAL BIOTECHNOLOGY Credit(s):4

History and development of animal tissue culture; Equipment and materials (culture vessels, CO2 incubator, inverted microscope, cell counters). Principles of sterile techniques; Sources of tissues, types of tissues - epithelial, muscle, connective, nerve and blood; Introduction to balanced salt solutions

Cell culture media- components of the medium, physical, chemical and metabolic functions of media; Role of serum and supplements, serum-free media, features and specifications of MEM, DMEM, RPMI and Ham’s medium. Role of antibiotics in media; Primary culture– Mechanical and enzymatic mode of desegregation, establishment of primary culture; Subculture- passage number, split ratio, seeding efficiency,
criteria for subculture; Cell lines - definite and continuous cell lines, characterization, authentication, maintenance and preservation of cell lines. Measurement of cell number - hemocytometer, coulter counter; Measurement of cell viability and cytotoxicity; Dye exclusion and inclusion tests, colonogenic assay, macromolecular estimation, MTT based assay. Measuring parameters of growth – growth curves, PDT, Plating efficiency and factors influencing growth; Gene therapy - ex vivo and in vivo gene therapy methods, applications; Application of animal cell culture - Vaccine production, specialized cell types. Concepts of tissue engineering - skin, liver, kidney, bladder and heart. Transgenic animals - retroviral, micro injection, and engineered embryonic stem cell method of transgenesis; Application of transgenic animal’s biopharming, disease models, functional knockouts.

Suggested Readings


5. Animal Cell Culture Techniques Ed Martin Clynes, Springer


S13004: RESEARCH METHODOLOGY AND BIOSTATISTICS Credit(s): 4

Understanding Research: Introduction, definition and meaning of research, characteristics of research, objective of research, motivation in research, types of research, research approaches, significance of research, research methods versus methodology, research in decision making, role of research in various areas, limitations of research, what constitutes a good research. Scientific Methods and Research: Scientific method, definitions of scientific method, characteristics of scientific method, basis of scientific method, scientific
methods and scientific research, components of scientific approach, bias and prejudice in scientific research Formulating Research Problem and Hypothesis: Introduction, Research process/planning process, research problem-need for defining, pre-requisites for formulating research problem, selection of the research problem, points to ponder on research problem, units of analysis, time and space co-ordination, characteristics of interest, environmental conditions, technique involved in defining a problem, formulation of a research problem and hypothesis testing Hypothesis Testing: Introduction, Hypothesis: definition and meaning, role of hypothesis, source of hypothesis, kinds of hypothesis, characteristics of hypothesis, formulation of hypothesis, importance of hypothesis, difficulties in formulating hypothesis, means to overcome difficulties, testing of hypothesis, steps in testing hypothesis, flow diagram for hypothesis testing, measuring the power of a hypothesis test, statistical hypothesis/tests of significance, limitations of tests of significance Testing of Hypothesis-I (Parametric or Standard Tests of Hypothesis): Tests of hypothesis, important parametric tests, hypothesis testing of means, hypothesis testing for differences between means, hypothesis testing for comparing two related samples, hypothesis testing of proportions, hypothesis testing for difference between proportions, hypothesis testing for comparing a variance to some hypothesized population variance, testing the equality of variances of two normal populations, hypothesis testing of correlation coefficients Research Design: Introduction, Meaning and definition of research design, need for research design, relation between problem formulation and research design, factors affecting research design, advantages of research design, steps in research design, various types of research design, basic principles of experimental designs Data Collection and Management: Introduction, Meaning and importance of data, Sources of data, choosing the method for data collection, methods of collection of primary data: definition and meaning, types, importance, advantages and disadvantages; methods of collection of secondary data, scrutiny of secondary data, merits and demerits of different methods of collection of primary data. The Computer: Its Role in Research: Introduction, the computer and computer technology, the computer system, important characteristics, the binary number system, computer applications, computers and researcher

Definitions and scope of Biostatistics: Variable in biology, collection, classification and tabulation of data. Graphical and diagrammatic representation, histogram, frequency polygon, frequency curve; Importance and applications Tabulation and Classification of data, Frequency distribution and Graphical distribution of data Measure of Central tendencies Mean, Media, mode and their properties. Measures and Dispersion, Mean deviation, Variance, Standard deviation and Coefficient of Variation. Correlation and regression Elements of probability theory; Probability distributions – binomial, Poisson and normal
distribution; Correlation coefficient; Simple linear regression. Probit and logit analysis
Hypothesis Testing Student T, r and Chi-square test; Probability and Distribution

Concepts and problems on probability, Binomial, Poisson, Normal Distribution and their Applications, Different Models of data presentation with special reference to biological samples.

Suggested Readings


S13005: Laboratory Exercises Credit(s): 6

1. Water quality analysis - MPN method
2. Determination of dissolved oxygen concentration of water sample
3. Determination of biological oxygen demand (BOD) of sewage sample
4. Determination of Chemical oxygen demand (COD) of sewage sample
5. Isolation of xenobiotic degrading bacteria by selective enrichment technique
6. Test for the degradation of aromatic hydrocarbons by bacteria
7. Detection of coliforms for determination of the purity of potable water
8. Estimation of nitrate in drinking water
9. Isolation of VAM from soil by wet sieving and decanting method
10. Isolation and cultivation of mushroom
11. Introduction to tissue culture laboratory
12. Preparation of M.S. media
13. Growth regulator concentration maintenance
14. Anther culture
15. Apical meristem culture
16. Leaf culture
17. Artificial seed preparation

18. Preparation of Media
19. Window making
21. Production of Ginger wine
22. Production of Grape wine
23. Citric acid production by aspergilis and its estimation
24. Estimation of alcohol content
25. Saurkraut production
26. Production of antibiotic

140005: Project (Dissertation) Credit(s): 22

Project: The students of M.Sc. Biotechnology should carry out a dissertation work for at least 16 weeks in a National Lab/Private industry/reputed lab/institute. Dissertation will be based upon research and actual bench work. It will begin from the end of III semester and will continue through the IV semester. Dissertation report will be submitted and evaluated at the end of IV semester and students should defend their work in front of a selected committee in their last semester.

Elective Paper: The students of M.Sc. Biotechnology should prepare a detailed report on an elective paper based on the advancements in the field.

Seminar: Credit(s): 2
M. Sc. BOTANY

Objectives of the course

The Curriculum for Post-graduate Programme of Botany envisages specialized education, simultaneously introducing the concepts of breadth and depth learning. With this in mind, we aim to provide a firm foundation in every aspect of Botany and to explain a broad spectrum of modern trends in Botany and to develop experimental, observational, computational skills also which lead him/her as an ambassador of sustainable development of our country.

It is imperative to know the importance and scope of the discipline, to inculcate interest in and love of nature with its myriad living forms, to impart knowledge of science as the basic objective of Education, to develop a scientific attitude to make students open minded, to develop an ability to work on their own and to make them fit for the society, to expose themselves to the diversity amongst life forms, to develop skill in practical work, experiments, equipments and laboratory along with collection and interpretation of biological materials and data, to make students aware of natural resources and environment and the importance of conserving it, to develop an ability for the application of the acquired knowledge in the fields of life so as to make our country self reliant and self sufficient and to make them able to appreciate and apply ethical principles to biological science research and studies.
# BOTANY

## SEMESTER – I

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<tr>
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<tbody>
<tr>
<td>S11006</td>
<td>CELL BIOLOGY</td>
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<tr>
<td>S11007</td>
<td>Molecular Biology</td>
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<td>S11008</td>
<td>CYTOGENETICS AND PLANT BREEDING</td>
<td>4</td>
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<td>S11009</td>
<td>ALGAE, FUNGI AND BRYOPHYTA</td>
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Total Credits 22

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<tr>
<td>S12007</td>
<td>TAXONOMY OF ANGIOSPERMS</td>
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<tr>
<td>S12008</td>
<td>MICROBIOLOGY</td>
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<td>S12009</td>
<td>PRINCIPLES OF PLANT PATHOLOGY</td>
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<tr>
<td>S13007</td>
<td>PLANT MORPHOLOGY &amp; DEVELOPMENTAL ANATOMY</td>
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<td>S13008</td>
<td>PLANT ECOLOGY</td>
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Total Credits 22

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<td>S14007</td>
<td>PLANT RESOURCE UTILIZATION &amp; ETHANOBOTANY</td>
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<td>S14008</td>
<td>PLANT BIOTECHNOLOGY &amp; GENETIC ENGINEERING</td>
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<td>ADVANCED PLANT PATHOLOGY-I</td>
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<td>S14010</td>
<td>Project (Dissertation)</td>
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Seminar 2

Total Credits 24

Total Credits of All Four Semesters 90
Botany

I semester

S11006: CELL BIOLOGY

Credit(s): 4

Introduction to modern tools and techniques of cell biology: advances in light and electron microscopy, techniques supplementing microscopy (cytochemistry, microprobe analysis, x-ray diffraction, etc.), Cell fractionation and visualization/characterization of various cell fractions.

Fundamentals of Cell: Structural organization of cell, difference between plant and animal cell; prokaryotic and eukaryotic cell, types of bonds and specialized plant cell types.

Cell wall, plasma membrane and plasmadesmata: Structure and functions, biogenesis, growth models and functions, sites for ATPases, ion carriers, channels and pumps, receptors. Role in movement of molecules and macromolecules, comparison with gap junctions.

Chloroplast and mitochondria: Structure, organization and function of mitochondrial and chloroplast genomes, diversity and evolution of organelle genomes, chloroplast protein targeting to different compartments, mitochondrial DNA and male sterility, transfer of genes between nucleus and organelles.

Plant vacuole: Structure and function.

Other Cellular organelles: Structure and functions of micro-bodies, Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, cytoskeleton.

Nucleus: Structure, nuclear pores, nucleosome organization, nucleolous, Chromatin organization: Chromosome structure and packaging of DNA, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, karyotype analysis, banding patterns, karyotype evolution, specialized types of chromosomes, polytene, lambrush, B-chromosomes and sex chromosomes, molecular basis of chromosome pairing.

Cell cycle and apoptosis: Control mechanisms, role of cyclins and cyclin-dependent kinases, retinoblastoma and E2F proteins, cytokinesis and cell plate formation, mechanisms of programmed cell death.

Suggested Readings

S11007: Molecular Biology

Credit(s): 4

DNA: Structure, types (A, B and Z forms), replication, damage and repair mechanisms. DNA Replication: Prokaryotic and eukaryotic DNA replication- Unit of replicon, enzymes involved, mechanism of DNA replication origin and replication fork. Structure and function of different types of RNAs- mRNA, t-RNA, r-RNA, snRNA, small nuclear proteins, ribosomes- subunits and its molecular structure and functions.

Transcription: Prokaryotic and eukaryotic transcription: Transcriptional factors and machinery, RNA polymerases, regulatory elements and mechanism of transcription regulation- formation of initiation complex, transcription activators and repressors, capping, elongation, and termination, RNA processing, RNA editing, splicing, polyadenylation, RNA transport- nuclear transport of mRNA, mRNA stability.


Cell signaling: Hormones and their receptors, Cell surface receptors, signaling through G protein coupled receptors, signal transduction pathways, mechanism and cellular response to environmental signaling. Cellular communication: Regulation of hematopoiesis, General principles of cell communication, Cell adhesion and role of different adhesion molecules, Gap junctions, Extracellular matrix integrins, Neurotransmission and its regulation.

Suggested Readings

USA.

S11008: CYTOGENETICS AND PLANT BREEDING


Genetic recombination and genetic mapping: Recombination, independent assortment and crossing over, molecular mechanism of recombination, role of RecA and RecBCD enzymes, site-specific recombination, chromosome mapping, linkage groups, genetic markers, construction of molecular maps, correlation of genetic and physical maps, somatic cell genetics - an alternative approach to gene mapping.

Mutations: Spontaneous and induced mutations, physical and chemical mutagens, molecular basis of gene mutation, transposable elements in prokaryotes and eukaryotes, mutation induced by transposons, site-directed mutagenesis, DNA damage and repair mechanisms, inherited diseases and defects in DNA repair, initiation of cancer at cellular level, protooncogenes and oncogenes.

Sex determination, sex, linked inheritance, sex limited characters and sex reversal, multiple allele's and blood groups in man.

Structural and numerical alterations in chromosomes: Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes, Origin, occurrence, production and meiosis of haploids, aneuploids and euploids, origin and production, of autopolyploids, chromosome and chromatid segregation, allopolyploids, types, genome
constitution and analysis, evolution of major crop plants, induction and characterization of trisomics and monosomics.

Molecular cytogenetics: Nuclear DNA content, C-value paradox, cot curve and its significance, restriction mapping - concept and techniques, multigene families and their evolution, in situ hybridization - concept and techniques, physical mapping of genes of chromosomes, flow cytometry and confocal microscopy in karyotype analysis.

Genetic system and breeding methods: Reproduction and breeding systems in plants. Recombination, genetic control and manipulation of breeding systems including male sterility and apomixis. Selection and breeding strategies for self-pollinated, cross-pollinated and clonally propagated crop plants, breeding for crop quality, biotic and abiotic stresses, gene pyramiding for multi-trait incorporation.

**Suggested Readings**

Algae in diversified habitats (terrestrial, fresh water and marine), thallus organization; cell ultra structure; reproduction (Vegetative, asexual and sexual); classifications of algae based on pigments, cell wall composition, reserved food material and flagellation; salient features of cyanophyta, chlorophyta, bacillariophyta, xanthophyta ,pyrrhophyta ,phaeophyta and rhodophyta with special reference to Spirullina, Nitella ,Pinnularia , Gonyaulax , Laminaria,Gelidium and Batrachospermum.

General characters; cell ultra structure ;thallusorganization; cell wall composition ; nutrition (saprobic, biotrophic and symbiotic); reproduction (vegetative, asexual and sexual), heterothallism;heterokaryosis; paraparkicity; sex hormones and recent trends in classification of fungi;Phylogeny of fungi; general account of mastigomycotina, zygomycotina, ascomycotina, basidimycotina and deuteromycotina with special reference to Physarum, Perenospora, Neurospora, Polyporus , Drechslera and Colletotrichum. Fungi in industries, medicines and as food. Fungal diseases in plants and animals including humans; Mychorrhizae; fungi as biocontrol agents.

Morphology, structure, distribution, reproduction and classification of bryophytes; General account of marchantiales, jungermaniales, anthocerotales, sphagnales, funariales and polytrichales with special reference to Plasiochasma, Notothylus and Polytrichum . Economic and ecological importance of bryophytes.

Recent trends in Phycology and Bryology:- Algae as a rich source of protein (SCP), algae in space, algae as biofertilizers, algal blooms, algae in food and industry, algae in pharmaceuticals and parasitic algae. Benthic macroalgae and factors affecting their environment Economic Importance of Bryophytes with special reference to Ecology, as pollution indicators and in monitoring pollution, anti microbial properties of bryophytes, geobotanical prospects.

Suggested Readings


S11010: Laboratory Exercises Credit(s): 6

Laboratory Exercises Based on S11006

1. Isolation of mitochondria and the activity of its marker enzyme, succinate dehydrogenase (SDH).
2. Isolation of chloroplasts and SDS-PAGE profile, of proteins to demarcate the two subunits of Rubisco.
3. Fluorescence staining with FDA for cell viability and cell wall staining with calcofluor.
4. Demonstration of SEM and TEM.

Laboratory Exercises Based on S11007

1. Isolation of nuclei and identification of histones by SDS-PAGE.
2. Isolation of plant DNA and its quantitation by a spectrophotometric method.
3. Isolation of DNA, and preparation of 'cot' curve.
4. Restriction digestion of plant DNA, its separation by agarose gel electrophoresis and visualization by ethidium bromide staining.
5. Isolation of RNA and quantitation by a spectrophotometric method.
6. Separation of plant RNA by agarose gel electrophoresis and visualization by EtBr staining.
7. Southern blot analysis using a gene specific probe.
8. Northern blot analysis using a gene Specific probe.
Laboratory Exercises Based on S11008

**Laboratory Exercises**

1. Linear differentiation of chromosomes through banding techniques, such as G-banding, C-banding and Q-banding.
2. Silver banding for staining nucleolus-organizing region, where 18S and 28S rDNA are transcribed.
3. Orcein and Feulgen staining of the salivary gland chromosomes of Chironomus and Drosophila.
4. Characteristics and behavior of B chromosomes using maize or any other appropriate material.
5. Working out the effect of mono- and tri-somy on plant phenotype, fertility and meiotic behavior.
6. Induction of polyploidy using colchicines, different methods of the application of Colchicines.
7. Effect of induced and spontaneous polyploidy on plant phenotype, meiosis, pollen and seed fertility and fruit set.
8. Effect of translocation heterozygosity on plant phenotype. Chromosome pairing and chromosome disjunction and pollen and seed fertility.
9. Isolation of chlorophyll mutants. following irradiation and treatment With chemical mutagens.
10. Estimation of nuclear DNA content through micro densitometry and flow cytometry.
11. Fractionation and estimation of repetitive and unique DNA sequences in nuclear DNA.
12. Analysis of morphological and molecular diversity in different cultivars/varieties of a crop plant.

Laboratory Exercises Based on S11009

Morphological study of representative members of algae, fungi and bryophytes present in your locality in their natural habitat with special reference to:

**Algae:** Microcystis, Spirullina, Dunella, Aulosira, Oocystis, Spirogyra, Pediastrum, Hydrodictyon, Ulva, Pithophora, Stigeoclonium, Drapanaldiopsis, Closterium, Cosmarium, Nuitella, Pinnularia, Laminaria, Gelidium and Batrachospermum; Isolation and culture of algae.

**Fungi:** Stemonites, Peronospora, Pythium, Albugo, Rhizopus, Pilobolus, Yeast, Emericella, Chaetomium, Pleospora, Morchella, Melampsora, Phallus, Polyporus, Drehslera, Curvularia, Phoma, Penicillum, Aspergillus, Colletotrichum, Fusarium and Alternaria; Symptomology of some diseased specimens: White rust, downy mildew, powdery mildew, rusts, smuts, ergot, groundnut leaf spot, red rot of sugarcane, wilts and paddy blast.

**Bryophytes:** Plasiochasma, Pellia, Notothyllus, Andreaea and Polytrichum.
Pteridophytes; Morphology, anatomy, reproduction; classification, distribution life history and general account of fossil pteridophytes, psilopsida, lycopsida, sphenopsida and pteropsida classes with special reference to Tmesipteris.


Gymnosperms; Morphology, anatomy, reproduction; classification, distribution, life history and evolution. Brief account of families of pteridospermales (Lygenopteridaceae, Medullosaceae, Caytoniaceae, Glossopteridaceae), Cycadeoidales, Cordaitales and living gymnosperms (families of Cycadals, Ginkgoales, Coniferales, Ephedrales, Welwitschiales and Gnetales).

Formation and types of fossils, techniques of study of fossils, geological time scale. Applied aspects of paleobotany; use in coal and petroleum exploration.

Suggested Readings


S12007: TAXONOMY OF ANGIOSPERMS

Origin of intrapopulation variation: Population and the environment, ecads and ecotypes, evolution and differentiation of species - various models.


Taxonomic evidence: Morphology, anatomy, palynology, embryology, cytology, phytochemistry, genome analysis and nucleic acid hybridization. Taxonomic tools: Herbarium, floras, histological, cytological, phytochemical, serological, biochemical and molecular techniques, computers and GIS.

Systems of angiosperm classification: Phenetic versus phylogenetic systems, cladistics in taxonomy, relative merits and demerits of major systems of classification, relevance of taxonomy.
to conservation, sustainable utilization of bio-resources and ecosystem research. Concepts of phytogeography: Endemism, hotspots and hottest hotspots, plant explorations, invasions and introductions, local plant diversity and its socio-economic importance.

Diagnostic features, systematics, phylogeny and economic importance of Ranunculaceae, Magnoliaceae, Fabaceae (Papillionaceae, Mimosaceae, Caesalpiniaceae), Rosaceae, Cucurbitaceae, Apiaceae, Apocynaceae, Asclepiadaceae, Convolvulaceae, Solanaceae, Acanthaceae, Lamiaceae, Chenopodiaceae, Euphorbiaceae, Orchidaceae, Liliaceae, Araceae and Poaceae.

Suggested Readings

General characteristics of microorganisms, scope, history and development of microbiology, contribution of Van Leeuwenhoek- Joseph Lister, Pasteur, Koch, Jenner.
Classification of microorganisms; Hackel’s three kingdom concept, Whittaker’s five kingdom concept. Modern trends in classification (ribotyping, nucleic acid hybridization, RNA fingerprinting, molecular chronometer).

Occurrence, salient features and designation of following:

Morphology & Ultra structure of Bacteria. Cultivation of Bacteria; anaerobic, aerobic culture media, growth curve, growth kinetics, batch, continuous culture, growth measurements. Pure culture techniques, preservation methods.
General account of Mycoplasma- Characteristics, cell morphology, diseases caused in plants by mycoplasma. Viruses- Nomenclature, classification, properties and structure of viruses Life cycle and pathogenesis of following RNA virus- Picorna, ortho, Rabdo, Hepatitis and HIV Vaccinations.

Immunology: General account of immunity, allergy, properties of antigens and antibodies. Antibody structure and function, affinity and antibody specificity, Monoclonal antibodies and their uses, antibody engineering, serology.

Suggested Readings

2. Industrial Microbiology, G. Reed (editor), CBS Publishers (AVI Publishing Company)
5. General Microbiology by R.Y. Stanier, John L. Ingraham and Mark L. Wheelis pagex, Mc Millian Press.
History and scope of plant pathology: General account of diseases caused by plant pathogens. Pathogen attack and defense mechanisms: Physical, physiological, biochemical and molecular aspects.

Plant disease management: Chemical, biological, IPM systems, development of transgenics, biopesticides, plant disease clinics. Information technology in plant pathology: Preliminary account of application of information technology in plant pathology.

Symptomology, identification and control of following plant diseases:
Fungal diseases: Wheat - Rust, Smut, Bunt
Pearl millet - Green ear, ergot and smut
Crucifers – rust
Paddy- Paddy blast
Cotton - Wilt
Grapes -Downy mildew and powdery mildew

Bacterial diseases: Wheat (Tundu), Citrus canker.
Viral diseases: Tobacco mosaic, Bhindi yellow vein mosaic.
Phytoplasma disease: Little leaf of brinjal
Nematode diseases: Root-knot of vegetables.

Suggested Readings

7. Mehrotra, R.S. Plant Pathology, Tata McGraw Hill.
S12010: Laboratory Exercises  Credit(s): 6

**Laboratory Exercises based on S12006**

Morphological and anatomical study of representative members of pteridophytes and gymnosperms in their natural habitat found in your locality with special reference to Psilotum, Lycopodium, Selaginella, Isoetes, Equisetum, Gleichenia, Pteris, Dryopteris, Adiantum, Ophioglossum and marsilea in pteridophytes and Zamia, Aurocaria, taxus, Thuja and Ephedra in gymnosperms.

Collection and study of fossils in their natural form.

**Laboratory Exercises based on S12007**

1. Description of a specimen from representative, locally available families.

**List of Locally Available Families:**


2. Description of a species based on various specimens to study intraspecific variation: a collective exercise.

3. Description of various species of a genus, location of key characters and preparation of keys at generic level.

4. Location of key characters and use of keys at family level.

5. Field trips within and around the campus, compilation of field notes and preparation of herbarium sheets of such plants, wild or cultivated, as are abundant.

6. Training in using floras and herbaria for identification of specimens described in the class.
7. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.
8. Comparison of different species of a genus and different genera of a family to calculate similarity coefficients and preparation of dendrograms.

**Laboratory Exercises based on S12008**

2. Isolation of pure culture by Pour plate, Serial dilution and Streak plate method.
3. Study of Growth curve.
4. Effect of pH, temp, Osmolarity and Oxygen, UV, Dessication on growth of bacteria.
5. Sterilization methods.
   - Total count (haemocytometer)
   - Viable count (Plate count)
7. Methods of staining bacteria.
8. Simple staining
9. Gram’s staining
10. Endospore staining
11. Negative staining
13. Fermentative production of ethyl alcohol by Yeast.
14. Extraction and detection of aflatoxin for infected foods.
15. Serological tests - Widal test, VDRL test,
16. WBC count. RBC count,
17. Blood grouping. Rh factor,
18. Haemoglobin estimation
19. To study spontaneous mutations by replica plating.
20. To study induced mutations in bacteria.
21. Isolation of antibiotic resistant mutants by gradient plate technique.
22. Isolation of antibiotic resistant mutants by antibiotic disc method.
24. Testing of milk by MBRT, Turbidity Test for Milk, Qualitative estimation of Phosphorus and calcium in milk.
25. Casien isolation from milk sample
26. Coliform Test for milk
27. Isolation of micro-organisms from air, water, soil and rhizosphere microflora
28. Isolation and identification of pathogens

**Laboratory Exercises based on S12009**

Exercises and Plant diseases as per theory syllabus.
Field visits to show diseases in crop plants.
Water relation of plants: Unique physiochemical properties of water Chemical potential, Water potential, Bulk movement of water. Soil plant atmosphere continuum (SPAC), Stomatal regulation of transpiration. 


Photobiology: Photoreceptors, Phytochrome-History, discovery, physiological properties. Interaction between hormones and phytochrome, role of different phytochromes in plant development and flowering. 


Respiration: Anaerobic and aerobic respiration. Amphibolic nature of TCA cycle, Pentose phosphate pathway, Glyoxylate pathway, oxidative phosphorylation, Gluconeogenesis, High energy compounds; their synthesis and utilization.

Fat metabolism: Synthesis of long chain fatty acids, lipid biosynthesis, alpha and beta oxidation.

Plant growth regulators: Auxins - chemical nature, bioassay, physiological effects and mode of action. 
Gibberellins - chemical nature, bioassay, physiological effects and mode of action.
Cytokinins - chemical nature, bioassay, physiological effects and mode of action.
Abscisic acid - chemical nature, bioassay, physiological effects and mode of action.
Ethylene - chemical nature, bioassay, physiological effects and mode of action.

Physiology of flowering: Photoperiodism and Vernalization.

**Suggested Readings**

S13007: PLANT MORPHOLOGY & DEVELOPMENTAL ANATOMY Credit(s): 4

Introduction: An overview of plant development.
Seed germination and seedling growth: Metabolism of nucleic acids, proteins and mobilization of food reserves, tropisms during seed germination and seedling growth, hormonal control of seedling growth, gene expression, use of mutants in understanding seedling development.

Shoot development: Organization of the shoot apical meristem (SAM), cytological and molecular analysis of SAM, control of cell division and cell to cell communication, Primary and Secondary tissue differentiation, control of tissue differentiation, especially xylem and phloem, secretory ducts and laticifers, wood development in relation to environmental factors.

Leaf growth and differentiation: Determination, phyllotaxy, control of leaf form, differentiation of epidermis (with special reference to stomata and trichomes) and mesophyll, Leaf traces and leaf gaps, Petiolar anatomy.

Root development: Organization of root apical meristem (RAM), cell fates and lineages, vascular tissue differentiation, lateral roots, root hairs, root-microbe interactions.

Seed coat development: Ontogeny of seed coat, mature structure, Spermoderm pattern.

Suggested Readings

S13008: PLANT ECOLOGY Credit(s): 4

Introduction to ecology, evolutionary ecology, ecological models; Characteristics of population, population size and exponential growth, limits of population growth, population dynamics, life history pattern, fertility rate and age structure, population growth. Competition and coexistence, intra-specific interactions, interspecific interactions, scramble and contest competition model, mutualism and commensalism, prey-predator interactions.

Vegetation organization: Concepts of community and continuum, community coefficients, interspecific associations, ordination, Species Diversity and Pattern Diversity in Community, Concept of Habitat and Ecological Niche.
Vegetation development: Temporal changes (cyclic and non-cyclic), mechanism of ecological succession. Changes in Ecosystem Properties during Succession, Concept of Climax.

Nature of ecosystem, production, food webs, energy flow through ecosystem, Biogeochemical Cycles (global) of C, N, P and S, resilience of ecosystem, ecosystem management. The biosphere, biomes and impact of climate on biomes.


Suggested Readings


S13009: Plant Biotechnology  Credit(s): 4

Basic concepts, principles and scope of Biotechnology Plant tissue culture: General introduction, history and scope of plant tissue culture, comparison of different plant tissue culture media, concept of totipotency, organogenesis, somatic embryogenesis (direct & indirect), callus culture and suspension culture, somaclonal variation, hardening and acclimatization of plants.
Protoplast culture: Isolation and culture of protoplast, somatic hybridization, hybrid selection and regeneration, concept of hybrid and cybrid, achievements and limitations of protoplast culture. (10 Hours)

Transgenic plants: Concept and history of transgenesis in plants, principles and techniques of gene cloning: direct DNA transfer to plant cells, Agrobacterium mediated transformation: Ti plasmid, process of T- DNA transfer and integration, vectors, promoter, terminator, marker and reporter genes, ethical and ecological issues of transgenesis, terminator technology (GURT)

Genetic engineering: Molecular tools and their applications: Restriction enzymes, DNA and genomic library, DNA sequencing, polymerase chain reaction, DNA fingerprinting, genetic markers-RFLP analysis, isolation and purification of DNA.

Suggested Readings


S13010: Laboratory Exercises

1. Effect of time and enzyme concentration on the rate of reaction of enzyme (e.g. acid phosphatase nitrate reductase).
2. Effect of substrate concentration on activity of any enzyme and determination of its Km value.
3. Demonstration of the substrate inducibility of the enzyme nitrate reductase.
4. Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum of chlorophylls and carotenoids.
5. To determine the chlorophyll a/ chlorophyll b ratio in C3 and C4 plants.
7. To demonstrate photophosphorylation in intact chloroplasts, resolve the phosphoproteins by SDS-PAGE and perform autoradiography.
8. Extraction of seed proteins depending upon the solubility.
9. Determination of succinate dehydrogenase activity, its kinetics and sensitivity to inhibitors.
11. Preparation of the standard curve of protein (BSA) and estimation of the protein content in extracts of plant material by Lowry's or Bradford's method.
12. Fractionation of proteins using gel filtration chromatography by Sephadex G100 or Sephadex G200.
13. SDS-PAGE for soluble proteins extracted from the given plant materials and comparison of their profile by staining with Coomassie Brilliant Blue or silver nitrate.
15. Radioisotope methodology, autoradiography, instrumentation (GM count and Scintillation counter) and principles involved.

**Suggested Readings (for laboratory exercises based on S13006)**


**Laboratory/Field Exercises based on S13007**

1. Effect of gravity, unilateral light and plant growth regulators on the growth of young seedlings.
2. Role of dark and red light/far-red light on the expansion of cotyledons and epicotylar hook opening in pea.
3. Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla*.
4. Study of cytohistological zonation in the shoot apical meristem (SAM) in sectioned and double-stained permanent slides of a suitable plant such as *Coleus*, *Kalanchoe*, *tobacco*. Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
5. Study of alternate and distichous, alternate and superposed, opposite and superposed, opposite and decussate leaf arrangement. Examination of rosette plants (*Launaea*, *Mollugo*, *Raphanus*, *Hyoscyamus* etc.) and induction of bolting under natural conditions as well as by GA treatment.
6. Microscopic examination of vertical sections of leaves such as *Cannabis*, tobacco, *Nerium*, maize and wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the C3 and C4 leaf anatomy of plants.
7. Study of epidermal peels of leaves such as *Coccinia*, *Gaillardia*, *Tradescantia*, *Notonea* etc. to study the development and final structure of stomata and prepare stomatal index. Demonstration of the effect of ABA on stomatal closure.

