Swami Ramanand Teerth Marathwada University, Nanded

Biotechnology Syllabus
For Ph.D. Entrance
Section - B

Unit I- Basic Bioscience
Diversity of living world, Whittaker's Five Kingdom System, Classification up to genus & species level. Prokaryotic & Eukaryotic cell.
Introduction to Apiculture, Sericulture, Aquaculture & Vermi culture

Unit II- Organization of plant body
Flower- parts and their functions. Inflorescence- Types, Flowers as modified shoots, physiology of flowering (In brief concept of photoperiodism, vernalization and dormancy) Internal Structure of anther a ovule. Fruits- Typoes, fruit formation parthenocarpy. Seed- Structure formation dormancy, embryo structure. Morphological Differences in Monocots & Dicots. Basic Internal Structure of Roots, Stem & Leaves of dicot & Monocot.

Unit III - Fungi
General characteristics of fungi, Justification of Kingdom Mycetae & an overview of Kingdom fungi. Characters in classification of fungi. Ultra structure of typical fungal cell and cell differentiation, cell wall composition, Unicellular & Multicellular organization, hyphae, Nonmotile cells, spores, dormancy population and colonization, effect of environment on growth, prevention of fungal growth. Nutrition (Saprophyte, Symbiotic biotrophic) Reproduction Physiological specification.

Unit IV -Basic Mathematics and Statistics
The set theory, properties of subsets; linear constant quadratic geometric functions, the binomial theorem of integer, limits of functions (basics idea of limits of Functions without analytic definition), logarithm.
Biostatistics: Introduction to biostatistics sampling techniques data collection tabular and Graphical representation of data. Mean, Mode, Median, range variance standard deviation and probability.

Unit V - Computers
Introduction to computer system, binary number system, low level and high level languages. Flow charts and programming techniques. Introduction to operating systems, windows, MS office covering word processing, spreadsheet and presentation of software.

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Unit I- Cell Biology

Cell Architecture:
Cell theory , principles and applications of different types of microscope, structure and organization of membrane. Membrane models, glycol conjugates and proteins in membrane systems, transport channels and pumps, cytoskeleton, and structural components. Extra cellular matrix-cell to cell and cell matrix adhesion, gap junction, cell motility

Study of cell organelles:
Structural organizations and functions of plasma membrane, cell wall, mitochondria, chloroplast , nucleus, endoplasmic reticulum (SER & PER) sarcoplasmic reticulum, glyoxyomes, peroxisomes, microtubules, microfilaments and melanosomes, nucleus gross structure of chromosome; specific gene sequences in chromosomes, chemical composition of chromosomes, chromosome banding, the nuclesome, supranucleosomal structures specialized chromosomes ; polygene and lamp brush Chromosomes cellular basis of differentiations and development

Cell Cycle:
Mechanism of cell division mitosis, meiosis & genetic recombination; regulation of cell Cycle; factors and genes regulating cell cycle. Biochemistry and molecular biology of Cancer, malignant growth, tumor suppressor genes & oncogenes chemical Carcinogenesis, hormonal imbalance

Cellular Development:
Cellular signaling ; cell differentiation; stem cell, introduction to stem cells history of stem cell research – classification of stem cells –stem cell banking –application of stem cells – importance of stem cells, regulations of stem cell research

Unit II –Biochemistry

Structure of atoms, molecules and chemical bonds; Principles of physical Chemistry: Thermodynamics, kinetics, dissociation and association Constants. Chemical foundations of Biology- pH, pK, acids, bases and buffers, Henderson — Hasselbach equation, biological buffer solutions. Concept of free Energy; Thermodynamic principles in biology; energy rich bonds; weak interactions.

Lipids; Classification, structure and functions. Triglycerides; Phospholipids; Steroids and terpenes. Glycolipids and lipoproteins-structure and function. Role of lipids in biomembranes.

Nucleic acids: Structure of double stranded DNA (B, A, C, D, T and Z DNA). The biological significance of double strandedness, sequence dependent variation in the shape of DNA. Physical properties of double stranded DNA Types of RNAs and their biological significance. DNA bending, DNA Supercoiling.

