



திருவள்ளூர் பல்கலைக்கழகம்  
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## **Common Admission Test for M.Phil/Ph.D.**

### **BIOTECHNOLOGY**

### **Syllabus**

#### **UNIT 1:**

**BIOCHEMISTRY:**Units of measurements of solutes in solution. Biomolecules: Definitions, nomenclature, classification, structure, chemistry and properties of carbohydrates, amino acids, proteins, lipids and Nucleic acids. Metabolism: Metabolism of Carbohydrates - EMP, TCA, HMP. Amino Acids, Lipids and Nucleic Acids-Their Biosynthesis. Mechanism of Oxidative Phosphorylation and its Inhibitors, Photophosphorylation. Enzymology: Enzyme – classification and structure, allosteric mechanism, regulatory and active sites, activation energy, isoenzymes, enzyme kinetics (MM, LB plot, Km) and hormones. Clinical biochemistry: Blood sugar level-factors controlling blood sugar level – hypo, hyper glycemia, diabetes mellitus & its types. GTT, Metabolism of bilirubin, jaundice types & differential diagnosis and liver function tests. Renal functional test and gastric function test.

**CELL AND MOLECULAR BIOLOGY:**Structure and function of cells in prokaryotes and eukaryotes, Structure and organization of Membrane - Membrane Model, active and passive, transport channels and pumps, Structure & Biogenesis of Mitochondria and Chloroplast. Structure of Endoplasmic reticulum, Golgi complex, lysosomes. Cell division: Mitosis, Meiosis, regulation of cell cycle; factors regulating cell cycle. Nucleic acid structure, Genome Organization. DNA replication: Enzymes and mechanisms of DNA replication in prokaryotes and eukaryotes, Telomeres, telomerase and end replication. Role of telomerase in aging and cancer. DNA replication models, DNA damage, Mutations, DNA repair and recombination. Transcription: Basic mechanism in prokaryotes and eukaryotes. RNA polymerase, Reverse transcriptase and regulation. Post-transcriptional processing: 5'-Cap formation; 3'-end processing and polyadenylation. Splicing: RNA editing. Nuclear export of mRNA. mRNA stability.

Translation: Prokaryotic and eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation, co- and post-translational modifications of proteins and localization. Gene regulation: Prokaryotic gene regulation-Operon concept; Lac operon and tryptophan operon. Eukaryotic gene regulation: Chromatin Structure, Regulation at transcriptional Level: DNA binding domains of the regulatory proteins. Biochemistry and applications of ribozyme technologies. Transposable genetic elements. CRISPR CAS gene editing. Epigenetics: Epigenetic regulation of gene expression, Modifications, Cancer Epigenetics. Cancer Biology: Viral and cellular oncogenes; Tumor suppressor genes - Structure, function and mechanism of action of pRB and p53, p21, BRACA1. Oncogenes as transcriptional activators.

**IMMUNOLOGY:** Historic perspective, Overview and Concepts, Humoral and cellular-Mediated Immunoresponses. Components of immunity, Innate and Adaptive immunity, Cells and Tissues of the immune system: Cells involved in the Immune response: Macrophages, B and T lymphocytes, Dendritic cells, Natural killer and Lymphokine activated killer cells, Eosinophils, Neutrophils and Mast cells. The lymphoid organs: Bone marrow, Spleen, lymph nodes, MALT. Hematopoiesis and differentiation, lymphocyte trafficking. Antigens and Immunogenicity. Nature of Antigens and antibodies. Theories of Antibody formation. Antibody structure, structural basis of Antibody diversity; Immunoglobulin as Antigen, Properties of immunoglobulin and subtypes. Antigen - Antibody Reaction, Strength of Antigen and Antibody reaction, Cross reactivity, Precipitation and Agglutination reactions, Radioimmunoassay and ELISA. B-cell generation, activation and differentiation. Antibody production, Regulation and Diversity. Cytokines: structure & function of Cytokines. Complement and its role in Immune Responses. Complement fixation. Structure and function of MHC class I and II molecules - antigen recognition and presentation, HLA typing, Cellular Immunity, Immune tolerance and suppression, Hypersensitivity Reactions, Types of Hypersensitivity, Autoimmunity. Hybridoma secreting monoclonal antibodies-Recombinant antibody molecules. Catalytic Antibodies. Vaccine technology including DNA vaccines. Immunological techniques for identification of infectious diseases: immune-electrophoresis, western blot, flowcytometry and immune-fluorescence microscopy including in situ localization techniques such as FISH and GISH.