**Laboratory Exercises based on S13008**

1. To determine minimum size and number of quadrat required for reliable estimate of biomass in grasslands.
2. To compare protected and unprotected grassland stands using community coefficients (similarity indices).
3. To estimate IVI of the species in a grassland/woodland using quadrat method.
4. To determine gross and net phytoplankton productivity by light and dark bottle method.
5. To determine soil moisture content, porosity and bulk density of soils collected from varying depths at different locations.
6. To determine the Water holding capacity of soils collected from different locations.
7. To determine percent organic carbon and organic matter in the soils of cropland, grassland and forest.
8. To estimate the dissolved oxygen content in eutrophic and oligotrophic water samples by azide modification of Wrinkler's method.
9. To estimate chlorophyll content in SO2 fumigated and unfumigated plants leaves.
10. To estimate rate of carbon dioxide evolution from different soils using soda lime or alkali absorption method.
11. To study environmental impact of a given developmental activity using checklist as a EIA method.

S14006: PLANT REPRODUCTIVE BIOLOGY  
Credit(s): 4

Reproduction: Vegetative options and sexual reproduction, flower development, genetics of floral organ differentiation, homeotic mutants in Arabidopsis sex determination.
Male gametophyte: Structure of anthers, microsporogenesis, role of tapetum, pollen development and gene expression, male sterility, sperm dimorphism and hybrid seed production, pollen germination, pollen tube growth and guidance, pollen storage, pollen allergy, pollen embryos.

Female gametophyte: Ovule development, meigasporogenesis, organization of the embryo sac, structure of the embryo sac.
Pollination, pollen-pistil interaction and fertilization: Floral characteristics, pollination mechanisms and vectors, breeding systems, commercial considerations, structure of the pistil, pollen-stigma interactions, sporophytic and gametophytic self-incompatibility (cytological, bio'chemical and molecular aspects), double fertilization, in vitro fertilization.

Seed development and fruit growth: Endosperm development during early maturation and desiccation stages, embryogenesis, ultrastructure and nuclear cytology, cell lineages during late embryo development, storage proteins of endosperm and embryo, polyembryony, apomixis, embryo culture, dynamics of fruit growth, biochemistry and molecular biology of fruit maturation.

Latent life - dormancy: Importance and types of dormancy, seed dormancy, overcoming seed dormancy, bud dormancy.
Senescence and programmed cell death (PCD) : Basic concepts, types of cell death, PCD in the life cycle of plants, metabolic changes, associated with senescence and its regulation, influence of hormones and environmental factors on senescence.

Suggested Readings


S14007: PLANT RESOURCE UTILIZATION & ETHANOBOTANY Credit(s): 4

World centres of primary diversity of domesticated plants: The Indo-Barmese centre, plant introductions and secondary centres.

Origin, evolution, botany, cultivation and uses of (i) Food, forage and fodder crops, (ii) fibre crops, (iii) medicinal and aromatic plants and (iv) vegetable oil-yielding crops. Important firewood and timber-yielding plants and non-wood forest products (NWFPs) such as bamboos, rattans, raw materials for paper making, gums, tannins, dyes resins and fruits.


Strategies for conservation - *in situ* conservation: International efforts and Indian initiatives, protected areas in India - sanctuaries, national parks, biosphere reserves, wetlands, mangroves and coral reefs conservation of wild biodiversity.

Strategies for conservation - *ex situ* conservation: Principles and practices, botanical gardens, field gene banks, Seed banks, *in vitro* repositories, cryobanks, general account of the activities of Botanical Survey of India (BSI), National Bureau of plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), and the Department of Biotechnology (DBT) for conservation, non formal conservation efforts.

*Suggested Readings*


Recombinant DNA Technology: tools and techniques, construction of genomic/cDNA libraries, polymerase chain reaction, DNA fingerprinting

Vectors for plant transformation: Basic features of vectors (Promoters and terminators, selectable markers, reporter genes, origin of replication, Co-integrative and binary vectors, Optimization, clean gene technology.


Metabolic Engineering and industrial Products: control mechanisms and manipulation of phenylpropanoid pathway, alkaloids, industrial enzymes, biodegradable plastics, polyhydroxybutyrate, therapeutic proteins, Antibiotics, ethanol, Polyketides, Vitamins, Biopolymers, Biological Pigments, Amino acids, solvents.

Suggested Readings


S14009- Elective Paper

Credit(s): 4

A student has to choose one of the following two papers for the course S14009.

S14009(A): ADVANCED PLANT PATHOLOGY-I


S14009(B): ADVANCED PLANT PATHOLOGY-II


Virus, viroid and phytoplasma disease: Symptomatology and transmission of viral diseases; Potato virus X & Y, Tomato ring mosaic, bunchy top of banana; viroids and important viroid diseases. Phytoplasma General account; Sesame phyllody, Spike disease of sandal.


**S14010: Laboratory Exercises**

**Credit(s): 6**

**Laboratory /Field Exercises based on S14006**

1. Study of microsporogenesis and gametogenesis in sections of anthers.
2. Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (maize, grasses, *Cannabis sativa*, *Crotoloria*, *Tradescantia*, *Brassica*, *Petunia*, *Solanum melongena*, etc.)
5. Role of transcription and translation inhibitors on pollen germination and pollen tube growth.
7. Study of ovules in cleared preparations, study of monosporic, bisporic and tetrasporic types of embryo sac development thorough examination of permanent, stained serial sections.
8. Field study of several types of flower with different pollination mechanisms (Wind pollination, thrips pollination, bee/butterfly pollination, bird pollination).
9. Emasculation, bagging and hand pollination to study pollen germination, seed set and fruit development using self compatible and obligate outcrossing systems. Study of cleistogamous flowers and their adaptations.
10. Study of nuclear and cellular endosperm through dissections and staining.
11. Isolation of zygotic globular, heart-shaped, torpedo stage and mature embryos from suitable seeds and polyembryony in citrus, jamun (*Syzygium cumini*) etc. by dissections.
12. Study of seed dormancy and methods to break dormancy.
**Suggested Readings (for Laboratory Exercises)**


**Laboratory Exercises based on S14007**

The Practical course is divided into three units: (I) Laboratory work, (2) Field survey and (3) Scientific visits.

**Laboratory Work**

1. Food crops: Wheat, rice, maize, chickpea (Bengal gram), potato, tapioca, sweet potato, sugarcane. Morphology, anatomy, microchemical tests for stored food materials.
2. Forage/fodder crops: Study of any five important crops of the locality (for example fodder orghum, bajra, berseem, clove, guar bean, gram, Ficus sp.)
3. Plant fibers: (a) Textile fibres : cotton, jute, linen, sunn hemp, *Cannabis*. (b) Cordage fibres: coir (c) Fibres for stuffing: silk cotton or kapok
   Morphology, anatomy, (microscopic) study of whole fibres using appropriate staining procedures.
4. Medicinal and aromatic plants: Depending on the geographical location college/university select five medicinal and aromatic plants each from a garden crop field (or from the wild only if they are abundantly available).
   Study of live or herbarium specimens or other visual materials. to become familiar with these resources.
5. Vegetable oils : Mustard, groundnut, soybean, coconut, sunflower, castor, Morphology, microscopic structure of the oil-yielding tissues, tests for oil and iodine number.

**Scientific Visits**

The students should be taken to one of the following:
1. A protected area (biosphere reserve, national park, or a sanctuary)
2. A wetland
3. A mangrove
4. National Bureau of Plant Genetic Resources, New Delhi-110012 or one of its field stations.
5. Head Quarters of the Botanical Survey of India or one of its Regional Circles.
vi. A CSIR Laboratory doing research on plants and their utilization.

vii. An ICAR Research Institute or a field station dealing with one major crop or crops.

viii. A recognized botanical garden or a museum (such as those at the Forest Research Institute, dehradun, National Botanical Institute, Lucknow, Tropical Botanical Garden and Research Institute, Trivendram), which has collection of plant products.

Note: The students are expected to prepare a brief illustrated narrative of the field survey and scientific Visits. After evaluation, the grades awarded to the students by the teachers should be added to the field assessment of the practical examination.

**Laboratory Exercises based on S14008**

1. Preparation of media.
2. Surface sterilization
3. Micro propagation technique
4. Organ culture.
5. Callus propagation, organogenesis, transfer of plants to soil.
6. Anther culture, production of Haploids.
7. Preparation of synthetic seeds
8. Cytological examination of regenerated plants.
9. Isolation of protoplasts from various plant tissues and testing their viability
10. Agrobacterium culture, selection of transformants, reporter gene (GUS) assays.
11. PCR
12. Techniques: Biolistics, Membrane Filtration, Cell Counting
M. Sc. CHEMISTRY

Objectives of the course

Chemistry is a subject which complements other various subjects including Biology, Physics and Environmental Science to give a holistic approach as well as a broad thinking to the students to excel in their field of competence. The basic objective of Chemistry is to educate the young generation of chemists with the capacity to solve real problems and provide opportunities for scientific study and creativity within a global context which will stimulates and challenges them.

It gives knowledge to synthesize, separate and characterize various compounds using published reactions, protocols, standard laboratory equipments, and modern instrumentation. Molecular designing is the result of comprehensive knowledge of chemistry. Sustainability of the environment is another great concern which may be addressed well by a true chemist only.

Chemistry at Post-graduate level will surely equip a student for various future challenges related to economic and industrial growth.
# CHEMISTRY

## SEMESTER – I

<table>
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<tr>
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<tr>
<td>S110011</td>
<td>Inorganic Chemistry</td>
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<tr>
<td>S110012</td>
<td>Organic Chemistry</td>
<td>4</td>
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<td>S110013</td>
<td>Physical Chemistry</td>
<td>4</td>
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<tr>
<td>S110014</td>
<td>Mathematics and Computer</td>
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<tr>
<td>S110015</td>
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**Total Credits** 22

## SEMESTER – II

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<td>Chemistry of Transition Metals</td>
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**Total Credits** 22

## SEMESTER – III

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<td>Elective I,II,III (Organic Chemistry)</td>
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**Total Credits** 22

The students should select any one of the Elective group that is from CHY-302, 303 & 304 in semester III

## SEMESTER – IV

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<td>Elective I,II,III (inorganic chemistry)</td>
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<td>Seminar</td>
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**Total Credits** 24

**Total Credits of All Four Semesters** 90

The students should select any one of the Elective group in semester IV. Or else, from an elective group, student could select S140015 that is a Project Work to be pursued under the Guidance of A Faculty Member.
Stereochemistry and Bonding in main group compounds
VSEPR. Walsh diagram. Hybridization including energetic of hybridization. Bents rule, dπ-pπ bond. Some simple reactions of covalently bonded molecules (i) Atomic inversion (ii) Bery pseudo rotation (iii) Nucleophilic displacement (iv) Free radical mechanism

Hydrogen, alkali and alkaline earth metals

Noble gases
Isolation and properties. Preparation and structure of noble gas compounds

Boron compounds
Preparation, structure, bonding, reactions and applications of boranes, carboranes, metalloboranes, metallocarboranes, borazines.

Compounds of carbon and silicon
Fullerenes and their compounds, Intercalation compounds of graphite, carbon nano-tubes: Synthesis, structure, properties, and applications. Carbides, fluorocarbons, silanes, silicates, zeolites and silicones.

Compounds of oxygen group elements
Metal selenides and tellurides, oxyacids and o xoanions of S & N.

Compounds of nitrogen group elements
Nitrogen activation. Oxidation states of nitrogen and their interconversion. BN, PN and SN compounds - preparation, structure and bonding.

Compounds of halogen group elements
Synthesis, properties, bonding, and applications of interhalogens, pseudohalogens, polyhalides, oxyacids and oxoanions of halogens.

Solvents
Classification of solvents. Characteristic properties of an ionizing solvent. Reaction in liquid ammonia, liquid sulphur dioxide dimethyl formamide (DMF), dimethyl sulphoxide (DMSO) and dioxane.

Suggested Readings
S11012: ORGANIC CHEMISTRY  Credit(s): 4

Nature of Bonding in Organic Molecules

Stereochemistry
Conformational analysis of cycloalkanes, decalines, effect of conformation on reactivity, conformation of sugars, strain due to unavoidable crowding Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spirane chirallity due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Reaction Mechanism: Structure and Reactivity
Type of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotopes effects Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity, resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants, aft equation.

Aliphatic Nucleophilic Substitution
The SN2, SN1 mixed SN1 and SN2 and SET mechanism. The neighbouring group mechanism, neighbouring group participation by p and s bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl systems, common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations. The SN1 mechanism. Nucleophilic substitutin at an allylic, aliphatic trigonal and a vinylic carbon.
Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity.

Suggested Readings


8. Pericyclic Reactions, S.M. Mukherji, Macmillan, India

S11013: PHYSICAL CHEMISTRY                  Credit(s):4

Quantum Chemistry
Introduction to Exact Quantum Mechanical Results
The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

Approximate Methods
The variation theorem, linear variation principle. Perturbation theory (First order and nondegenerate). Applications of variation method and perturbation theory to the Helium atom.

Angular Momentum
Ordinary angular momentum, eigenvalues of angular momentum operator using ladder operators, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

Molecular Orbital Theory
Huckel theory of conjugated systems bond and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc.

Surface Chemistry
Adsorption
Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), Surface films on liquids (Electro-kinetic phenomenon).
Micelles
Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization-phase separation and mass action models, solublization, micro emulsion, reverse micelles.

Electrochemistry

Overpotential

Suggested Readings
1. Physical Chemistry, P.W. Atkins, ELBS.
4. Coulson's Valence, R.Mc Weeny, ELBS.

S11014: MATHEMATICS AND COMPUTERS

Matrix Algebra.
Addition and multiplication; inverse, adjoint and transpose of matrices, special matrices (Symmetric, skew-symmetric, Hermitian, Skey-Harmitian, unit, diagonal, unitary etc.) and their properties. Matrix equations: Homogeneous, non-homogeneous linear equations and conditions for the solution, linear dependence and independence. Introduction to vector spaces, matrix eigenvalues and digenvetors, diagonalization, determinatnts (examples from Juckel theory).

Differential Calculus
Functions, continuity and differentiability, rules for differentiation, applications of differential
calculus including maxima and minima (examples related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution etc.). Integral calculus, basic rules for integration, integration by parts, partial fractions and substitution. Reduction formulae, applications of integral calculus. Functions of several variables, partial differentiation, co-ordinate transformations (e.g. cartesian to spherical polar).

**Elementary Differential equations**
First-order and first degree differential equations, homogenous, exact and linear equations. Applications to chemical kinetics, secular equilibria, quantum chemistry etc. second order differential equation and their solutions.

**Introduction to computers**
Basic structure and functioning of computer with a PC as illustrative example. Memory I/O devices. Secondary storage Computer languages. Operating systems Introduction to UNIX and WINDOWS. Principles of programming Algorithms and flow-charts.

**Computer Programming in C**
History of “C” constants, variables and data types, operators and expression, input & output operation, decision making and branching looping, arrays, function, structures and unions,

**Suggested Readings**

1. The chemistry Mathematics Book, E.Steiner, Oxford University Press.
5. Applied Mathematics for Physical Chemistery, J.R. Barante, Prenice Hall.
6. Basic Matchematics for Chemestry, Tebbutt, Wiley
7. Fundamentals of Computer : V. Rajaraman (Prentice Hall)

**S11015: Laboratory exercises**

credit(s): 6

**Inorganic Chemistry**

I. Qualitative Analysis of mixture consisting of eight radicals (cational/anionic forms):

a. Less common metal ions : Ti, MO, W, Ti, Zr, Th, V, U
b. Insolubles : Oxides, sulphates and halides.
c. Interfering anionic radicals.
II. Qualitative Analysis: Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe etc. involving volumetric and gravimetric methods.

**Organic Chemistry**

**Qualitative Analysis**
Separation, purification and identification of compounds of binary mixture (two solids, one liquid and one solid) using tlc and columns chromatography, chemical tests. IR spectra to be used for functional group identification.

**Quantitative Analysis**
1. Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method
2. Determination of iodine and Saponification values of an oil sample.
3. Determination of DO, COD and BOD of water sample.

**Physical Chemistry**

(i) **Error Analysis and Statistical Data Analysis**
Errors, types of errors, minimization of errors distribution curves precision, accuracy and combination; statistical treatment for erro analysis, student 't' test, null hypothesis, rejection criteria. F & Q test; linear regression analysis, curve fitting. Calibration of volumetric apparatus, burette, pipette and standard flask.

(ii) **Adsorption**
(i) To investigate the adsorption of oxalic acid from aqueous solution by activated charcoal, and examine the validity of Freundlich and Langmuir adsorption isotherm.
(ii) To investigate the adsorption of acetic acid from aqueous solution by activated charcoal, and examine the validity of Freundlich and Langmuir adsorption isotherm.

(iii) **Phase Equilibria**

i. Determination of congruent composition and temperature of a binary system (e.g. diphenylamine-benzophenone system).

ii. Determination of glass transition temperature of given salt (e.g., CaCl2) conductometrically.

iii. To construct the phase diagram for three component system (e.g. chloroform-acetic acid-water).

iv. To construct the phase diagram for three component system (e.g. alcohol-benzene-water).

v. To determine CST of phenol and water in presence of 1.0%NaCl, 0.5% naphthalene, 1% succinic acid.

(iv) **Electrochemistry/ Conductometry**

Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically.

i. Determination of solubility and solubility product of sparingly soluble salts 9e.g. PbSO4, BaSO4) conductometrically.
ii. Determination of the strength of strong and weak acid in a given mixture conductometrically.

iii. to study of the effect of solvent on the conductance of AgNO3/acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Huckel-Onsager theory.

iv. Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Huckel's limiting law.

Suggested Readings

5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
9. Findley's Practical Physical chemistry, B.P. Levitt, Longman.

S12011: CHEMISTRY OF TRANSITION METALS

Credit(s): 4

Metal-Ligand bonding
Valence Bond Theory (VBT), Crystal field theory (CFT) for octahedral, trigonal bipyramidal, square pyramidal, tetrahedral and square planar complexes. Crystal field stabilization energy (CFSE), Factor affecting the crystal field parameters, weak and strong field complexes, spectrochemical series, John-Teller effect. Thermodynamic and related aspects of crystal fields - ionic radii, heats of ligation, lattice energy, site preference energy. Merits and limitations of CFT. Molecular orbital theory of octahedral, tetrahedral and square planar complexes. Pi bonding in bonding in octahedral complexes.

Metal ligand equilibria in solution
Stepwise and overall formation constants and their interaction, trends in stepwise constants. Factors affecting stability of metal complexes with reference to the nature of metal ion and ligand chelate effect and its thermodynamic origin. Determination of binary formation constant by pHmetry and spectrophotometry

Electronic spectra of transition metal complexes
Magnetic properties of transition metals

Reaction mechanism of transition metal complexes
Energy profile of a reaction, reactivity of metal complex, inert and labile complexes, A, D and I mechanisms for metal complexes, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage.

Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction. Redox reaction, electron transfer reactions, mechanism of one electron transfer reactions, outer sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions.

Compounds with metal-metal multiple bonds and Poly-ions: Metal carboxylate and halide compounds with metal –metal multiple bonds.

Suggested Readings


S12012: ORGANIC CHEMISTRY Credit(s):4

Aromatic Nucleophilic Substitution
The SNAr SN1, benzyne and SN1 mechanism, Reactivity effect of substrate structure, leaving group and attacking nucleophile. The Von Richte. Sommelet-Hauser, and Smiles rearrangements.

Free Radical Reactions
types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic
halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkenes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction

**Aliphatic Electrophilic Substitution**
Bimolecular mechanisms SE2 and SE1. The SE1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving groups and the solvent polarity on the reactivity.

**Aromatic Electrophilic Substitution**
The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gatterman-Koch reaction

**Addition to Carbon-Carbon Multiple Bonds**
Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration, Michael reaction, sharpless asymmetric epoxidation.

**Addition to Carbon-Hetero Multiple bonds**
Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acid esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Witting reaction. Mechanism of condensation reactions involving enolates-Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

**Elimination Reactions**
The E2, E1 and E1 cB mechanisms and their spectrum. Orientation of the double bond. Reactivity-effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

**Pericyclic Reactions**
Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlatino diagrams. FMO and PMO approach. Electrocyclic reactions-conrotatory and disrotatory motions, 4n 4n+2 and allyl systems. Cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements-suprafacial and antarafacial shifts of H, sigmatropic involving carbon moieties, 3,3- and 5,5 sigmatropic rearrangements. Claise n, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

**Suggested Readings**

9. Pericyclic Reactions, S.M. Mukherji, Macmillan, India

S12013: PHYSICAL CHEMISTRY Credit(s): 4

Theoremodynamic
Classical Thermodynamics

Statistical Thermodynamics

Chemical Dynamics-I
Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, Dynamic chain reaction (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical reaction (hydrogen-bromine and hydrogen-chlorine reactions),

Chemical Dynamics-II
kinetics of enzyme reactions, general features for fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method, dynamics of unimolecular reactions (Lindeman Hinshelwood and Rice-Ramsperger-Kassel-Marcus (RRKM) theories for unimolecular reactions).
**Suggested Readings**

1. Physical Chemistry, P.W. Atkins, ELBS.
4. Coulson's Valence, R.Mc Weeny, ELBS.

**S12014: Group Theory, Spectroscopy-II**

**Credit(s): 4**

**Symmetry and Group theory in Chemistry**
Symmetry elements and symmetry operation, definition of group, subgroup. Conjugacy relation and classes. Point symmetry group. Schönflies symbols, representations of groups by matrices (representation for the CN, CNV, etc, group to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use; spectroscopy. Derivation of character table for C2v and C3v point group

**Unifying Principles**
Electromagnetic radiation, interaction of electromagnetic radiation with matter-absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, results of the time dependent perturbation theory, transition moment, selection rules spectral lines.

**Ultraviolet and Visible spectroscopy**
Various electronic transitions (185-800 nm) Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Fieser Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic compounds. Steric effect in biphenyls.

**Infrared Spectroscopy**
Instrumentation and Sample handling, Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ether's, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketone's, aldehyde's, esters, amides, acids, anhydride's, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and fermi resonance.
Vibrational Spectroscopy
Symmetry and shapes of AB2, AB3, AB4, AB5 and AB6, mode of bonding of ambidentate ligands, ethylenediamine and diketonato complexes, application of resonance Raman spectroscopy particularly for the study of active sites of metalloproteins.

Electronic Spectroscopy
A. Atomic Spectroscopy
Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.

B. Molecular Spectroscopy
Energy levels, molecular orbitals, vibraonic transitions, vibrational progressions and geometry of the excited states, Franck-Condon principle, electronic spectra of polyatomic molecules.
Emission spectra; radiative and non-radiative decay, internal conversion, spectra of transition metal complexes, charge-transfer spectra.

C. Photoelectron Spectroscopy
Basic principles; photo-electric effect, ionization process, Koopman's theorem. Photoelectron spectra of simple molecules, ESCA, chemical information from ESCA. Auger electron spectroscopy-basic idea.

Optical Rotatory Dispersion (ORD) and Circular Dichroim (CD)
Definition, deduction of absolute configuration, octant rule for ketones.

Mossbauer Spectroscopy
Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe+2 and Fe+3 compounds including those of intermediate spin, (2) Sn+2 SN=4 compounds nature of M-L bond, coordination number, structure and (3) detection of oxidation state and inequivalent MB atoms

Suggested Readings

7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, V. Parish, Ellis Haywood.

S12015: Laboratory exercises

Credit(s): 6

INORGANIC CHEMISTRY

Chromatography Separation of cations and anions by

- Paper Chromatography.
- Chromatography: Ion exchange.

Chromatographic Separations

- Cadmium and zinc
- Zinc and magnesium.
- Thin-layer chromatography-separation of nickel, manganese, cobalt and zinc. Determination of Rf values.
- Separation and identification of the sugars present in the given mixture of glucose, fructose, and sucrose by paper chromatography and determination of Rf values.

Preparations (Any Six)

Preparation of selected inorganic compounds and their studies by I.R. electronic spectra, Mossbauer, E.S.R. and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds.

1. VO (acac)2
2. TiO (C9H8NO)2H2O
3. cis-K[Cr(C2O4)2(H2O)2]
4. Na[Cr(NH3)2(SCN)4]
5. Nm(acac)2
6. K3[Fe(C2O4)3]
7. Prussian Blue, Turnbull's Blue.
8. [Co(NH3)6][Co(NO2)6]
9. cis-[Co(trien) (NO2)2] Cl.H2O
10. Hg[Co(SCN)4]
11. [Co(Pv)2Cl2]
12. [Ni(NH3)6]Cl2
13. Ni(dmg)2
14. [Cu(NH3)4]SO4H2O

ORGANIC CHEMISTRY

Organic Synthesis
1. Acetylation: Acetylation of cholesterol and separation of cholesteryl acetate by column chromatography.

2. Oxidation: Adipic acid by chromic acid oxidation of cyclohexanone.


4. Aldol condensation: Dibenzal acetone from benzaldehyde.

5. Sandmeyer reaction: p-Chlorotoluene from p-toluidine.


7. Connizzaro reaction: 4-Chlorobenzaldehyde as substrate.

8. Friedel Crafts reaction: b-Benzoyl propionic acid from succinic anhydride and benzene.

9. Aromatic electrophilic substitution: Synthesis of p-nitroaniline and p-bromoaniline. The products may be characterized by spectral techniques.

10. Estimation of amines/phenols using bromate bromide solution or acetylation method.

**PHYSICAL CHEMISTRY**

(i) Chemical Kinetics

i. Determination of the effect of (a) Change of temperature (b) Charge of concentration of reactant and catalyst and (c) Ionic strength of the media on the velocity constant of hydrolysis of an ester/ionic reaction.

ii. Determination of the velocity constant of hydrolysis of an ester/ionic reaction in micellar media.

iii. Determination of the velocity constant for the oxidation of iodide ions by hydrogen peroxide study the kinetics as an iodine clock reactions.

iv. Flowing clock reactions (Ref: Experiments in Physical Chemistry by Showmaker)

v. Determination of the primary salt effect on the kinetics of ionic reaction and testing of the Bronsted relationship (iodide ion is oxidized by persulphate ion).

vi. Oscillatory reaction.

vii. To determine the relative strength of the acids by studying the hydrolysis of an ester. (at room and at any higher temperature)

viii. Determine the energy of activation for the hydrolysis of an ester.

(ii) Solution:

1. Determination of molecular weight of non-volatile and electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.

2. Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.

(iii) Potentiometry/pHmetry

1. Determination of strengths of halides in a mixture potentiometrically.

2. Determination of the valency of mercurous ions potentiometrically.

3. Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.
5. Determination of the formation constant of silver-ammonia complex and stoichiometry of the complex potentiometrically.
6. Acid-base titration in a non-aqueous media using a pH meter.
8. Determination of the dissociation constant of acetic acid in DMSO. DMF, acetone and dioxane by titrating it with KOH.
9. Determination of the dissociation constant of monobasic/dibasic acid by albert-Sderjeant method.
10. Determination of thermodynamic constants, DG, DS, and DH for the reaction by e.m.f. method. Zn + H2SO4 -> ZnSO4 + 2 H

(iv) Polarimetry

1. Determination of rate constant for hydrolysis/inversion of sugar using a polarimeter.
2. Enzyme kinetics-inversion of sucrose.

Suggested Readings

5. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold.
9. Findley's Practical Physical chemistry, B.P. Levitt, Longman.

S13011: GREEN CHEMISTRY

Credit(s): 4

INTRODUCTION, PRINCIPLE AND CONCEPTS OF GREEN CHEMISTRY:
What is green chemistry? Need for green chemistry; inception and evolution of green chemistry; twelve principles of green chemistry with their explanations and examples; designing a green synthesis using these principles; green chemistry in day to day life.

Basic principles of Green Chemistry and their illustrations with examples.
(i) Prevention of waste/byproducts.
(ii) Maximum Incorporation of the materials used in the process into the final product (Atom Economy): Green metrics
(iii) Prevention/Minimization of hazardous/toxic products.
(iv) Designing safer chemicals - different basic approaches
(v) Selection of appropriate auxiliary substances (solvents, separation agents etc)
(vi) Energy requirements for reactions—use of microwave, ultrasonic energy
(vii) Selection of starting materials—use of renewable starting materials.
(viii) Avoidance of unnecessary derivatization—careful use of blocking/protection groups.
(ix) Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents.
(x) Designing biodegradable products.
(xi) Prevention of chemical accidents.
(xii) Strengthening/development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes. Development of accurate and reliable sensors and monitors for real time in process monitoring.

Application of non conventional energy sources : Microwave induced and ultrasound assisted green synthesis.
Introduction of microwave induced organic and inorganic synthesis; microwave activation – equipment; time and energy benefits; limitations;
(a) Synthesis of nitrogen-oxygen/sulphur donor ligands and their coordination complexes; synthetic organic transformations under microwaves
(b) Reactions in organic solvents – esterifications; Fries rearrangement; Diels alder reaction and decarboxylation.
(c) Solvent free reactions (solid state reactions): deacetylation; deprotection; saponification of ester; alkylation of reactive methylene compounds; synthesis of nitriles from aldehydes; heterocyclic synthesis – B-lactams, pyrrole, quinoline. Ultrasound assisted green synthesis: introduction; instrumentation; physical aspects; oxidation; reduction; addition; substitution reactions and synthesis of chromenes.

Environmentally benign solutions to organic solvents (focus on water and ionic liquids).
(a) Ionic liquids as green solvents – introduction; properties and types of ionic liquids; synthetic applications—Diels-Alder reaction; epoxidation; Heck reaction; preparation of pharmaceutical compounds; enzyme catalysed synthesis.
(b) Aqueous phase reactions—introduction; Pseudo organic solvent
(1) Application in oxidation of nitro-aromatic and carbonyl compounds; reduction of carbon-carbon multiple bond, Benzoin condensation; Michael reaction; Claisen rearrangement; Knoevenageal reaction.
(2) Electrochemical synthesis– introduction, synthesis of sebacic acid, adiponitrile introduction on role of fluorous solvents and supercritical carbon dioxide in green chemistry.

Hazard assessment and mitigation in chemical industry
Future trends in Green Chemistry: Oxidation-reduction reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; Noncovalent derivatization. Biomass conversion, emission control. Biocatalysis

Suggested Readings
1. Organic synthesis in water, Paul A. Grieco Blackie.
4. Green Chemistry For Sustainability, Sanjay K. Sharma and A. Mudhoo, CRC Taylor & Francis, USA
7. Lancaster, M. Green chemistry; An Introductory Text; the Royal Society of Chemistry: Cambridge, UK, 2002.

S13012(A): PHOTOINORGANIC CHEMISTRY AND X-RAY DIFFRACTION
Credit(s):4

Basic of Photochemistry

Properties of Excited States

Excited States of Metal Complexes
Excited states of metal complexes : Comparison with organic compounds, electronically excited states of metal complexes, charge transfer spectra.

Ligand Field Photochemistry
Photosubstitution, photooxidation and photoreduction, lability and selectivity, zero vibrational levels of ground state and excited state.

Metal Complex Sensitizers
Metal complex sensitizer, electron relay, metal colloid systems, water photolysis, nitrogen fixation and carbon dioxide reduction.

X-RAY DIFFRACTION
Suggested Readings


S13012(B): BIOINORGANIC CHEMISTRY Credit(s): 4

Metal Ions in Biological Systems
Bulk and trace metals with special reference to Na, K, Mg, Ca, Fe, Cu, Zn, Co, and K+/Na+ pump.

Metal Storage and Transport
Ferritin transferrin, and siderophores.

