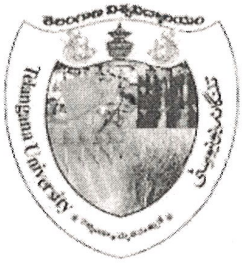
Master of Science (M.Sc. Biotechnology)

Scheme & Structure of Syllabus - Choice Based Credit System (CBCS)

(With Effect from the Academic Year 2020-21 Batch)



Department of Biotechnology,
University College of Science.

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Telangana - 503322.

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Computer Science
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TELANGANA UNIVERSITY
M.Sc. BIOTECHNOLOGY
CHOICE BASED CREDIT SYSTEM (CBCS)
(Proposed Scheme & Structure of Syllabus from The Academic Year 2020-21 Onwards)

Department Vision

The Department of Biotechnology has a vision to impart national and international standard of quality education and research in the field of biosciences.

Department Mission

- To create state of the art infrastructure for Research and Training in the field of Biotechnology.
- To provide globally acceptable quality education for post graduate students.
- To nurture graduates and post graduates for innovation and creativity in their fields not compromising on ethical and social concerns.
- To promote collaboration with Academia, Industries and Research Organisations at state, national and international level and enhance the quality of education and research with recent advances.
- To contribute to society and economic development through education and bio entrepreneurship.

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M.Sc. BIOTECHNOLOGY
CHOICE BASED CREDIT SYSTEM (CBCS)
(Proposed Scheme & Structure of Syllabus from The Academic Year 2020-21 Onwards)

SEMESTER - I							
S.no	CODE NO	SUBJECT	CREDITS	TEACHING HOURS/WEEK	MARKS		
					INTERNAL ASSESSMENT	SEMESTER EXAM	TOTAL
THEORY							
1.	BT 101 T	GENETICS	4	4	20	80	100
2.	BT 102 T	CELL BIOLOGY	4	4	20	80	100
3.	BT 103 T	BIOCHEMISTRY	4	4	20	80	100
4.	BT 104 T	MICROBIOLOGY	4	4	20	80	100
PRACTICALS							
1.	BT 151 P	GENETICS	2	4	---	50	50
2.	BT 152 P	CELL BIOLOGY	2	4	---	50	50
3.	BT 153 P	BIOCHEMISTRY	2	4	---	50	50
4.	BT 154 P	MICROBIOLOGY	2	4	---	50	50
TOTAL			**24**	**32**	**80**	**520**	**600**

SEMESTER - II							
S.no	CODE NO	SUBJECT	CREDITS	TEACHING HOURS/WEEK	MARKS		
					INTERNAL ASSESSMENT	SEMESTER EXAM	TOTAL
THEORY							
1.	BT 201 T	MOLECULAR BIOLOGY	4	4	20	80	100
2.	BT 202 T	INDUSTRIAL BIOTECHNOLOGY	4	4	20	80	100
3.	BT 203 T	IMMUNOLOGY	4	4	20	80	100
4.	BT 204 T	BIOSTATISTICS & BIOPHYSICAL TECHNIQUES	4	4	20	80	100
PRACTICALS							
1.	BT 251 P	MOLECULAR BIOLOGY	2	4	---	50	50
2.	BT 252 P	INDUSTRIAL BIOTECHNOLOGY	2	4	---	50	50
3.	BT 253 P	IMMUNOLOGY	2	4	---	50	50
4.	BT 254 P	BIOSTATISTICS & BIOPHYSICAL TECHNIQUES	2	4	---	50	50
TOTAL			**24**	**32**	**80**	**520**	**600**

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SEMESTER - III							
S.no	CODE NO	SUBJECT	CREDITS	TEACHING HOURS/WEEK	MARKS		
					INTERNAL ASSESSMENT	SEMESTER EXAM	TOTAL
THEORY							
1.	BT 301 T	GENETIC ENGINEERING & R-DNA TECHNOLOGY	4	4	20	80	100
2.	BT 302 T	BIOINFORMATICS	4	4	20	80	100
3.	BT 303 T	BIOPROCESS ENGINEERING	4	4	20	80	100
4.	BT 304 T	INTELLECTUAL PROPERTY RIGHTS- ETHICS, ENTREPRENEURSHIP, LABORATORY MANAGEMENT-BIOSAFETY & RESEARCH METHODOLOGY	4	4	20	80	100
PRACTICALS							
1.	BT 351 P	GENETIC ENGINEERING & R-DNA TECHNOLOGY	2	4	---	50	50
2.	BT 352 P	BIOINFORMATICS	2	4	---	50	50
3.	BT 353 P	BIOPROCESS ENGINEERING	2	4	---	50	50
TOTAL			**22**	**28**	**80**	**470**	**550**

SEMESTER - IV							
S.no	CODE NO	SUBJECT	CREDITS	TEACHING HOURS/WEEK	MARKS		
					INTERNAL ASSESSMENT	SEMESTER EXAM	TOTAL
THEORY							
1.	BT 401 T	PLANT BIOTECHNOLOGY	4	4	20	80	100
2.	BT 402 T	ANIMAL BIOTECHNOLOGY	4	4	20	80	100
3.	BT 403 T(A/B) (ELECTIVE)	I. MEDICAL (OR) II. ENVIRONMENTAL BIOTECHNOLOGY	4/4	4/4	20	80	100
4.	BT 404 T	PROJECT WORK	4	4	20	80	100
PRACTICALS							
1.	BT 451 P	PLANT BIOTECHNOLOGY	2	4	---	50	50
.	BT 452 P	ANIMAL BIOTECHNOLOGY	2	4	---	50	50
3.	BT 453 P (A/B) (ELECTIVE)	I. MEDICAL (OR) II. ENVIRONMENTAL BIOTECHNOLOGY	2/2	4/4	---	50	50
TOTAL			**22**	**28**	**80**	**470**	**550**
GRAND TOTAL			92	120	320	1980	2300

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SEMESTER I: PAPER I – GENETICS (BT101 T)

Credit I: Principles of Genetic Inheritance

1.1 Mendelian Genetics: Monohybrid, Dihybrid and Trihybrid crosses/ratios and associated laws.

1.2 Extension to Mendelian Genetics: Incomplete dominance (Flower Colour), Co-dominance (MN Blood groups). Multiple Allelism (Coat colour in Rabbits, Eye colour in Drosophila, ABO Blood groups, Rh blood groups– incompatibility; Complex loci - R-locus in maize), Pseudo allelism, Pleiotropism (Bardet Biedel Syndrome, Marfan's syndrome), Phenocopy (microcephaly), Penetrance and Expressivity - Irregular dominance (Polydactyly, Warrensburg Syndrome), Quantitative Inheritance - polygenic inheritance - Additive effect (Skin colour in man, Kernel colour in Maize).