## UNIT 2:

**GENETIC ENGINEERING:** Tools of Genetic Engineering: Enzymes - endo&exo nucleases, Restriction endonucleases types, nomenclature, recognition sequences and mechanism of action; Isochizomers, Isocaudomers - star activity, Methylation and modification. Ligases – types (NAD and ATP dependent), mechanism of action. Role of Kinases, phosphatases, polynucleotide phosphorylase, polynucleotide kinases, terminal transferase, Alkaline phosphatase, Reverse transcriptase - Taq polymerase. Cloning vectors: General characteristics of vectors, naturally occurring plasmids. Promoter, MCS, Ori, and Marker genes-lac Z. Construction of pBR 322, pBR325, pBR327, pUC8 , pUC 18 & 19 vectors and Expression vectors, Bacteriophage vectors, Lambda phage, Insertion vectors, Replacement vectors, Cosmids, Phagemids, Mini chromosomes, BAC's, YAC's, Shuttle vectors, Ti plasmids, Vectors for animals-SV40 and Bovine papilloma virus. Gene cloning strategies and transformation techniques: Chimeric DNA, Cloning strategies ligation, Transformation and selection, use of adaptors and linkers, Homopolymer tailing in cDNA cloning, genomic DNA libraries, Short gun method, Partial digestion, End modification, Cloning from mRNA- Isolation and purification of RNA, Synthesis of cDNA, Isolation of plasmids, Cloning cDNA in plasmid vectors, Cloning cDNA in bacteriophage vectors. cDNA library. Advanced cloning strategies-synthesis and Cloning of cDNA, PCR amplified DNA. Transformation techniques: Preparation of competent cells, Physical methods - Electroporation, Microinjection, Gene gun, chemical methods - PEG, DEAE, CaCl<sub>2</sub>, calcium phosphate precipitation method, liposome mediated method Selection, screening and analysis of recombinants: Genetic selection - Insertional inactivation, Antibiotic Resistant genes, lac Z genes, Blue white screening,  $\alpha$  - Complementation, colony hybridization, Immunological screening, Plaque hybridization, Blotting techniques, DNA sequencing - chemical and enzymatic methods, PCR and its variants, Preparation of radiolabeled and non - radiolabeled probes and its applications. Applications of rDNA technology: Production of vaccines – Hepatitis B, Edible Vaccine, Hormones – Somatotropin, Humulin, Blood clotting factor VIII, Interferons, Diagnostics of inherited disorders and infectious diseases, Gene therapy, ADA- Cystic fibrosis.

**GENETICS:** History of Genetics: Definition and scope of Genetics- Pre-mendelian genetic concepts. Basis of Mendelian Inheritance and Mendelian genetics. Simple Problems Relating to

Inheritance. Structure of gene- Why genetic code is Degenerate, Non ambiguous, non-overlapping triplet code? Interaction of Gene-Commentary factors, Supplementary factors, Inhibitory and lethal Factors-Atavism. Chromosome theory of linkage, crossing over, recombinations and mapping of genes on chromosomes. Blood Groups and their Inheritance in Human – Linkage and Crossing Over: *Drosophila* – Morgans' Experiments – Complete and Incomplete Linkage, Linkage Groups, Crossing Over types, Mechanisms – Cytological Evidence for Crossing Over, Mapping of Chromosomes – Interference and Coincidence. Sex Linkage in *Drosophila* and Man, Sex influenced and Sex-limited Genes – Non-Disjunction and Gynandromorphs – Cytoplasmic Inheritance – Maternal Effect on *Limnaea* (Shell Coiling), Male Sterility (Rode's Experiment). CO<sub>2</sub> sensitivity in *Drosophila*, Kappa particles in *Paramecium*, Milk factor Mice. Nature and Function of Genetic Material – Genetic code – Why the genetic code is comma less, non-ambiguous, degenerate triplet code. Fine Structure of the Gene – Cistron, Recon, Muton – Gene Regulation – Operon Concept – Lac Operon – Positive and Negative Regulation. Mutation – Molecular Basis of Mutation, Types of Mutation, Mutagens, Mutable and Mutator Genes. Chromosomal Aberrations – Numerical and Structural Examples from Human. Genetic engineering – Objectives, tools, gene cloning, and gene isolation. Transgenic plants and animals, Animal Breeding – Heterosis, Inbreeding, Out Breeding, Out Crossing, Hybrid Vigour. Population Genetics- Hardy Weinberg Law – Gene Frequency, Factors Affecting Gene Frequency, Eugenics, Euphenics and Ethenics, Bioethics.