Polysaccharides: classification, occurrence, isolation, purification, properties and biological reactions. Structural features of homoglycans, heteroglycans and complex carbohydrates. Proteins: **Amino acids and peptides**-classification, chemical reactions and physical properties. Peptide bond, Primary structure of proteins, structural comparison at secondary and tertiary levels, conformation of proteins and polypeptides (secondary, tertiary, quaternary and domain structure)

Enzymes: Classification - IUB system, rationale, overview and specific examples. Characteristics of enzymes, enzyme substrate complex. Concept of active centre, binding sites, stereo specificity and ES complex formation. Effect of temperature, pH and substrate concentration on reaction rate. Activation energy. Transition state theory.
Enzyme catalysis: Factors affecting catalytic efficiency - proximity and orientation effects , distortion or strain, acid - base and nucleophilic catalysis. Methods for studying fast reactions. Chemical modification of enzymes. Isoenzymes and multiple forms of enzymes.

Enzyme kinetics: Michaelis - Menten Equation - form and derivation, steady state enzyme kinetics. Significance of Vmax and Km. Bi substrate reactions.
Enzyme inhibition - types of inhibitors - competitive, non-competitive and uncompetitive, their mode of action and experimental determination. Enzyme activity, international units, specific activity, turnover number, end point kinetic Assay

Immobilized Enzymes: Relative practical and economic advantage for industrial use, effect of partition on kinetics and performance with particular emphasis on charge and hydrophobicity (pH,temperature and Km). Various methods of immobilization – ionic bonding, adsorption, covalent bonding (based on R groups of amino acids) , microencapsulation and gel entrapment. Immobilized multienzyme systems

Unit III -Microbiology, Virology & Immunology

Bacteria: Purple and green bacteria, Cyan bacteria, Homoacetogenic bacteria. Acetic acid bacteria, Budding and appendaged bacteria, Spirilla, Spirochetes, Gliding and sheathed bacteria, Pseudomonades; Lactic and propionic acid bacteria, Endospore forming rods and cocci, Mycobacterium, Rickettsias, Chlamydias and Mycoplasms. Archaea: Archaea as earliest life forms, Halophiles, Methanogens, Hyperthermophilic archaea, Thermo plasma. Viruses : Bacterial Plant. Animal and Tumor viruses; Viroids and Prions. Eukarya: Algae. Fungi. Slime moulds and Protozoa.

Microbial Growth: The definition of growth, mathematical expression of growth, growth curve, measurement of Growth and growth yields; Synchronous growth: Continuous culture; Growth as affected by Environmental factors like temperature, acidity, alkalinity, water availability and oxygen; Culture collection and maintenance of cultures.

Bacterial Viruses ;Bacteriophage : Structural organization Lytic cycle: Infection of host cell. Viral-multiplication cycle: Maturation & Release, Lysogenic cycle ,State of prophage in lysogenic cycle, Mechanism of Insertion & Recombination Multiplication of prophage
Establishment of Lysogenic state, Induction of Lysogenic cell Episomes ,Integration of Episomes, Bacteriocin & Bacteriocinogen Phages as transducing agents: Genralised transduction, Specialized transduction Phages (T2, T4, T7, Lambda, M13 life cycle)

Animal viruses: Baltimore classification system, Culture techniques for animal viruses, Stages of infection, Adsorption & entry, Multiplication of RNA, DNA, & retroviruses,Tumor viruses, Adeno viruses, Herpes viruses, Pico rna viruses, Pox viruses, orthomixo viruses, Paramyxo viruses. Antiviral therapy,Emerging viruses. Conventional vaccines, killed and attenuated, modern vaccines—recombinant proteins, subunits, DNA vaccines, peptides, immunomodulators (cytokines), vaccinede livery and adjuvants. Interferons (Type I and II), designing and screening for antivirals, mechanisms of action, antiretrovirals—mechanism of action and drug resistance
Modern approaches of virus control

Plant viruses: Classification & Nomenclature of Plant viruses, Symptoms of viral diseases on plants (Macroscopic, Histological, Cytological) Common viral diseases of paddy, cotton, tomato & sugarcane Life cycle of TMV, CMV, PVX Transmission of plant viruses with vectors (insect, nematode, fungi) & Without vectors (contact, seed, pollen)

Basic concepts of Immune system: Cells & organs of immune system, Immunity Humoral & cell mediated, Hematopoiesis and differentiation, Lymphocyte trafficking

Antigens- General properties, types, epitope, hapten.adjuvant,

Antibodies- Types, biological functions. Biology of Superantigen, Introduction of vaccines
BCR & TCR (structure & properties), MHC Antigen processing & presentation (antigen presenting cells, endocytic, cytosolic pathway) Maturation & Activation of B-cells Maturation & Activation of T-cells

Vaccine technology and recombinant vaccines, Idetifications of B and T epitopes for vaccine development. In situ characterization of cells in tissues, Immunoscreening of Recombinent Library, Hybridoma Monoclonal Antibody, Production and applications of MAb in diagnosis and therapy, Catalytic antibodies, FACS

Unit IV- Bioinstrumentation

Microscopy: Light microscope, Fluorescence microscope, Phase contrast microscope, Electron microscope, confocal microscopy.