1.3 Non-Allelic Interactions: Epistasis -Types, modification of dihybrid ratios, environmental Effects on phenotypic expression.

1.4 Sex Linked Inheritance: Sex determination in Drosophila, Birds, Man, Bonellia; X-linked inheritance - Haemophilia, Colour blindness, X-inactivation (Lyonization); Y-linked inheritance - Holandric genes. Sex limited & sex influenced characters.

1.5 Inheritance patterns in Man: Pedigree analysis.

Credit II: Chromosome Organization & Developmental Genetics

2.1 Chromosomes: structure & morphology (centromere & telomere), classification & karyotyping, Specialized chromosomes (polytene & Lamp brush chromosomes).

2.2 Chromosomal Theory of Inheritance.

2.3 Variation in chromosome number: Euploidy, Aneuploidy; Variation in chromosome structure: deletions, duplications, translocations and inversions.

2.4 Chromatin organization: Nucleosome, loops and Scaffolds. Chromatin under transcription, Euchromatin and Heterochromatin, Nucleosome phasing.

2.5 Developmental genetics: basic concepts, development of drosophila body plan- setting up the body axes and segment identity. Patterning the vertebrate body plan: axes, germ layers and somites.

Credit III: Linkage and Gene mapping

3.1 Cytological proof of crossing over: Creighton & Mc Clintock's experiment

3.2 Linkage: Phases of linkage, test cross, recombination frequency, gene mapping, determination of map distances based on two- and three-point test crosses, coincidence, Interference (Drosophila, Maize).

3.3 Mitotic Crossing Over.

3.4 Tetrad analysis (Neurospora).

3.5 Gene mapping in man: Genetic mapping, sib pairs, Lod scores, homozygosity mapping, Linkage disequilibrium, TDT test.

Credit IV: Extra Nuclear Cytoplasmic Inheritance & Population Genetics

4.1 Plastidial (Maternal) Inheritance: Variegation (leaves of *Mirabilis jalapa*).

4.2 Mitochondrial (Maternal) Inheritance: Poky in Neurospora, Male sterility in Maize, LHON (Leber's Hereditary Optic Neuropathy) in Man.

4.3 Maternal Effect: Shell coiling in Snails; Plasmids, Is elements, episomes.

4.4 Uniparental Inheritance: Extra nuclear genes in Chlamydomonas, S-gene in Nicotiana.

4.5 Population genetics: gene pool and gene frequency, Hardy Weinberg law and its applications in calculating gene frequencies in a population, QTLs, genetic polymorphism.

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SEMESTER I – GENETICS (BT151 P)

PRACTICALS

1. Monohybrid and dihybrid ratios, Multiple alleles, Epistasis -Problems
2. Quantitative Inheritance – Problems
3. Inheritance patterns in Man – Pedigree analysis
4. Karyotyping of normal and abnormal chromosomal sets.
5. Preparation of polytene chromosomes
6. Localization of genes – two- & three-point test crosses –Problems
7. Tetrad analysis -Problems
8. Localization of genes in man by sib pair method & Lod score estimations - Problems, Multipoint analysis- determining flanking loci
9. Gene mapping by Transmission disequilibrium test (TDT) -Problems

SPOTTERS: Test cross; back cross; ABO blood groups; Barr body; Pedigree analysis for Haemophilia: Polytene & Lamp Brush chromosomes; Nucleosome; Translocation; Tetrad analysis; two-point test cross; Shell coiling.

Books Recommended:

1. An introduction to Genetic Analysis by Anthony, J.F. J.A. Miller, D.T. Suzuki, R.C. Richard Lewontin, W.M- Gilbert, W.H. Freeman publication,1998.
2. Principles of Genetics by E.J.Gardner and D.P. Snusted. John Wiley & Sons, New York 7th edition1984.
3. The science of Genetics, by A.G. Atherly J.R. Girton, J.F. Mcdonald, Saundern College publication,1999.
4. Principles of Genetics by R.H. Tamarin, International edtn Mc Graw hill -1996
5. Theory & problems in Genetics by Stansfield, Schaum out line series McGrawhill–2000

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SEMESTER I: PAPER II – CELL BIOLOGY (BT102T)

Credit I: Internal Organization & Transport of a Cell

1.1 Cell Membrane: lipid bi layer: structure and properties (Electrical action potential, neurotransmitters), membrane constituents, membrane proteins: peripheral, integral and transmembrane.

1.2 Intra cellular compartmentalization: Cytosol & its organelles, Cell pH (cytosolic & organellar), cellular enzymes and their function.

1.3 Intra cellular Transport: Transport of molecules between nucleus and cytosol, Transport into nucleus, mitochondria and chloroplast, endocytosis and exocytosis.

1.4 Inter cellular Transport: Transport across membranes – active & passive transport, ionic gradient, carrier proteins, Na+ Ka+ pump, ATPase, ABC transporters, Ion channels, Multi drug resistant (MDR) efflux forms.

1.5 Protein sorting.

Credit II: Cell Communication & Signalling

2.1 Extracellular Signalling: Paracrine, endocrine, autocrine hormonal signalling, mechanism of action of steroid, protein and amino acid derived hormones.