Bioenergetics and ATP Cycle.
DNA polymerisation, glucose storage, metal complexes in transmission of energy; chlorophyll's, photosystem I and photosystem II in cleavage of water.

DNA and RNA
Metal complexes of polynucleotide, nucleosides and nucleic acids (DNA and RNA)
Template temperature stability of DNA.

Transport and Storage of Dioxygen
Haem proteins and oxygen uptake structure and function of haemoglobin's, myoglobin, haemocyanms and hemerythrin, model synthetic complexes of iron, cobalt and copper.

Metals in Medicine
Metal deficiency and disease,(Iron, Zinc, Copper) toxic effects of metals. metals used for diagnosis and chemotherapy with particular reference the anticancer drugs.

Nitrogen fixation
Nitrogen in biosphere, nitrogen cycle, nitrification role microorganism, nitrogen fixation in soils.
Biological nitrogen fixation, and its mechanism, nitrogenase, Chemical nitrogen fixation.

Suggested Readings

3. Inorganic Biochemistry Vols I and II Ed.

S13012(C): ORGANO TRANSITION METAL CHEMISTRY-I  

**Alkyls and Aryls of Transition Metals**
Types, routes of synthesis, stability and decomposition pathways organocopper in organic synthesis.

Compounds of Transition Metal-Carbon Multiple Bonds alkylidenes, alkylidynes, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

**Transition Metal p-Complexes**
Transition metal p-Complexes with unsaturated organic molecules, alkenes, alkynes, allyl, complexes, preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.

Transition metal p-Complexes with unsaturated organic molecules, diene, dienyl, arene and trienyl complexes, preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis

**Suggested Readings**

4. Organometallic Chemistry, R.C. Mehrotra and A. Singh New Age International

S13013(A): ORGANIC SYNTHESIS-I  

**Oxidation**
Reduction

Rearrangements - I
General mechanistic considerations—nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements. Pinacol-pinacolone, Wagner-Meerwein.

Rearrangements - II

Suggested Readings

S13013(B): HETEROCYCLIC CHEMISTRY –I Credit(s): 4

Nomenclature of Heterocycles
Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic fused and bridged heterocycles.

Aromatic Heterocycles
General chemical behaviour of aromatic heterocycles, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in 1H NMR-spectra. Empirical resonance energy, delocalization energy and Dewar resonance energy, diamagnetic susceptibility exaltations). Heteroaromatic reactivity and tautomerism in aromatic heterocycles.

Non-aromatic Heterocycles
Strain-bond angle and torsional strains and their consequences in small ring heterocycles. Conformatino of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interaction. Atereo-electronic effects

**Small Ring Heterocycles**
Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiranes, azetidines, oxetanes and thietanes.

**Benzo-Fused Five-Membered Heterocycles**
Synthesis and reactions including medicinal applications of benzopyrroles, bezofurans and benzothiophenes

**Suggested Readings**

2. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.

**S13013(C): NATURAL PRODUCTS**

**Terpenoids**

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules : Citral, Gerniol a-Terpeneol, Menthol.

**Carotenoids**

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules : Abietic acid and b-Carotene.

**Alkaloids**

Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine , (+)- Coniine, Nicotine, Atropine, Quinine and Morphine.

**Steroids**
Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry, Isolatin, Structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progestrone, Aldosterone, Biosynthesis of Steroids.

Suggested Readings

2. Organic Chemistry : Vol. 2 1L. Finar, ELBS
8. Insecteides of Natural Origin, Sukh Dev, Harwood Academic Publishers

S13014(A): ELECTROANALYTICAL TECHNIQUES Credit(s): 4

Introduction

Errors and Evaluation
Definition of terms in mean and median. Precision-standard deviation, relative standard deviation. Accuracy-absolute error, relative error. Types of error in experimental data determinate (systematic), indeterminate (or random) and gross. Sources of error and the effects upon the analytical results. Methods for reporting analytical data. Statistical evaluation of data-indeterminate errors. The uses of statistics.

Chromatography and analysis
Introduction, Principle, experimental detail of thin layer chromatography (TLC), Adsorption (column) chromatography, High-performance liquid chromatography, (HPLC) and Gas chromatography.

Conductometry
Important laws, definitions, relations, effect of dilution on conductivity, measurement of conductivity, types of conductometric titrations, its applications and limitations.
Potentiometry
Principle instrumentation, types of potentiometric titrations and its applications, pH measurements, determination of pH, ion selective electrodes, instrumentation and its applications.

Coulometry
Introduction, principle, experimental details of coulometry at constant current and constant potential, titrational applications.

Suggested Readings
2. Principles of Instrumental Analysis D.A. Skoog W.B. Saunders.

S13014(B): ELECTROCHEMISTRY-I

Credit(s): 4

Electrochemical Energy Storage

Bioelectrochemistry
Membrane Potentials, Simplistic theory, Modern theory, Electrical conductance in biological organism: Electronic, Protonic electrochemical mechanism of nervous systems, enzymes as electrodes.

Corrosion and Stability of Metals

Inhibiting Corrosion
Cathodic and Anodic Protection. (i) Inhibition by addition of substrates to the electrolyte environment, (ii) by charging the corroding method from external source, anodic Protection, Organic inhibitors, The fuller Story Green inhibitors.

Passivation
**Kinetic of Electrode Process:**
Essentials of Electrode reaction. Current Density, Overpotential, Tafel Equation, Butler Volmer equation. Standard rate constant (K0) and Transfer coefficient (a), Exchange Current.

**Irreversible Electrode processes**
Criteria of irreversibility, information from irreversible wave. Methods of determining kinetic parameters for quasi-reversible and irreversible waves Koutecky's methods, Meits Israel Method, Gellings method.

**Suggested Readings**

4. Modern Polarographic Methods by A.M. Bond, Marcel Dekker.
7. Electroanalytical Chemistry by Basil H. Vessor & alen w. ; Wiley Interscience.
8. Topics in pure and Applied Chemistry, Ed. S. K. Rangrajan, SAEST Publication, Karaikudi (India)

**S13014(C): CHEMICAL KINETICS-I**

Credit(s): 4

**Oscillatory Reactions**
Autocatalysis and oscillatory reactions, Kinetics and mechanism of Belousov-Zhabotinski (B-Z) reactins.

**Enzymes and Inhibitions**
Kinetics of one enzymes-Two substrate systems and their experimental characteristics. Enzyme inhibitions and their experimetnal characteristics. Kinetics of enzyme inhibited reactions.

**Dynamics of Gas-surface Reactions**
Adsorption/desorption kinetics and transition state theory. Dissociative adsorption and precursor state. Mechanism of Langmur's adsorption of the oxidation of carbon monoxide to carbon dioxide. True and apparent activation energies. Industrial important of heterogeneous catalysis.

**Transition State**
A brief aspect of statistical mechanics and transition state theory. Application in calculation of the second order rare constant for reactions with collision for (1) and + (2) atom + molecular (3)
+ molecule reactions. Static solvent effects and thermodynamics formulatins. Adiabatic electron transfer reactions, energy surfaces.

**Metal ion catalysis**

Kinetics and mechanism of following reaction

A. When reaction rate is independent of one of the reactants in presence of metal ion catalyst.

B. When reaction rate retarded of one of the products in presence of metal ion catalyst.

C. When metal ion catalysis indicate an intermediate species.

D. Cyclodextrines are acting as catalyst mode of catalysis.

**Suggested Readings**

3. N.L. Bender, Mechanism of Homogeneous Catalysis from protein to protein, Wiley.

**S13015: Laboratory exercises**

**Credit(s): 6**

**Inorganic Chemistry**

**Preparation (Any Six)**

Preparation of selected inorganic compounds and their study by IR, electronic spectra, Mossbauer. ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines. Selection can be made from the following:

3. Atomic absorption analysis of Mg and Ca.
4. Trialkoxyboanes-IR and NMR spectra.
5. PhBd2 Dichlorophenylborane - Synthesis in vacuum line.
6. Preparation of Tin (IV) iodide, Tin (IV) chloride and Tin (II) iodide, Inorge, Synth., 1953, 4.119.
7. Relative stability of Tin (IV) and Pb (IV). Preparation of ammonium hexachlorostannate (NH4)2 SnCl6 ammonium hexachlorophlumbate (NH4)2PbCl6.
10. Sodium tetrathionate Na2S4O6.
14. Magnetic moment of Cu (acac)2H2O.
15. Cis and Trns [Co(en)2Cl2]+.
21. Reaction of Cr(III) with a multidentate ligand; a kinetics experiment (visible spectra Cr-EDTA complex) J.A.C.S., 1953, 75, 6570.
25. Any other experimtn such as conversion of p-xylene to terephtalic acid catalyzed by CoBr2 (homogeneous catalysis).
26. Preparation of [Co(phenathroline-5,6 quinone)].

Spectrophotometric Determinations (Any One)

   c. Fluoride/nitrite/phosphate.
   e. Copper-Ethylene diamine complex : Slope-ratio method.

Flame Photometric Determinations (Any One)

   a. Sodium and potassium when present together.
   b. Lithium/calsium/barium/strontium.
   c. Cadmium and magnesium in tap water.

Quantitative determinations of a three component mixture : (Any One)

One Volumetrically and two gravimetrically
Organic Chemistry

Qualitative Analysis
Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid or two solids and one liquid), using tlc for checking the purity of the separated compounds, chemical analysis, IR, PMR and mass spectral data.

Multi-step Synthesis of Organic Compounds
The exercise should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques.
1. Photochemical reaction: Benzophenone $\rightarrow$ Benzpinacol $\rightarrow$ Benzpinacolone
2. Beckmann rearrangement: Benzanilide from Benzene $\rightarrow$ Benzophenone $\rightarrow$ Benzphenone
3. Benzilic acid rearrangement: Benzilic acid from benzoin $\rightarrow$ Benzil $\rightarrow$ Benzilic acid
4. Skraup synthesis: Preparation of quinoline from aniline
6. Enzymatic synthesis Enzymatic synthesis
7. Enzymatic reduction: reduction of ethyl acetoacetate using Baker's yeast to yield enantiomeric excess of S (+) ethyl-3-hydroxybutanoate and determine its optical purity.
8. Biosynthesis of ethanol from sucrose.
10. Synthesis using phase transfer catalyst. Alkylation of diethyl malonate or ethyl acetoacetate with an alkylhalide.

1. Paper Chromatography
   Separation of identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

Spectroscopy
Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS) Spectrophotometric (UV/VIS) Estimations

1. Amino acids
2. Proteins
3. Carbohydrates
4. Cholesterol
5. Ascorbic acid
6. Aspirin
7. Caffeine
Physical Chemistry

(A) Thermodynamics

i. Determination of partial molar volume of solute (e.g. KCl) and solvent in a binary mixture.

ii. Determination of the temperature dependence of the solubility of a compound in two solvents having similar intramolecular interactions (benzoic acid in water and in DMSO water mixture and calculate the partial molar heat of solution.

(B) Spectroscopy

i. Determination of kPa of an indicator (e.g. methyl red) in (a) aqueous and (b) micellar media.

ii. Determination of stoichiometry and stability constant of Ferricisothiocyanate complex ion in solution.

iii. Determination of rate constant of alkaline bleaching of Malachite green and effect of ionic strength on the rate of reaction.

iv. To verify Beer's law for solution of KMNO4 and determine concentration of a given aqueous solution of unknown concentration of this salt

(C) Polarography

i. Identification and estimation of metal ions such as Cd+2, Pb+2, Zn+2, and Ni+2 etc. polarographically.

ii. Study of a metal ligand complex polarographically (using Lingane's Method).

(D) Chemical Kinetics

i. Determination of rate constant and formation constant of an intermediate complex in the reaction of Ce(IV) and Hypophosphorous acid at ambient temperature.

ii. Determination of energy and enthalpy of activation in the reaction of KMnO4 and benzyl alcohol in acid medium.

iii. Determination of energy of activation of and entropy of activation from a single kinetic run.

iv. Kinetics of an enzyme catalyzed reaction.

Suggested Readings

1. Inorganic Experiments, J. Derek Woolings, VCH.
MEANING OF RESEARCH AND DATA ANALYSIS:
The search for knowledge, purpose of research, scientific method, role of theory, characteristics of research, Types of research: fundamental or pure research, applied research, action research, historical research, experimental research. Sources of chemical information: primary, secondary and tertiary sources, Indexes and abstracts in science and technology: applied science and technology, index, biological abstracts, chemical abstracts, chemical titles, current chemical reactions, current contents, engineering index, index chemicus, index medicus, physics abstracts, science citation index. Classical and comprehensive reference works in chemistry. compilations of data, synthetic methods and techniques, treatises, reviews.

DATA ANALYSIS:
Errors in chemical analysis, classification of errors, determination of accuracy of Methods, improving accuracy of analysis, significant figures, mean, standard Deviation, comparison of results, rejection of results, presentation of data. Sampling: introduction, definitions, theory of sampling, techniques of sampling, statistical criteria of good sampling and required size, stratified sampling vs random sampling – minimization of variance in stratified sampling – transmission and storage of samples.

SCIENTIFIC WRITING
Scientific writings: research reports, theses, journal articles, and books. Requirement of technical communications: eliminating wordiness and jargon tautology, redundancy, imprecise words, superfluous phrases. Steps to publishing a scientific article in a journal: types of publications communications, articles, reviews; when to publish, where to publish, specific format required for submission, organization of the material. Documenting: abstracts-indicative or descriptive abstract, informative abstract, footnotes, end notes, referencing styles, bibliography-journal abbreviations (CASSI), abbreviations used in scientific writing.

OPTICAL METHODS
Atomic absorption: Principle, Instrumentation, Flame sources, Hollow cathode lamp, Analysis of Zn2+, Cu2+, Pb2+ and Cd2+. Flameless AAS for Hg2+ analysis, Inductively coupled plasma (ICP) method of analysis of Ca2+ and Mg2+ in water samples. Optical rotatory dispersion method, circular dichroism studies, application.

SPECTROSCOPY AND DIFFRACTION STUDIES
IR spectroscopy – characteristic absorption bands of functional groups - applications.
1H NMR: Principle, instrumentation, chemical shift, splitting – Use of 13C and 15N NMR
applications.

**Mass spectrometry**: Principle, instrumentation, fragmentation in alkane, alkene, aldehydes, ketones, carboxylic acids and aromatic compounds - Tandem mass spectrometry – Applications.

**X ray methods**: Braggs law, calculation of d values, powder diffractogram, single crystal analysis – Significance and applications. Applications of neutron and electron diffraction.

**Suggested Readings**

5. H. M. Kanare, Writing the Laboratory Notebook; American Chemical Society: Washington, DC, 1985.
17. Principles of instrumental analysis – D.A. Skoog and M. West.
20. Analytical chemistry – J.D. Dick.

**S14012(A): ORGANOTRANSITION METAL CHEMISTRY-II**

Credit(s): 4

**Transition metal compounds with bonds to hydrogen**

Transition metal compounds with bonds to hydrogen.
**Homogeneous Catalysis**
Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins,

Catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxoreaction), explanation reactions, activation of C-H bond.

**Fluxional Organometallic Compounds**
Flexionality and dynamic equilibrium in compounds such as n-2 olefine, n3-allyl and dienyl complexes.

**Suggested Readings**


**S14012(B): INORGANIC POLYMERS**

**Basics**


**Polymer Characterization**

Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity an molecular weight distribution.

Structure, Properties and Applications of Polymers based on boron-borazines, boranes and carboranes.

Structure, Properties and Applications of Polymers based on Silicon, silicone's polymetalloxanes and polymetallosiloxanes, silazanes.

Structure, Properties and Applications of -

a. Polymers based on Phosphorous-Phosphazenes, Polyphosphates
b. Polymers based on Sulphure-Tetrasulphur tetranitride and related compounds.
**Suggested Readings**

5. Inorganic Rings and Cages : D.A. Armitage.

**S14012(C): MINERAL BASED INDUSTRIAL CHEMISTRY**  
**Credit(s):4**

**INDUSTRIAL CHEMISTRY**

Ferrous and non-ferrous industries-quality ,control methods, general principles applied in studying an industry –manufacture of iron ,steels metallurgy of gold and silver.

**CEMENT**

Classification of cement, manufacture of Portland cement –setting and hardening of cement, chemical constitution of Portland cement and their characteristics – special cement and their characteristics –special cements and their uses.

**Ceramics**

Classification of ceramics,basic raw materials-application of colours to pottery porcelain and china ware-manufacture,glass-raw materials,manufacture of special glass-optical,borosilicate,flint and coloured glass.

**Poisons**

Industrial poisons and their classification solid liquid and gaseous poisons –their identification-physiological activity and control;solids:Pb,As,Hg,asbestos,textile fibres;liquids:organic solvents,gases oxides of S ,N and H2S,cyanides,aldehydes,ketones and hydrocarbons.

**Suggested Readings**

2. Applied Chemistry for Engineer; Diamont.
3. Industrial Poisons and solvents; Jacobs.
4. Chemistry of engineering materials; Jain & Jain
5. Engineering chemistry; B.K. Sharma.
Disconnection Approach

An introduction to synthons and synthetic equivalents. Disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reaction, amine synthesis.

Protecting Groups
Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

One Group C-C Disconnections
Alcohols and carbonyl compounds, regioselectivity, alkene synthesis, use of acetylenes and aliphatic Nitro compounds in organic synthesis.

Two Group C-C Disconnections
Diels-Alder Reaction, 1,3-difunctionalised compounds, a-b- unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Micheal addition and Robinson annelation.

Ring Synthesis
Saturated heterocycles, synthesis of 3,4,5 and 6 membered rings. aromatic heterocycles in organic synthesis. General strategy and stereoselectivity, Cyclisation and insertion reaction, rearrangement in synthesis, Photocycloaddition and use of ketenes, Pericyclic rearrangement and special methods, carbonyl condensation, Diels–Alder reaction and reduction of aromatic compounds.

Suggested Readings

Meso-ionic Heterocycles
General classification, chemistry of some important meso-ionic heterocycles of type-A and B and their applications.

Six-Membered Heterocycles with one Heteroatom
Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and phridones. Synthesis and reactions of quionlizinium and benzopyrylium salts, coumarins and chromones.

Six Membered Heterocycles with Two or More Heteroatoms Synthesis and reactions of diazones, triazines, tetrazines and thiazones. Seven-and Large-Membered Heterocycles Synthesis and reactions of azepines, oxepines, thiepines, diazepines thiazepines, azocines, diazocines, dioxocines and dithiocines.

**Heterocyclic Systems Containing P and B**

Heterocyclic rings containing phosphorus : Introduction, nomenclature, synthesis and characteristics of 5- and 6-membered ring systemsphosphorinaes, phosphorines, phospholanes and phospholes,. Heterocyclic rings containing B : Introduction, synthesis reactivity and spectral characteristics of 3- 5- and 6- membered ring system.

**Heterocyclic Systems Containing As and Sb**

Heterocyclic rings containing As and Sb : Introduction, synthesis and characteristics of 5- and 6-membered ring system

**Suggested Readings**

2. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.

**S14013(C): NATURAL PRODUCTS**

**Plant Pigments**

Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Apigenin, Luteolin Quercetin, Myrcretin, Quercetin 3-glucoside, Vitexin, Daidzein, Buttein, Aureusin, Cyanidin-7arabinoside, Cyanidin, Hirsutidin, Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.
Prophyrins
Structure and synthesis of Haemoglobin and Chlorophyll.

Prostaglandins
Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE2 and PGF2a.

Pyrethroids and Rotenones
Synthesis and reactions of Pyrethroids and Rotenones. (For structure elucidation, emphasis is to be placed on the use of spectral parameters wherever possible).

Suggested Readings

1. Natural Products : Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope adn J.B. Harbome, Longman, Esses.
2. Organic Chemistry : Vol. 2 1L. Finar, ELBS

S14014(A): CHEMICAL ANALYSIS

Credit(s): 4

Food analysis

Analysis of soil and Fuel

Analysis of Water

**Clinical Chemistry**
Compositio of blood-collection and preservation of samples. Clinical analysis. Serum electrolytes, blood glucose, blood urea nirogen, uric acid, albumin, globulins, barbiturates, acid and alkaline phosphates. Immuno assy : principles of radio immunoassay (RIA) and applications. The blood gas analysis trace elements in the body.

**Drug analysis**
Narcotics and dangerous drug. Classification of drugs. Sceening by gas and thin-layer chromatography and spectrophotometric measurements.

**Suggested Readings**

6. Principles of Instrumental Analysis D.A. Skoog W.B. Saunders.

**S14014(B): ELECTRO CHEMISTRY-II**  
Credit(s): 4

**FUEL CELL**
Electrochemical Generators (Fuel Cells) : Hydrogen oxygen cells, Hydrogen Air cell, Hydrocarbon air cell, Alkaine fuel cell, Phosphoric and fuel cell, direct NaOH fuel cells, applications of fuel cells.

**Electrocatalysis**

**VOLTAMMETRY**
General principle and applications, linear sweep voltammetry (LSV), cyclic voltammetry (CV), square wave voltammetry, stripping voltammetry, cathodic and anodic adsorptive stripping voltammetry (CAdSV and AAdSV).

**ELECTRO-ORGANIC SYNTHESIS**
Types of electroorganic reaction, constant current and constant potential electrolysis, cell design, effect of variable, nature of medium, nature of electrode materials, over voltage, effect of redox couple, application of sewage waste water treatment.

**Suggested Readings**

2. Electrochemistry by Carl H. Hamann, Andrew Hanmett and wolf vielstich.

**S14014(C): CHEMICAL KINETICS-II**

**Credit(s)-4**

**Micelles catalysis and inhibition**
Kinetics and mechanism of micelle catalyzed reactions (1st order and second order) Various type of micelle catalized reactions. Micelle inhibited reactions.

**Kinetics and Mechanism of Substitution Reaction**

**Radiation Chemistry**

**Induced Phenomena**
Metal ion catalyzed reactins, their kinetics and reaction mechanism in solutions. Induced reactions, their characteristics. Mechanism of (i) Fe (II) induced oxidotin of iodine by Cr(VI). (ii) As (III) induced oxidation of Mn(II) by chromate in acid solutions. Kinetics and mechanism of induced reactions in metal complexes (octahedral complexes of Cobalt (III) only).

**Electron Transfer Reaction in Metal Complexes**
Kinetics and mechanism of 1:1,1:2,1:3 metal substrate complexes as intermediate, Henry Taubes classical reaction, its kinetics and mechanism, Inner-sphere and outer sphere, electron transfer
reactinos and mechanism. Various types of inner sphere bridges, adjustment and remote attack. Linkage isomerism. Chemical and resonace mechanism. Marcus-Cross relation in outersphere reactions (no mathematical derivation). Its application in reactions:

\[ \text{Ce(IV)} + \text{Mo(CN)}_5^{4-} \rightarrow \text{Ce(III)} + \text{Mo (CN)}^{3-} \]
\[ \text{Fe(CN)}^{3-} + \text{Fe(CN)}^{4-} \rightarrow \text{Fe(CN)}^{4-} + \text{Fe(CN)}^{3-} \]

Bridged outer-sphere electron transfer mechanism. Kinetics of reactions in the presence of cyclodextrines. Considering one full case study, Nucleophilic and electrophilci catalyst and their mode of action.

**Suggested Readings**

3. N.L. Bender, Mechanism of Homogeneous Catalysis from protein to protein, Wiley.

**S14015: PROJECT**

A student will be assigned a topic for the project at the beginning of semester IV. The student is expected to complete the major literature survey during the semester IV and present a tentative research plane in the end of the first month of the semester IV. The candidate will do the experimental work during semester IV under the supervision of a guide and submit the result in the form of the thesis at the end of semester IV.

**Seminar:**

Credit(s): 2
Mathematics

Semester –I

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<td>S11017</td>
<td>Real Analysis-I</td>
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<tr>
<td>S11018</td>
<td>Topology</td>
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<td>S11019</td>
<td>Differential Geometry of Manifolds-I</td>
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<td>S11020</td>
<td>Set Theory &amp; Complex Analysis</td>
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<td>S12018</td>
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<td>S12020</td>
<td>Theory of Optimization</td>
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<td>S13017</td>
<td>Normed Linear Spaces &amp; Theory of Integration</td>
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<td>S13018</td>
<td>Numerical Analysis</td>
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<td>S13019(A)</td>
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<td>Operations Research</td>
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<td>Advanced Topology-II</td>
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<td>Functional Analysis</td>
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<td>S14017</td>
<td>Partial Differential Equations</td>
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<td>Numerical Solution of Partial Differential Equations</td>
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<td>Number Theory and Cryptography</td>
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<td>S14018(D)</td>
<td>Fuzzy Sets and Applications</td>
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<td>S14018(E)</td>
<td>Advanced Graph Theory</td>
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<td>S14018(G)</td>
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<td>S14018(H)</td>
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<td><strong>Total Credits of All Four Semesters</strong></td>
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*More Elective papers can be added subject to the availability of subject experts.*
SEMESTER- I

S11016: Algebra-1
Credit(s): 4
The class equation, Cauchy’s theorem, Sylow $p$-subgroups, Direct product of groups. Structure theorem for finitely generated abelian groups. Normal and subnormal series. Composition series, Jordan-Holder theorem. Solvable groups. Insolvability of $S_n$ for $n \geq 5$.


Suggested Readings


S11017: Real Analysis-I
Credit(s): 4
Suggested Readings


S11018: Topology Credit(s): 4


Suggested Readings


**S11019: Differential Geometry of Manifolds-I**


**Suggested Readings**


**S11020: Set Theory & Complex Analysis**

Suggested Readings


SEMESTER - II

S12016: Algebra-II Credit(s): 4


Suggested Readings


S12017: Real Analysis-II  Credit(s): 4


Suggested Readings


S12018: Analytic Dynamics

Rotation of a vector in two and three dimensional fixed frame of references. Kinetic energy and angular momentum of rigid body rotating about its fixed point. Euler dynamic and geometrical equations of motion. Generalized coordinates, momentum and force components. Lagrange equations of motion under finite forces, cyclic coordinates and conservation of energy. Lagrangian approach to some known problems—motions of simple, double, spherical and cycloidal pendulums, motion of a particle in polar system, motion of a particle in a rotating plane, motion of a particle inside a paraboloid, motion of an insect crawling on a rod rotating about its one end, motion of masses hung by light strings passing over pulleys, motion of a sphere on the top of a fixed sphere and Euler dynamic equations.


Suggested Readings

1. A. S. Ramsay, *Dynamic* – Part II.

S12019: Differential Geometry of Manifolds-II

Topological groups. Lie groups and Lie algebras. Product of two Lie groups. One parameter subgroups and exponential maps. Examples of Lie groups. Homomorphism and isomorphism. Lie transformation

Credit(s): 4
groups. General linear groups. Principal fiber bundle. Linear frame bundle. Associated fiber bundle. Vector
derivative. Almost complex and Almost contact structures. Nijenhuis tensor. Contravariant and covariant
almost analytic vector fields in almost complex manifold. F-Connexion. Almost complex and almost
contact submanifolds and hypersurfaces.

**Suggested Readings**


5. R. S. Mishra, *Structures on a Differentiable Manifold and Their Applications*, Chandrama

**S12020: Theory of Optimization**

**Credit(s):** 4

Unconstrained Optimization: Introduction, Gradient methods, Conjugate Direction Methods, Newton’s
Method, Quasi Newton Method. Linear Programming: Simplex Method, Duality and Non- simplex
Methods. Non-Linear Constrained Optimization: Introduction, Lagrange’s multipliers, Kuhn- Tucker
conditions, Convex Optimization. Evolutionary Algorithms: Neural Networks: Introduction, Basic
Hopfield Model, Delta Rule, Single Neuron Training, Backpropagation algorithm. Genetic Algorithm:
Basic description, Simple real number algorithm.

**Suggested Readings**


**Semester –III**

**S13016: Hydrodynamics**

Credit(s): 4

Equation of continuity, Boundary surfaces, streamlines, Irrotational and rotational motions, Vortex lines, Euler’s Equation of motion, Bernoulli’s theorem, Impulsive actions. Motion in two-dimensions, Conjugate functions, Source, sink, doublets and their images, conformal mapping, Two-dimensional irrotational motion produced by the motion of circular cylinder in an infinite mass of liquid, Theorem of Blasius, Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere, Equation of motion of a sphere.

Stress components in real fluid, Equilibrium equation in stress components, Transformation of stress components, Principal stress, Nature of strains, Transformation of rates of strain, Relationship between stress and rate of strain, Navier-Stokes equation of motion.

**Suggested Readings**


**S13017: Normed Linear Spaces & Theory of Integration**

Credit(s): 4


**Suggested Readings**


**S13018: Numerical Analysis**

Credit(s): 4


Numerical solutions of second order boundary value problems (BVP) of first, second and third types by shooting method and finite difference methods. Finite Element method: Introduction, Methods of approximation: Rayleigh-Ritz Method, Gelarkin Method and its application for solution of ordinary BVP.
Suggested Readings


7. Naveen Kumar, *An Elementary Course on Variational Problems in Calculus*.

ELECTIVE(Any two of the following)

S13019(A): Mathematical Modeling  
Credit(s): 4

Simple situations requiring mathematical modeling, techniques of mathematical modeling, Classifications, Characteristics and limitations of mathematical models, Some simple illustrations. Mathematical modeling through differential equations, linear growth and decay models, Nonlinear growth and decay models, Compartment models, Mathematical modeling in dynamics through ordinary differential equations of first order. Mathematical models through difference equations, some simple models, Basic theory of linear difference equations with constant coefficients, Mathematical modeling through difference equations in economic and finance, Mathematical modeling through difference equations in population dynamic and genetics. Situations that can be modeled through graphs. Mathematical models in terms of Directed graphs, Mathematical models in terms of signed graphs, Mathematical models in terms of weighted digraphs. Mathematical modeling through linear programming, Linear programming models in forest management. Transportation and assignment models.

Suggested Readings


**S13019(B): Operationas Research**

Credit(s): 4


**Suggested Readings**


**S13019(C): Discrete Mathematics**

Credit(s): 4

**Suggested Readings**

2. Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*, Prentice-Hall of India.
6. P. Linz, *An Introduction to Formal Languages and Automata*, 3rd Edition,

**S13019(D): Advanced Topology**


**Suggested Readings**


**S13019(E): Integral Equations**


Integral equations and transformations: Fourier, Laplace and Hilbert transformation.
Suggested Readings

1. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekkar Inc. NY.
2. L.G. Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976,

SEMESTER – IV

S14016: Functional Analysis


Suggested Readings

Partial Differential Equations


Suggested Readings


ELECTIVE (Any Three of the following)

Fluid Dynamics


of shock waves. Mach number, Mach lines and cones. Isentropic flow relations. Pressure density and
temperature in terms of Mach number.

**Suggested Readings**


**S14018(B): Numerical Solution of Partial Differential Equations**

Numerical solutions of parabolic PDE in one space: two and three levels explicit and implicit difference
schemes. Convergence and stability analysis. Numerical solution of parabolic PDE of second order in two
space dimension: implicit methods, alternating
direction implicit (ADI) methods. Non linear initial BVP. Difference schemes for parabolic PDE in
spherical and cylindrical coordinate systems in one dimension. Numerical solution of hyperbolic PDE in
one and two space dimension: explicit and implicit schemes. ADI methods. Difference schemes for first
order equations. Numerical solutions of elliptic equations, approximations of Laplace and biharmonic
operators. Solutions of Dirichlet, Neuman and mixed type problems. Finite element method: Linear,
triangular elements and rectangular elements.