Centrifugation: Small bench top centrifuges, large capacity refrigerated centrifuges, High speed refrigerated centrifuges, preparative and analytical ultra centrifuge.

Electrochemical techniques: Principles of electrochemical techniques, redox reactions, the pH electrode, ion-sensitive and gas-sensitive electrodes, The Clark oxygen electrode, Biosensors.

Chromatographic techniques: Principles of chromatography, size exclusion, lonexchange and affinity chromatographies. High performance liquid chromatography (HPLC), Gas liquid chromatography (GLC), Thin layer chromatography (TLC), Paper chromatography, GC-MS, LC-MS, Maldi Tof.

Electrophoresis: General principles, Electrophoresis of proteins: SDSPAGE, Native gels, Gradient gel, Is electric focusing , 2-D gel electrophoresis (2-D PAGE), cellulose acetate electrophoresis, continuous flow electrophoresis; Detection, estimation and recovery of proteins, Western blotting. Electrophoresis of nucleic acids: agarose gel electrophoresis of DNA, DNA sequencing gels, Pulse field gel electrophoresis, electrophoresis of RNA, Capillary electrophoresis.

Spectroscopic techniques: Properties of electromagnetic radiation, interaction with matter. Spectrophotomery visible and UV spectrophotometery. Gamma ray spectroscopy, X-ray spectroscopy, UV and Visible spectroscopy,Infrared and Raman spectroscopy, Electron spin resonance spectroscopy, Nuclear magnetic resonance spectroscopy, Circular dichorism spectroscopy,Atomic spectroscopy. Lasers, Spectrofluorimetry, turbidometry and nephelometry.

Radio isotope techniques: The nature of radioactivity, detection and measurement of radioactivity: detection based on gas ionization- Geiger Muller counter- principles and applications. Detection based on excitation- Liquid Scintillation counter-principle and applications. Supply, storage and purity of radiolabelled compounds, specific activity, inherent advantages and restrictions of radiotracer experiments, safety aspects, applications- of radio isotopes in biological sciences. Flowcytometry, ELISA, immunoblotting.

Unit V- Molecular Biology & Genetic Engineering

Mendelian Genetics: Principles of Mendalian inheritance and Gene interactions: incomplete dominance, codominance, epistasis, complementary genes, duplicate genes, polymeric genes, modifying genes, lethal genes.
Population and gene frequencies; The Hardy Weinberg Law Gene linkage, Sex linked inheritance, Crossing over with respect to chromosome mapping. Genetic diseases due to defects in autosomal genes, nondisjunction, chromosomal aberrations.

DNA Replication-DNA as genetic material, Genome Replication in prokaryote & Eukaryotic organisms, Replication regulation in Eukaryotics, various modes of DNA replication, Initiation elongation and termination, enzymes involved.
Molecular basis of genome evolution: Mutations, causes types and effects, Hyper mutation, DNA Repair, Recombination: homologous, site specific, transposition
Transcription-Initiation, elongation and termination, Post transcriptional processing of m-RNA, t-RNA, r-RNA, RNA Stability & Half life period
Translation -Initiation, elongation and termination, Post translational modifications of proteins and protein localization.

Gene regulation in prokaryotes-operon concept, Lactose, Tryptophan and Arabinose. Role of cAMP and CRP in lac operon, tryp operon.Catabolite repression Gene regulation in eukaryotes-Conserved mechanism, activation and repressor role in gene regulation. Gene silencing, Signal integration.

Genetic Engineering: Restriction endonucleases, Modification methylases and other enzymes needed in genetic Engineering.
Cloning vectors: Plasmids and plasmid vectors, Phages and Phage Vectors, phagemids, cosmids, artificial chromosome vectors (YAC, BAG), Animal virus derived vectors - SV40 and retroviral vectors
Molecular cloning: Recombinant DNA techniques, construction of genomic DNA and cDNA libraries, screening of recombinants. Expression strategies for heterogonous genes DNA analysis: labeling of DNA and RNA probes. Southern and fluorescence in situ hybridization, DNA fingerprinting, chromosome walking.