2.2 Cell Junctions: Tight junctions and Gap junctions

2.3 Second messengers and their role in signal transduction: Camp, Cgmp, lipid (phosphatidyl inositol) derived second messenger &IP3, calcium as second messenger.

2.4 Cell surface receptors in signal transduction: G-protein coupled receptor – structure, Function & signalling pathways, Ion channel receptors, Tyrosine kinase linked receptors (receptors for cytokines), Receptors with intrinsic enzyme activity (RTK- Receptor Tyrosine Kinases).

2.5 Interaction and regulation of cell signalling pathways: Wnt signalling pathway, Toll-like receptor signalling pathway, JAK – STAT pathway, RTK signalling pathways.

Credit III: Cell Cycle and Cell Division

3.1 Cell Cycle: phases (events).

3.2 Cell Cycle: Check points, Cyclins, CDKs, Phase dependent cyclic CDK complexes (Yeast), Intracellular control of cell cycle events.

3.3 Abnormalities in Cell Cycle – Cancer.

3.4 Cell Division: Mechanism, Cohesins and Condensins – chromosome segregation.

3.5 Mitosis& Meiosis: Stages, Microtubules in spindle assembly, kinetochore, centrosomes, Synaptonemal complex, Recombination nodules, Significance of Mitosis & Meiosis.

Credit IV: Cell Death Pathway

4.1 Introduction to cell death pathway: Necrosis, Senescence, Apoptosis (Programmed cell death).

4.2 Mechanism of Apoptosis: Apoptosis inducing factors

4.3 Apoptosis: triggered by internal signals, triggered by external signals.

4.4 Apoptosis in cancer, organ transplants.

4.5 Apoptosis in plants.

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SEMESTER I – CELL BIOLOGY (BT152P)

PRACTICALS

1. Demonstration of osmosis.
2. Identification of different stages of mitosis (onion root tips) by squash method.
3. Identification of different stages of meiosis (in onion flower buds) by smear method.
4. Isolation of nucleus, mitochondria& chloroplast by centrifugal techniques.
5. Isolation of naked plant cells (protoplast) and animal cell dissociation with trypsin.
6. Cell Cycle Synchronization.
7. Estimation of Na+ K+ ATPase in Red Blood Cells.
8. Determination of activity of Proton, Na^+, Antiport from Plant cells.

SPOTTERS: Na+ Ka+ pump; Phagocytosis; Endoplasmic reticulum; Tight and Gap junctions; G-protein; Cyclins and CDKs; Synaptonemal complex; Kinetochore; Necrosis; Endocytosis.

Books Recommended:

1. Cell & Molecular Biology. E.D.D De Robertis & E.M.F De Robertis, waverly publication.
2. Molecular Biology of the cell. Alberts, B; Bray, D, Lews, J., Raff, M., Roberts, K and Watson, J.D. 1991 3rd edn. Garland publishers, Oxford

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SEMESTER I: PAPER III – BIOCHEMISTRY (BT103T)

Credit I: Biomolecules - I

1.1 Carbohydrates–Classification, properties and biological significance.
1.2 Structure& functions of Monosaccharides, Disaccharides & Oligosaccharides.
1.3 Structure & functions of Polysaccharides.
1.4 Amino Acids: Classification, structure, properties &general reactions of amino acids, Nonprotein or unusual amino acids.
1.5 Proteins: Classification, structural organization and properties, Peptide bond stability & formation, Polypeptides, glycoproteins, Methods for determining Molecular weight, Denaturation and Renaturation. Conformation of proteins - Ramachandran's plot, protein isolation and purification.

Credit II: Biomolecules - II

2.1 Nucleic Acids: Types (purines, pyrimidines), structure, properties, biosynthesis, degradation& disorders of nucleotide metabolism. Formation & stability of phosphodiester bond.
2.2 DNA: Watson & Crick model of DNA, Alternative forms of DNA (A, B, Z), Types (circular & super coiled).
2.3 RNA: Types (mRNA, non-coding RNAs- tRNA, rRNA, ScRNA, SnRNA, SiRNA, miRNA), properties &Structure.
2.4 Lipids: Structure, properties & classification, Types (fatty acids, waxes, phospholipids, sphingolipids, cerebrosides, lipoproteins and gangliosides). Prostaglandins (prostacyclins, leukotrienes, thromboxane and physiological implications).
2.5 Porphyrins - Steroids and bile acids. Structure / function of Haeme &chlorophyll, synthesis and degradation of Haeme (formation of bilirubin and jaundice), biological significance of cytochrome and carotenoids.

Credit III: Enzymes & Vitamins

3.1 Enzymes: Nature, Properties, Nomenclature & Classification, Catalytic RNA, abzymes, ribozymes, synzymes.
3.2 Rate of reaction: Factors affecting the rate of reaction/enzyme activity. Enzyme Kinetics: Michaelis-Menten equation – derivation, Briggs - Haldane equation, steady state assumptions.
3.3 Techniques of enzyme immobilization: adsorption, entrapment, covalent binding, cross linking, Properties and applications of immuno enzymes.
3.4 Enzyme Inhibition & Enzyme Regulation. Applications of enzymes in medicine and industry.
3.5 Vitamins: source, structure, biological role, and deficiency disorders of fat soluble and water-soluble vitamins.

Credit IV: Intermediary Metabolism & Bioenergetics

4.1 Glycolytic Pathway: Glycolysis, TCA Cycle, Electron Transport Chain, Oxidative Phosphorylation, Photophosphorylation.
4.2 Glyoxylate Pathway: Pentose Phosphate Pathway, Gluconeogenesis (Glucuronic Acid Cycle), Glycogenesis, Glycogenolysis.
4.3 Photosynthesis: Photosystems I & II, Light & Dark Phases, C3 & C4 and CAMP pathways, Bioluminescence.
4.4 Fatty acid Metabolism: β- Oxidation of fatty acids; Nucleotide metabolism: synthesis and degradation of purines and pyrimidines and associated disorders (Lesch Nyhan syndrome, Gout and SCID).
4.5 Nitrogen Metabolism: Cori cycle, Entner–Duodonoff Pathway, Nitrate & Ammonium assimilation, transamination and oxidative deamination, protein turnover.