**Suggested Readings**


S14018(C): Number Theory and Cryptography

Credit(s): 4


Suggested Readings


S14018(D): Fuzzy Sets and Applications

Credit(s): 4


Suggested readings


14018(E): Advanced Graph Theory  
Credit(s): 4


Suggested Readings

1 D.B.West, Graph Theory , Pearson Publ. 2002.
2 F.Harary, Graph Theory. Narosa Publ. ND.

S14018(F): Advanced Topology-II  
Credit(s): 4


Suggested Readings


S14018(G): Integral Equations  
Credit(s): 4


Integral equations and transformations: Fourier, Laplace and Hilbert transformation.
Suggested Readings

1. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekker Inc. NY.

2. L.G. Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976,


S14018(H): Non-linear Dynamical Systems


Suggested Readings


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<th>Project (Dissertation)</th>
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<td>Seminar</td>
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M. Sc. Physics

Objectives

Physics being one of the oldest academic disciplines is fundamental and foremost to all natural sciences. It has been influential through advances in its understanding that have translated into new technologies. The story of physics is also about people who thought out of the box. The progress of science, and Physics in particular is rooted in addressing fundamental questions about the Nature and to test the validity of a hypothesis or a physical theory, using a methodical approach to compare the implications of the theory in question with the associated conclusions drawn from experiments and observations conducted to test it.

The M.Sc. Physics course is aimed at imparting a rigorous study program at post graduate level covering both depth and breadth of all relevant areas. The course structure is designed with a due emphasis on wider conceptual base, including experiments and modern computational techniques. The three courses on Quantum Mechanics and one on Quantum Field Theory assure us of comprehensive and futuristic education that can pave way for Upcoming and Cutting Edge Technologies that mushroom from the laboratories of Physics and transform the society of tomorrow. The program aims to train future generations of physicists with specialization in one of the frontier areas of research, e.g. in Astrophysics and Cosmology/ Atomic and Nuclear Physics/ Atmospheric Physics and Weather Science/ Quantum Information Sciences/ Energy Studies etc.

The M.Sc. Physics is a (post) graduate Four Semester Course spanning over two years duration.

Course Structure: M. Sc. Physics
<table>
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<td>3L-1T</td>
<td>4</td>
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<tr>
<td>S11022</td>
<td>Quantum Mechanics-I</td>
<td>3L-1T</td>
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<tr>
<td>S11023</td>
<td>Classical Electrodynamics-I</td>
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<tr>
<td>S11024</td>
<td>Mathematical Physics</td>
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<td>S11025</td>
<td>Laboratory exercises –I (Ten Great Experiments)</td>
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<td>Advanced Solid State Physics</td>
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**Total Credits of All Four Semesters** 90

A student has to opt one of the two papers *viz.*, S13021 (A) or S13021 (B)

Towards courses S13022 and S13023 a student has to choose two papers from four elective groups listed on the following pages.

Students have to opt for any one of the following four Elective Groups
Elective Group A

EC 1: General Theory of Relativity and Cosmology
EC 2: Astrophysics

Elective Group B

EC 1: Ionospheric Physics
EC 2: Atmospheric Physics and Weather Science

Elective Group C

Elective 1: Particle Physics-I
Elective 2: Particle Physics-II

Elective Group D

EC 1: Condensed Matter Physics-I
EC 2: Condensed Matter Physics-II

- Semester Exchange and Project Work: Students of M.Sc. Physics Course will have a choice of studying one semester (Fourth Semester) at University of Alabama Systems, USA (which has three campuses namely: UA Birmingham, UA Huntsville, and UA Tusculussa). It is pertinent to mention that JECRC University has an academic collaboration with the University of Alabama Systems, USA.

** Alternatively, a student can visit University of Alabama for his/her Project Work as well.**
**S11021: Classical Mechanics**

**Credit(s):** 4


Generalized momentum, Legendre transformation and the Hamilton’s Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh’s procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical Equation from Hamilton's variational principle. The principle of least action.


**Canonical transformation, integral invariant of Poincare:** Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem, Hamilton-Jacobi equation and its application.

**Action angle variable adiabatic invariance of action variable:** The Kepler problem in action angle variables, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications. Orthogonal transformation, Euler's theorem, Eigenvalues of the inertia tensor, Euler equations, force free motion of a rigid body.

**Suggested Readings**

3. A. Raychoudhary: Classical Mechanics, Oxford University Press
5. Ronald L. Greene: Classical Mechanics with Maple, Springer

**S11022: Quantum Mechanics - I**

**Credit(s):** 4

**Linear spaces and Operators:** Vector spaces, Linear independence, Bases, dimensionality and Isomorphisms. Linear transformations, inverses, matrices, similarity transformations, Eigenvalues and Eigenvectors. Inner product, orthogonality and completeness, complete
orthogonal set, Gramm-Schmidt orthogonalization procedure, Eigenvalues and Eigenvectors of Hermitian and Unitary transformations, diagonalization. Function space and Hilbert space. Complete orthonormal sets of functions.

**Structure of Quantum mechanics:** Postulates of QM, Hilbert space; Hermitian and unitary operators; Orthonormality, completeness and closure. Dirac’s bra and ket notation. Matrix Representation and change of basis. Operators and observables, significance of eigenvector and eigenvalues, Commutation relation; Uncertainty principle for two arbitrary Operators.

**Measurement in quantum mechanics:** Double Stren-Gerlach experiment for spin 1/2 system. Expectation values, time dependence of quantum mechanical amplitude, observable with no classical analogue, super position of amplitudes, identical particles. Hamiltonian matrix and the time evolution of Quantum mechanical States, time independent perturbation of an arbitrary system, simple matrix examples of time independent perturbation, energy given states of a two state system, diagonalization of energy matrix, time independent perturbation of two state system the perturbative solution. Ammonia molecule as an example of two state system, weak field and strong field cases, general description of two state system, Pauli matrices.

**Three dimensional problem in Spherical Polar coordinate:** Hydrogen Atom. Orbital angular momentum, angular momentum algebra, raising and lowering operators, Matrix representation for j = 1/2 and j = 1; spin; addition of two angular momentum, Clebsch-Gordan coefficients.

**Suggested Readings**

2. Albert Messiah: Quantum Mechanics, Dover Publications
5. J. J. Sakurai: Modern Quantum Mechanics, Pearson Education.
Electromotive force: Ohm’s law. Electromotive force. Motional EMF


Maxwell’s equations: Maxwell equations for Electromagnetic fields in matter and vacuum. Electro-magnetic waves. Boundary conditions

Potential formulation: Four potentials: Divergence-less and curl-less quantities. Gauge transformations. Coulomb’s gauge and Lorentz’ force. Lorentz’ force in potential forms

Electromagnetism (Without Matter and Medium)

Relativistic electrodynamics using potential formulation: Field tensor and Electrodynamics in tensor notations. Maxwell’s equations in potential formulation. Relativistic transformations of electro-magnetic fields

Dipole radiations: Retarded potentials. Electric dipole radiations. Magnetic dipole radiations. Radiation from an arbitrary distribution of charges

Radiation from a point charge: Lienard-Wiechert potentials. The fields of a point charge in motion. Power radiated by a point charge

Radiation reaction: The Abraham-Lorentz’ formula. The physical origin of the radiation reaction.


Suggested Readings

1. L. D. Landau & Lifshitz: Classical Theory of Electrodynamics; Pergamon Press.
2. L. D. Landau & Lifshitz: Electrodynamics of continuous media; Pergamon Press.
4. David J. Griffiths: Introduction to Electro-dynamics; Prentice Hall.
5. Panofsky & Phillip: Classical electrodynamics and magnetism


Suggested Readings
3. Merle C. Potter and Jack Goldberg: Mathematical Methods, PHI.
Students have to perform any ten experiments

1. Frank-Hertz’ experiment to determine Planck’s constant.

2. Millican’s Oil Drop experiment to determine e/m of electron.

3. Thomson’s experiment to determine e/m of electron.


8. Davisson Germer’s experiment:


10. Michelson’s Interferometer: Experiment of interference with Michelson’s Interferometer.

11. Hall effect: To study Hall effect and determine Hall coefficient.

12. Foucault’s Pendulum: Determination of time period of rotation of the Earth.

Suggested Readings


Elementary probability theory: Preliminary concepts, Random walk problem, Binomial distribution, mean values, standard deviation, various moments, Gaussian distribution, Poisson distribution, mean values. Probability density, probability for continuous variables.

Extensive and intensive variables: laws of thermodynamics, Legendre transformations and thermodynamic potentials, Maxwell relations, applications of thermodynamics to (a) ideal gas,
magnetic material, and (c) dielectric material. The laws of thermodynamics and their consequences.

**Statistical description of system of particles**: State of a system, microstates, ensemble, basic postulates, behavior of density of states, density of state for ideal gas in classical limit, thermal and mechanical interactions, quasi-static process. Statistical thermodynamics: Irreversibility and attainment of equilibrium, Reversible and irreversible processes. Thermal interaction between macroscopic systems, approach to thermal equilibrium, dependence of density of states on external parameters, Statistical calculation of thermodynamic variables.

**Canonical and Grand Canonical ensembles**: Concept of statistical distribution, phase space, density of states, Liouville's theorem, systems and ensemble, entropy in statistical mechanics. Connection between thermodynamic and statistical quantities micro canonical ensemble, equation of state, specific heat and entropy of a perfect gas, using micro canonical ensemble. Canonical ensemble, thermodynamic functions for the canonical ensemble, calculation of mean values, energy fluctuation in a gas, grand Canonical ensemble, thermodynamic functions for the grand canonical ensemble, density fluctuations.


**Maxwell-Boltzmann gas velocity and speed distribution**: Chemical potential, Free energy and connection with thermodynamic variables, First and Second order phase transition; phase equilibrium.


**Ideal Bose system**: Thermodynamic behavior of an Ideal Bose gas, Bose-Einstein condensation. Thermodynamics of Black body radiation, Stefan-Boltzmann law, Wien’s displacement law. Specific heat of solids (Einstein and Debye models).

**Ideal Fermi System**: Thermodynamic behavior of an ideal Fermi gas, degenerate Fermi gas, Fermi energy and mean energy, Fermi temperature, Fermi velocity of a particle of a degenerate gas.

**Suggested Readings**

1. F. Reif: Fundamentals of Statistical and Thermal Physics, McGraw Hill.

**S12022: Quantum Mechanics- II**

**Credit(s): 4**

**Symmetry in Quantum mechanics**: Symmetry Operations and Unitary Transformations, conservation principles, space and time translation, rotation, space inversion and time reversal, symmetry and degeneracy.
**Identical particles**: Meaning of identity and consequences; Symmetric and anti-symmetric wavefunction; incorporation of spin, symmetric and antisymmetric spin wave function of two identical particles, later determinant, Pauli exclusion principle.

**Time Independent Approximation Methods**: Non-degenerate perturbation theory, degenerate case, Stark effect, Zeeman effect and other examples, variational methods, WKB method, tunneling.

**Time-dependent Perturbation Theory**: Interaction Picture; Constant and harmonic perturbations; Fermi Golden rule; Sudden and adiabatic approximations. Beta decay as an example.

**Scattering Theory**: Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering.

**Density Matrices**: Basic definition and some properties. Pure and Mixed states.

**Quantum Computing**: Basic Idea of Quantum Computation and Quantum Information Theory.

**Suggested Readings**

5. J. J. Sakurai: Modern Quantum Mechanics, Pearson Education.

**S12023: Classical Electrodynamics-II**

(Classical Electrodynamics in Matter and Medium)

**Credit(s): 4**

**Special techniques for calculating potentials**

**Laplace’s equation**: Laplace’s equation in one dimension. Laplace’s equation in two dimensions. Laplace’s equation in three dimensions. Boundary conditions and Uniqueness theorems. Conductors and second uniqueness theorem

**The method of images**: The classic image problem. The induced surface charge. Other image problems

**Multi-pole expansion**: Approximate potentials at large distances. The monopole and dipole terms. Origin of coordinates in multi-pole expansion. The electric field of an electric charge
**Electro-magnetic waves in conducting and non-conducting media**

**Electro-magnetic waves in non-conducting media:** Monochromatic plane waves in vacuum. Energy and momentum of electro-dynamic waves. Propagation through linear media. Reflection and transmission at normal and oblique incidence

**Electromagnetic waves in conductors:** The modified wave equation. Monochromatic plane waves in conducting media. Reflection and transmission at conducting surface

**Dispersion:** The frequency dependence of $\varepsilon$, $\mu$ and $\sigma$. Dispersion in non-conductors. Free electrons in conductors and plasma

**Guided waves:** Wave guides. TE waves in rectangular wave-guides. The coaxial transmission lines

**Magneto-Hydrodynamics and Plasma Physics**


**Suggested Readings**

1. L. D. Landau & Lifshitz: Classical Theory of Electrodynamics; Pergamon Press.
2. L. D. Landau & Lifshitz: Electrodynamics of continuous media; Pergamon Press.
4. David J. Griffiths: Introduction to Electro-dynamics; Prentice Hall.
5. Panofsky & Phillip: Classical electrodynamics and magnetism

**S12024: Computational Physics**

Credit(s): 4

Students are required to learn the following exercises with at least two from each unit.

Solving differential equations

(i) Evaluating integrals
(ii) Stochastic methods, especially Monte Carlo methods
(iii) Specialized partial differential equation methods, for example the finite difference method and the finite element method
(iv) The matrix eigen value problem – the problem of finding eigen values of very large matrices, and their corresponding eigenvectors (eigen states in quantum physics).
(v) Understanding Molecular dynamics by computational means. Understanding Computational fluid dynamics
(vi) Understanding Computational Magneto-hydrodynamics

**Suggested Readings**


**S12025: Laboratory exercises–II**

*Credit(s): 6*

**Students have to perform any ten experiments**

1. Complete study of characteristics of Photovoltaic Cells (Solar Cells).
2. To study temperature variation of resistivity for a semi-conductor and to obtain band gap using *Four Probe method*.
3. To verify *Hartmann's formula* using constant deviation spectrograph.
4. To study *ESR* and determine *g*-factor for a given spectrum.
5. To find *e/m* of electron using *Zeeman effect*.
6. To determine *internal friction* at the *grain boundaries of solids* using *torsional pendulum*.
7. To study a *driven mechanical osciullator*.
8. To study *coupled pendulums*.
9. To study the *dynamics of a lattice* using electrical analog.
10. To study the variation of rigidity of a given specimen as a function of the temperature.
11. Verification of *Bragg's law* using microwaves.
12. Study of analog to digital and digital to analog conversion.
Interaction of radiation and charged particle with matter (No derivation): Law of absorption and attenuation coefficient; Photoelectric effect, Compton scattering, pair production; Klein-Nishina cross sections for polarized and unpolarized radiation, angular distribution of scattered photon and electrons, Energy loss of charged particles due to ionization, Bremsstrahlung; energy target and projectile dependence of all three processes, Range-energy curves; Straggling.

Nucleon-Nucleon Scattering and Potentials: Partial wave analysis of the neutron-proton scattering at low energy assuming central potential with square well shape, concept of the scattering length, coherent scattering of neutrons by protons in (ortho and para) Hydrogen molecule; conclusions of these analyses regarding scattering lengths, range and depth of the potential; the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential; A qualitative discussion of Proton- Proton scattering at low energy: General features of two-body scattering at high energy Effect of exchange forces: Phenomenological Hamada- Johnston hard core potential and Reid hard core and soft core potentials; Main features of the One Boson Exchange Potentials (OBEP) no derivation.

Two Nucleon system and Nuclear Forces: General nature of the force between nucleons, saturation of nuclear forces, charge independence and spin dependence, General forms of two nucleon interaction, central, noncentral and velocity dependent potentials, Analysis of the ground state (3S1) of Deuteron using a square well potential, range-depth relationship, excited states of deuteron, Discussion of the ground state of Deuteron under noncentral force, calculation of the electric quadrupole and magnetic dipole moments and the D-state admixture.

Experimental Techniques: Gas filled counters; Scintillation counter, Cerenkov counters; Solid state detectors; Surface barrier detectors; Electronic circuits used with typical nuclear detectors; Multiwire proportion chambers; Nuclear emulsions, techniques of measurement and analysis of tracks; Proton synchrotron; Linear accelerations; Acceleration of heavy ions.

Nuclear Shell Model: Single particle and collective motions in nuclei: Assumptions and justification of the shell model, average shell potential, spin orbit coupling; single particle wave functions and level sequence; magic numbers; shell model predictions for ground state parity; angular momentum, magnetic dipole and electric-quadrupole moments; and their comparison with experimental data; configuration mixing; single particle transition probability according to the shell model; selection rules; approximate estimates for the transition probability and Weisskopf units: Nuclear isomerism.

Collective Nuclear Model: Collective variable to describe the cooperative modes of nuclear motion; Parametrization of nuclear surface; A brief description of the collective model Hamiltonian (in the quadratic approximation); Vibrational modes of a spherical nucleus, Collective modes of a deformed even-even nucleus and moments of, inertia; Collective spectra and electromagnetic transition in even nuclei and comparison with experimental data; Nilsson model for the single particle states in deformed nuclei.
**Nuclear gamma and beta decay:** Electric and magnetic multipole moments and gamma decay probabilities in nuclear system (no derivations), Reduced transition probability, Selection rules; zero- zero transition. General characteristics of weak interaction; nuclear beta decay and lepton capture; electron energy spectrum and Fermi- Kurie plot; Fermi theory of beta decay (parity conserved selection rules Fermi and Gamow-Teler) for allowed transitions; ft-values; General interaction Hamiltonian for beta decay with parity conserving and non conserving terms; Forbidden transitions ,Experimental verification of parity violation; The V-A interaction and experimental evidence.

**Nuclear Reactions:** Theories of Nuclear Reactions; Partial wave analysis of reaction Cross section; Compound nucleus formation and breakup, Resonance scattering and reaction- Breit-Wigner dispersion formula for S-waves (l= 0), continuum cross section; statistical theory of nuclear reactions, evaporation probability and cross section for specific reactions; The optical model, Stripping and pick-up reactions and their simple theoretical description (Butler theory) using plane wave Born approximation (PWBA) Short comings of PWBA nuclear structure studies with Deutron stripping (d, p) reactions.

**Suggested Readings**


**S13022: Quantum Mechanics-III**

*Relativistic Quantum Mechanics*

**Scattering:** Differential and total scattering cross section, transformation from CM frame to Lab frame, solution of scattering problem by the method of partial wave analysis, expansion of a plane wave into a spherical wave and scattering amplitude, the optical theorem, Applications,- scattering from a delta potential, square well potential and the hard sphere scattering of identical particles, energy dependence and resonance scattering. Breit-Wigner formula, quasi stationary states. The Lippman-Schwinger equation and the Green's function approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering problem under first Born approximation in elastic scattering.

**Relativistic Formulation and Dirac Equation:** Attempt for relativistic formulation of quantum theory, The Klein-Gordon equation, Probability density and probability current density, solution of free particle KG equation in momentum representation, interpretation of negative probability density and negative
energy solutions. Dirac equation for a free particle, properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction). Solution of the free particle. Dirac equation, orthogonality and completeness relations for Dirac spinors, interpretation of negative energy solution.

**Symmetries of Dirac Equation:** Lorentz covariance of Dirac equation, proof of covariance and derivation of Lorentz boost and rotation matrices for Dirac spinors, Projection operators involving four momentum and spin. Parity (P), Charge conjugation(C), time reversal (T) and CPT operators for Dirac spinors, Billinear covariants, and their transformations behaviour under Lorentz transformation, CP, T and CPT, expectation values of coordinate and velocity, involving only, positive energy solutions and the associated problems, inclusion of negative energy solution, Zitterbewegung, Klein paradox.

**The Quantum Theory of Radiation:** Classical radiation field, transversality condition, Fourier decomposition and radiation oscillators, Quantization of radiation oscillator, creation, annihilation and number operators; photon states, photon as a quantum mechanical excitations of the radiation field, fluctuations and the Uncertainty relation, validity of the classical description, matrix element for emission and absorption, spontaneous emission in the-dipole approximation, Rayleigh scattering. Thomson scattering and the -Raman effect, Radiation damping and Resonance fluorescence.

**Suggested Readings**


**S13023: Advanced Solid State Physics**

**Band Theory:** Block theorem, Kronig Penny model, effective mass of electrons, Wignier-Seitz approximation, NFE model, tight binding method and calculation of density for a band in simple cubic lattice, pseudo potential method.

**Semiconductors:** law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall effect, recombination mechanism, optical transitions and Schockely-Read theory excitons, photoconductivity, photo-Luminescence. Points line, planar and bulk defects, colour centres, F-centre and aggregate centres in alkali halides.

**Theory of Metals:** Fermi- Dirac distribution function, density of states, temperature dependence of Fermi energy, specific heat, use of Fermi. Dirac statistics in the calculation of thennial conductivity and electrical conductivity, Widemann- Franz ratio, susceptibility, width of conduction band, Drude theory of light, absorption in metals.
Lattice Vibrations and Thermal Properties: Interrelations between elastic constants C11, C12 and C44 wave propagation and experimental determination of elastic constant of cubic crystal, vibrations of linear mono and diatomic lattices, Determination of phonon dispersion by inelastic scattering of neutrons.


Superconductivity: (a) Experimental results: Meissner effect, heat capacity, microwave and infrared properties, isotope effect, flux quantization, ultrasonic attenuation, density of states, nuclear spin relaxation, Giver and AC and DC, Josephson tunnelling. (b) Cooper pairs and derivation of BCS Hamiltonian, results of BCS theory (no derivation).

Spin Waves and Plasma

Suggested Readings

5. S. O. Pillai, Solid State Physics, Wiley Eastern.

S13024: Solar Energy and Energy Studies  Credit(s): 4


**Flat Plate solar collectors:** Selective absorber surfaces. Transparent plates. Collector energy losses. Thermal analysis of flat plate water and air heating collectors. Collector performance testing. Simple appliances working with flat plate collectors: solar cooker; water heater, air dryer and stills.

**Concentrating collectors:** Optical concentration, flat plate collectors with plane reflectors, cylindrical parabolic concentrating collectors. Tracking requirements.


**Solar space conditioning:** Energy requirements in buildings, Performance and design of Passive system architecture, Absorption refrigeration cycle, Performances of solar absorption air conditioning.

**Essentials of wind energy:** Classifications and Description of Wind machines. Performances of wind machine (soladity factor Y(Lamda); Energy in the wind.

**Suggested Readings**


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**S13025: Physics Laboratory-III**

(Experiments in Nuclear Physics)

**Students have to perform all ten experiments**

1. To study G.M. detector characteristics and determine operating voltage of a G.M. tube.

2. To study random nature of radioactive decay using G.M. counter.
3. To determine the resolving time of G.M. counting set up (single and double source methods).

4. To study the absorption of $\beta$ - particles and determine end point energy using G.M. counter.

5. To determine absorption coefficient of $\gamma$ - rays.

6. Study of secular equilibrium in radioactive decay.

7. To determine end point energy of $\beta$ - particles using Scintillation counter.

8. To study Compton scattering of $\gamma$ - rays using Scintillation counter.

9. Study of absorption curve of $\alpha$ - particles using semiconductor detectors.

10. Study of specific energy loss and straggling of $\alpha$ - particles using semiconductor detectors.

Suggested Readings

1. Nuclear Detectors: Knoll.

2. Experimental Nuclear Physics: S.S. Kapoor and Ramamurthy; Tata McGraw Hill.

S140021(A): Quantum Field Theory

Scalar and vector fields: Classical Lagrangian field theory, 'Euler-Lagrange's equation, Lagrangian density for electromagnetic field. Occupation number representation for simple harmonic oscillator, linear array of coupled oscillators, secondquantization, of identical bosons, second quantization of the real Klein Gordan field and complex, Klein-Gordan field, the meson propagator. The occupation number representation for fermions, second quantization of the Dirac filed, the femion propagator, the electromagnetic interaction and gauge invariance, covariant quantization of the free electromagnetic field, the photon propagator.

S-matrix formulation: S-matrix expansion. Wick's theorem. Diagrammatic representation in configuration space, the momentum representation, Feynman diagrams of basic processes, Feynman rules of QED.

**Path Integral Formalism**: Applications

**Suggested Readings**

1. F. Mandal & G. Shaw: Quantum Field Theory, John Wiley.


**S14021(B): Instrumentation techniques**

**Credit(s): 4**

**Classification**

Absolute and Secondary instruments, indicating instruments, control, balancing and damping, construction details, characteristics, errors in measurement.

**Wattmeters**: Induction type, single phase and three phase wattmeter's, compensations.

**Energy meters**: AC Induction type single phase and three phase energy meter compensation, creep, error, testing.

**Frequency meters**: Vibrating reed type, electrical resonance type


**Electronic Instruments**

- **CRO**: Block Diagram, sweep generation, vertical amplifiers, use of CRO in measurement of frequency, phase, Amplitude and rise time of a pulse.
- **Digital Multimeter**: Block diagram, principle of operation, Accuracy of measurement
- **Electronic Voltmeter**: Transistor Voltmeter, Block diagram, principle of operation, accuracy of measurement: metering amplifier.

**Power Semiconductor Devices**

Power Diodes: Types, characteristics

**Thyristsors**: SCR, Static V-I characteristics of SCR, two transistor analogy of SCR, dynamic characteristics of SCR, Gate characteristics of SCR, Thyristor ratings, DIAC, TRIAC, GRO, UJT.

**Power Transistors**: Power BJT, Power MOSFETS, IGBT.

**Triggering Circuits**: R- Triggering, R-C Triggering, UJT triggering, Design of UJT triggering circuit, Cosine law triggering, triggering circuit using pulse train.

Sensors and Transducers

**Basic concepts and Classification:** Introduction, System Configuration, Problem Analysis, Basic Characteristics of Measuring Devices, Calibration

**Transducer classification:** Introduction, Electrical Transducer, Classification, Basic Requirements of a Transducer. Introduction, Principles of Transduction, Digital Transducers, Level Measurements

**Strain Measurement:** Introduction, Factors affecting Strain Measurements, Types of Strain Gauges, Theory of Operation of Resistance Strain Gauges, Types of Electrical Strain Gauges, Materials for Strain Gauges, Gauging Techniques and Other Factors, Strain Gauge Circuits, Temperature Compensation, Applications.

**Pressure Transducer:** Introduction, Diaphragms, Other Elastic Elements, Transduction Methods, Force-Balance Transducer, Solid State Devices, Thin Film Pressure Transducers, Piezoelectric Pressure Transducer, Vibrating Element Pressure Sensors, Pressure Multiplexer, Pressure Calibration

**Temperature Transducer:** Introduction, Temperature Scales, Mechanical Temperature Sensors, Resistance-Type Temperature Sensors, Platinum Resistance Thermometer, Thermistors. Thermocouples, Solid-State Sensors, Quartz

**Temperature Transducer:** Thermostat, Temperature Measurement by Radiation Methods, Optical Pyrometer, Calibration of Thermometers.


**Suggested Readings**

3. Electronic measurement & Instrumentation systems: Larry Jones & A foster Chin
6. Instruments and Transducers: D.V.S. Murty, PHI.
7. Power Electronics: M.H. Rashid, Pearson Publication
General Theory of Relativity


Cosmology


Suggested Readings


Astrophysics: Overview

The structure, origin, and evolution of the major components of the Universe: planets, stars, and galaxies. Formation of the Sun and planets.

Luminosity and magnitudes of stars. Saha’s ionisation equation.
Astrophysical processes: Basics of electromagnetic radiations; Statistical mechanics of Astrophysical phenomena; Radiative processes; Spectra; Neutral fields and plasma in Astrophysics.

Stellar evolution; X-ray sources, Binary stars, Pulsars, Quasars and other compact stars. The origin and search for life in the Universe.

**Structure Formation and the Evolution of the Universe**


_Suggested Readings_


Passage of the Electromagnetic waves through Ionosphere: Dispersion. A wave in the continuous medium of specific dielectric constant. Polarization of E-M waves. Curves of \( R(X) \). Quasi-Longitudinal (QL) and Quasi-Transverse (QT) approximations.

The Role of Ionosphere in the communication of Radio waves. The Skip distance.


Suggested Readings


Atmosphere and its constituents: Synoptic observations - surface and upper air. Preparation of weather charts and their analysis, Diurnal variation of temperature, pressure, relative humidity, clouds etc.

Tropical meteorology: Easterly Waves, ET-ITCZ, Inversion.

Extratropical Meteorology: Air mass, Fronts- Frontogenesis and Frontolysis, Extratropical Cyclones and Anticyclones, Jet Streams

Synoptic systems: Winter - Western disturbance, Rossby Waves,

Westerly Jet Stream, Fog, Cold Wave etc. Summer - Thunderstorms, Dust storms, Heat wave, Cyclonic disturbances. Monsoon - Onset, Activity, Withdrawal, Breaks,


Global Climatology: Global distribution of pressure and temperature at m.s.l. in winter and summer, distribution of annual rainfall and its variability, distribution of moisture and clouds. Vertical distribution of temperature. General circulation of atmosphere.

Development of monsoons. Major categories of world climates.

Indian Climatology - Different seasons, Distribution of Means Sea level

Pressure/temperature in different seasons, Wind circulation and temperature distribution over India in lower, middle and upper troposphere in different seasons. Indian rainfall in different seasons. Indian summer monsoon, onset, withdrawal, rainfall distribution, inter annual variability of monsoon. Main synoptic pressure systems causing weather over India in different seasons.

Suggested Readings

1. Atmosphere, Weather and Climate R.J. Barry and R.G. Chorley (Methuen Publication)
3. An Introduction to Meteorology by S. Pettersen
4. Elements of meteorology by Miller, Thompson and Paterson
5. General Meteorology by H.R. Byer
6. Monsoon by P.K. Das
7. Tropical Meteorology by T.N. Krishnamurthy
8. Tropical Meteorology by Riel.
90. Tropical Meteorology Vol 1, 2, 3, by G.C. Asnani
Elementary particles and the fundamental forces. Quarks and leptons. The mediators of the electromagnetic, weak and strong interactions. Interaction of particles with matter; particle acceleration, and detection techniques. Symmetries and conservation laws.

Bound states. Discoveries and observations in experimental particle physics and relation to theoretical developments. Symmetries, group theory, The group SU(2), Finite Symmetry Group: P and C, SU(2) of Isospin, The group SU(3)


Decay rates and Cross sections: Feynman diagrams Introduction to Feynman integrals. The Dirac equation. Feynman rules for quantum electrodynamics (no derivation). Moller scattering, trace theorems and properties of gamma matrices, helicity representation at high energies., the electron propagator, the photon propagator.


QCD: Electron positron annihilation into hadrons, heavy quark production, three jet events, QCD corrections, Perturbative QCD, Drell-Yan process

Weak Interactions: Parity violation, V-A form of weak interaction, Nuclear beta decay, muon decay, pion decay, charged current neutrino electron scattering, neutrino quark scattering, weak neutral currents, the Cabibo angle, weak mixing angles, CP invariance.

Suggested Readings

1. Francis Halzen and Allan D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley and Sons
3. The Review of Particle Physics, (Particle Data Group)
5. Byron Roe: Particle Physics at the New Millennium.
Gauge Symmetries: U(1) Local gauge invariance and QED, Non-abelian gauge invariance and QCD, massive gauge bosons, spontaneous breakdown of symmetry, the Higgs mechanism.


Standard Model of Particle Physics: Unified models of weak and electromagnetic interactions, flavor group, flavor-changing neutral currents. Weak isospin.