**MICROBIOLOGY:** History of Microbiology - Classification of microorganism – Kingdom - Protista, Prokaryotic and eukaryotic microorganisms, Five kingdom concept of classification, Archae bacteria, Eubacteria and eukaryotes. Microscope - Light field, Dark field, Fluorescent and Electron microscope, Prokaryotic and Eukaryotic cell structure. Staining techniques - Simple and Differential staining. Nutritional classification of bacteria, Isolation, cultivation, enumeration and preservation of microbes; Culture media and its types - Pure culture technique - Growth curve; Axenic culture, Synchronous culture, Continuous culture; Effect of physical and chemical factors on microbial growth. Sterilization and Disinfection: Moist heat, Dry heat, Radiation, Filtration, Phenols, Halogens, Phenol coefficient method. Antibiotics - Inhibitors of Nucleic acid, protein and cell wall synthesis. Chemotherapeutic agents - Anti microbial susceptibility test. Microbial diversity- methods to assess microbial diversity, Culture dependent and culture independent methods. Molecular analysis of bacterial community; Denaturing Gradient Gel

Electrophoresis (DGGE), Terminal Restriction Fragment Length (TRFL) Polymorphism (TRFLP), Amplified Ribosomal DNA and Restriction Analysis (ARDRA). Microbial community in natural habitats – air, water, soil, food and milk. Food and milk borne diseases, Extremophiles-habitant & Classification, Halophiles, Thermophiles, Alkaliphiles, Acidophiles, Biotechnological applications of Extremophiles.

### **UNIT 3:**

**PLANT BIOTECHNOLOGY:** Genome organization in Plants: Nucleus, Chloroplast and Mitochondria, Molecular Marker-aided Breeding: RFLP maps, linkage analysis, RAPD markers, STS, Microsatellites, SCAR, SSCP AFLP, QTL, map-based cloning, molecular marker assisted selection. Plant Cell and Tissue Culture: Tissue culture media (composition and preparation), Callus and suspension culture, Somaclonal variation, Micropropagation, Organogenesis, Somatic embryogenesis, transfer and establishment of whole plants in soil, greenhouse technology. Embryo culture and embryo rescue. Artificial seeds. Protoplast fusion and somatic hybridization, cybrids, anther, pollen and ovary culture for production of haploid plants. Cryopreservation and DNA banking for germplasm conservation. Concepts in Plant Genetic Engineering: Plant vectors: Co-integrate, binary vectors and viral vectors, 35S and other promoters, Terminators, selectable Antibiotic resistance marker and reporter genes GUS gene, Lux gene and GFP protein. Transgene stability and gene silencing. Methods of gene transfer in plants Transient and stable gene transformation: Agrobacterium mediated gene transfer, Ti&Ri plasmid, the process of T DNA transfer and integration. Physical method of gene transfer, Particle bombardment, electroporation, microinjection, chemical mediated transformation, silicon carbide mediated and floral dip method. Transplastomics: Chloroplast transformation: advantages, vectors, success with tobacco and potato. Strategies for marker free transformation. Application of transgenesis in crop improvement: Insect resistance, disease resistance, virus resistance, herbicide resistance, and resistance to biotic & abiotic stress. Transgenesis for male sterility and terminator seed. Transgenesis for quality improvement: Protein, lipids, carbohydrates, vitamins & mineral nutrients. Molecular pharming: Exploitation of Biotechnological techniques for plant therapeutic compounds - production of recombinant proteins in plants. Expression of antibodies in plants for immunotherapy. Expression of recombinant antibody fragments in plants.