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SEMESTER I – BIOCHEMISTRY (BT153P)

PRACTICALS

1. Qualitative analysis of carbohydrates.
2. Qualitative analysis of amino acids.
3. Determination of iso electric point of Glycine.
4. Estimation of protein by Lowry's, Biuret and Folin's method.
5. Assay of salivary amylase, bovine pancreatic trypsin.
6. Partial purification of enzymes- salt precipitation, gel filtration, ion exchange chromatography.
7. Factors affecting enzyme activity, calculation of activation energy.
8. Determination of aldose and ketose sugars. Determination of acid value, saponification and Iodine
   number of oils and fats.
9. Chromatographic methods:

Paper chromatography of carbohydrates, amino acids, purines and pyrimidines. 2D paper chromatography, TLC of fatty acids/lipids. Paper electrophoresis of amino acids. Cellulose acetate electrophoresis of serum proteins, Column Chromatography; Ion Exchange Chromatography determination of exchange capacity of resins (titric method), Identification of ion exchange resins separation of amino acids by Dowex - 50: Gel Filtration: Determination Vo separation of Blue dextran and Cobalt chloride or Protein and amino acid by Sepahdex-G10.

SPOTTERS:

Cellulose; Starch; Secondary Proteins; Quaternary Proteins; Heme &Chlorophyll; DNA supercoiling; Gluconeogenesis; Bioluminescence; Allosteric inhibition; Isozymes.

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SEMESTER I: PAPER IV – MICROBIOLOGY (BT104T)

Credit I: General Characters of Microorganisms

1.1 Introduction to microbiology: history, evolution and development. Diversity of microorganisms: distribution in nature, scope and importance.
1.2 Classification, structure, general characters and economic importance of microorganisms: Bacteria, Archaea, Cyanobacteria, Protozoa, Fungi and Algae
1.3 Diseases caused by bacteria, fungi and protozoans& clinically important bacteria and protozoa.
1.4 Types of antimicrobial agents, development of resistance by microorganisms to various chemicals, antiseptics, disinfectants.
1.5 Identification methods of bacteria and other microorganisms (morphology, physiology, biochemistry, ecology, numerical taxonomy, chemo taxonomy and molecular based approaches).

Credit II: Viruses

2.1 Classification &General characters of each group
2.2 Structure and replication of Bacteriophage (T2), Lambda
2.3 Retroviruses, TMV, HIV, Hepatitis, Rota virus, Adeno, Polio, Corona, SV40, Prions
2.4 Methods of cultivation of viruses
2.5 Importance of viruses in biotechnology

Credit III: Microbiological Techniques

3.1 The study of microbial structure: Microscopy (principles and types), preparation and staining of specimens, fixation, dyes.
3.2 The study of microbial control: Sterilization (Concept, methods and its application in industry)
3.3 Concept of pure culture and methods of pure culture development
3.4 Methods of preservation of microbial cultures of industrial application
3.5 Culturing of microorganisms- Methods of microbial culturing in laboratory and industry

Credit IV: Microbial Physiology, Growth & Diversity

4.1 Nutrition in Microorganisms: nutritional and growth factors requirement of microorganisms, assimilation and uptake of nutrients, Nutritional groups of microorganisms and their importance in fermentation industry, Microbiological media: types and applications.
4.2 Microbial growth – (Exponential, Synchronous), batch fed batch and continuous cultures, Factors affecting growth, growth curve, Methods for measurement of growth in microbes, control of microbial growth by physical and chemical agents.
4.3 Environmental microbiology: Distribution of microbes in air and water, allergic disorders by air microflora, air sampling, water treatment, bacteriological analysis of water, bioleaching, bioremediation.
4.4 Agricultural microbiology: plant- microbes interaction, microbial biodeterioration of Agricultural products, control of microbes and safe storage of agricultural products, biofertilizers.
4.5 Medical microbiology: host parasite interactions, recognition and entry process of different Pathogens in plants and animals, toxins produced.

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BT154 P - MICROBIOLOGY
PRACTICALS

1. Isolation methods: pour plate, streak plate and dilution methods
2. Staining methods: simple, Gram, spore, capsule, acid fast and negative
3. Determination of motility: by hanging drop method
4. Determination of potability of water by MPN test
5. Microbiological examination of milk y Resazurin test.
6. Antibiotic sensitivity test by disc and well diffusion method
7. Observation of permanent slides of protozoa, fungi and algae.
8. Isolation of bacteria, fungi and algae
9. Isolation of bacteriophages from sewage and soil.
10. Measurement of microbial growth (Viable count and turbidometry)
11. Study for bacterial growth curve
12. Evaluation of disinfectants and antiseptics

SPOTTERS: General structure -Bacteria; HIV/ Corona virus; Prions; Autoclave; Microbial growth curve; Lyophilization; Electron microscope; Bacteriophages, serial dilution.

Books Recommended:

1. Microbiology by M.J. Pelzar, E.S.N. Cfan and N.R. Kreig, McGraw Hill Publ.
2. Introductory Microbiology by J. Heritage, E.G.V. Erans, R.A. Killington, Cambridge University Press.
3. General Microbiology by H.G. Schlegel Cambridge University Press.
4. General Microbiology by Stanier, R.Y, J.L. Ingrahm, M.L. Wheel is & P. R. Painter.
5. Microbiology – concepts and Application. John Wiley and Sons, New York,1988.