Quark and lepton mixing: CP violation. Neutrino oscillations. CKM quark mixing matrix, GIM mechanism, rare processes, neutrino masses, seesaw mechanism

QCD confinement and chiral symmetry breaking, instantons, strong CP problem

Suggested Readings

1. Francis Halzen and Allan D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley and Sons
4. David Griffiths, Introduction to Elementary Particles
5. Byron Roe Particle Physics at the New Millennium
6. Donald Perkin, Introduction to high energy physics.
7. Martin and Shaw, Particle Physics
Structure Factor: Static structure factor and its relation with the pair correlation function. Determination of structure factor by X-ray and neutron scattering. Inelastic neutron scattering and dynamic structure factor, space time correlation function and its relation with dynamic structure factor, properties of space time correlation function. Langevin's equation for Browninan Motion and its modifications. Velocity autocorrelation function, mean square displacement, Relation between velocity autocorrelation function and diffusion coefficient.


Quantum Liquids: Distinction between classical and quantum liquids, critetria for freezing, phase diagram of He4, He I and He II Tisaza's two fluid model, entropy filter, Fountain effect, superfluid film vehicle, Viscosity and specific heat of He4, first sound, second sound, third sound and fourth sound, Landau theory: Rotons and Phonis, t-matrix theory of superfluid He. Basic differences in superfluidity in He3 and He4.


References Books

1. Egelestaff: In Introduction to the Liquid State (Chapters 2, 3, 5, 6, 7 and 8.)


Electronic Structure Determination: Basic principles of X-ray, photo-emission and positron annihilation techniques. Qualitative discussion of experimental arrangement and typical results for both simple as well as transition metals.

Suggested Readings (for Condensed Matter Physics I & II)

1. Egelstaff: An introduction to the liquid state (Chapters 2, 3, 5, 6, 7 and 8).
2. Hansel and Mc Donald: Theory of Simple liquids (Chapters 3, 5, 8 and 9).
S14024: Project (Dissertation)  Credit(s): 10
Work at any University/ Academic Inst./ Research Lab

S14025: Seminar (Presentation of Project Work)  Credit(s): 2
M. Sc. ZOOLOGY

Objectives of the course

The undergraduate curriculum in zoology is designed to equip the scholars in life sciences with in-depth knowledge and practical skills in various aspects of animal biology. The curriculum endeavors’ to prepare students in a wide range of science-based skills that provide the learning base for future careers in disciplines such as health sciences, agriculture, environmental management, the emerging biotechnologies, publishing, teaching, research and consultancy. Zoology is the study of Animal Biology in all its aspects, from cells to populations and from neurones to behaviour. In this course the student will gain an in-depth study of various invertebrate and vertebrate specimens. The purpose of this course is to acquaint students with the identification, systematics, life history, anatomy, and adaptive strategies of the vertebrates and to expose them to field techniques used in their study.

Course Objectives:

- To inspire and encourage an interest in zoology.
- To acquaint students with evolutionary principles and animal diversity.
- To instill in students an understanding, appreciation and respect for the other animals which share our planet.
- To make students aware of the various disciplines encompassed by the field of zoology and to encourage them to pursue those areas that interest them through further reading and coursework.
- To encourage the development of inductive and deductive reasoning and to promote better study and test-taking skills necessary for this and other courses.
- To determine an array of organisms classification based upon domains, kingdoms, phylums and classes.
- To identify the characteristics and anatomy with the related functions of an array of organisms including but not limited to sponges, cnidarians, flatworms, round worms, segmented worms, mollusks, arthropods, echinoderms, and chordates.
- To describe the evolutionary trends across the animal kingdom relating to the nervous, digestive, circulatory, excretory, respiratory, and reproductive systems using specific terminology with appropriate examples.
- To understand the systemic and functional morphology of various groups of chordates.
- To understand the integrated activity of the whole cell as in mitosis, meiosis and protein synthesis.
- To understand the molecular basis of cell structure DNA structure and functions.
- To know the principles of genetics, pedigree analysis and population genetics.
• To integrate biology with technology.
• To study the application of scientific and engineering processes in the processing of materials by biological agents.
• To get a basic knowledge of statistical methods and computations in biology.
• To study the basic principles of animal physiology, chemical and physical properties of living matter.
• To understand the physiology of various organs and organ systems.
• To realize the importance of inter relationship between every organism and environment.
• To study the impact of eco factors on the morphology & distribution of organisms.
• To study, the theories of evolution.
• To disseminate information on economic aspects of Zoology
• To inculcate knowledge on useful animals to Mankind
• To satisfy the learners with modern techniques of Animal culture
• To acquire the knowledge of basic principles and applications of tools.
• To know the techniques for the measurement of physical, physiological, biochemical and biological factors in man and other living organism.
• To understand the structure and function of some of the glands in our body.
• To develop an understanding of form, function and adaptation in organ systems central to the maintenance of life and interaction with the environment
• To understand the fine structure of genetic materials and regulation of their action.
• To know the chromosomal basis of genetic disorders, development and differentiation. Also, to know the importance of population genetics, genetic engineering and applied genetics.
• To generate up-to-date knowledge on environmental conservation and management through a comprehensive understanding of the components of ecosystem, biological cycles, habitat ecology, resource ecology, pollution and its management.
• To familiarize the use of the data and techniques of engineering and technology in biology for the study of living organisms, or derivatives of there of, to make or modify products or processes for specific use.
• To comprehend the chemical constituents of living matter, chemistry of food stuffs and their transformation in animal systems, the energy changes associated with these transformation and hormonal regulation.
• To Understand the Structural and functional basis of immunoglobulins, the mechanism, mediators, detection and application of antigen-reaction in the immune system.
• To comprehend the scientific concepts of animal evolution through an understanding of its evidences, its mechanics, process and products
• To acquire a basic knowledge of the microbes in general and of the environmental, medical and industrial important microbes in particular in order to have an integrated approach in biology.
## ZOOLOGY

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<td>TAXONOMY AND EVOLUTION</td>
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SEMESTER-I

S11026: TAXONOMY AND EVOLUTION

Credit(s): 4


Concepts of evolution and theories of organic evolution with an emphasis on Darwinism Neo- Darwinism: Gene pool, Gene frequency, Hardy-Weinberg law of genetic equilibrium. Detailed account of destabilizing forces- Natural selection, Mutation, Genetic drift, Migration, Meiotic drive.

Variation, Mimicry


Suggested Readings

- The Biology of Biodiversity, M.Kato, Springer.
- Elements of Taxonomy. E. Mayer.
- Genes and Evolution. Jha A.P. John Publication, New Delhi
Organization of Body: Uni and multi cellular organisms,
Body cavity: Acoelome, Pseudocoelome, Coelome (schizo and enterocoelous)
Fate of Blastopore (Protostome, Deuterostome) and Blastomeres (Determinate and Indeterminate blastomeres)
Type of cleavage (Spiral and Radial)
Type of symmetry: Body planes, Asymmetry, Radial, biradial, bilateral symmetry
Segmentation: Pseudo, superficial and metameric
Locomotion: Flagellar, ciliary movement in Protozoa and Hydrostatic movement in coelenterate, annelid and echinodermata,
Nutrition and Digestion in invertebrates and lower Metazoa. Filter Feeding in Polycheata, Mollusca and Echinodermata.
Excretion: Excretory organs in invertebrates (Coelomoducts, Nephridia and Malphigian tubules, organ of bojanus, green gland), Mechanism of excretion
Nervous System: Primitive type (Coelenterata and Echinodermata) and Advanced type (Annelida, Arthropoda (Crustacea and insecta) and Mollusca (Cephalopoda))
Reproduction: Asexual (Paramecium, Obelia) and sexual reproduction (annelida, arthropoda and mollusca)
Larval forms of invertebrates, Evolutionary significance of larval forms.
Organization and general characters of Minor Phyla: Entoprocta, Ctenophora, Rhyncoela, Bryozoa, Rotifera, Phoronida

Suggested Readings

- Invertebrate structure and function. Barrington, E.J.W. Thomas Nelson and Sons Ltd. London.
- Invertebrate Zoology Barnes, RD. W.B.Saunders Co., Philadelphia
- Invertebrates Richard C. Brusca , Gary J. Brusca and Nancy J. Haver
Bioenergetics- types of chemical bonds, pH, Acid, Base, Buffer, Concept of free energy. Laws of thermodynamics and biological system, Enthalpy, Entropy.

Enzymes- Classification- (I.U.B. system), Specificity of enzyme action, Mechanism of enzyme action, Enzyme kinetics- Michaelis-Menten equation, Enzyme inhibition ,Allosteric enzymes, Iso-enzyme and ribozyme, conoenzymes and cofactors, Factors influencing enzyme action.

Vitamins-Classification, structure, occurrence and functions of fat soluble vitamins, Classification, structure, occurrence and biological functions of water soluble vitamins

Phenolics and alkaloids: structure, biological properties and functions

Carbohydrates-Monosaccharides-Classification with examples, Biological roles of monosaccharides, Disaccharides -Structure and biological roles, Polysaccharides - Homopolysaccharides– Structure and biological roles, Heteropolysaccharide- Structure and biological roles

Carbohydrate Metabolism: Glycolysis, Fate of pyruvic acid, Citric acid cycle, Electron transport system and oxidative phosphorylation; Redox potential, Chemiosmotic hypothesis; inhibitors of electron transport chain, Gluconeogenesis, Glycogenesis, Glycogenolysis; regulation of glycogen synthesis and breakdown, Pentose-phosphate pathway (HMP pathway), Regulation of metabolism.


Protein Metabolism : Transamination, Deamination, Decaboylation, fate of ammonia (Ornithine cycle).

Amino acid metabolism : Biosynthesis and degradation of amino acids.

Lipids -Fatty acids – structure, nomenclature. Classification and Biological roles of lipids.

Prostaglandins – Chemical nature and functions.

Lipid Metabolism: β-oxidation of fatty acids, Biosynthesis of fatty acids, Biosynthesis of cholesterol.

In born errors of metabolism

Suggested Readings

S11029: BIOSTATISTICS AND COMPUTER APPLICATION  
Credit(s): 4

Introduction: Biostatistics: Definition, Terms, Applications, Role of biostatistics in modern research.
Data collection: Types of data: Primary, secondary, qualitative, quantitative
Methods of data collection and classification:- Types of sampling method- Advantages and disadvantages of census and sampling method, Classification of data, Tabulation, Methods of classification, Class intervals- exclusive and inclusive method, Diagrammatic and graphical presentation of data, Bar diagram – (types), Pie diagram, Histograms, Frequency polygon, Frequency curve (types- skewness, kurtosis, ogive)
Statistical Methods: Measures of central tendency and dispersal, Mean, median, mode, quartile; Range, Mean deviation, Quartiles deviation, variance, Standard deviation, Standard error, degree of freedom, Standard error of mean.
Probability distributions: Basic concepts and definition: Laws of probability, Probability distribution: Binomial, Poisson and Normal
Correlation and Regression Types of correlation, Methods to measure correlation, types of Regression analysis, differences between regression and correlation analysis.
Statistical inference: Difference between parametric and non-parametric statistics; Testing of hypothesis, Errors, Student’s t-test, F-test, Testing goodness of Fit, Chi-square test, Chi-square distribution and characteristics, Applications of Chi-square test, Yate’s correction. Analysis of Variance (ANOVA) One-way classification. Two-way classification. Variance and coefficient of variation Computer Application: Introduction to computers: Computer application, basics, organization, PC, mainframes and Super-computers, concept of hardware and software, concept of file, folders and directories, Commonly used commands. Introduction in MS Office software concerning Word processing, spread sheets and presentation software. Networking fundamentals, client, server, LAN, WAN, Fip, TelNET, INTERNET, ICNET,WWW, HTML, e-mail, introduction to MEDLINE, CCOD and PUBMED for accessing biological information.

Suggested Readings

S11030: Laboratory exercises  Credit(s): 4

- Composition assessment of taxonomic diversity in a habitat. (grassland, arid land, wet land etc.)
- Use of taxonomic keys to identify at least 6-10 orders of insects (upto order level only).
- Visit river/pond/ sea for study of zooplankton.
- Collection, Preservation and curation of specimens
- Identification of animals (Fish/es/insects/any other) up to family/ generic / species level-minimum specimens.
- Preparation of dichotomous (simple bracket) keys; minimum ten sets from the identified specimens.
- Invertebrates
- Identification, classification & study of distinguishing features of representatives from various groups.
- Phylum Protozoa- Polystomella, Formanifera, Opalina, Paramecium(Fission & conjugation)
  Vorticella, Euglena, Trypanosoma, Monocytis, Plasmodium.
- Phylum Porifera-Sycon L.S & T.S, Spicules, Spongion fibres, Leucosolenia, Euplectella
- Phylum Cnidaria- Obelia, (polyp & Medusa), Millepora, Physalia, Pennatula, Metridium,
  Madrepora, Alcyonium, Gorgonia, Aurelia.
- Phylum Helminthes- Ascaris, Taenia, Planaria Phylum Annelida- Pontobdella, Aphrodite, Leech,
  Polygordius, Chaetoptyerus, Neries, Heteroneries, Arenicola.
- Phylum Arthropoda- Cyclops, Peripatus, Balanus, Lepas, Hippa, Belostoma, Limulus, Eupagurus,
  Julus, Scolopendra, Praying mantis.
- Phylum Mollusca- Murex, Bulla, Cardium, Arca, Turritella, Pinctada, Cypraea, Octopus,
  Nautilus.
- Phylum Echinodermata- Echinus, Holothuria, Antedon, Asterias
- Minor Phyla- Bugula, Plumatella, Crestatella, Pectinella, Phoronis, Dendrostoma
- Larval Stages: Planula, Redia, Miracidium, Sporocyst, Cercaria, Metacercaria Trophore,
  Nauplius, Zoa, Mysis, Phyllosoma, Trilobite larva of Limulus, Velligar, Bipinnaria,
  Echinoplateus, Auricularia, Tornaria
- Mounting: Hydra, Obelia, paramecium, different zooplanktons.
- Determination of pH of different solutions.
- Identification of unknown carbohydrates (Glucose, Fructose, Lactose, Maltose,
  Sucrose, Dextrin & Starch) by suitable tests.
- Qualitative estimation of protein, carbohydrate and lipid in various tissues/food materials
• Quantitative estimation of glycogen, glucose and ascorbic acid, sialic acid, total proteins, total lipid, phospholipids and cholesterol.
• Estimation of Enzymes: Acid and alkaline phosphates
• Preparation of frequency tables, bar diagrams, histograms, frequency curves, ogives and pie diagrams.
• Calculation of standard deviation and coefficient of variation.
• Estimation of significance between samples using Student’s t-test, F-test and Chi-square test.
• Plotting of regression lines, calculation of correlation and regression analysis.
• Analysis of variance (One-way & Two-way classification).
SEMESTER-II

S12026: BIOLOGY OF CHORDATES Credit(s): 4
Origin and outline classification of the chordates.
Salient features and Interrelationships of Hemichordata, Urochordata and Cephalochordata.
Life – histories of- Pyrosoma, Salpa, Doliolum and Oikopleura
General characters of Agnatha: Ostracoderms and Cyclostomes.
The early Gnathostomes (Placoderms).
A general account of the Elasmobranchii, Holocephali, Dipnoi and Crosspterygii.
Adaptive radiation in bony fishes.
Adaptive radiation of Amphibia.
Parental care in Amphibia, Neoteny in Amphibia
Basic types and outline classification of reptiles.
Living reptiles: a brief account of Rhynchocephalia.
Origins of mammals: Primitive mammals (Prototheria and Metatheria).
General account on adaptive radiations in Eutherian mammals excluding detailed reference to individual orders.
Organogenesis: Morphogenetic processes in epithelia and mesenchyme in organ formation, Morphogenesis of the brain. Development of the eye, heart.
Metamorphosis in Amphibia: Structural and physiological changes during metamorphosis, Endocrine control of metamorphosis.
Regeneration: Types of regeneration (physiological, reparative and compensatory hypertrophy) regenerative ability in chordates. Morphological and histological process in amphibian limb regeneration.

Suggested Readings

- Comparative anatomy of vertebrates. Kent. C.G.
- Text Book of Zoology, Sedgwick, A.A. Students Vol.II.
- An Introduction of vertebrates anatomy. Messers. H.M.
• The Phylogeny of vertebrate. Lovtrup.S.JohnWiley and Sons. London

S12027: TOOLS AND TECHNIQUES
Credit(s): 4
Principle and application of:- Light microscopy and micrometry, Phase contrast microscopy, Interference microscopy, Polarized microscopy, Fluorescence microscopy, Transmission electron microscopy, Scanning electron microscopy, Confocal scanning microscopy
Ultracentrifugation: Differential and density gradient
Principle and application of:-
Electrophoresis: Agarose, PAGE, isoelectro-focussing points and capillary electrophoresis
Chromatography: Paper, TLC, GLC, HPLC, ion-exchange and affinity chromatography
X-ray diffraction, Lamberts – Beer’s Law and Colorimetry,
Spectrophotometry: fluorescence, UV, NMR., ESR.
Flow cytometry/fluorescence activated cell sorter
Principle and application of: radiation techniques in biology, Radioisotopes and half life of isotopes, Tracer techniques in biology, Autoradiography, Geiger Muller counter, Scintillation Counter
Principles and technique of : nucleic acid hybridization and cot curves, Sequencing of nucleic acids, Blotting techniques (southern, northern and western), Polymerase chain reaction, Screening of genomic and complementary DNA libraries
Assay: Definition and types - Chemical assays, Biological assays-in vivo and in vitro assays.
Principles of cytological and cytochemical techniques: Fixation chemical basis of fixation by formaldehyde, gluteraldehyde, chromium salts, mercury salts, osmium salts, alcohol and acetone, Chemical basis of staining of carbohydrate, protein lipids and nucleic acids.
Principles and techniques of Genetic Engineering: Basic techniques, Cutting and joining of DNA molecules, Changing genes: site directed mutagenesis, Cloning strategies, DNA transformation techniques and their application in agriculture, health, medicine and industry, Introducing genes in animal cells, Application of recombinant DNA technology, Hybridoma Technology.
Cell Culture techniques: Design and functioning of tissue culture laboratory, Cell proliferation measurements, Cell viability testing, Culture media preparation and cell harvesting methods

Suggested Readings
• Animals Cell Culture - A practical approach, John R.W.Masters, IRL Press.
S12028: GENERAL PHYSIOLOGY : Credit(s): 4

Digestion and Metabolism: Nature of food-stuff. Various types of digestive enzymes and their action in alimentary canal, Absorption and assimilation of food, Nervous and hormonal control of digestion.

Circulatory system: Composition and function of blood, blood groups, Haemopoiesis, blood clotting, Blood volume, blood volume regulation, homeostasis, anatomy of heart structure, Myogenic heart, cardiac cycle, ECG – its principle and significance.

Gas Exchange and Acid-base Balance: Respiratory organs (lungs), respiratory pigments. Mechanism of breathing, Physiology of respiration, Oxygen and Carbon dioxide transport in blood, The role of hemoglobin, control of breathing.


Muscle Function and Movement: Types and properties of muscles, Anatomy of muscle, Regulation of contraction, Excitation-contraction coupling, Molecular theory of muscle contraction, cori cycle, muscle fatigue, tetani.

Nervous system: Functional architecture of neurons, Origin and propagation of nerve impulse through neuron (myllenated, non-mylleinated), Action potential, Synapses and neurotransmitters, Reflex arc and reflex action.

Sensory Transduction: Sensing the environment, Auditory receptors, Chemoreceptors; taste and smell, Mechanoreceptors tactile systems and escape responses, Vision and Photoreception, Thermoreception and infrared detection.

Stress Biology: Basic concepts of environmental stress and strain, Adaptation, Acclimation and acclimatization, Concept of Homeostasis, Physiological response to oxygen deficient stress, physiological response to body exercise, Meditation, yoga and their effects.

Endocrinology: Aims and scope of endocrinology, Discovery of hormones. Hormones as messengers. Classification of hormones, endocrine glands (Pituitary, pancreas, adrenal, thyroid,
testes, ovary). Neuroendocrine system and neurosecretion, General principles, structure and hormone action. Neuroendocrine regulators in insects.

**Suggested Readings**


**S12029: MOLECULAR BIOLOGY & BIOTECHNOLOGY**

Credit(s): 4

DNA replication: Prokaryotic and eukaryotic DNA replication, Mechanics of DNA replication, Enzymes and Accessory proteins involved in DNA replication, Models of DNA replication, Inhibitors of DNA replication
Recombination and repair: Holiday junction, gene targeting, gene disruption, FLP/FRT and Crelox recombination, RecA and other recombinases, DNA repair mechanisms
Transcription of mRNA in prokaryotes and eukaryotes: Structural organisation and life span of mRNA; monocistronic and polycistronic mRNA
Initiation, elongation and termination of transcription, Promoter (Pribnow, TATA, CAAT and GC box), enhancer and silencer Sites, Transcription factors; Transcription activators and repressors, Characteristic features of RNA polymerases of phages, prokaryotes and eukaryotes and their functions, Post transcriptional modification of RNA- Capping, Polyadenylation, Splicing, RNA editing: site specific deamination and role of gRNAs
mRNA transport

Genetic code: Characteristics of genetic code, Start codons and stop codons, Degeneracy of the code: Wobble hypothesis and isoacceptor tRNAs
Translation in prokaryotes and eukaryotes: Aminoacylation of tRNA & initiation, elongation and termination of protein synthesis, Aminoacyl tRNA synthetases & initiation, elongation and termination factors, Translational proof-reading, Differences in protein synthesis between prokaryotes and eukaryotes, Translational inhibitors in prokaryotes and eukaryote – role of tetracycline, streptomycin, neomycin, chloramphenicol, erythromycin, puromycin and diphtheria
toxin, Post-translational modification of proteins: protein folding (role of chaperones) and biochemical modifications.

Molecular mapping of genome: Genetic and physical maps, Physical mapping and map-based cloning, Southern hybridization, fluorescence in situ hybridization (FISH) for genome analysis. Molecular markers in genome analysis (RFLP, RAPD and AFLP).

Transgenic animals and knock-outs: Production, Applications, Cloning of animals by nuclear transfer, Embryonic stem cells, Care and breeding of experimental animals including bioethics.

**Suggested Readings**

- Russel, P. J. (2009): Cell and Molecular Biology, Cengage learning
- Veer Bal Rastogi (2008): Fundamentals of Molecular Biology, Ane Books India
S12030: Laboratory exercises

Museum specimens:
Lower Chordates: Salpa Asexual and Sexual stage, Doliolum oozoid, Botrylus, Herdmania, and Amphioxus.
Cyclostomata: Petromyzon, Myxine,
Pisces; Rhinobatus, Pristis, Trygon, Chimaera, Polydon, Acipenser, Amia, Lepidosteus, Proteocterus, Lepidosiren, Neoceratodus, Notopterus, Exocetus, Echeneis, Pleuronectes, Diodon, Tetradon, Ostracion, Syngnathus, Hippocampus, Anguilla, Labeo.
Reptilia: Testudo, Chelonea, Sphenodon, Calotes, Hemidactylus, Phryosoma, Draco, Varanus, Chamaleon, Cobra, Hydrophis, Viper, Pit Viper, Krait, Eryx, Gavialis, alligator, crocodile.
Mammals: Ornithorhynchus, Echidna, Macropus, Hedgehog, Manis, Loris, Bat.
Microscopic Slides:
Pisces: Placoid scale, Cycloid scale, Ctenoid scale.
Amphibia: V S skin of Frog, T S passing through stomach, duodenum, intestine, liver, pancreas, lung, kidney, testes, ovary.
Reptilia: V S skin of lizard.
Aves: V S skin of bird, contour feather, down feather.
Mammals: V S skin of mammals, T S passing through stomach, intestine, liver, pancreas, kidney, testes, ovary, thyroid gland, adrenal gland, pituitary gland, lung, bone, spinal cord.
Comparative Osteology:
Comparative account of Axial and Appendicular skeletons of Frog, Varanus, Fowl and Rabbit (both articulated and disarticulated).
Skull of Reptiles (Anapsida and Diapsida).

- pH meter and measurement of pH
- Paper chromatography of amino acids, mixtures, identification of unknown amino acids and sugars.
- Thin layer chromatography of amino acids and sugars.
- Photometric determination of haemoglobin in blood sample.
- Determination of RBC, WBC, MCV, MCH, MCHC of the given sample of blood.
- Demonstration of the blood clotting time, erythrocyte sedimentation rate, haemolysis and crenation.
- Determination of the glucose in serum/plasma.
- Determination of SGPT and SGOT.
- Squash and smear preparations of testis of cockroach / grasshopper aceto-orecin and Fuelgen staining of these preparations.
- Study of mitosis in onion root tip and meiosis in testes of insect or mammal.
- Study of giant chromosomes in the salivary gland of Chironomus larva or Drosophila
• Study of prepared microscope slides, including those showing various cell types, mitosis, meiosis and giant chromosomes.

SEMESTER-III

S13026: GENETICS


Developmental Genetics: Human embryo development- Cleavage, 2 cells, 4 cells, 8 cells, 16 cells, 32 cells, Morula, Bltula, Gatrula, Organogenesis, Gonadal differentiation, Placental types, implantation, Formation of extra embryonic tissue, Study of human birth defects-Syndromology, Dysmorphology, Neural tube defect, Anencephaly, Meningocele, Spina bifida, Herlequin ichthyosis.

Reproductive Genetics: Spermatogenesis, oogenesis, Computer assisted Semen Analysis (CASA), Assisted Reproductive Techniques (ART) IUI, IVF, ICSI, ZIFT, GIFT.

Pre-implantation Genetic Diagnosis (PGD).

Molecular Diagnosis: DNA fingerprinting, Linkage analysis - RFLP, blotting techniques (southern, northern and western), Gene sequencing, Probes- Preparation and classification, in-situ hybridization, FISH, mFISH, fiber, FISH, application of FISH.

Prenatal Diagnosis: Historical perspective, Non-invasive techniques- Ultrasonography, foetal MRI, Invasive techniques- Amniocentesis, chorionic villus sampling, fetal blood sampling, fetal skin sampling, Chromosome analysis, metabolic disorders, DNA Analysis, Current knowledge of prenatally diagnosed genetic disorders, haemoglobinopathies, coagulation disorders.

Treatment of genetic disorders.

Suggested Readings

• Gardnor: Principles of Gentics
• Mange, Elanine, Johnson: Basic Human Genetics
• Pierce Benjamin: Genetics- A Conceptual Approach
• Scriver et al. (2002): The metabolic and molecular basis of inherited diseases. 8th edition, McGraw–Hill.
• Strickberge: Genetics
• Tomarin Robert, H: Principles of Genetics
Introduction: History and scope of microbiology, Composition of the microbial world, Modern age of micro biology.

Microbial Taxonomy and Phylogeny: Major characteristics (classic and molecular), Numerical taxonomy, Phenetic classification, Bergey’s Manuel (mention major groups)

Bacterial cell structure and function: Plasma membrane and internal system - Cytometrix, inclusions, ribosomes, nucleoid, Bacterial cell wall Peptidoglycan - structure-Gram positive and gram negative cell wall- Mechanism of gram staining, Components external to cell wall; pili and fimbriae, capsule and slime layers, Flagella and motility.

Viruses: General structural properties, Types: DNA viruses, RNA viruses, and enveloped viruses.

Microbial diseases: Human diseases caused by bacteria.
Human diseases caused by viruses.

Fungal diseases- Candidiasis

Control of microorganisms: Disinfectants; (A) - physical- Heat, filtration and radiation
(B)-Chemical agents - Phenol and Phenolic compounds, alcohols, halogens and aldehydes.
Antibiotics- Penicillin’s, Cephalosporins, Chloramphenicol, Tetracyclines.

Microbial drug resistance.

Microbial fermentation: Lactic fermentation-Homolactic and heterolactic fermenters, dairy products, cheese, Yogurt, kefir etc. Alcoholic fermentation-Alcoholic beverages.

Environmental microbiology: Aquatic microbes, Microbiological analysis of drinking water, Waste water- microbial characteristics and treatment, Microbial Bioremediation.

Economic importance of Protozoa and Helminthes.

Economic importance of Arthropods: Beneficial and Harmful mites and ticks, crustaceans, spiders, insects. Life cycles of Lac insect, Honey bee, Silk worm and industries related to them. Some important parasites and pests

Important insect pest and their management. Edible Freshwater and Marine Fishes of India. Pisciculture and products of fishing industry, Prawn fisheries. Economic importance of mollusca: Pearl culture. Pearl industry in India.

Suggested Readings

- Gandhi-Microbiology and Immunology notes and cases-Blackwell publishing
- Mansi- Fermentation, Microbiology and Biotechnology-Taylor and Francis
S13028-ANIMAL BIOTECHNOLOGY Credit(s): 4

Introduction: Definition, branches, scope and importance of biotechnology;
Animal cell and tissue culture: Culture media– natural and artificial. Culture methods– primary explantation techniques, various methods of cell and tissue culture, Tissue and organ culture.
Equipments required for setting the animal cell laboratory;
Vectors for gene transfer (plasmids and phages).
Basic concepts in Genetic Engineering and Ethics of Genetic engineering
Protoplast fusion in prokaryotes and eukaryotes.
Recombinant DNA technology and hybridomas and their application,
Monoclonal antibodies and their applications.
Genomic and cDNA library: Construction, Screening– By DNA hybridization, Screening by immunological assay, and screening by protein activity.
Blotting techniques- Southern blot, Northern blot, Western blot, Dot blot and Slot blot, FISH and GISH, Chromosome walking.
DNA sequencing–Maxam and Gilbert’s chemical degradation method, Sanger’s dideoxynucleotide synthetic method.
Transfection methods and transgenic animals: Definition, Methods - Electroporation, DNA micro injection, Calcium phosphate, precipitation, Dextran mediated transfer, shot gun method, virus mediated, lipofection method, engineered embryonic stem cell method, Transgenic animals for human welfare.
Cloning: Cloning procedures (adult DNA cloning, Therapeutic cloning, Embryo cloning) – Advantages and disadvantages of cloning.
Environmental biotechnology: Pollution control – cleaner technologies, toxic site reclamation, removal of oil spill, reducing of pesticides and fertilizers, biosensors, biomonitoring, pest control, waste water treatment, metal and petroleum recovery.
Polymerase Chain Reaction: Basic PCR—raw materials and steps involved. Inverse PCR, Anchored PCR, Asymmetric PCR, PCR for mutagenesis and Real Time PCR, Applications of PCR in Biotechnology and genetic engineering. Molecular markers (brief notes)-RFLP, AFLP, RAPD, Minisatellites (VNTR), Microsatellites (SSR), SNPs. Animal and human health care: Vaccines, Disease diagnosis, Gene therapy, Transplantation of bone marrow, artificial skin, artificial blood, Antenatal diagnosis, DNA finger printing, Forensic medicine. elementary idea of Human Genome Project.

Suggested Readings
- Charles Hardin (2008): Cloning, Gene expression, and Protein purification-
- Experimental procedures and process rationale - Oxford University Press.
- Chatterji, A.K. -Introduction to environmental biotechnology-Prentice Hall of India
- Colin Ratledge and Bjorn Kristiasen-Basic Biotechnology - Cambridge University press.
- Dominic, W.C. Wong-The ABCs of gene cloning-Springer international edition
- Singh, B.D.-Biotechnology-Kalyani publishers.

S13029: DEVELOPMENTAL BIOLOGY

Introduction: Basic concepts of development: Potency, Commitment, Specification -autonomous, conditional, Induction, Competence, Determination and differentiation, Morphogenetic gradients

Environmental regulation of animal development: Environmental regulation of normal development—types of polyphenism

Sex determination in Bonellia; primary and secondary sex determination, environmental sex determination, Environmental disruptions of normal development (Teratogenesis), Teratogenic agents- Alcohol, retinoic acid, bisphenol, heavy metals, pathogen, Environmental oestrogens.