Techniques for gene expression: Northern and Western blotting, gel retardation technique, DNA foot printing, Primer extension, SI mapping, Reporter assays Sequencing of DNA, chemical synthesis of oligonucleotides,techniques of in vitro mutagenesis, Site-directed mutagenesis, gene replacement and gene targeting. Polymerase chain reaction and its applications

Biosafety regulation: Physical and Biological containment

Unit VI- Bioprocess Technology

Isolation, Screening, Preservations and maintenance of Microorganisms, strain improvement, Mutagenesis, Genetic Engineering for Strain Improvement.

Bioreactor: Basic aspect of Bioreactor Designing, Types of Bioreactors, Ideal Properties, Body Construction, Agitator, Impeller, Baffles etc. Types of Bioreactor (Packed-bed reactor, Air –lift, Trickle bed Photo bioreactors, Rotating Biological Reactors pneumatic)

Media formulation & optimization its need and significance, Sterilization of media and air, exhaust air, Batch sterilization; Del factor D and Z value Continuous Sterilization: Design and Methods sterilization kinetics, Inoculum development, Microbial growth and its kinetics (Batch & Continuous) Types of processes-Batch, fed batch, continuous, concept of scale up of fermentation. Comparative account of batch and continuous sterilization, Development of inocula

Fluid flow and mixing, Classification of fluids, concept of Reynold's number, Rheological properties of fermentation process (Viscosity, cell concentration, product concentration etc) Mass transfer in bioreactors (Oxygen and heat transfer). Measurement and control of Bioprocess parameters, Automation for monitoring and Control (online and offline sensors, Biosensors) Use of Computers: Data logging, data analysis, and process control, Process scale up: factors involved, steps involved,

Downstream processing: Strategy for recovery, Harvesting of Biomass and Product, Removal of microbial cells and solid matter, foam separation, filtration, centrifugation, cell disruption, Liquid liquid extraction Ext, chromatography and membrane processes, Drying and crystallization, Process economics. Comparison between SSC and SLC, Factors affecting solid-state fermentations, Economic Applications

Unit VII- Plant and Animal Biotechnology

Plant Tissue Culture

Introduction to cell and tissue culture, Tissue culture media: Types, Composition and Preparation. Initiation and maintenance of callus and suspension culture, **Organogenesis:** Principles, Concept and Applications of Somatic embryogenesis.

Shoot tip culture, rapid clonal propagation and production of virus free plants.

Protoplast culture: Importance, Isolation of protoplasts, method of protoplast culture, culture media, Growth and division of protoplast, regeneration of plants.

Embryo culture and embryo rescue, Anther, Pollen and Ovary culture for production of haploid plants and homozygous lines

Cryopreservation, slow growth and DNA banking for germ plasm conservation, Commercial application of tissue culture technology, examples: banana and Sugarcane.

Transgenic Crops: Crops with resistance to biotic stresses, viruses, fungal and bacterial diseases: strategy and examples. Crops with resistance to abiotic stresses (Herbicides and drought conditions): strategy and examples, Terminator technology. Ecological risk assessment of genetically modified crops

Animal Cell Culture:

Structure and organization of Animal cells - Culture media; Balanced salt solutions and simple growth medium, Physical, chemical and metabolic functions of different constituents of culture medium; Role of carbon dioxide, serum, growth factors, glutamine in cell culture; Serum and protein free defined media and their applications.

Types of Animal cell culture: primary and established culture; organ culture; tissue culture; three dimensional culture and tissue engineering; feeder layers; disaggregation of tissue and primary cell culture; cell separation; cell synchronization; cryopreservation. Biology and characterization of cultured cells: tissue typing; cell-cell interaction; measuring parameters of growth; measurement of cell death; Apoptosis and its determination; cytotoxicity assays - application of animal cell culture - Engineered cell culture as source of valuable products and protein production

Molecular techniques in cell culture: cell transformation; physical, chemical and biological methods; Viral gene delivery systems: Adenoviruses, ALVs, Bacculoviruses; manipulation of genes; cell cloning and micro manipulation; hybridoma technology and its applications; cell fusion methods; gene mapping; vaccine production; gene therapy, targeting, silencing and knockout. Selectable markers like pSV and pRSV plasmids -reporter genes.

Embryology: Collection and preservation of embryos; culturing of embryos; Gametogenesis and fertilization in animals; types of cleavage pattern; role of maternal contributions in early embryonic development; genetic regulation of embryonic development in Drosophila; homeotic genes in development; stem cell culture, embryonic stem cell and their applications.