SEMESTER II: PAPER I – MOLECULAR BIOLOGY (BT201T)

Credit I: Genome Organization

1.1 Prokaryotic genome organization

1.2 Organization of eukaryotic genome: Genome size, c-value paradox, DNA re-association kinetics, Kinetic classes – unique, repeated sequences – (high & moderate), Palindromes & Satellite DNA

1.3 Special features of eukaryotic genes – gene structure and organization, structure of chromatin, Fine structure of gene, different kinds of genes – split genes, overlapping genes, assembled genes, polyprotein and nested genes.

1.4 Organization of mitochondrial & chloroplast genome

1.5 Gene clusters and gene families – Immunoglobulin gene cluster, Globin gene family

Credit II: Genetic Material, Replication and Recombination

2.1 DNA as genetic material (Experiments of Griffith, Avery et al and Hershey &Chase), RNA as genetic material (TMV)

2.2 Replication of DNA – Meselson and Stahl's experiment, enzymes involved, Mechanism (prokaryotic, eukaryotic: nuclear, organellar), types, regulation, inhibition, Replication of circular and linear DNA, replication of telomeres and its significance.

2.3 Recombination in bacteria: Transformation (mechanism, competence factors), Conjugation (F plasmid, H, Hfr).

2.4 Recombination in viruses: Transduction (generalized, specialized), RNAi and gene silencing, genome editing technologies: TALENS, CRISPR-CAS9.

2.5 mapping genes by transformation, conjugation and transduction

Credit II: DNA Damage, Repair & Rearrangements

3.1 DNA Damage: Mutations (Spontaneous and Induced)– Physical and Chemical mutagenesis

3.2 Molecular mechanisms of mutagenesis – Transition, Transversion, Frame Shifts, mis-sense and non-sense mutations, detection of mutations: CLB method & attached method.

3.3 DNA Repair: mechanism, types (Photo-reactivation, Excision, Mismatch, Post-replication, SOS)

3.4 Genome Rearrangements: Duplication (Complete and Segmental Duplication), Insertion, Deletion, Translocation & Transposon and Repeats mediated Rearrangements, Molecular mechanisms of Gene Conversion

3.5 Homologous Recombination – rec Pathways, Site specific Recombination, Non-homologous End Joining

Credit IV: Transcription, Translation & Regulation

4.1 Transcription: RNA polymerases& Mechanism (prokaryotic, eukaryotic), Post transcriptional Events (RNA processing m, r, t): Splicing – mechanism & types (alternate splicing, trans splicing, self- splicing, tRNA splicing), Capping and polyadenylation), RNA editing and transport, Transcription factors, activators (zinc fingerprints, GAL4, Homeodomain), enhancers and mediators, molecular tools: run off transcription and G Less cassette transcription, nuclear run on transcription, reporter gene transcription, Role of enhancers, cis trans elements, DNA methylation and chromatin re modelling in gene expression.

4.2 Translation: Mechanism, assembly of ribosomal subunits, Peptide chain formation & Post translational modifications.

4.3 Genetic Code: Properties, correspondence of amino acid sequence in proteins with nucleotide sequence in DNA, single letter codes for amino acids

4.4 Co-ordinated Regulation of Gene expression in prokaryotes: positive and negative control, concept of operon, Regulation of lactose operon, Tryptophan operon

4.5 Regulation of gene expression in Eukaryotes: Genes controlling yeast mating type, Xenopus 5S rRNA in oocytes, chicken Globin genes, silk fibroin gene, Drosophila sex determination, Environmental regulation of gene expression.

SEMESTER II – MOLECULAR BIOLOGY (BT251P)

PRACTICALS

1. Isolation of genomic DNA from bacteria.
2. Isolation of plasmid DNA from bacteria
3. Isolation of eukaryotic genomic DNA (plant/animal).
4. Southern blotting & Northern blotting techniques.
5. DNA denaturation and hyperchromic effect.
6. Demonstration of cDNA synthesis from RNA.
7. Determination of purity and concentration of DNA – Spectrophotometric method
8. Induction of mutations by chemical agents
9. Determination of DNA damage by commet assay
10. Determining melting temperature of DNA
11. Reassociation Kinetics and estimation of cot values, construction of cot curves

SPOTTERS: Griffith experiments; Meselson and Stahl's experiment; telomerases; thymine dimers; Conjugation mapping; Transposons; Duplication of genomes; SOS repair; Hfr; Homologous recombination. Satellite DNA; Mitochondrial genome; c-value paradox; alternate splicing: Genetic code, Wobble hypothesis; Lac operon, Drosophila sex determination; Tryptophan operon; coupled transcription translation.

References

1. Molecular Biology of the Gene by J.D. Watson, N.H. Hopkins, J.W, Robertis , A. Steitz& A.M.Weiner, Benjamin cummings Publ. California - 1988
2. Genes VII. Benjamin Lewin, Oxford Univ. Press, Oxford(2000)
3. Molecular Biology by D, FreifelderNarosa Publishing house New York, Delhi,1987.
4. Molecular Cell Biology Lodish, H., Baltimore, D; fesk, A., Zipursky S.L., Matsudaride, P. and Darnel 4th edn. American Scientific Books. W.H. Freeman, NewYork (2000).
5. Advance Molecular Biology Twyman, R.M., Bios Scientific publishers Oxford1998.
6. Molecular Biology by Brown, 3rdedition.
7. Essentials of Molecular Biology. D. Freifelder, Panima publishing corporation.

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SEMESTER II: PAPER II – INDUSTRIAL BIOTECHNOLOGY (BT202T)

Credit I: Selection of Industrial Microorganisms

1.1 Technology of microbial growth: principles of microbial growth, methods to increase yield of microbes.
1.2 Industrial cultures – Bacteria, Algae, Fungi, Actinomycetes
1.3 Primary and secondary screening of microorganisms for industrial products.
1.4 Isolation, preservation & maintenance of industrially useful microorganism strains.
1.5 Strain improvement (Strain development- mutation, selection & recombination) of industrially useful microorganism strains.