Gametogenesis, fertilization and early development: Production of gametes, Cell surface molecules in sperm-egg recognition in animals, Zygote formation, Cleavage and blastula formation, Gastrulation and formation of germ layers in amphibian.
Embryogenesis and Organogenesis: Axis formation in amphibians - primary embryonic induction, Anterior posterior patterning in Amphibians - Hox code hypothesis, Anterior posterior patterning in Drosophila - gap genes, bicoid gradient, segmentation genes, pair rule genes, homeotic selector genes, realistor genes, Dorsoventral patterning and Left right patterning - dorsal protein gradient, Limb development in chick, Insect wings and legs
Cellular and Molecular basis of development: Cellular interactions during development, Epithelial - mesenchymal interactions, paracrine factors, RTK pathway, cell death pathways, Cellular interactions concerned in fertilization, Cellular changes during blastulation and gastrulation, Cellular interactions in organogenesis, Molecular basis of cellular differentiation – cadherins.
Metamorphosis, Regeneration and Aging.
Metamorphosis in Amphibians and Insects and their hormonal control, Types of regeneration - Super, Hetero, Epimorphic, Morphallactic and Compensatory regeneration, Histological process during regeneration, Ageing– cellular and extra cellular aging, Causes- Wear and tear, Oxidative damage, Mitochondrial genome damage, genetically programmed aging.

Suggested Readings
- Development Biology S.F.Gilbert, Sinauer Associates Inc., Massachusetts
- An Introduction to embryology, Balinsky, B.I.: W.B. Saunders Comp.
- Modern embryology, Bodemer, C.W.: Holt Chart and Winston, Inc. New York; Chicago
- Balinsky, B. I. An introduction to Embryology.
- Berril, N. J. Developmental biology.

S13030: Laboratory exercises

- Identification of male and female Drosophila.
- Identification of wild and mutant forms of Drosophila
- Monohybrid and dihybrid inheritance in Drosophila
- Simple problems based on mendalism.
- Identifications of blood groups in man.
- Demonstration of sex chromatin.
- Embryology of Frog
- Embryology of Chick

- Selective isolation and enumeration of bacteria.
• Turbidity test for contamination of milk.
• Phosphate activity of milk.
• Preparation of media and sterilization. E.g., Nutrient agar, Mac conkey agar, sterilization by wet and dry heat, disinfection.
• Isolation of pure colonies of bacteria.
• Bacteriological analysis of water e.g., fecal pollutants.
• Antibiotic sensitivity test.
• General introduction to stains, preservations and fixatives.
• Museum specimens
• Protozoa- Selected species of economic importance
• Platehelminthes- Selected species of economic importance
• Arthropoda- Mites, Ticks, Spiders, Insects
• Life cycle of silk worm, honey bee, mosquitos, and other economic important species.
• Permanent preparations- Whole mounts, various mouth parts/Appendages
• Visit to fish industry/Poultry farm/ Dairy/ Leather industry etc.

• Isolation of plasmid DNA.
• Isolation of total RNA from tissues
• Separation of DNA by electrophoresis.
• Bacterial transformation.
• Cell immobilization
• Separation of proteins and DNA by agarose electrophoresis
• Separation of proteins and isoenzymes on SDS-PAGE and PAGE
• Electrophoretin of proteins, DNA/RNA from electrophoretic gels
• Separation of amino acids by paper chromatography
• Separation of phospholipids by TLC
• Preparation of salivary gland chromosomes from Drosophila / Chironomous larva and stain with acetocarmine/aceto-orcein/ fuelgen
• Estimation of DNA by Diphenyl Amine method
• Estimation of RNA by Orcinol method
• Estimation of Protein by Lowry’ method.
• Isolation of RNA from Yeast.
• Isolation of plasmid DNA.
• Isolation of genomic DNA.

• Life cycle of Drosophila.
• Demonstration of sex chromatin.
• Embryology of Frog
• Embryology of Chick
• Preparation of salivary gland, polypetne chromosome from drosophila larva.
• Dosophila banding technique and Karyotyping.
• Grass hopper – (testes –squash preparation) to study various meiotic stages
SEMESTER IV

LIST OF SPECIAL PAPERS (Any one is to be taken)

S14026A - Cell and Molecular Biology
S14026B - Environmental Biology
S14026 C- Reproductive Biology

SPECIAL PAPER-(A)- CELL AND MOLECULAR BIOLOGY

S14026(A): CELL AND MOLECULAR BIOLOGY Credit(s): 4


Cytoskeleton: Microfilaments; Actin cytoskeleton. Myosin(a) Structure and mechanism of movement with actin. (b) Conformational changes in myosin during movement. Microtubules: Microtubules structure and microtubule assembly from organizing centers, Microtubule dynamics, Microtubule associated proteins (MAP’s) and cross-linking of microtubules, Microtubules and mitosis, Cilia and Flagella- Structure and movements.


Cell-Cell Signaling: Endocrine, paracrine and autocrine signaling. Receptor Proteins-Cell Surface receptors and intracellular receptors. Cell Surface receptors-G-protein coupled receptors, ion channel receptors, tyrosine kinase-linked receptors and receptors with intrinsic enzymatic Activity. Second messenger System - cAMP and IP3, DAG 7.5 MAP kinase cascade, JAK/STAT and TGF-β / Smad signaling, NF-kB signaling.
Signaling from plasma membrane to nucleus (a) CREB links cAMP signals to transcription (b) MAP kinase. Signal- Mediated transport through Nuclear Pore, Nuclear pore complex 8.2 Nuclear exports signals and transport of cargo proteins from nucleus to cytosol. Nuclear localization signal and transport of cargo proteins from cytoplasm to nucleus.

**S14027(A): CELL AND MOLECULAR BIOLOGY**

**Credit(s): 6**


**S14028(A): CELL AND MOLECULAR BIOLOGY**

**Credit(s): 4**

Viral infections (a) Viral neutralization by humoral antibody. (b) Cell-mediated antiviral mechanism. (c) Viral evasion of host defense mechanisms.
Bacterial infections (a) Immune responses to extra cellular and intracellular bacteria. (b) Bacterial evasion of host defense mechanism.
Protozoa and diseases. Diseases caused by helminthases.
Vaccine: Active and passive immunization. Designing vaccines for active immunization. Whole organism vaccine. Attenuated viral or bacterial vaccines. Inactivated viral or bacterial vaccines.
Hypersensitivity: Type I, II, III and IV, In vivo and in vitro, Autoimmunity, Organ specific autoimmune disease, Systemic autoimmune disease.
Tumor immunology: Tumor antigen. Tumor evasion. Immune system against tumors.
Immunosuppressive drugs, role of monoclonal antibodies in transplantation.

**S14029(A): CELL AND MOLECULAR BIOLOGY**

Immunology: Introduction- Innate and adaptive immunity, Cells and organs of the immune system (Primary lymphoid organs, Secondary lymphoid organs, B-lymphocytes, T-lymphocytes and Antigen presenting cells), Humoral and cell-mediated immune responses (CMI), Antigenecity, immunogenecity and Haptens, Factors influencing immunogenicity, Recognition of antigen by B-and T-lymphocytes, Antigens,
Antibodies: Structure and functions of Antibody Molecules, Molecular structure of Ig, Immunoglobulin classes (IgG, IgM, IgE and IgD and their biological activities. Generation of Antibody diversity.
Immune effector Mechanisms: Cytokines & Antagonists, Compliment System-components & functions, Compliment activation and regulations (classical, alternate and lectin pathways), Inflammation & hypersensitivity.
Major Histocompatability Complex (MHC): General organisation and inheritance of MHC, MHC genes & molecules, Antigen processing and presentation— Endogenous and Exogenous pathways.
Immune system in Health and Diseases: Immune responses during bacterial (Tuberculosis) parasitic (malaria) and viral (HIV) infections. Autoimmune diseases (organ specific and
systemic), Primary Immunodeficiency diseases (Bruton’s disease, Di-george Syndrome & Severe combined immunodeficiency (SCID), Secondary immunodeficiency Diseases (AIDS). Origin, means of infection, course of infection, structure and types of HIV, viral multiplication, mutation, diagnosis, antiretroviral therapy and AIDS vaccine.

Suggested Readings

- Das Gupta, Modern Immunology
- Roit, Essentials of Immunology.
- Abbas AK Lichtman, AR. and Pahes, J.S. Molecular Immunology, WB Saunders & Co, London
- Malacinski G.M. and Freifelder D. Essentials of Molecular Biology Jones and Bartlett Publishers Boston, 1999

S14030(A): Laboratory exercises

1. Operation of various microscopes : Use of occulometer-standardization and measurements of cell height, nuclear diameters and tabular diameters
   Use of occular grid-standardization and counting of cells or nuclei in cross section or epithelium
2. Preparation of biological tissues and sectioning for : Paraffin wax histology by microtome Fresh- frozen
   by cryostat Ultra-thin sectioning by ultratome
3. Cytochemistry : 3.1 Carbohydrate (a) PAS method (b) Alcian blue method 3.2 Proteins (a) Mercury bromophenol blue method (b) Ninhydrin method 3.3 Lipids (a) Phosphomolybic acid method (b) Copper phthalocynin n method 3.4 Nucleic acid (a) Feulgen method (b) Methyle green- Pyronin method.
4. Biochemical methods: 4.1 Determination of pK value of buffer 4.2 Determination of absorption maximum of a solution 4.3 Determination of relationship between absorption and various concentration
of a solution using a colorimeter, spectrophotometer. 4.4 Preparation of standard curve for proteins, lipids and carbohydrates. 4.5 Quantitation of enzymes - alkaline and acid phosphatase.
6. Permanent slides: Types of cells (squamous, cuboidal, columnar epithelial cells, blood cells, nerve cells, muscle cells), connective tissues of various types. adipose tissue, mitotic & meiotic chromosomes and their different phases. Thymus, lymph nodes, spleen, bone marrow and cancer cells of various types.
10. Histology of organs of immune system.
12. Demonstration of agglutination reaction.
13 Demonstration of ELISA technique.

**SPECIAL PAPER(B) - ENVIRONMENTAL BIOLOGY**

**S14026 (B): ENVIRONMENT & NATURAL RESOURCES**

Credit(s): 4

Environment and climate, Earth (core, mantle, tectonic plates); Atmosphere- structure and composition; Clouds and their formation. Cloud categories: low, middle, and high clouds: Cirrus (Ci), Cirrocumulus (Cc), and Cirrostratus (Cs), Altocumulus (Ac), Altostratus (As), and Nimbostratus (Ns), Cumulus (Cu), Stratocumulus (Sc), Stratus (St), and Cumulonimbus (Cb). Element and factors of climate: External factors: solar radiation, Internal factors. Global climate changes – causes and consequences. Human population: Exponential growth – geometric growth or geometric decay-Malthusian growth model – population momentum age structure – population pyramid, age structure diagram. Types of population pyramid, Population explosion. Ecosystem: Ecosystems-a) types, natural & artificial, agroecosystems, City ecosystems and Spacecraft ecosystems. Functions of Ecosystems, Ecological energetics - Fixation and utilization of energy- Primary production, factors affecting & measurements of primary production,
Lindmann’s work, Single channel, Y shaped and universal energy flow models, Place of man in the food chain, Nutrient cycling, selection, diversity, decomposition and stability.

Development of ecosystems, Types and factors controlling, changes in the trends of ecological attributes,

Human impact on ecosystems, Human settlements, Human cultural evolution, Environmental crisis, Environmental protection and sustainable development.

Resources of the Earth – Renewable & Non renewable

Natural resources-Renewable and nonrenewable natural resources. Depletion of natural resources and its effects. Aquaculture. economically important crustaceans, mussels, oysters, clams and sea weeds(in Brief). Marine products - Food value of fish, Fish meal, fish body oil, Fish liver oil, Fish maw and other products. Forest products -major and minor products of both plant and animal origin,

Economically important insects and their products-Honey, Lac and Silk.

Mineral resources with special reference to India.

Water as a resource- Characteristics of water. Major water compartments.

Hydrological cycle.

Water management and conservation– Rain water harvesting techniques.

Energy resources: Conventional energy sources (coal, Oil and natural gas and oil shale)

Non conventional energy sources -solar energy, wind energy,geothermal energy, hydropower, biomass, biogas,Tidal energy, Energy from waste, Hydrogen, and Nuclear energy. Energy crisis

Biomes: Desert, Grassland, Tundra, Tropical and temperate forests, Deciduous and evergreen rain forests; Ecozones of India

Species interactions: Herbivory, Carnivory, parasites, Prey– Predator, Commensalisms, mutualism and Symbiosis

Conservation: Environmental degradation, role of men in changing the environment, IUCN classification of endangered species, red data book, Restoration of wildlife populations by reintroduction (Soft and hard release) and Captive breeding, in situ and ex situ conservation

National and international organizations

S14027(B): ENVIRONMENTAL POLLUTION Credit(s): 4

AIR POLLUTION: Primary air pollutants: occurrence, sources and sinks of the following pollutants: (a) compounds of carbon, (b) compounds of sulphur, (c) compounds of nitrogen, (d) gaseous halogens, (e) ozone, (f) mercury, (g) particulate matter

Method of sampling and monitoring of the following gaseous air pollutants (Two methods for each pollutant)-(a) Oxides of Carbon, Hydrocarbons, (b) SO2, H2S, Mercaptans, (c) Oxides of Nitrogen, Ammonia, (d) Ozone
Sample collection—settlement, filtration, particle count, evaluation by optical microscopy, particle size analysis—projected diameter and statistical diameter (Ferete’s diameter and Martin’s diameter). Interaction of air pollutants in the atmosphere. Secondary pollutants: photochemical-smog, Acid rain, and green house effect.

Effect of air pollution: (a) On materials, buildings, metals etc., (b) On vegetation, (c) On weather and atmospheric conditions, (d) On human health- a brief survey of major air pollution episodes.

Acid rain, Global warming: The green house effect, green house gases, potential effect of global warming, Noise pollution-sources, effects and abatement.

WATER POLLUTION: Types and effects of water pollution, Plant nutrients and cultural eutrophication, Toxic inorganic and organic materials, Biocides: Classification and types of Biocides- Fungicides, Pyrethroids and pesticides. Effects of Biocides, Biological magnification Toxic effects on non target organisms- hazards to man.

Heavy metals sources and effects of the following in the ecosystem and human population

Thermal pollution-sources, effects- cooling towers as control measures. Oil spills-sources effects and control. Hazards of Radioactive materials in the environment, Biological effects of ionizing radiations, Nuclear waste disposal. Carcinogens in the environment

Water pollution abatement technology: (a) Primary, secondary and tertiary treatment systems (b) Principles of design and operation of (1) screens (2) Grit chambers (3) Sedimentation tanks (4) Oxidation ponds and (5) algal pond.

Design and operation of biological treatment systems: (1) Aerated lagoons (2) Activated sludge process (3) Trickling filters (4) sludge digest.

Sewage and sewage treatment: composition, bacteriology of sewage treatment, stabilisation-properties of sewage, categories of sewage, use of effluents in irrigation

Air pollution- abatement technology: basic principles of design and working of: (a) Bag filters (b) Inertial collection- cyclones (c) Electrostatic precipitators (d) Scrubbers (e) Adsorption (f) Device for controlling automobile emissions


Solid waste disposal methods: Sanitary land fill, plasma gasification, deep well injection, incineration, recycling biogas.

S14028(B): ECOTOXICOLOGY AND ENVIRONMENTAL MICROBIOLOGY

Credit(s): 4

Environmental Health and Toxicology: Introduction of Environmental Health and Toxicology, Fundamentals of Toxicology: Toxicants of Public Health (Pesticides, metals, solvents, Radiation), Dose & Toxicity

Movement, distribution and fate of toxins: Bioaccumulation, Biomagnification, Translocation of Xenobiotics: Absorption, Biotransformation, Excretion
Measuring toxicity (Acute, Sub Chronic and Chronic), Environmental impact assessment (EIA); Process and Methods, Risk Assessment, Sustainable Development

Environmental Management: Solid Waste Management, E-Waste & Hazardous Waste, Legislative approach for Waste management, Bioterrorism / Biological warfare
Climate disasters: Tsunami, earth quack, cyclone
Environmental awareness and education regarding conservation of wildlife
Impact of tourism related activities on environment, Basic principles of ecotourism, Island ecology and tourism, Pollution related to tourism- solid and liquid waste from tourist destination
Wildlife: History, causes of depletion, Techniques of studying - Radiometry, photographic identification of animals and remote sensing
Wildlife of India- Wild life schedules, Ecozones, National parks, sanctuaries, reserves Management, special protection programs (Tiger, Rhino, Lion tailed macaque, elephant)

Microbial Interaction with Xenobiotic Inorganic Pollutants: Persistence and Biomagnification of xenobiotic molecules, Polychlorinated Biphenyls and Dioxins, Synthetic Polymers, Microbial Interaction with some Inorganic pollutants, Acid mine drainage, Microbial Conversions of Nitrate, Microbial Methylation, Microbial Accumulation of Heavy Metals and Radionuclides
Biodegradability Testing and Monitoring the Bioremediation of Xenobiotic Pollutant : Biodegradability and ecological side effect testing, Biosensor detection of Pollutants, Bioremediation, Environmental modification for bioremediation, Microbial Seeding and Bioengineering Approaches to the Bioremediation of Pollutants, Bioremediation of Marine Oil pollutants, Bioremediation of air pollutants.
Microbial Control of Pests: Microbial control of plant and animal pests, Microbial control of weeds and cyano bacterial blooms, Genetic engineering in biological control, Frost protection, Bacillus thuringiensis pesticide, other applications
Environment awareness: Earth summits, Carbon footprint and carbon tax, Global warming, ozone layer depletion

S14029(B): ENVIRONMENTAL CONSERVATION  
Credit(s): 4

Habitat Conservation: Forest Ecology- Major vegetation types, Tropical rain forests; Shola forests (Cloud forests); Mangroves.
Deforestation and its consequences: Need for scientific management and conservation of forests, Social forestry and agro forestry, Habitat destruction, Fragmentation and Degradation causes and consequences, Wetlands and waterfowl conservation.
Ocean acidification; Ocean Warming and Coral Bleaching.


Ex situ conservation-Zoo, Aquarium, Seed bank, Gene bank, Pollen bank, etc-
In situ conservation.- National parks, sanctuaries, Biosphere reserves,Community reserves and other protected areas.


Suggested Readings

- Ecological Methodology Charles J. Krebs.
- Ahluwalia & Sunita Malhotra-Environmental Science-Ane books Pvt. Ltd
- Ananthakrishnan, T.N. - Bioresource Ecology- Oxford and IBH.
- Cunningham &Cunningham 2003- Principles of Environmental Science:, Tata
McGraw Hill
- Franco K.G-- Man and the changing environment
- Ramakrishnan, P. S.-Ecology and sustainable development-National book trust India

S14030(B): Laboratory exercises  
Credit(s): 6

- Mark important sanctuaries and national parks of Rajasthan on map, and write details of any three
- Estimation (biochemical/ GC/TLC) of any environmental toxicants
- Bacterial examination of water – MPN index.
- Study of microbial diversity (bacteria and fungi) in soil, air and water.

Bioassay Studies and Insecticides
- Fish/Daphnia bioassay test to find out the toxicity of heavy metals/pesticides
- Bioassay- Determination of LC50 (in fish) and LD50 (in mice) of any toxicant.
- Determination of the concentration of the following insecticides in water: DDT, Methyl parathion
- Estimation of the following metals in effluent and sediment samples – Copper, Zinc, Chromium (Hexavalent)

Water Evaluation Analysis
- Determination of chloride in the given water sample.
- Estimation of total hardness of given water sample.
- To determine the acidity of water.
- To determine the alkalinity of water.
- To estimate total solid in water.
- To estimate total dissolved solid in water sample.
- To determine the dissolved oxygen in given water sample.
- To determine the BOD of given water sample.
- To determine the free CO2 of given water sample.
- To estimate the Calcium hardness of water.
- To estimate Magnesium hardness of given water sample.
- Species diversity indices and indicator species
- Estimation of salinity, phosphates, sulphates, silicates and nitrates in water samples
- Separation and identification of soil arthropods using Berlese funnel.
- Soil Analysis
- Determination of organic matter in soil sample.
- Determination of Co3- & HCo3- in soil sample.
• Estimation of chlorophyll in plant material.
• Determination of moisture content of soil sample.
• Determination of water holding capacity of soil sample.
• FIELD STUDY-A study tour of at least five days duration (need not be at a stretch) to observe the ecology and behaviour of animals should be undertaken. The places of visit include inter tidal region, fresh water bodies, lakes, rivers, hill streams, wetlands, mangroves, forests, grasslands, drinking water treatment plants, and sewage treatment plants.
• A report of the field study is to be included in the practical record to be submitted at the time of Examination

SPECIAL PAPER(C)-REPRODUCTIVE BIOLOGY

S14026 (C): ENDOCRINE GLANDS- I Credit(s): 4

Historical background. scope and status of endocrinology. Endocrine glands an overview, Study of the following major endocrine glands of vertebtrates.
Pituitary General, developmental and comparative anatomy; functional cytology of the pituitary gland of mammalian and submammalian vertebtrates; adenohipophyseal hormones, their chemistry and physiology, chromatophore regulation among vertebtrates; neuroendocrine peptides: their chemistry and phylectic distribution; formation, storage, release and transport of neuroendocrine principles; effects of hypophysectomy.
Thyroid General, developmental and comparative anatomy; evolution of thyroidal function, biochemistry biological actions of thyroid hormones and their interrelationship with other endocrine secretions; effects of thyroidectomy; calcitonin its chemistry and physiology.
Parathyroid General, developmental and Comparative anatomy; biochemistry and physiology of the parathyroid hormone; effects of parathyroidectomy.
Pancreatic Islets General, developmental comparative anatomy; biochemistry and physiology of insulin and glucagon; effects of pancreatectomy.
Pineal General, developmental and comparative anatomy; biochemistry and physiology of the pineal principles.
Adrenal General developmental and Comparative anatomy anatomy; chromaffin tissue biochemistry and physiology of catecholamines: the sympathetico-chromaffin complex; steroidogenic tissue structure and nomenclature of steroid hormones; biochemistry and physiology of adrenal steroids; effects of adrenalectomy.
Hormonal imbalance and major endocrine diseases: Gigantism, Acromegaly, Dwarfism, Addison's disease, Cushing's syndrome, Goitre, Cryptorchidism, Hypogonadism, Amenorrhoea, Diabetes mellitus, Tetany.

S14027(C)- ENDOCRINE GLANDS II Credit(s): 4
Endocrine glands and their Hormones (Brief account)
Hormone secreting tissues –skin, liver, kidney, heart.
General classes of chemical messengers- Peptide, thyroid, steroid hormones, neurotransmitters and pheromones

Physical characteristics of hormones – latency, post-secretory modification and half-life

Synthesis and delivery of hormones- storage, secretion and transportation.

Physiological roles of hormones.

Control of hormone secretion.

General mechanisms of Hormonal action

Cell signalling

Receptors and transducers; types of receptors, regulation of receptor number, receptor activation

Second messengers of hormone action, receptor signal transduction

Eicosanoids and hormone action

The gonadal hypophyseal hypothalamus relationship.

Neurohormones :Gases as neural messengers, Endorphins- physiological roles, mechanism of action and pathophysiology, Brain hormones and behavior, Neuroendocrine pathophysiology.

Vertebrate neuroendocrinology: Ultrastructure and function of the neurosecretory cell.

hypothalamo-hypophyseal relationship, hypothalamus in relation to higher nervous centres, other neurosecretory systems in vertebrates, the urophysis, the subcommisural organ and the pineal complex.

Endocrine integrations: Diffuse effects of hormones: neoplastic growth; migration in birds and fishes: birdplumage; hibernation; osmoregulation; blood pressure regulation.

Pheromones

S14028(C): ENDOCRINE GLANDS AND REGULATORY PROCESSES     Credit(s): 4

The female reproductive system: Comparative anatomy and physiology of the mammalian and sub mammalian ovary and ductal system. Follicular growth, kinetics and atresia, ovarian hormones, two cell theory of estrogen biosynthesis. Autocrine, Paracrine and endocrine regulation of ovarian functions.

The male reproductive system: Comparative anatomy and physiology of the mammalian and sub mammalian testis and the sex accessory glands; Functional Organization of testis, spermatogeneric cycle. Testicula androgens, autocrine, paracrine and endocrine regulation of testicula functions. Semen and its, biochemical nature

Role of thyroid, pineal and adrenal glands in reproduction , Breeding seasons and reproductive cycles, Hormonal regulation of reproductive behaviour, Biology of Sex-determination and Sex differentiation, Biology of spermatozoa and ovum: structure, development and function. Fertilization -Pre-fertilization events, biochemistry of fertilization and post-fertilization events.

mechanism of action and their role in reproduction. Miscellaneous factors affecting reproduction:
nutrition, light, temperature, pheromones, environmental disruptors.

S14029(C): REPRODUCTIVE TECHNOLOGIES  Credit(s): 4
Fundamental aspects of control of fertility in males: Mechanical, Surgical, Chemical, Immunological methods.
Control of fertility in Insects. Induced spawning in Fishes
Reproductive dysfunctions in males and females.
Diagnosis of female infertility: Monitoring of ovarian and reproductive cycles. Endometrial biopsy. Ductal blockage. Endocrine diagnosis
Cryopreservation of semen, oocytes and embryos.
Cloning, transgenic animals.
Teratological effects of Xenobiotics
Pre-natal diagnosis
Impact of aging, hormone replacement therapy

Suggested Readings
• Nieschlag F. and Behre H.M. Andrology Male reproductive Health and dysfunction. Springer-Verlag, Berlin-2001
• Young, W. C. : Sex, and Internal Secretions Vols. I and II.
• Bentley, P. J. Comparative vertebrate endocrinology
• Bern, H. A. Text book of comparative endocrinology

S14030(C): Laboratory exercises Credit(s): 6

• Dissection and gross examination of various endocrine gland of representative vertebrates.
• Microscopical study of various endocrine glands of representative vertebrates through microtechnical procedure.
• Study of estrous cycle in mouse or rat by the vaginal smear technique
• Surgical procedures: castration, ovariectomy, adrenalectomy, thyroidectomy and hypophysectomy.
• Hormonal bioassays: Bioassays for estrogens, androgens and antiestrogens; Biochemical estimations of cholesterol and ascorbic acid content in adrenal tissue; glycogen content in uterine tissue; fructose content in male sex accessory glands.
• Sperm count and motility.
• Study of the sex chromatin.
• Study of microscopic slides of endocrine and related structures.
• Dissection of male and female reproductive systems.
• Histology of the genital organs in normal and pathological conditions.
• Biochemical investigations of the reproductive glands with special reference to their markers
• Induction of superovulation and collection of oocytes.
• Demonstration of in-vitro fertilization (GIFT, ZIFT, TET, ICSI, etc.)
• Pregnancy test: the Ascheim Zondek pregnancy test.

Seminar: 

Credit(s): 2
M.Sc. MICROBIOLOGY

Objectives of the course

Course objectives:

Enable the student to:

1. This course aims to impart an insight into the morphology, internal structure and reproduction of the most primitive to evolved group of algae, fungi, virus and bacteria.
2. Familiarize with the basic skills and techniques related to microbiology.
3. Understand DNA as the basis of heredity and variation in microbes.
4. Understand the role, structure and importance of the bio molecules associated with microbiology.
5. Familiarize with the various microbial diseases and measures adopted to control diseases.
6. Understand the importance of genetic engineering in human welfare.
7. Familiarize with applied aspects of microbial physiology in other fields like agriculture, environment and food industry.
8. Acquaint the student with the significance of Environmental microbiology.
9. Use of computers to handle biological data base.
10. Help the student to explore the potentialities of various underutilized microbes to project as the future food prospects.
11. Familiarize with the fundamental principles of microbiology, various developments in microbiology and potential applications.
12. Familiarize with the recent trends in the field of applied microbiology.
# M.Sc. MICROBIOLOGY

## SEMESTER – I

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<td>BACTERIOLOGY</td>
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<td>S110032</td>
<td>INSTRUMENTATION</td>
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<td>S110033</td>
<td>BIOCHEMISTRY &amp; ENZYMOMYLOGY</td>
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<td>S110034</td>
<td>VIROLOGY, MYCOLOGY AND PHYCOLOGY</td>
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<td>S110035</td>
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Total Credits 22

## SEMESTER – II

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<td>S120032</td>
<td>MOLECULAR BIOLOGY AND MICROBIAL GENETICS</td>
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<td>IMMUNOLOGY</td>
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<td>S120034</td>
<td>BIOSTATISTICS AND COMPUTER APPLICATIONS</td>
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Total Credits 22

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<td>S130032</td>
<td>GENETIC ENGINEERING</td>
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<td>S130033</td>
<td>MICROBIAL TECHNOLOGY</td>
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<td>S130034</td>
<td>APPLIED ENVIRONMENTAL MICROBIOLOGY</td>
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Total Credits 22

The students should select any one of the Elective group that is from CHY-302, 303 & 304 in semester III

## SEMESTER – IV

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<tr>
<td>S140032</td>
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Seminar 2

Total Credits 24

Total Credits of All Four Semesters 90

The students should select any one of the Elective group in semester IV. Or else, from an elective group, student could select S140015 that is a Project Work to be pursued under the Guidance of A Faculty Member.
Classification

Classification of microorganisms- introduction, Haeckel’s three kingdom concept, Whittaker’s five kingdom concept, five domain system of classification. Modern trends in classification (ribotyping, NA hybridization, RNA fingerprinting). Classification and salient features of bacteria according to Bergey’s manual of systematic bacteriology (a brief outline) Morphological types of bacteria. Nutritional classification of bacteria

Ultra structure of bacteria:


Eubacteria and Archaeabacteria


Microbial Growth

The definition of growth, growth curve, measurement of growth and growth yields, Synchronous growth, Continuous, Batch and Fed Batch Culture; Growth as affected by environmental factors like temperature, acidity, alkalinity, water availability oxygen and pH, activity of water and gaseous environment, maintenance and preservation of microorganisms
Microbial Physiology

Photosynthesis: Oxygenic photosynthetic microbes and anoxygenic photosynthetic microbes. Brief account of photosynthetic and accessory pigments—chlorophyll and bacteriochlorophylls, rhodopsin, carotenoids, phycobiliproteins; oxygenic-anoxygenic photosynthesis.

Suggested Readings


8. Benson’s Microbiological application: Laboratory Manuual in general th Mirobiology (9 edition), Brown A E, Mc Gr aw Hill, 2005

10. General Microbiology, R Y Stanier, J L Ingharam, M L Wheelies, P R Painter, Mac Millan Education Ltd, 1999

11. Laboratory Fundamentals of Microbiology, I E Alcamo, Jones and Barlett publishers, 2001


S11032: INSTRUMENTATION Credits: 04

Microscopy: construction of a microscope, Principle and applications of light microscopy (bright field, dark field, phase-contrast, interference, fluorescence, polarization microscopy). Electron microscopy- TEM, SEM, Scanned probe microscopic techniques (STEM, AFM).

Centrifugation: Principle, sedimentation analysis & RCF, ultracentrifugation: Preparative (differential and density gradient) and analytical centrifuges.

Chromatography: Principle, techniques of chromatography (Paper chromatography, TLC, Column chromatography), types of chromatography (GC, HPLC, Adsorption chromatography, Partition chromatography, Gel filtration, Ion-exchange chromatography and Affinity chromatography).