**ANIMAL BIOTECHNOLOGY:**Culture of mammalian cells, Tissues and Organs, Primary Culture, Secondary Culture, Continuous cell lines, Suspension cultures, Cryopreservation and transport of Animal germplasm (Embryo, Semen and ovum). Cell cultures media and Growth parameters of animal cell culture, Role of serum and essential supplements to medium and their applications. Cell Synchronization, Cell cloning Methods and Micromanipulation. Gene transfer to Animal cell, Animal Germ cell and development, Valuable genes for Animal biotechnology, Transgenic Animals (story of Dolly) and gene knockout, Somatic cell cloning and Hybridization, Transfection and Transformation of cells, Production of transgenic animals – mice, sheep and fish. Potential applications of transgenic animals – Animal models for diseases and disorders. Transgenic poultry, transgenic insects as bioreactor. Commercial scale production of animal cells, application of animal cell culture for in vitro, testing of drugs, testing the toxicity of environmental pollutants in cell culture, application of cell cultures technology in production of pharmaceutical proteins, human and animal viral vaccines. Stem cell culture, embryonic stem cells and their applications. Cytotoxicity, Apoptosis, Tissue engineering. Diagnostic antigens and other pharmaceutical agents.

**MICROBIAL BIOTECHNOLOGY:**Scope and importance of bioprocess engineering technology, Development and strain improvement of industrially important microorganisms. Bioreactors: Typical structure of advanced bioreactor and their working mechanism. Design features - Heat transfer and Mass transfer. Specialized bioreactors- design and their functions. Airlift bioreactor, Tubular bioreactors, Membrane bioreactors, Tower bioreactors, Fluidized bed reactor, Packed bed reactors and Photo bioreactors. Fermentation technology: Natural and synthetic media; Strategies for media formulation, sources of carbon, nitrogen, vitamins and minerals. Role of buffers, precursors, inhibitors, inducers and antifoam agents. Types of fermentation process-submerged fermentation, surface or solid-state fermentation, batch fermentation, continuous fermentation, kinetics of fermentation process, bioprocess control, monitoring of variables-temperature, agitation, pH and pressure. Downstream processing: cell disruption, precipitation methods, solid-liquid separation, liquid-liquid extraction, filtration, centrifugation, chromatography, drying devices (Lyophilization and spray dry technology), crystallization-biosensors-construction and applications. Immobilization and Biotransformation: Methods of immobilization - adsorption, crosslinking, ionic bonding, entrapment, encapsulation; Advantages and industrial applications of Immobilization of enzymes and whole cells.

Biotransformation of antibiotics, steroids and their applications. Production of Industrially important products: Alcohol- Ethanol, glycerol, butanol, Acetone; Organic acids- citric, acetic, and gluconic acid; Amino acids- lysine, glutamic acid; Antibiotics- penicillin, streptomycin, tetracycline; Vitamins- riboflavin; Enzymes- amylase, protease; biodegradable plastic- polyhydroxyalkanoates (butyrate, propionate).

**ENVIRONMENTAL BIOTECHNOLOGY:**Environmental pollution: Basic concepts and global issues-Global warming & Acid rain. Pollution measurements- air and water.Biosensor in environmental monitoring. Bioremediation of environmental pollutants in soil and water- oils, heavy metals and detergents. Biofouling and Biosensors. Waste treatment: Waste water treatment: Physical, chemical and biological treatment processes. Various industrial effluent treatment methods- Sugar, distillery, dairy, tannery and pharmaceutical industries. Solid wastes: Types and characteristics. Solid waste disposal- land filling, incineration.Biogas from solid waste.Composting and vermicomposting.Monitoring parameters for composting. Bioremediation: Introduction of Bioremediation advantages and applications; Types of bioremediation. Microbial remediation of phenolics-sewage nutrients (phosphate and nitrate).Impact of bioremediation in petroleum industry, paper industry, marine oil pollutants and chemical industry.Phytoremediation advantages and applications (agriculture).Biorrosion and microbial mediated recovery: Microbial corrosion and its control (petroleum industry and cooling tower system). Bio metallurgy- Bioleaching- application, biotechnology approaches for heavy metal elimination from effluents. Bio-mediated recovery of metals (gold and platinum).Recovery of petroleum-MEOR- Biosurfactant. Biodegradation: Biodegradation of organic pollutants: Mechanisms and factors affecting biodegradation. Pollution problems and biodegradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, azo dyes, lignin and pesticides.Bioenergy.