Credit II: Fermentation Process

2.1 Fermenter/ Bioreactor: types & operations, limitations
2.2 Fermentation: process (batch, fed batch and continuous), types (aerobic, anaerobic), factors affecting, stages of fermentation processes,
2.3 Design of Fermentation media.
2.4 Introduction to Batch, Fed batch and continuous culture systems.
2.5 Solid substrate fermentation, advantages and disadvantages of solid substrate and liquid fermentations.

Credit III: Production of Microbial Products

3.1 Production of primary and secondary metabolites: a brief outline
3.2 Production of primary metabolites: Organic acids (citric acid, lactic acid, acetic acid & Gluconic acid), Amino acids (glutamic acid, lysine & aspartic acid).
3.3 Production of primary metabolites: Alcohols (beer, wine) & Organic solvents (ethanol, acetone & butanol) Enzymes (proteases, amylases, lipases, cellulases & pectinases).
3.4 Production of secondary metabolites: Antibiotics (penicillin, streptomycin & erythromycin),
3.5 Production of Vitamins (B_{12}, D, Riboflavin & C)

Credit IV: Health Care Products and Food Additives

4.1 Production of biopesticides, biofertilizers, biodiesel, bio preservatives (Nisin).
4.2 Production of single cell proteins
4.3 Production of dairy products – cheese, yoghurt & other products
4.4 Production of recombinant proteins with therapeutic and diagnostic applications.
4.5 Production of Vaccines – BCG, hepatitis-B & recombinant vaccines

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SEMESTER II – INDUSTRIAL BIOTECHNOLOGY (BT252P)

PRACTICALS

1. Production and estimation of citric acid by *Aspergillus niger.*
2. Production and estimation of alcohol by *Saccharomyces cerevisiae.*
3. Production and estimation of red wine from grapes.
4. Production and estimation of glutamic acid from *Corynebacterium glutamicum.*
5. Production and assay of amylase activity by shake flask method batch fermentation.
6. Isolation of proteolytic enzymes from soil sample
7. Production of baker's yeast and inoculum preparation.
8. Immobilization of an enzyme by gel entrapment.
9. Selective isolation of actinomycetes and fungi from soil samples.
10. Microbiological assay of an antibiotic including the construction of standard curve.

SPOTTERS: Penicillin; Vitamin B12; Recombinant vaccines- Banana; Amylase; Citric acid; Fermenter; Biosensors; Strain improvement; Yoghurt

References

1. Comprehensive Biotechnology Vol. 1-4: M.Y. Young (Eds.), PergamonPress
2. Biotechnology- A Text Book of industrial microbiology, T.D. Brock, Smaeur Associates1990
3. Industrial Microbiology: L.E. Casida, Willey Eastern ltd.,1989
4. Industrial Microbiology: Prescott & Dunn, CBS Publishers,1987
5. Bioprocess technology – Fundamentals & applications, S.O. Enfors & L.Hagstrom (1992), RIT, Stockholm
6. Biotechnology, Economic & Social Aspects: E. J. Dasilva, C. Ratledge & A. Sasson, Cambridge Univ. Press
7. Biotechnology – Handbook of Industrial microbiology: W. Crueger & A. Crueger
8. Microbial Biotechnology: A. N. Glazer and H.Nikaids

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SEMESTER II: PAPER III – IMMUNOLOGY (BT203T)

Credit I: Basics of Immunology

1.1 Introduction to Immunology: Immunity (Innate & Acquired), Immune system and its components, barriers (external & internal), phagocytosis, pattern recognition and Toll like receptors in innate immunity.

1.2 Cells (B & T Lymphocytes; macrophages, neutrophils, NK, NKT cells, T-cell sub-sets; Antigen Presenting Cells) & organs of the Immune System (Primary lymphoid organs - Bone marrow and Thymus; Secondary lymphoid organs -lymph nodes, spleen and mucosal-associated lymphoid tissue.

1.3 Antigens – immunogens, Adjuvants, Haptens, super antigens, Immunogenicity versus Antigenicity, Factors influencing immunogenicity, Epitopes -Properties of B- and T-cell epitopes.

1.4 Antibodies: Fine structure, Immunoglobulin domains, Immunoglobulin classes and functions.

1.5 Organisation and expression of immunoglobulin genes, Antibody diversity, Class switching, Monoclonal Antibodies - Formation and selection of hybrid cells; Production of Monoclonal Antibodies and their clinical uses, hybridoma technology.

Credit II: Techniques in Immunotechnology

2.1 Antibody and Antigen interactions: Types (affinity, avidity, antibody valency, agglutination, precipitation) and kinetics of antigen antibody interactions, models of antigen antibody interaction with single and multiple binding sites.

2.2 Agglutination & blood groups: AB, Rh system, precipitin curve. Immunodiffusion, immune electrophoresis, radioimmunoassay: ELISA. Immuno fluorescence, biosensor assays for assessing ligand – receptor interaction

2.3 Staining techniques for live cell imaging and fixed cells

2.4 Flow cytometry: instrumentation and applications

2.5 Cell functional assays: lymphoproliferation, cell cytotoxicity, mixed lymphocyte reaction, cytokine expression, apoptosis, reporter assays.

Credit III: Major Histocompatibility Complex (MHC)

3.1 General organization and inheritance of MHC; MHC Haplotypes

3.2 Structure and Organization of MHC Class –I and class-II molecules, peptide binding of MHC molecules. Polymorphism of MHC class I and class II molecules; the role of HLA typing in organ transplantation.

3.3 Cellular distribution of MHC molecules, MHC molecules and immune responsiveness.

3.4 Structure and function of T cell receptors (TCR), B Cell activation and proliferation by thymus independent and Thymus dependant antigens; *in vivo* sites for induction of humoral response;

3.5 Cell mediated immunity: General properties of effector T cells; Direct cytotoxic response; experimental assessment of cell mediated cytotoxicity. Types of hypersensitive reaction, Auto immunity and auto immune diseases (Insulin dependent diabetes, Rheumatoid Arthritis an Auto immune Thyroid disease

Credit IV: Immune Responses

4.1 Nature of immune response in different types of infections: viral infections (influenza, H5N1), bacterial infections, parasitic infections. Inflammation – mechanisms of inflammatory response, inflammasome activation.