Electrophoresis: Principle, factors affecting electrophoresis, types of electrophoresis - Agarose gel electrophoresis, PAGE, SDS-PAGE, 2-D electrophoresis, Pulsed field gel electrophoresis, isoelectric focusing, immuno electrophoresis.
**Spectroscopy:** Beer-Lambert law, UV-Vis spectroscopy, fluorescence spectroscopy, IR spectroscopy, Raman spectroscopy, Atomic absorption spectroscopy, NMR, ESR, Flame emission photometry, flow cytometry. **Radioisotopic Techniques:** Principle and applications of radiation techniques (Radioisotopes; nature of radioactivity, types of radioactive decay, unit of radioactivity), detection and measurement of radioactivity (Geiger-Muller counter, Solid and liquid scintillation counter, autoradiography).

**Suggested Readings**

3. Principles and Practice of Bioanalysis, R F Venn, Taylor and Francis, 2003
5. Bioinstrumentation, J G Webster, John Wiley & Sons Inc. 2004
8. Spectroscopy for the Biological Sciences, G G Hames, John Wiley & Sons Inc. 2005
**Chemical foundations of Biology:** pH, pK, acids, bases, buffers, weak bonds, chemical bonds, Bioenergetics: Principles of thermodynamics: free energy, important energy, rich molecules, standard free energy change, concept of redox reactions. Principles of self assembly, Hierarchy of molecular organization of living systems.

**Amino acids and proteins:** Structure and chemistry of Amino acids, Classification, Chemical Reactions and Physical Properties, Proteins-purification and criteria for homogeneity, structural organization of proteins- primary, secondary, tertiary and quaternary structure. Ramachandran plot. Protein sequencing, glyco and lipo protein structure and function.

**Carbohydrates:** Classification and reactions of aldehyde and ketone group, types, structural features (ring structure, tautomeric forms, mutarotation) of carbohydrates. Metabolism of carbohydrates, glycolysis, Krebs cycle, terminal oxidation/oxidative phosphorylation, reverse TCA cycle, gluconeogenesis, mechanism of ATP synthesis.

**Lipids:** Classification, Structure and functions, Biosynthesis of saturated and unsaturated fatty acids, Metabolism of Lipid and fat bodies: Beta-oxidation and channeling of the products to ATP production: minor pathway of fatty acid oxidation, (alpha and omega oxidation), Biosynthesis of saturated and unsaturated fatty acids. Purines and pyrimidines, denovo and salvage pathways.

**Enzymes:** as biocatalyst, classification, specificity, active site, isozymes.

**Enzyme Kinetics:** Rate of reactions, specific activity, molecular activity, Km, K, Michaelis Menten & Line weaver Burk plot and Bisubstrate Reaction, enzyme inhibition, mechanism of enzyme catalysis (acid-base electrostatic, metal ion, free radicals, transition state binding and covalent, proximity and orientation effects, Contribution of strain). Factors affecting enzyme activity, enzyme inhibition.

**Suggested Readings**


S11034: VIROLOGY, MYCOLOGY AND PHYCOLOGY

Credits: 04

Brief outline on discovery of viruses, nomenclature and classification of viruses[LHT system, classification as per VII report of the international committee on taxonomy of viruses], distinctive properties of viruses; morphology & ultra structure; capsids & their arrangements; types of envelops and their composition-viral genome, their types and structure, virus related agents (viroids, virusoids, prions) cultivation of viruses in embryonated eggs, experimental animals, cell cultures; Primary & secondary cell cultures; suspension cell cultures and monolayer cell cultures, cell certains, cell lines and transgenic systems.

**Plant viruses**: Classification and nomenclature, effect of viruses on plants, external appearance of plants; histology, physiology and cytology of plants; Viruses of cyanobacteria, algae and fungi. Transmission of plant virus with vectors (insects, nematodes, fungi) and without vectors (contact, seed and pollens), Prevention of crop loss due to virus infection-virus free planting material; vector control.

**Mycology**: An Introduction to fungi-History, general features of fungi, Classification of fungi, according to Ainsworth and Alexopolus and Mims with the general aspects of Major division of fungi. Nutrition of fungi, Homothallism, Heterothallism, Heterokaryosis,and the Parasexual cycle, Sex Hormones in Fungi. Fungi as insect symbiont. Mycotoxins and Mycotoxicoses. Attack on fungi by other microbes. Economic importance of fungi.

**Suggested Readings**


5. Diagnostic procedures for viral and Rickettsial diseases.american public Health association, NY. Lennetter1984


S11035: Laboratory Exercises Credits: 6

1. Instrumentation and general lab introduction

2. To determine the acid value of the given oil sample.

3. To prepare biologically important buffers (phosphate and acetate).

4. To Separate and identify amino acids by using TLC.

5. To separate and identify carbohydrates using TLC.

6. To find out the concentration of amino-acids in the given sample using ninhydrin.

7. Qualitative analysis of carbohydrates.

8. Qualitative analysis of Amino acids.

9. Classification and Identification of various Algal members.

10. Preparation of potato dextrose Agar medium.

11. To carry out the complete coliform test to check the presence of E.coli.

12. To check Oligodynamic effect(effect of heavy metals) on the given bacterial sample.

13. To check the given bacterial culture for amylase (strach hydrolysis) activity.

14. To check the presence of coliform bacteria using LBCP broth.
To check the presence of coliform bacteria (E.coli) using EMB agar

15. (confirmatory test).

16. To study DNA profile of the given sample by using AGAROSE GEL ELECTROPHORESIS.

17. Classification and Identification of various fungal members.

18. Endospore staining.

19. Study of viral symptoms and transmission.

20. To check the given bacterial culture for its tryptophan utilizing activity.

21. To estimate the total proteins present in the given sample using lowry's method.

22. Isolation and identification of airflora.

23. Isolation and identification of fungi from sewage water.


25. To compare the Rhizospheric and Non-Rhizospheric bacteria (R.S.ratio)

26. To evaluate alcohol as disinfectant.

27. To find out the size of the given spore.

28. To estimate the carbohydrate present in the given sample using Anthrone reagent.

29. To find out the thermal death time of the given bacterial samples.

30. To find out thermal death point of the given bacterial samples.

31. To study the effect of pH on microbial growth

32. To perform simple bacterial staining.

33. To perform the capsule staining of given bacterial samples.

34. To find out the concentration of DNA in the given sample using DPA.

35. To check the given bacterial culture for its Citrate utilizing activity.

36. To check the given bacterial culture for its MRVP activity.

37. To study the effect of osmotic pressure on microbial growth.
SEMESTER II

S12031: FERMENTATION TECHNOLOGY

Fermentor: Main components and its uses, peripheral parts and accessories. Control systems and sensors. Fermentor preparation and use: disassembly and cleaning of vessel, autoclaving, inoculation of fermentor vessel, sampling from fermentor vessel and routine maintenance of a fermentor. Specialized bioreactors (pulsed, fluidized bed, airlift bioreactor).


Isolation, preservation and improvement of industrially important Microorganism. Isolation of industrially important microorganisms. Primary and secondary screening. Preservation of industrially important microorganisms. Strain improvement by genetic recombination approaches and directed screening for mutants with altered metabolism. 15hrs

Downstream processing, detection and assay of fermentation products. Removal of microbial cells and solid matter, foam separation, cell disruption, precipitation, filtration, centrifugation, liquid-liquid extraction, chromatography, membrane process, drying and crystallization. Physical, chemical and biological assays for detection of fermentation products.

Suggested Readings


4. Principles of Fermentation Technology by P.F. Stanbury, A. Whittaker & Hall


S120032: MOLECULAR BIOLOGY AND MICROBIAL GENETICS         Credits: 04


Prokaryotic & Eukaryotic transcription (Initiation, Elongation & Termination), general apparatus of transcription, RNA Polymerase, General & Specific Transcription Factors, Regulatory elements & mechanism of transcription regulation, Post transcriptional gene silencing (PTGS), Modifications in RNA.

Prokaryotic and Eukaryotic Translation, the translation machinery, Mechanism of initiation, elongation, termination, Regulation of translation, Co & post translational modification of proteins, Localization of proteins, synthesis of secretory & membrane proteins, mitochondria, chloroplast & peroxisomes.

Bacterial genetics: Molecular mapping of genome, genetic and physical mapping, map based cloning. Gene transfer mechanisms-Transformation- molecular mechanism, mapping and other uses of transformation, Transduction - generalized transduction, cotransduction and linkage, mapping by cotransduction, specialized transduction, specialized transducing phage as a cloning vehicle.

Bacteriophages, Lytic phages-T7 and T4. Lysogenic phages Lambda phage, and P1, M13 and F, Ø X174 life cycles, Phage MU and their uses in microbial genetics. Role of microbial genetics in vaccine designing. Microbial genetics and design of vaccines. BCG and design of vaccine for TB and leprosy. DNA vaccines, design and advantages.

Suggested Readings


S12033: IMMUNOLOGY  

Credits: 04


mediated immune responses, B- and T- cell maturation, activation and differentiation, Cytokines and their role in immune regulation, T-cell regulation, MHC restriction,

**Antigen-antibody interactions:** Precipitation, Immunodiffusion, Immunoelectrophoresis, Agglutination, RIA, ELISA, Immunofluorescence. Advanced concepts in Immunology: Hypersensitivity, Autoimmunity, Vaccine development and immunization programme, Transplantation, Immunity of infectious agents (intracellular parasites, helminthes and viruses), AIDS and other immunodeficiencies, Hybridoma Technology and Monoclonal antibodies.

**Transplantation and Autoimmunity:** organ specific autoimmune disease, systemic autoimmune diseases, graft rejection, evidence and mechanism of graft rejection, prevention of graft rejection, immunosuppressive drugs, HLA and disease, mechanism of immunity to tumor antigen, Autoantibodies in human pathogenic mechanism, experimental models of autoimmune disease treatment of autoimmune disorders.

**Suggested Readings**


S12034: BIOSTATISTICS AND COMPUTER APPLICATIONS  


Tests of significance: Hypothesis testing, Nulls hypothesis and alternative hypothesis, level of significance. Chi-square test, t-test, F-test, ANOVA-one way and two way classifications. Simple correlation and simple regression.


NOTE: Calculators are permitted in examination

Suggested Readings


7. Practical statistics for Experimental Biologists, A C Swardlaw, John Wiley
and sons Inc., 1985

**S12035: Laboratory Exercises-II**  

**Credits: 6**

1. Isolation of antibiotic resistant microorganisms by replica plating.

2. Isolation of antibiotic resistant microorganisms by Gradient plate technique.


4. Isolation of plasmid DNA

7. Ouchterlony double diffusion

8. ELISA

9. Demonstrations:
   a. Sandwich ELISA

10. Restriction digestion of DNA

11. Conjugation

14. Study of various symptoms produced in plants due to virus infection.

15. Study of viral diseases of plants/animals/human (Specimen/photographs)

16. Different type of viruses (Photographs/sketches).

18. Isolation and identification of fungi.

19. Study of permanent slides of algae
Normal micro flora and factors responsible for pathogenesis Classification of medically important micro organisms; Normal microbial flora of human body; role of the resident flora. Entry of pathogens into the host; colonization and mechanism of bacterial adhesion establishment, spreading, tissue damage and anti-phagocytic factors; factors predisposing to infections, types of toxins and their structure; mode of action.

Pathogenic bacteria-I:

Diagnostic features of important diseases including their pathogenicity and control. Pyogenic cocci- *Staphylococci, Streptococci, Neisseria meningitides, N. gonococcus*

Gram positive cocci- *Clostridium tetani, Mycobacteria-M. tuberculosis, M. leprae*

Pathogenic bacteria I

Fungi and Protozoan: Enteric Gram negative bacteria-

*Salmonella, Shigella, Vibrio cholera, E. coli Spirochaetes- Treponema palladium*

Chlamydiae- Trachoma, Rickettesial diseases, Diseases caused by Mycoplasma,

Pathogenic fungi- *Candida albicans* Protozoan diseases – Malaria, Amoebiasis


Chemotherapy and Antimicrobial agents Mode of action of penicillin, Sulfa drugs, streptomycin, tetracycline and other broad spectrum antibiotics. Antifungal drugs, antiviral drugs. Brief account on available vaccines
Suggested Readings


Instant Notes Medical Microbiology, Irving W, Boswell T, Ala Aldeen D, Taylor and Francis group, 2005


Medical Microbiology and Immunology: Examination and Board Review (7th edition), Warren Levinson and Ernst Jawetz, Mc Graw Hill, 2002

Medical Microbiology vol. 1 Microbial infection, vol. 2

Practical Medical microbiology, Churchill Livingstone, 1996


S13032: GENETIC ENGINEERING Credits: 04

Sequencing of genes DNA and genomic library: m-RNA enrichment, reverse transcription, Linkers, Adaptors, Screening of cDNA and genomic library, Sequencing and mapping: Sequencing vector, fluorescent tagging, Automated DNA sequencing, Pyrosequencing. Restriction mapping and map construction, Application of sequence information for identification of defective genes.

Molecular Mapping of Genome Genetic and physical mapping, Genome sequencing: genome size, organelle genome, YAC, BAC libraries, strategies of genome sequencing, Analysis of genetic variations: RAPD, RFLP, AFLP and other molecular marker techniques, application of RFLP in forensic studies, disease prognosis, genetic counselling, pedigree analysis etc.


**Suggested Readings**


Industrial production of organic feed stocks- ethanol, acetone/ butanol fermentations, organic acids- citric acid, acetic acid, amino acids- glutamic acid, lysine, vitamins- riboflavin. Microbial transformation of steroids.

Industrial application of microorganisms- Industrial uses of molds. Industrial production of antibiotics- penicillin, streptomycins, tetracyclines, polyketides and polyketide antibiotics.

Enzymes as fermentation products- amylases, proteases. Techniques of enzyme immobilization. Microbial cells as fermentation products- commercial production of bakers yeast, food and feed yeast, mushrooms and algae.

Introduction to food fermentation technology. Microorganisms responsible for spoilage.

General Principle underlying spoilage. Elementary idea of canning and packing, Sterilization and pasteurization of Food Products, Food preservation by Radiations, low and high Temperature. Chemical preservation and naturally occurring antimicrobials. Fermented foods (Soya sauce, bread, Sauerkraut, idly), fermented beverages (wine, Beer) Microbiological examination of food.

Industrial Dairy fermentations. Classification of various groups of microorganisms associated with dairy industry. Starter cultures for fermented dairy products (Streptococcus thermophilus, Lactobacillus bulgaricus), Acid fermented milks (Yoghurt, Cultured butter milk, Kefir). Cheese production. Alcoholic beverages and alternative energy sources: Commercial production of beer, wines.

Suggested Readings


3) Food Poisoning and Food Hygiene B.C.Hobbs and D. Roberts Edward Arnold (A division of Hodder and Stoughton London) 1993


S13034: APPLIED ENVIRONMENTAL MICROBIOLOGY Credits: 04


Biodegradation of natural compounds (cellulose, hemicelluloses, lignin, chitin,). Biodegradation of xenobiotics in environment – Organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, synthetic polymers, detergents and hydrocarbons Bioremediation- ex situ and in situ. Bioaccumulation, biomagnifications.

Biodeterioration and Bioleaching: Definition, biodeterioration of paper, wood, paint, textiles, leather, metals (corrosion).Control of biodeterioration. Microorganisms and metal pollutants-metal bioavailability in environment, mechanism of microbial metal resistance and
detoxification, metal–microbe interaction, Bioleaching of metals, Microbial enhanced oil recovery.

Biofertilizers: Definition and types of biofertilizers, Mass cultivation and methods of inoculation of microbial inoculants – (Rhizobium, Azotobacter, & Asospirillium.) Cyanobacteria – Azolla– Anabaena association and its role in rice cultivation Quality control and ISI specifications for Rhizobium cultures. Mycorrhizal Relationship, Biopesticides and Bioplastics

Suggested Readings

1. Environmental Biotechnology – Basic concepts and applications, Indu Shekhara Thakur, I K International publications. 2006


3. Introduction of Environmental Microbiology, Michel. R. 1999


S13035: Laboratory Exercises – III

Credits: 6

1. Enumeration of the following in blood sample

a. RBC b. WBC
2. Preparation of blood smear and determination of differential WBC count

3. Antibiotic sensitivity test by disc method

4. Determination of MIC of antibiotics

5. Use of alginate for cell immobilization

6. Isolation of Lactobacillus species from curd.

7. Isolation of rhizospheric microflora


9. Isolation of microorganisms from soil, water and air

10. Detection of coliforms for determination of the purity of potable water.

11. Determination of biological oxygen demand (BOD) of sewage sample.

12. Determination of chemical oxygen demand (COD) of sewage sample.

13. Isolation and identification of common microorganisms spoiling food (Fungi and bacteria).

14. Preparation of fermented foods (Sauerkraut).

15. Testing of milk by MBRT

16. Isolation and identification of Rhizobium from root nodules of leguminous plants.

17. Isolation and identification of Azotobacter from soil.

18. Study of ammonification by bacteria

SEMESTER IV

S14031: Review Report

Credits: 10
The review report of M.Sc. IV semester will be based on a detailed review of any one of the topics listed in syllabus in about 100 pages. This review will be evaluated by a supervisor, Head of the Department and any other person appointed by the Principal.

S14032: Dissertation  Credits: 12

The dissertation work will involve practical work on a problem suggested by the supervisor of the candidate. The student will submit the dissertation report at the end of IV semester. This dissertation report will be examined by the supervisor of the student, Head of the Department and any other person appointed by Principal.
M.Sc Life Sciences

Objective of the course

Biology was a term introduced in the nineteenth century to encompass all aspects of the scientific study of life. Since then, the biological sciences have undergone an explosive growth of knowledge making it possible to spend an entire career within the confines of a single subdiscipline. This module outline the historic development of life sciences from origin of life to the present day. It covers key milestones events such as identifying the structure of DNA and genetic engineering. This module involve making connections between subdisciplines like biotechnology and microbiology.

This course answers the questions about the, function, evolution, and interaction of organisms, both now and in the past. The syllabi goes on examining the significance of studying life sciences reflecting primary interest in specific groups (plants, animals, micro-organisms); in a particular level of organization (unicellular or multicellular) types of habitat (ecological systems, evolutionary genetics); in an approach (biomechanics, developmental biology); or even in a desire to sample broadly across many topics. Life sciences is, therefore, inherently an interdisciplinary field, ranging over different levels of biological organization, evolutionary process, biological taxa, and physiological systems.

The aim of this syllabus is to broaden and strengthen both the practical and generic skill of the student and gave them a feeling for the number of different types of careers available in lifesciences.
# M.Sc Life Sciences

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<td>S11037</td>
<td>MICROBIAL DIVERSITY AND PHYSIOLOGY</td>
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<td>S11038</td>
<td>DIVERSITY OF LIFE FORMS</td>
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<td>S11039</td>
<td>SYSTEMATICS, TAXONOMY AND BIOINFORMATICS</td>
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<td>CELL MOLECULAR BIOLOGY AND IMMUNOLOGY</td>
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<td>S12037</td>
<td>BIOCHEMISTRY OF LIVING ORGANISM</td>
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<td>ECOLOGY AND ENVIRONMENTAL BIOTECHNOLOGY</td>
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**S11036: Evolution of Life and Ethology**

**UNIT I: Evolution of life**
Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; the evolutionary synthesis. Origin of Life: Classical experiments current concepts.
Natural Selection: Darwinism, its critical review and modern theory of evolution, Lamarkism, speciation, isolation, Genetic basis of evolution, Human evolution
Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

**UNIT II Evolutionary History**
Paleontology and evolutionary history: The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants and animals; stages in primate evolution including Homo sapiens.
Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

**UNIT III Population Genetics**
Population genetics – populations, gene pool, gene frequency; Hardy-Weinberg law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; adaptive radiation and modifications; isolating mechanisms; speciation; allopatricity and sympatricity, convergent evolution; sexual selection; co-evolution.

**UNIT IV Ethology**
Brain, Behavior and Evolution: Approaches and methods in study of behavior; proximate and ultimate causation; altruism and evolution-group selection, kin selection, reciprocal altruism; neural basis of learning, memory, cognition, sleep and arousal; biological clocks; development of behavior; social communication; social dominance; use of space and territoriality; mating systems, parental investment and reproductive success; parental care; aggressive behavior; habitat selection and optimality in foraging; migration, orientation and navigation; domestication and behavioral changes.

**S11037: Microbial diversity and Physiology**

**Unit I General Bacteriology**
Introduction: History and scope of microbiology, Composition of the microbial world, Modern age of micro biology.
Microbial Taxonomy and Phylogeny: Major characteristics (classic and molecular), Numerical taxonomy, Phenetic classification, Bergey’s Manuel (mention major groups)
Bacterial cell structure and function: Plasma membrane and internal system - Cytometrix, inclusions, ribosomes, nucleoid, Bacterial cell wall Peptidoglycan - structure-Gram positive and gram negative cell wall- Mechanism of gram staining, Components external to cell wall; pili and fimbriae, capsule and slime layers, Flagella and motility.
Unit II Microbial Pathology
Viruses: General structural properties, Types: DNA viruses, RNA viruses, and enveloped viruses.
Microbial diseases: Human diseases caused by bacteria.
Human diseases caused by viruses.
Fungal diseases: Candidiasis

Unit III Applied Microbiology
Control of microorganisms: Disinfectants; physical - Heat, filtration and radiation
Chemical agents - Phenol and Phenolic compounds, alcohols, halogens and aldehydes.
Antibiotics - Penicillin's, Cephalosporins, Chloramphenicol, Tetracyclines.
Microbial drug resistance.
Microbial fermentation: Lactic fermentation-Homolactic and heterolactic fermenters, dairy products, cheese, Yogurt, kefir etc. Alcoholic fermentation-Alcoholic beverages.
Environmental microbiology: Aquatic microbes, Microbiological analysis of drinking water, Waste water- microbial characteristics and treatment, Microbial Bioremediation.

Unit IV Environmental Microbiology

S11038: DIVERSITY OF LIFE FORMS
UNIT I Diversity
Understanding diversity of prokaryotes and eukaryotes Salient features of the systems of plant, animal and microbial taxonomy from Haeckel to Whittaker to Carl Woese and beyond.
Principles and methods of taxonomy: Concepts of species and hierarchical taxa, biological nomenclature, classical and quantitative methods of taxonomy of plants, animals and microorganisms.
Levels of structural organization: Unicellular, colonial and multicellular forms; levels of organization of tissues, organs and systems; comparative anatomy.

UNIT II Classification of organism
Outline classification of plants, animals and microorganisms: Important criteria used for classification in each taxon; classification of plants, animals and microorganisms; evolutionary relationships among taxa.

UNIT III Biodiversity
Biodiversity: Species diversity, ecosystem diversity, genetic diversity and molecular Diversity.
Alpha, Beta and Gamma Diversity
Biodiversity indices. Measuring -species richness, species evenness Simpson's diversity
Index and Shannon's diversity index.

UNIT IV Biodiversity in India
Biodiversity act of India and Biodiversity hot spots in India (with special reference to Western Ghats and North east)
Natural history of Indian subcontinent: Major habitat types of the subcontinent, geographic origins and migrations of species; common Indian mammals, birds; seasonality and phenology of the subcontinent.

S11039: Systematics and Taxonomy, Bioinformatics

Unit I Biosystematics

UNIT II Taxonomic Tools I

UNIT III Taxonomic Tools II
Taxonomic tools : Herbarium, floras, histological, cytological, phytochemical, serological, biochemical and molecular techniques, computers and GIS.
Systems of angiosperm classification : Phenetic versus phylogenetic systems, cladistics in taxonomy, relative merits and demerits of major systems of classification.
Phylogeny of Angiosperms : Ancestors of Angiosperms, time and place of origin of Angiosperms, Habit of Angiosperm, Primitive living Angiosperms, Inter relationship among the major groups of Angiosperms.

UNIT IV Bioinformatics
Computer System : Concepts and type of Computers - Main, mini and Micros System.
Configuration - Primary and secondary storage devices , peripherals - Hardware and software,system software, Application software – DOS, Unix and WINDOWS – Word.
Information Sources, System and services: Primary, secondary and tertiary source. Information Dissemination, information retrieval concepts – Boolean, relational, arithmetic’s operations. Database concepts: Definition, Structure and Type of Databases, bibliographic and Nonbibliographic.
Network Concepts: Definition Network types ( LAN MAN ANI) WAN – Applications and services
Email  Remote logging, file transfer, News Groups - ERNET, SIRNET, NCNET, AND BTNET Communication softwares - On line access - Internet tools: FTP TELNET.

Suggested Practicals:
1. Description of a species based on various specimens to study intraspecific variation: a collective exercise.
2. Description of various species of a genus, location of key characters and preparation of keys at generic level.
3. Location of key characters and use of keys at family level.
4. Field trips within and around the campus, compilation of field notes and preparation of herbarium sheets of such plants, wild or cultivated, as are abundant.
5. Training in using floras and herbaria for identification of specimens described in the class.
7. Isolation of pure culture by Pour plate, Serial dilution and Streak plate method.
8. Study of Growth curve.
10. Sterilization methods.
   - Total count (haemocytometer)
   - Viable count (Plate count)
    - Simple staining
    - Gram’s staining
    - Endospore staining
    - Negative staining
13. Composition assessment of taxonomic diversity in a habitat.
    (grassland, arid land, wet land etc.)
14. Use of taxonomic keys to identify at least 6-10 orders of insects (upto order level only).
15. Visit river/pond/sea for study of zooplankton
16. Identification of animals (Fishes/insects/any other) up to family/ generic / species level - minimum specimens.
17. Preparation of dichotomous (simple bracket) keys; minimum ten sets from the identified specimens.

Suggested Readings

- Elements of Taxonomy. E. Mayer.
• David W. Mount, Bioinformatics: Sequence and Genome Analysis, Second Edition.
• Jae K. Lee Statistical Bioinformatics: A Guide for Life and Biomedical Science Researchers.
• Evolution and population genetics, Rashmi Sisodia, Paragon, International Publishers.
• Industrial Microbiology, G. Reed (editor), CBS Publishers (AVI Publishing Company)
• General Microbiology by R.Y. Stanier, John L. Ingraham and Mark L. Wheelis page,Mc Millian Press.
• Microbiology by Michael J. Pcleczar, Chan and Krieg, Mac Graw Hill.
• Brock- Biology of Microorganisms by Madigan, Martina and Parker, Prentice
SEMESTER II

S12036 : Cell, Molecular biology and Immunology

UNIT I: Cell biology
Cell as a macromolecular assembly, cellular compartmentalization and organelle architecture. Nucleosome, chromatin and chromosome structure, nucleic acid protein interactions: histones and non-histones, topoisomerases, helicases and DNA-binding proteins. Membrane – receptor interactions: G-protein coupled receptors, tyrosine kinase receptors, ser-thr kinase receptors and cytokinereceptors structural features of transmembrane receptors, hormonereceptor interaction.
Signal transduction: Two component signalling in prokaryotes, basic concepts in eukaryotic signalling role of phosphoinositides, ion channels and second messenger, representative signalling pathways and their role in metabolism (e.g. Peptide hormone), development (e.g. Steroid hormone) neuronal transmission, cell cycle control & apoptosis.

UNIT II: Molecular Biology I
Basics of gene structure, split genes, introns/exons and overlapping genes Eukaryotic genome complexity: C value paradox, Cot analysis and estimation of coding potential repetitive / satellite DNA, Gene clusters, pseudogenes, global view of genome organization (comparative genomics in prokaryotes and eukaryotes.).
Functional organization of genes in eukaryotes: promoters, operators, enhancers, control elements, Open Reading Frame (ORF), operons, terminator regions, genes for mRNA, tRNA & rRNA and their independent RNA polymerases DNA replication and its regulation, telomere replication.
DNA mutagenesis, repair and recombination (homologous, sitespecific and illegitimate), transposons and retrotransposons..
Global view of gene expression and its regulation at various levels.

UNIT III: Molecular Biology II
Transcription: Components of transcriptional machinery in prokaryotes and eukaryotes initiation elongation, termination, RNA polymerase (s) and their interaction with +ve and –ve regulators, sigma factors.
RNA processing & Post-transcriptional gene regulation: Capping, polyadenylation, splicing and splice and developmental stage-specific expression of genes, transcription factors.
Translation: apparatus and mechanism, genetic code, codon preferences, ribosome structure assembly, components of translation, initiation elongation and termination, translation fidelity, antibiotics / inhibitors of translation, regulation of translation.
UNIT IV: Immunology
Basic & cellular immunology: Types of immunity & immune response, lymphoid organism
Antigen structure and classes of antibodies, antigen and antibody reactions, complement system,
Major histocompatibility antigens (MHC) and their role in antigen presentation & cytotoxicity,
cell adhesion molecules & their role in immunity.
Hypersensitivity reactions/autoimmunity. Vaccines (types).

S12037: Biochemistry of Living Organism
Unit I Bioenergetics and Enzymes
Bioenergetics - types of chemical bonds, pH, Acid, Base, Buffer, Concept of free energy. Laws of
thermodynamics and biological system, Enthalpy, Entropy.
Enzymes - Classification- (I.U.B. system), Specificity of enzyme action, Mechanism of enzyme
action, Enzyme kinetics - Michaelis-Menten equation, Enzyme inhibition, Allosteric enzymes,
Iso-enzyme and ribozyme, conozymes and cofactors, Factors influencing enzyme action.
Vitamins - Classification, structure, occurrence and functions of fat soluble vitamins,
Classification, structure, occurrence and biological functions of water soluble vitamins
Phenolics and alkaloids: structure, biological properties and functions

Unit II Carbohydrate Structure and Metabolism
Carbohydrates- Monosaccharides- Classification with examples, Biological roles of
monosaccharides, Disaccharides - Structure and biological roles, Polysaccharides -
Hompoly saccharides – Structure and biological roles, Heteropolysaccharide - Structure and
biological roles
Carbohydrate Metabolism: Glycolysis, Fate of pyruvic acid, Citric acid cycle, Electron transport
system and oxidative phosphorylation; Redox potential, Chemiosmotic hypothesis; inhibitors of
electron transport chain, Gluconeogenesis, Glycogenesis, Glycogenolysis; regulation of glycogen
synthesis and breakdown, Pentose-phosphate pathway (HMP pathway), Regulation of
metabolism.

Unit III Proteins
Proteins - Amino acids – Classification, Peptide bond and peptides, Structure of protein -Primary
structure, Secondary structure (α-helix – parallel & antiparallel and β pleated sheet), Tertiary
structure, Quaternary structure. Brief note on protein domains, motifs, folds and Ramachandran
plot. Biological roles of proteins.

Protein Metabolism: Transamination, Deamination, Decarboxylation, fate of
ammonia (Ornithine cycle).

Amino acid metabolism: Biosynthesis and degradation of amino acids.

Unit IV Lipids
Lipids - Fatty acids – structure, nomenclature. Classification and Biological roles of lipids.
Prostaglandins – Chemical nature and functions.

Lipid Metabolism: β-oxidation of fatty acids, Biosynthesis of fatty acids, Biosynthesis of
cholesterol.
Inborn errors
S12038 : Ecology and Environmental Biotechnology

UNIT I Environment and Population Ecology
The Environment: Physical environment; biotic environment; biotic and abiotic interactions.
Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

UNIT II Community, Succession and Ecosystem.
Species interactions: Types of interactions, interspecific competition, herbivory, carnivory.
Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.
Ecosystem: Structure and function; mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine).

UNIT III Environmental Biology I
Ecosystems: energy flow in ecosystems, Ecological productivity, ecosystem modelling and systems approach to resource management and conservation.
Renewable energy and biofuels.
Environmental health: Environmental stress and adaptations (Fauna and Flora), Effect of pollutants on living systems, human disorders related to environmental pollution, biomonitoring bioindicators, bioremediation of pollution.