Transgenics: Transgenic animal: production and application; transgenic animals as models for human diseases; transgenic animals in live-stock improvement; expression of the bovine growth hormone; transgenics in industry; chimera production; Ethical issues in animal biotechnology.

Unit VIII- Biostatistics and Bioinformatics

Biostatistics: Brief description and tabulation of data and its graphical representation Measurement of central tendency and dispersion- mean , mode , median, range Mean deviation, standard deviation, variance . Idea of two types of errors and level of significance. Tests of significance- F-Test ,andchi-squaret test.linear regression and correlation.

Bioinformatics

Biological Data Bases The need for computation in Biology: An introduction to Bioinformatics, Historical overview, the principles involved, development of tools, internet based access.Introduction to Biological Databases, Database Browsing and Data Retrieval, Sequence databases, Genome Databases.

Applications of Bioinformatics: Approaches for analysis and interpretation of Sequence Data Homology Searches, Sequence Alignments, Pattern Searching, Gene prediction, Full Genome comparison etc.

Introduction to computational structural biology: Protein structure prediction using computational methods, Structure analysis, Classification of Proteins etc.

Proteomics: Proteomics applications: Understanding the mechanism of pathogenesis, Drug discovery, Disease diagnosis, identification and characterization of novel proteins.

Genomics -Introduction sequencing strategies for whole genome analysis, sequence data analysis.Comparative Genomics: Protein evolution from exon shuffling, Protein structural genomics, Gene function by sequence comparison.

Global expression profiling : whole genome analysis of mRNA and protein expression, microarray analysis, types of microarrays and their applications. Functional genomics. Toxicogenomics. Pharmacogenomics. Metagenomics, Metabolic engineering

Unit IX- Environmental Biotechnology

Basic concepts: Interactions between environment and biota; Concept of habitat and ecological niches; Limiting factor; Energy flow, food chain, food web and tropic levels; Ecological pyramids and recycling, biotic community-concept, structure, dominance, fluctuation and succession; Concepts and theories of evolution - Population ecology - community structure.

Ecosystem dynamics and management: Stability and complexity of ecosystems; Speciation and extinctions; environmental impact assessment; Principles of conservation; Conservation strategies; sustainable development.

Global environmental problems: ozone depletion, UV-B green house effect and acid rain, their impact in biotechnological approaches for management.

Environmental pollution: Types of pollution,Methods for the measurement of pollution Methodology of environmental management - the problem solving approach, its limitations. Air pollution and its control through Biotechnology. Water Pollution and control: Need for water management, Measurement and sources water pollution. Kind of aquatic habitats, (fresh and marine), distribution and impact of environmental factors on the aquatic biota, productivity, mineral cycles and biodegradation different aquatic ecosystems.

Waste water treatment : Waste water collection, Physico-chemical properties of water, physical, chemical and biological treatment processes. Activated sludge, oxidation ditches, trickling filter, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic digestion, anaerobic filters, Up flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar, antibiotic industries. Management of estuarine, coastal water systems and man-made reservoirs; Biology and ecology of reservoirs.

Xenobiotics : Ecological considerations, decay behaviour and degradative plasmids; hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides. Biopesticides in integrated pest management. Bioremediation of contaminated soils and wastelands. Solid waste: Sources and management (composting, vermiculture and methane production). Environmental mutagenesis and toxicity testing.

Unit X –System Physiology

Respiration: Mitochondria- Structure, biogenesis, respiration and photorespiration – Citric acid cycle; plant mitochondrial electron transport chain and ATP synthesis; alternate oxidase; photorespiratory pathway.

Photosynthesis: Chloroplast- structure, biogenesis, molecular events, photosynthesis - Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways.

Nitrogen Cycle: Nitrate and ammonium assimilation; amino acid biosynthesis, N2 fixing bacteria as microbial biofertilizers: Symbiotic and nonsymbiotic bacteria.
Microbial inoculants for sustainable agriculture: Microorganisms, Physiology and Production technology of (i) Cyanobacteria (ii) Plant growth promoting rhizobacteria (iii) Phosphate solubilizing microorganisms (iv) Mycorrhizae

Biotransformation: Microbial transformation: Basic concept involved, Types of bioconversion reactions: Oxidation, Reduction, Hydrolytic reactions, Condensations
Transformation of steroids and sterols. Transformation of nonsteroid compounds: L-Ascorbic acid, Prostaglandins, Antibiotics

Plant hormones – Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action. Plant hormones by bacteria