4.2 Immune response in immunodeficiency diseases: congenital immunodeficiencies - SCID, Wiskott Aldrich syndrome (WAS), X linked agammaglobulinemia, common variable immunodeficiency (CVI), acquired immunodeficiencies – immunobiology of HIV infection and AIDS.

4.3 Immunobiology of cancer: malignant transformation of cells, oncogenes and cancer induction, tumour antigens, immune response against tumours, tumour editing, cancer immunotherapy.

4.4 Transplantation immunology, immunological response in transplantation and graft rejection,

clinical manifestation of graft rejection, tissue typing, GVHD. General and immunosuppressive therapies, immune tolerance to allografts, applications of organ and cellular transplantations.

4.5 Immunological tolerance: factors involved in maintaining tolerance. Auto-immunity and auto-immune diseases-organ specific and systemic, Insulin Dependent Diabetes; Rheumatoid Arthritis and Auto- immune Thyroid disease, hypersensitivity- mechanism and pathophysiology of different types of hypersensitivity. Complement system: classical, alternate and mannose binding lectin pathways, biological functions and regulation.

SEMESTER II – IMMUNOLOGY (BT253P)

PRACTICALS

1. To detect the blood group of a given sample.
2. To perform differential count (DLC) of a given sample.
3. To perform the technique of Radial Immune Diffusion
4. To learn & perform the technique of Ouchterlony Double Diffusion.
5. To perform the pregnancy test using a diagnostic kit.
6. To learn the technique of Immuno electrophoresis.
7. To study the technique of Rocket Immuno electrophoresis for determination of concentration of antigen in an unknown sample.
8. To perform Widal test for detection of typhoid, VDRL test.
9. Micro-hemagglutination Test
10. Enzyme-Linked Immuno-sorbent Assay
11. Cell-viability Test by Trypan Blue
12. Principle and procedure for Enumeration of specific blood types by FACS (Florescent Activated Cell Sorter)
13. Demonstration of Western Blot by Enzyme-conjugated antibody
14. Blood smear identification of leucocytes by Giemsa staining.

SPOTTERS: Radial immuno diffusion (RID); ELISA; FACs; Antibody; HIV; B-cell & T-cell; Thymus; Monoclonal Antibodies; MHC; Rheumatoid arthritis.

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SEMESTER II: PAPER IV – BIOSTATISTICS & BIOPHYSICAL TECHNIQUES (BT204T)

Credit I: Descriptive Statistics & Probability Distribution

1.1 Sampling - Sampling procedure, homogenization of samples, samples size, Selection of random sample, Limitation of analytical methods, classification of errors, measurement of averages and variation, minimization of errors.

1.2 Types of data, Frequency distribution, Measure of central values - Mean, median and mode, Measures of dispersion - range, mean deviation, standard deviation, coefficient of variation, moment, Skewness and kurtosis. Graphical representation of Data, Histogram, Frequency polygon, Pie Chart

1.3 Probability, Concept of Probability Theory, Events, Trials, Mutually exclusive events, Favourable events, exhaustive events, Bayesian theorem of Probability, Addition theorem, Multiplication theorem

1.4 Binomial distribution, Normal distribution, Poisson distribution & their applications.

1.5 Discriminating power, Derivation, Evaluation of evidence by discriminating powers. Combination of independent systems, Correlated attributes, transfer of evidence, Likelihood ratio

Credit II: Statistical Inference of Qualitative & Quantitative variables

2.1 Concept of Test of hypothesis, Null & Alternative hypothesis, level of significance, Chi square test & its applications, Large Sample Tests- Z-test of Means & Proportions, Small sample test - T-test for Means, Paired T-test.

2.2 Analysis of variance and Co-variance

2.3 One-Way ANOVA, Two-way ANOVA, F-test

2.4 Simple regression and correlation

2.5 Test of regression coefficient and correlation Coefficient

Credit III: Biophysical Techniques - I

3.1 Principles and applications of chromatographic techniques: paper, TLC, gel filtration, ion exchange, affinity, GC, HPLC, GC-MS.

3.2 Electro kinetics: electro osmosis, and electrophoresis, Helmholtz-Smoluchowski equation, zeta potential

3.3 Principles and concepts of electrophoretic techniques: native PAGE, SDS-PAGE, AGE, capillary, IEF, 2D, pulse field & diagonal.

3.4 Principles and applications of centrifugation techniques: differential, density gradient, rate zonal, isopycnic, types of rotors, analytical centrifugation: sedimentation coefficient, boundary sedimentation, band sedimentation.

3.5 Biosensors: principle, design and applications.

Credit IV: Biophysical Techniques - II

4.1 Spectroscopy: beer lamberts law, principles, instrumentation and applications of visible and UV spectrophotometry.

4.2 spectrofluorimetry (FRET), FTIR, NMR spectroscopy.

4.3 Spectroscopy and thermal analysis: principles, instrumentation and applications of emission/ absorption spectrophotometry and their comparative study, mass spectroscopy.