#### **UNIT 4:**

**VIROLOGY:**General Virology: Structure of viruses: Enveloped and non-enveloped viruses, Capsid symmetries-icosahedral, polyhedral and helical, structural proteins-matrix proteins and lipoproteins, viral genomic organization and replication-types of nucleic acids, protein nucleic acid interactions and genome packaging, Virus related structures-viroids and prions. Cultivation of viruses: Ex vivo/In vivo,Ex vitro/In vitro. Cytopathic effect-pock forming unit. Viral

diagnostic and detection methods: Sample processing-enrichment and concentration, Direct methods of detection-light microscopy (inclusion bodies), electron microscopy, Immunodiagnosis, hemagglutination, Complement fixation, neutralization, Western blot, Radioactive Immuno precipitation Assay (RIPA), Flow Cytometry and Immunohistochemistry. Nucleic acid -based diagnosis: Nucleic acid hybridization, PCR, microarray and nucleotide sequencing, LINE probe assay. Bacteriophages and plant viruses: Bacteriophage: Morphology, genome organization, classification-Lifecycle-Lytic and Lysogenic Cycle, Head and tail phages-T4 phagephage-Filamentous Bacteriophages-174-M13, phage therapy for control of bacterial poultry diseases. Viral Disease in Plants: Histological, physiological and cytological changes in infected plants, Behavior of viruses in plants, Methods for detection of plant viruses, Transmission of plant viruses through vectors-insects, nematodes and fungi. UNIT IV Clinical virology: Pathogenesis, clinical symptoms, epidemiology and prophylaxis of DNA Viruses-pox virus, Herpes Virus, Adenovirus, Hepatitis Virus. RNA Viruses, Picorna Virus, Orthomyxo Virus, Rabies Virus, HIV. Oncogenic viruses; Virus induced cell transformation and oncogenesis, Mechanism of cell transformation by tumor viruses, Retrovirus mediated oncogenesis. Viral vaccines and anti-viral drugs: Viral vaccine, conventional vaccines-killed and attenuated, Modern vaccines-DNA vaccines, recombinant DNA/protein vaccines, subunits vaccines, peptide vaccines, anti-idio type vaccines, edible vaccines, immunomodulators (cytokines), adjuvants to increase immunogenicity of vaccines. Antivirals: Interferons, designing and screening for antivirals, mechanisms of action, antiretrovirals-mechanism of action and drug resistance.

**GENOME TECHNOLOGY:** Structural Organization: Definition, historical prospective and strategies. Prokaryotic and Eukaryotic genome size & structure-genome physical mapping Structural and functional annotations of genes and genomes. Genes and Genomes: Interpreting expression data using Gene ontology; Evolution of modularity and transcriptional networks, Ribo switches metabolite sensing and translational control-Microarrays-types and applications. Taxonomy and phylogeny: Basic concepts in Systematics, taxonomy and phylogeny; molecular evolution; nature of data used in Taxonomy and Phylogeny, Definition and description of phylogenetic trees various types of trees, phylogenetic analysis algorithms such as maximum parsimony, UPGMA. Whole genome library: Whole genome shotgun sequencing: DNA sequencing theory pair wise and end sequencing, the Institute for Genomic Research



(TIGR), Celera Genomics. Hierarchical shotgun sequencing, High throughput pyro sequencing, Next-generation sequencing and full genome sequencing platforms and sequencing – tools in genome analysis. Synthetic biology and bio engineering introduction to synthetic biology – metabolomics and synthetic microbiology, predictive model building (metabolomes)- secondary metabolism and synthetic biology – synthetic bacterium, mycoplasma laboratorium, omics concept – metabolomics, transcriptomics, intactomics, phenomics, localizomes, gene networks – integration of networks.