UNIT IV Environmental Biology II
Toxicology: Basic principles of toxicology including LD50 and ED50, management of acute intoxication, natural detoxification – biochemical and genetic mechanisms.
Solid waste: Sources, generation, classification & composition and management of solid wastes.
Hazardous Waste: Sources & Classification, physicochemical properties, Hazardous Waste Control & Treatment & Management.
Waste water: Sources, generation, classification & composition and management of waste water.

S12039 : Developmental Biology
Unit I Basic concepts and Environmental regulation of animal development.
Potency, Commitment, Specification - autonomous, conditional, Induction, Competence, Determination and differentiation, Morphogenetic gradients
Environmental regulation of normal development – types of polyphenism, Sex determination in Bonellia; primary and secondary sex determination, environmental sex determination, Environmental disruptions of normal development (Teratogenesis), Teratogenic agents - Alcohol, retinoic acid, bisphenol, heavy metals, pathogen, Environmental oestrogens. Differentiation of sex, structure, function and cellular interactions in mammalian testis and ovary, mechanism of ovulation and fertilisation, early embryonic development, implantation and placentation. Concept of totipotency, determination and induction, role of maternal genes in early embryonic development, homeotic genes, patternformation and morphogenesis
Unit II  Gametogenesis, fertilization and early development
Production of gametes, Cell surface molecules in sperm-egg recognition in animals and plants. Zygote formation, Cleavage and blastula formation, Gastrulation and formation of germ layers in animals. embryo sac development and double fertilization in plants; embryogenesis, establishment of symmetry in plants; seed formation and germination.

UNIT III: Morphogenesis and organogenesis in animals and Plants
Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans; eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis.
Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.

Unit IV : Metamorphosis, Regeneration and Aging
Metamorphosis in Amphibians and Insects and their hormonal control, Types of regeneration - Super, Hetero, Epimorphic, Morphallactic and Compensatory regeneration, Histological process during regeneration, Ageing – cellular and extra cellular aging, Causes - Wear and tear, Oxidative damage, Mitochondrial genome damage, genetically programmed aging.
Programmed cell death, aging and senescence.. Seed dormancy, germination, vegetative growth, flowering, fruiting, senescence and their regulation by phytohormones, auxins, gibberellins, cytokines, ethylene, abscissic acid, mechanisms of phytohormone action.

Suggested Practicals:
1. Isolation of plant DNA and its quantitation by a spectrophotometric method.
2. Isolation of DNA, and preparation of 'cot' curve.
3. Isolation of RNA and quantitation by a spectrophotometric method.
4. Orcein and Feulgen staining of the salivary gland chromosomes of Chironomas and Drosophila.
5. Effect of gravity, unilateral light and plant growth regulators on the growth of young seedlings.
6. Role of dark and red light/far-red light on the expansion of cotyledons and epicotylar hook opening in pea.
7. Microscopic examination of vertical sections of leaves such as Nerium and wheat to understand the internal structure of leaf tissues.
8. Study of whole roots in monocots and dicots.
9. To determine minimum size and number of quadrat required for reliable estimate of biomass in grasslands
10. To determine gross and net phytoplankton productivity by light and dark bottle method
11. To determine soil moisture content, porosity and bulk density of soils collected from varying depths at different locations.
12. To determine the Water holding capacity of soils collected from different locations.
13. To determine percent organic carbon and organic matter in the soils of cropland, grassland and forest.
14. To estimate the dissolved oxygen content in eutrophic and oligotrophic water samples by azide modification of Wrinkler's method.
15. Study of microsporogenesis and gametogenesis in sections of anthers.
17. Study of ovules in cleared preparations, study of monosporic, bisporic and tetrasporic types of embryo sac development.
18. Emasculation, bagging and hand pollination to study pollen germination, seed set and fruit development.
19. Determination of pH of different solutions.
20. Identification of unknown carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose, Dextrin & Starch) by suitable tests.
22. Quantitative estimation of glycogen, glucose and ascorbic acid, sialic acid, total proteins, total lipid, phospholipids and cholesterol.
23. Study of mitosis in onion root tip and meiosis in testes of insect or mammal.
24. Study of prepared microscope slides, including those showing various cell types, mitosis, meiosis and giant chromosomes.
25. Embryology of Frog.

Suggested Readings:

- Jain,J.L. Fundamentals of Biochemistry, S.Chand publishers New Delhi.
  - An Introduction to embryoology, Balinsky, B.I.: W.B. Saunders Comp
  - Balinsky, B. I. An introduction to Embryology.
  - Berril, N. J. Developmental biology.
SEMESTER III

S13036 : Physiology of Biological Organism
UNIT I: Animal Physiology I
Digestive system: Nature of food-stuff, Various types of digestive enzymes and their action in alimentary canal, Absorption and assimilation of food, Nervous and hormonal control of digestion.
Circulatory system: Composition and function of blood, Haematopoiesis, blood clotting, anatomy of heart structure, Myogenic heart, ECG – its principle and significance, cardiac cycle, Heartbeat, blood pressure and blood groups. 
Respiratory system: Respiratory organs (gills, trachea and lungs), respiratory pigments, Mechanism of breathing, Physiology of respiration, control of breathing.
UNIT II Animal Physiology II
Excretory system: Physiology of excretion, Functional architecture of kidney and nephron, Nitrogenous end products, formation of urine and its hormonal control, Role of kidney in osmoregulation, urine concentration.
Muscular system: Types and properties of muscles, Functional architecture of skeletal muscles, Biophysical and biochemical events during muscular activity.
Nervous system: Functional architecture of neurons, Origin and propagation of nerve impulse through axon, Action potential, synaptic transmission, Reflex arc and reflex action.
UNIT III Plant Physiology I
Water relations in plants: Properties of water and solution, determination of vapour pressure, osmotic and chemical potential plant - soil atmosphere continuum, Responses of plants to water deficit.
Respiration: Architecture of plant mitochondrial membrane, electron transfer complexes and components of plant mitochondria cyanide-resistant pathway, Photorespiration.
UNIT IV Reproduction in Plants and Animals
Endocrine system: Structure, function and regulation of endocrine organs with special reference to hypothalamus,pituitary, adrenal and thyroid glands.
Reproduction: Reproductive cycle, Reproductive processes (implantation, parturition and lactation), neuroendocrine regulators in insects and mammals, pheromones.
Seed dormancy, germination, vegetative growth, flowering, fruiting, senescence and their regulation by phytohormones.`jasmonate and salicylate, Phytochrome and photomorphogenesis: The structure and optical properties of phytochrome, cryptochrome and their role in photomorphogenesis, Phototropism, photoperiodism, gravitropism.

S13037 : Techniques in Biology
UNIT I: Physicochemical Techniques-I
Cell separation and flow cytometry.
Chromatography: Principles, methodology and applications.
Electrophoresis: Principles and types and applications.
Radioisotope methods and tracer techniques in biology: Basic principles of radioactivity, properties & handling of radioisotopes. in biology & medicine, radiation units, Geiger Muller & scintillation counters, autoradiography, radio nuclide imaging, CT scan.

UNIT II: Physicochemical Techniques-II
Blotting techniques: Southern, northern, western, south-western blotting techniques choice of membranes and blotting conditions.
Cytogenetic techniques: Banding, karyotyping, in-situ hybridization, image analysis.
Immunological methods: ELISA, immunodiffusion, immunoelectrophoresis, radioimmunoassay, immunohistochemistry Antibody production (poly/monoclonal).

UNIT III: Principles and Practice of Physicochemical Techniques-I
pH, Buffers and calorimetry: principles and theory, pH meters.
Colorimetry & Spectroscopy: Basic principles, nature of electromagnetic radiation, Beer-Lambert laws, colorimetric methods & instruments, principles of spectroscopy, types of spectra-absorbance, emission, fluorescence and action spectra, single and double beam spectrophotometers, densitometers, flame photometers, nuorimeters, circular dichorism & their applications.

UNIT IV: Principles and Practice of Physicochemical Techniques-II
Microscopy: Basic principles, instrumentation, sample preparation for optical, phase contrast, interference, polarisation, inverted, fluorescence, confocal & electron microscopes & their applications.
Microtomy: Principles & types, sample preparation & sectioning parameters.
Centrifugation: Principles & types simple & differential, ultracentrifugation preparative & analytical.
X-ray. Crystallography Nuclear Magnetic Resonance (NMR) spectra, Magnetic Resonance Imaging (MO, lasers in biology and medicine.

S13038: Biostatistics ,Genetics and Genetic Engineering

UNIT I: Statistics in Biology-I
Aim, scope, definition and elementary idea of Statistics in Biology, Compilation, classification, tabulation and diagrammatic presentation of statistical data, Frequency distribution tables.
Measures of Central tendency:Mean, Mode and Median.
Dispersion and its measures : range and its coefficient,
Variance and Standard Deviation, and Standard Error of Mean, Coefficient of Variation.
Simple measures of skewness and Kurtosis.
Probability and Probability distributions

UNIT II: Statistics in Biology II
Correlation and regression, linear and non-linear regression, multiple regression , Bivariate data, scatter diagram and interpretation, calculation and interpretation of Karl Pearson’s correlation coefficient,
Standard distributions – Binomial, Poison, Normal,
Statistical estimation and tests of significance, some commonly used tests of significance Normal test, student’s ‘t’ test.Chi-square test for independent attributes
Testing of hypothesis: Hypothesis and its types, errors and its types, levels of significance.

UNIT III: Genetics
Mendelian laws and inheritance and Gene interactions.
Allelism: simple and multiple alleles
Chromosomes: Structure and organization, Centromeres and telomeres.
Mutations : Chromosomal and gene mutations, crossing over and linkage gene mapping in eukaryotes.
Concept of, bacterial genetics: Restriction–modification system, Transformation, Conjugation and Transduction,
Sex-determination and sex-linked inheritance, Extra-chromosomal inheritance.

**UNIT IV: Genetic Engineering**
Core techniques and essential enzymes used in r-DNA technology, Restriction digestion, ligation and transformation. Cloning vectors- Plasmids, phages and cosmids. Cloning strategies –
Cloning and selection of individual genes, gene libraries – cDNA and genomic libraries.
Genetic engineering: method and applications,
Monoclonal antibody and hybridoma technology

**S13039: Pathology of Biological organism**

**Unit I Host parasite Interaction**
Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.

**Unit II Classification of Parasites.**
Classification of Parasites: Diversity of parasites causing human and plant diseases; Biology of protozoan parasites, *Entamoeba histolytica* and other amitochondriates; Kinetoplastids includes *Leishmania* and *Trypanosomes*; *Apicomplexans* e.g *Plasmodium, Toxoplasma gondii*, Entrie protozoan parasites.
Diagnostics; Biology of selected protozoan, helminthes and nematode Parasites

**Unit III: Disease Management**
Pathogen attack and defense mechanisms : Physical, physiological, biochemical and molecular aspects.
Plant disease management : Chemical, biological, IPM systems, development of transgenics biopesticides, plant disease clinics.
Information technology in plant pathology: Preliminary account of application of information technology in plant pathology.

**UNIT IV Plant Pathology**
Symptomology, identification and control of some plant diseases :
Fungal diseases : Wheat - Rust, Smut, Bunt
Pearl millet - Green ear, ergot and smut
Crucifers – rust
Paddy-Paddy blast
Cotton - Wilt
Grapes - Downy mildew and powdery mildew
Bacterial diseases : Wheat (Tundu), Citrus canker.
Viral diseases : Tobacco mosaic, Bhindi yellow mosaic.
Phytoplasma disease : Little leaf of brinjal
**Suggested laboratory Exercises**

1. Exercises and Plant diseases as per theory syllabus
2. Field visits to show diseases in crop plants.
3. Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum of chlorophylls and carotenoids.
4. To determine the chlorophyll a/chlorophyll b ratio in C3 and C4 plants.
5. Extraction of seed proteins depending upon the solubility.
6. Preparation of frequency tables, bar diagrams, histograms, frequency curves, ogives and pie diagrams.
7. Calculation of standard deviation and coefficient of variation.
8. Estimation of significance between samples using Student’s t-test, F-test and Chi-square test.
10. Analysis of variance (One-way & Two-way classification).
11. pH meter and measurement of pH.
13. Thin layer chromatography of amino acids and sugars.
15. Determination of RBC, WBC, MCV, MCH, MCHC of the given sample of blood.
16. Demonstration of the blood clotting time, erythrocyte sedimentation rate, haemolysis and crenation.
17. Determination of the glucose in serum/plasma.
18. Determination of SGPT and SGOT.
19. Identification of male and female, wild and mutant forms of Drosophila.
20. Simple problems based on mendalism.

**Suggested Readings**

- General and Comparative Animal Physiology, Hoar, W.S. Prentice Hall of Indian.
- Animal Physiology: adaptation and Environment, Schiemdt Neilsen. Cambridge
- Text Book of Endocrinology, R.H. Williams, W.B. Saunders.
- Biology of Plants, American Society of Plant Physiologists, Maryland, USA.
- Principles and Practice of Bioanalysis, R F Venn, Taylor and Francis, 2003
- Bioinstrumentation, J G Webster, John Wiley & Sons Inc. 2004
- Mehrotra, R.S. Plant Pathology, Tata McGraw Hill.
SEMESTER IV

S14036 : Cell and Tissue culture

Unit I  Tissue culture technique and Application
Reflections on aseptic culture Embryogenesis, organogenesis and plant regeneration.
Clonal multiplication: meristem, shoot-tip maintenance and manipulation of development in embryogenic suspension cultures
\textit{In vitro} pollination and fertilization, Embryo culture, Endosperm culture, Triploid production, Haploid production- androgenic, gynogenic, uses of haploids
Protoplast isolation and culture, Somatic hybridization: fusogens, mechanisms of protoplast fusion, Selection of somatic hybrids, cytoplasmic hybridization (cybridization), genetic and breeding applications Manipulation with cells and protoplast in culture: Somaclonal variation, induction and selection of mutants.

Unit II  Transgenesis in Plants and Environmental Biotechnology
Genetic transformation of plants, direct DNA uptake, liposome-mediated DNA delivery, Ti-plasmids, particle gun-mediated transformation, Production of Secondary plant products, Cryopreservation disease- and herbicide-resistant mutants, stress-tolerant mutants.
Environmental biotechnology : Pollution control – cleaner technologies, toxic site reclamation, removal of oil spill, reducing of pesticides and fertilizers, biosensors, biomonitoring, pest control, metal and petroleum recovery.

Unit III  Animal Cell culture
Introduction : Definition, branches, scope and importance of biotechnology;
Animal cell and tissue culture : Culture media – natural and artificial. Culture methods – primary explantation techniques, various methods of cell and tissue culture, Tissue and organ culture.
Equipments required for setting the animal cell laboratory;
Transfection methods and transgenic animals : Definition, Methods - Electroporation, DNA micro injection, Calcium phosphate, precipitation, Dextran mediated transfer, shot gun method, virus mediated, lipofection method, engineered embryonic stem cell method, Transgenic animals for human welfare.

Unit IV PCR and Molecular Markers
Polymerase Chain Reaction : Basic PCR – raw materials and steps involved. Inverse PCR, Anchored PCR, Asymmetric PCR, PCR for mutagenesis and Real Time PCR, Applications of PCR in Biotechnology and genetic engineering.
Molecular markers (brief notes)- RFLP, AFLP, RAPD, Minisatellites (VNTR), Microsatellites (SSR), SNPs.
Cloning: Cloning procedures (adult DNA cloning, Therapeutic cloning, Embryo cloning) – Advantages and disadvantages of cloning.
Animal and human health care : Vaccines, Disease diagnosis, Gene therapy, Transplantation of bone marrow, artificial skin, artificial blood, Antenatal diagnosis, DNA finger printing, Forensic medicine. elementary idea of Human Genome Project.
S14037 : ECONOMIC BIOLOGY

UNIT I Economic Zoology I
Economic importance of Protozoa and Helminthes.
Economic importance of Arthropods: Beneficial and Harmful mites and ticks, crustaceans, spiders, insects. Life cycles of Lac insect, Honey bee, Silk worm and industries related to them. Some important parasites and pests Important insect pest and their management.

UNIT II Economic Zoology II
Edible Freshwater and Marine Fishes of India. Pisciculture and products of fishing industry, Prawn fisheries. Economic importance of mollusca: Pearl culture. Pearl industry in India.
Poultry, Dairy farming and Piggery. Leather industry, wool industry, Fur Industry. Pharmaceuticals from animals (Snake venom).

UNIT III Economic Botany I
Origin, evolution, botany, cultivation and uses of (i) Food, forage and fodder crops, (ii) fibre crops, (iii) medicinal and aromatic plants and (iv) vegetable oil-yielding crops.

UNIT IV Economic Botany II
Strategies for conservation: Principles and practices, botanical gardens. field gene banks, Seed banks, in vitro repositories, cryobanks, general account of the activities of Botanical Survey of India (BSI), National Bureau of plant Genetic Resource (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), and the Department of Biotechnology (DBT) for conservation, non formal conservation efforts.

Suggested Practicals:

1. Protozoa- Selected species of economic importance
2. Platehelminthes- Selected species of economic importance
3. Arthropoda- Mites, Ticks, Spiders, Insects
4. Life cycle of silk worm, honey bee, mosquitos, and other economic important species.
5. Permanent preparations- Whole mounts, various mouth parts/Appendages
6. Visit to fish industry/Poultry farm/ Dairy/ Leather industry etc
7. Laboratory Work
   1. Food crops: Wheat, rice, maize, chickpea (Bengal gram), potato, tapioca, sweet potato, sugarcane. Morphology
   2. Forage/fodder crops: Study of any five important crops of the locality (for example fodder sorghum, bajra, berseem,)
      (b) Cordage fibres: coir (c) Fibres for stuffing: silk cotton or kapok
      Morphology, anatomy, (microscopic) study of whole fibres.
   4. Medicinal and aromatic plants
Papaver somniferum, Atropa belladonna, Catharanthus roseus, Adhatoda cylanica (syn A. vasica) Allium sativum, Rauwolffia serpentina, Withania somnifera, Phyllanthis amarus, (P. fratermus), Andrographis paniculata, Aloe barbadens, Mentha arvensis, Rosa sp.
5. Vegetable oils : Mustard, groundnut, soybean, coconut, sunflower, castor, Morphology, tests for oil and iodine number.

Suggested Readings:

- Culture of Animal Cells, (3rd Edn) R Ian Fredhney. Wiley-Liss
  - Cell Growth and Division: A Practical Approach Ed. R. Basega, IRL Press
  - Animal Cell Culture Techniques Ed Martin Clynes, Springer

S14038 ELECTIVE PAPER

Elective Paper: The students of M.Sc. life sciences should prepare a detailed report on an
elective paper based on the topic mentioned in the curriculum.

**S14039 DISSERTATION/PROJECT TRAINING**

**Project:** The students of M.Sc. life sciences should carry out a dissertation work for at least 12 weeks in a National Lab/Private industry/reputed lab/institute. Dissertation will be based upon research and actual bench work. It will begin from the end of III semester and will continue through the IV semester. Dissertation report will be submitted and evaluated at the end of IV semester and students should defend their work in front of a selected committee in their last semester.

**S14040 Practical**
M.Sc STATISTICS

Course Objective:
This course is designed to provide the science student an intense foundational introduction to the fundamental concepts in Statistics. The course continues the introduction to the student started in Statistics to many branches of Sciences and concentrates on pertinent and concrete examples and applications. After completing the course the student should be able to work basic problem and word problems in probability, and statistics.

It is imperative to know the importance and scope of the discipline, to inculcate interest in statistics to impart knowledge of science as the basic objective of Education, to develop a scientific attitude to make students open minded, to develop an ability to work on their own and to make them fit for the society, to expose themselves to the diversity amongst life forms, to develop skill in practical analysis along with collection and interpretation of statistical materials and data, to develop an ability for the application of the acquired knowledge in the fields of statistics so as to make our country self reliant and self sufficient and to make them able to appreciate and apply ethical principles to statistical research and studies.

The science/mathematics/engineering/business student should have mastered and demonstrated the following quantitative skills after completing Statistics:

• the student is able to reason and recognise patterns and be able to make conjectures
• the student is able to create, read, and interpret graphs, charts, histograms, and diagrams
• the student is able to perform operations on matrices and apply them
• the student is able to perform set-theoretic operations and understand their applicability to surveys
• the student is able to collect, organise, and represent data, and be able to recognise and describe relationships
• the student is able to understand and use the basic measure of central tendency
• the student is able to understand and use the language of probability
• the student is able to compute the probabilities of composite events using the basic rules of probability
• the student is able to understand the significance of statistics and probability in the real world
• the student is able to understand the significance of the connection between logic and sets and their applicability to the real world
• the student is able to understand the significance of the connection between linear algebra and probability and their applicability to the real world
• the student is able to understand the significance of the connection between statistics and probability and their applicability to the real world
• the student is able to understand the concept of approximation, quantities, estimation, error, precision, and accuracy in interpreting the results of such measurements
### Semester - I

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<td>S11042</td>
<td>Probability Theory</td>
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<td>Measure Theory</td>
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<td>S11044</td>
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Total credit = 22

### Semester - II

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<td>Sampling Distributions and Bivariate Distributions</td>
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<tr>
<td>S12042</td>
<td>Statistical Inference-I</td>
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<tr>
<td>S12043</td>
<td>Design of Experiments-I</td>
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<td>S12044</td>
<td>Sample Surveys-I</td>
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<tr>
<td>S12045</td>
<td>Practical II</td>
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Total credit = 22

### Semester - III

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<td>Multivariate Analysis</td>
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<td>S13042</td>
<td>Statistical Inference-II</td>
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S13043: Design of Experiments-II  4
S13044: Sample Surveys-II  4
S13045: Practical III  6

Total credit =22

Semester - IV

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<td>Stochastic Process and Demography</td>
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<tr>
<td>S14042</td>
<td>Statistical Quality Control and Operations Research</td>
<td>4</td>
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<td>S14043</td>
<td>Economic Statistics and Econometrics</td>
<td>4</td>
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<td>S14044</td>
<td>Operation Research-II</td>
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<td>S14045</td>
<td>Practical IV</td>
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<td>Seminar</td>
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Total credit =24

S11041: STATISTICAL MATHEMATICS  Credit 4


**Suggested Readings:**


**S11042: PROBABILITY THEORY**

Credit 4


**Suggested Readings:**


**S110413: MEASURE THEORY**

**Credit 4**

Classes of sets: semi ring, ring, field, sigma field, monotone classes. Sequence of sets, limit supremum and limit infimum of a sequence of sets. Additive set functions, measure, outer measure and their properties. Cartheodry extension theorem (statement only) definition of complete measure. Lebesgue and Lebsegue Stieltjes measure (one dimension only) Probability measure, distribution function and its correspondence with Lebesgue Stieltjes. Measurable sets and measurable space. Simple, elementary and measurable functions. Sequence of measurable functions. Integrability of measurable function, properties of integrals. Lebesgue monotone convergence theorems, Fataous lemma, dominance convergence theorem, Absolute continuity, Random Nikodym theorem (statement only) and applications, product measure (idea only), Fubinies theorem.

**Suggested Readings :**

   Press.

**S11044: PROBABILITY DISTRIBUTIONS**

**Credit 4**

Measures of location and dispersion, moments, Sheppard’s correction, moment and cumulant generating functions, probability generating function. Bernoulli, binomial (compound and
truncated also), poisson (compound and truncated also), negative binomial, geometric, hyper-
geometric and multinomial distributions. Rectangular, normal (truncated also), exponential, 
lognormal and triangular distributions. Gamma, beta, Cauchy (truncated also), Laplace 
distributions, Pearson’s distribution (Type I, IV and VI).

Suggested Readings:


Muffin.


McGraw Hill.


Wiley Eastern.


S11045 PRACTICAL – I

credit-6

Additive and multiplicative laws of probability. Conditional probability. Baye’s theorem and its 
applications. Lagrange’s method of undetermined multipliers. Interpolation formulae due to 
Lagrange’s, Newton-Gregory, Newton’s divided Difference, Inverse and rank of a matrix, 
solution of linear equations, orthogonal matrix, Mathematical expectation, Moments, conditional 
expectation, moment generating functions, Zero one law of Borel and Kalmogorov, Measures of 
location and dispersion, moments, Sheppard’s correction, Bernoulli, binomial (compound and 
truncated also), poisson (compound and truncated also), negative binomial, geometric, hyper-
geometric and multinomial distributions. Rectangular, normal (truncated also), exponential, 
lognormal and triangular distributions.

S12041 Sampling Distributions and Bivariate Distributions

credit 4

Sampling Distributions: Basic concepts, standard error, Chi-Square, t and F distributions (central 
and non-central) and their applications. Standard errors of functions of moments.

**Suggested Readings:**


S12042 Statistical Inference-I credit 4


Methods of Estimation: Maximum likelihood method, moments, minimum Chi-square and modified minimum Chi-square methods. Properties of maximum likelihood estimator (without proof). Confidence intervals: Determination of confidence intervals based on large samples, confidence intervals based on small samples. Statistical Hypothesis: Simple and composite, critical region, types of errors, level of significance ,power of a test., most powerful test and Neyman-Pearson lemma.

**Sequential Analysis:** Definition and construction of S.P.R.T. Fundamental relation amongga ,b ,A and B. Wald’s inequality. Determination of A and B in practice. Average sample number and operating characteristic curve.

**Non-Parametric Tests:** Sign tests, signed rank test, Kolmogorov-Smirnov one sample test. General two sample problems: Wolfowitz runs test, Kolmogorov Smirnov two sample test (for sample of equal size), Median test, Wilcoxon-Mann-Whitney test. Test of randomness using run test based on the total number of runs and the length of a run.

**Suggested Readings:**


**S12043 Design of Experiments-I** 

credit 4


**Suggested Readings:**


**S12044 Sample Surveys-I** 

credit 4

Planning, execution and analyses of small large and sample surveys with illustrative examples. Errors in survey, sources of non-sampling errors. Determination of sample size. Role of NSSO, CSO. Basic finite population sampling techniques: Simple random sampling with and without replacement. Stratified sampling. Sample allocation problems in stratified sampling and related results on estimator of mean/total. Systematic sampling, cluster sampling, two-stage sampling with equal and unequal number of second stage units. Use of Auxiliary Information: Ratio, product and regression methods of estimation, their comparisons among them and with sampling without replacement. Concept of double sampling and its use in ratio, product and regression method of estimation.

**Suggested Readings:**

S12045  **Practical II**  
**credit 6**
Correlation and regression coefficients for Bivariate frequency distributions. Large sample tests.(i) For population mean (ii) equality of two population means.(iii) For population variance (iv) equality of two population variances. Small sample tests viz. t, F, x² and Z tests. Bartlett’s test for homogeneity of variances. Test of significance of sample correlation coefficient. Sign, median and run tests for small and large samples. Sequential probability ratio test and calculation of constants and graphical representation for testing simple null against simple alternative for (i) Binomial (ii) Poisson (iii) Normal (iv) Exponential distributions.

One-way classified data, Two way classification with single and equal observations, Two way classification with unequal observations, Analysis of CRD, Analysis of RBD, Analysis of LSD, Analysis of BIBD, Analysis of RBD, LSD with missing observations, Yates method for analys₂n factorial experiments - n=3,₂n factorial experiments – n = 4, Total confounding in 2n, n = 3, 4, Partial confounding in 2n, n = 3, 4m , 3₂ factorial experiments, Analysis of a confounded factorial experiment, Analysis of covariance in one way classified data, Analysis of covariance in two way classified data

Drawing of random samples from finite populations, Drawing of random samples from Binomial and Normal populations, Estimation of population mean and estimation of variance in SRS with and without replacement, Estimation of mean and variance in stratified sampling under proportional and optimum allocations, Gain in precision due to stratification, Estimation of mean and variance in systematic sampling and comparison with S.R.S., Estimation of mean and variance in cluster sampling and comparison with S.R.S., Estimation of mean and variance by (i) ratio and (ii) regression methods of estimation.

S13041  **Multivariate Analysis**  
**credit 4**


**Suggested Readings :**


**S13042 Statistical Inference-II**

*credit 4*


*Suggested Readings:*


**S13043 Design of Experiments-II**

*credit 4*


*Suggested Readings:*)

**S13044 Sample Surveys-II**

Rational behind the use of unequal probability sampling: Probability proportional to size with and without replacement method (including cumulative total method and Lahri’s method), related estimators of finite population mean (Hansen-Hourwitz, Desraj’s estimators for general sample size & Murthy’s estimator for a sample of size of 2). Horvitz Thompson estimator (HTE) of a finite population total/mean and expression for variance of HTE and its unbiased estimator due to Horvitz-Thompson and Yates & Grundy.

P.P.S. Schemes of sampling due to Midzuno-Sen, Brewer, Durbin and JNKRao (sample size of 2 only), Rao-Hartley and Cochran sampling scheme and their estimation procedure. Theory of multi-stage sampling with varying probabilities (with or without replacement) due to Durbin.

Narain and Sukhatme sampling schemes.

Quenouille’s technique of bias reduction and its application to ratio type estimator, Hartley and Ross unbiased ratio type estimator. Ratio method of estimator under Midzuno scheme of sampling when X is known. Multivariate extension of ratio and regression method of estimator (when population mean of auxiliary variable is known). Non Sampling Errors: Hansen-Hurwitz approach of estimations from incomplete sample. Politz and Simmon’s techniques of estimation, randomized response model due to Warner. Simmon’s unrelated question randomized response model.

**Suggested Readings:**

Testing of Hypotheses regarding equality of some treatment effects in one and two way classifications, Analysis of Incomplete block designs without specific from of C matrix, Group divisible designs, Linked Block designs, Simple lattice designs with 2 or more replications, Youden square Designs, estimation of total and its variance, Horvitz and Thompson's procedure of estimating mean (total) and variance of the population, Yates and Grundy estimator of variance, Midzuno's sampling schemes, Rao-Hartley-Cocharan schemes, Two-stage sampling method, where f.s.u. being selected with pps with replacement and s.s.u., with equal prob. without replacement. Estimation of optimum number of s.u. and s.s.u.

**S14041 Stochastic Process and Demography**  
Credit 4


**Suggested Readings:**


**S14042 Statistical Quality Control and Operations Research**  
Credit 4

Inspection Plans for Variables: One sided specification standard (Known and Unknown Cases), two sided specifications (for known standards).

Operation Research: Definition, scope, phases, principles, models. Linear Programming Problems, Duality Problems. Transportation and Assignment Problems. Replacement Models for items that fail or deteriorate. Monte-Carlo Simulation Technique and its Applications. Inventory Control System: Inventory models, costs, advantages, EOQ models without shortages, reorder level and optimum buffer stock, EOQ models with shortages. ABC analysis. Queuing System: Characteristics of queuing system, Poisson process, pure birth and pure death process. Steady state solution of (M/M/1) and (M/M/C) models. (M/G/1) model–Pollaczek Khintchine formula.

Suggested Readings:


S14043 Economic Statistics and Econometrics

Credit 4


Suggested Readings:


S14044  Operation Research-II  

credit 4


Suggested Readings:


S14045  Practical IV  

credit 6

Limit theorems for Markov Chain, stationary distribution, random walk, gambler’s ruin’s problem. construction of control charts for variables and attributes and their OC Curve. Modified control limits, Acceptance Sampling Plans by Attribute: AQL, AOQL, Producer's Risk and Consumer Risk. Rectification and their O.C. function, ASN and ATI. Single and double