**STEM CELL BIOLOGY:** Introduction to concepts in stem cell biology (renewal and potency etc) introduction to stem cells, Germ line stem cells and germ line derived pluripotent cell, Epigenetics, nuclear transfer and cloning, introduction to cell, tissues and organ. Stem cell basic: embryonic development of human, introduction to embryonic and adult stem cell, sources of adult stem cells, reprogramming and induced pluripotent cells (iPS cells), chromatin and stem cells, telomeres and stem cells, stem cell differentiation and characterization: CD antigens and its role in stem cell differentiation. Neuronal stem cell, mesenchymal stem cell, cardiac stem cells, planaria stem cells, prostate and breast stem cells, transforming growth factor (TGF $\beta$ ), G PROTEIN – COUPLED RECEPTORS (GPCRs), hematopoietic stem cells, stem cells and diabetes, techniques used for stem cell isolation, enumeration and Ex-VIVO expansion, techniques used for stem cell characterization. Therapeutic applications of stem cell: fundamentals of regenerative medicine, autologous and allogeneic stem cell transplantation, HLA typing, Animal models of regeneration. Stem cell banking – cryopreservation techniques, national guideline by ICMR, recent advances in stem cell biology.

## **UNIT 5:**

**PHARMACEUTICAL TECHNOLOGY:** Drug- structural feature and pharmacology activity, pro drug concept. Absorption – first – pass effect, distribution, metabolism- phase I, II reactions, action of cytochrome p450 & elimination of drug receptor- localization, type and subtypes, models and their drug- receptor interaction, agonist & antagonist. Adverse response to drugs, drug tolerance, drug intolerance, Idiosyncrasy (pharmacogenesis), drug allergy. Tachyphylaxis, drug abuse, vaccination against infection, factor that modifies the effect of drug. Assay of drug potency – bioassay and immunoassay. Biotechnology and pharmacy: genetically engineered protein and peptide agents. novel drug delivery systems – non

conventional routes of administration. Anti - AIDS drug development, oncogenes target for drugs, multi- drugs resistance. UNIT IV Mechanism of action of drugs used in therapy of: respiratory system-cough, bronchial asthma, pulmonary tuberculosis. GIT – digestants, appetite suppressants. hypolipidemia agents, vomiting, constipation and peptic ulcer. antimicrobial drugs- sulfonamide, trimethoprim, cotrimoxazole, penicillin and macrolides, aminoglycosides, cephalosporin and bacterial resistance. Insulin and oral diabetic drugs, anti-fertility and ovulation inducing drugs. UNIT V Drugs of plant origin: drug dependence and abuse- management of self-poisoning cancer. Chemotherapy- cytotoxic drug. immunosuppressive drug therapy. New biological targets for drug development. Novel drug screening strategies.

**BIOINFORMATICS:** Biological data bases: gen bank: sequence data/ types; - protein data bases – ESTs STSs – GSSs – HTGS; NCBI- PubMed- Entrez –BLAST – OMIM; Types of Accession Numbers Locus Link, Unigene, Entrez, EBI and ExPasy. Sequence alignment: alignment algorithms – global and local – significance, BLAST search steps –BLAST algorithm –BLAST search strategies, advanced BLAST-alignment tools. Gene expression analysis tools: the mRNA-c DNA-libraries, microarrays- experimental design – probe – hybridization – image analysis – data analysis- biological confirmation – microarray database. UNIT IV Proteomic analysis tools: protein domains and motifs – bio informatic tools for high throughput protein analysis – protein structure – homology and functional genomics. UNIT V Pathway bioinformatics: protein – carbohydrate metabolism – biochemical cycles – interconnection of pathways – metabolic regulation – translating biochemical networks into linear algebra –KEGG: theory and practice. computational methods: nucleic acid and protein sequence databases; determining methods for sequence analysis, web-based tools for sequence searches, motif analysis and presentation.

**RESEARCH METHODOLOGY:** Objectives and types of research: Motivation and objectives – Research methods vs Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research Formulation – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review -

Development of working hypothesis. Research design and methods – Research design – Basic Principles- Need of research design — Features of good design – Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan - Exploration, Description, Diagnosis, experimentation. Determining experimental and sample designs. Research techniques microscopy, HPLC, HPTLC, GC-MS, FTIR, SEM/TEM, NMR and AAS. Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation. Reporting and ethics – Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports. Environmental impacts - Ethical issues - ethical committees - Commercialization – Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism - Citation and acknowledgement - Reproducibility and accountability.