4.4 Principles and applications of optical rotator dispersion (ORD), circular dichroism (CD),

4.5 Electron spin resonance spectroscopy, fluorescence spectroscopy, X ray diffraction.

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SEMESTER II – BIOSTATISTICS & BIOPHYSICAL TECHNIQUES (BT254T)

PRACTICALS

1. problems on measures of central tendency- mean, median, mode
2. problems on variance, standard deviation, standard error
3. Problems on probability distribution – binomial, poisson, normal.
4. problems on chi square test
5. Large sample test (Z test) for sample means and proportions.
6. Small sample test (T test) for sample means and proportions.
7. Calculation of correlation and regression coefficient.
8. ANOVA- one way and two-way classification.
9. Separation of bio molecules by paper chromatography
10. Separation of bio molecules by thin layer chromatography
11. Separation of amino acids/proteins by ion exchange chromatography
12. Separation of proteins by gel filtration and determination of molecular weight of a protein.
13. Separation of protein by SDS PAGE and determination of molecular weight
14. Purification of enzyme by affinity chromatography
15. Determination of molar extinction coefficient of tryptophan/ tyrosine

Spotters: Graphical representation of data; HPLC; SDS-PAGE, Spectroscopy: Isopycnic Centrifugation; T-test; Chi-square test; TLV; Z-test, Standard error.

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SEMESTER III: PAPER I
R-DNA TECHNOLOGY (BT301T)

Credit I: Enzymes and Vectors Used in Molecular Cloning

1.1 Host controlled restriction modification
1.2 Restriction endonucleases and classification
1.3 Modifying enzymes used in molecular cloning: methylases, polymerases, ligases, kinases, phosphatases, nucleases, RNA dependent DNA polymerase, Terminal Deoxy nucleotidyl transferase.
1.4 Vectors used for cloning: *E. coli* plasmid vectors – pBR322, pUC18, pET21; expression vectors: (pET)
1.5 Vectors for library preparation: Bacterio-phage vectors – λ andM13; cosmids, phagemids, Phasmids; Shuttle vectors; Viral vectors: SV40, Baculo virus, CaMV (cauliflower mosaic virus), BAC, YAC.

Credit II: Construction of Genomic and cDNA Libraries

2.1 Introduction to cloning (conventional and recombinant based).
2.2 Strategies for construction of genomic libraries.
2.3 Chromosome walking and chromosome jumping for positional cloning of genes.
2.4 Strategies for construction of cDNA libraries, subtraction libraries & normalized libraries.
2.5 PCR: principle, types and applications.

Credit III: Selection and Characterization of Recombinant Clones

3.1 Genetic selection – alpha complementation and insertional inactivation.
3.2 Labelling of nucleic acids and proteins, nucleic acid probes and probe construction.
3.3 Selection of recombinant clones: Blotting and Hybridization techniques – Southern, Northern, Western, South-Western and Zoo blots; Colony hybridization & fluorescent in situ hybridization; Hybrid arrest and hybrid released translation.
3.4 DNA sequencing methods – Maxam - Gilbert and Sanger's method; automated sequencing.
3.5 DNA arrays: principle, spotted DNA array; oligonucleotide chips.

Credit IV: Techniques and Applications of Recombinant DNATechnology

4.1 Site directed mutagenesis and RNA interference.
4.2 Knock-in and knock-out technology.
4.3 Genome editing: CRISP-CAS system, TALENs and zinc finger nucleases.
4.4 Next Generation Sequencing – principle, types and applications.
4.5 Applications of rDNA technology in agriculture, animal husbandry, medicine and industry.

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SEMESTER III –R-DNA TECHNOLOGY (BT351P)

PRACTICALS

1. Amplification of genomic DNA by PCR technique.
2. Restriction digestion of genomic or lambda DNA, separation of DNA fragments by agarose gel electrophoresis and size determination of the fragments.
3. Elution of DNA from agarose gels, ligation of DNA fragments.
4. RAPD and RFLP analysis.
5. Double digestion of DNA and restriction mapping, problems on restriction mapping.
6. Cloning of foreign DNA fragments into E. coli/yeast.
7. Selection of recombinant clones by alpha complementation / insertional inactivation.
8. Analysis of recombinant clones.
9. Expression of foreign protein in heterologous host.
10. PCR based site directed mutagenesis.

SPOTTERS: Restriction endonucleases; Phage vector; Thermocycler; Blotting; Electrophoresis; DNA sequencing methods; Golden rice; Recombinant insulin; Linkers and adaptors; Alpha complementation.

References:

1. Molecular Biology of the gene by J. Watson
2. Genes Vol VI, VII and VIII by Benjamin Lewin
3. Molecular Biotechnology Principles and application of recombinant DNA
4. Principles of Gene manipulation by R.W. Old and S. B. Primrose
5. Molecular Biology by Robert F. Weaver
6. Recombinant DNA: A short course by J. Watson, Tooze and Kurtz
7. Molecular Biology by J. Watson

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SEMESTER III: PAPER II – BIOINFORMATICS (BT302T)

Credit I: Foundations to Bioinformatics

1.1 Bioinformatics: a historical perspective.
1.2 Bioinformatics data – nucleic acid sequence, protein sequence, protein structure, genomic, proteomic and metabolomic information.
1.3 Bioinformatics databases – types, design, file formats, access tools with examples.
1.4 Bioinformatics tools and Resources – free online tools, downloadable free tools, software packages, Bioinformatics books and Journals, Bioinformatics web-portals.
1.5 Role of internet in Bioinformatics.

Credit II: Comparison Methods in Bioinformatics

2.1 Basics of sequence alignment - homology, match, mismatch, gaps, scoring alignments, gap penalty, sequence relationships (homologs, orthologs, paralogs & xenologs)
2.2 DNA vs protein alignment: permissible replacements, similarity core, scoring matrices- PAM, BLOSUM.
2.3 Pairwise alignment – Dot-matrix comparison, dynamic programming algorithms (global-Needleman and Wunch algorithm, local-Smith and Waterman algorithm).
2.4 Pair wise alignment-based database searching: heuristic algorithms- Blast algorithm, FASTA algorithm.
2.5 Multiple sequence alignment: algorithms (progressive, Iterative), Multiple sequence alignment-based databases searching (profile BLAST), Consensus sequence, profile and position specific scoring matrix.

Credit III: Genomic Applications of Bioinformatics

3.1 Bioinformatics for genome sequencing (reads, contigs, scaffolds).
3.2 Transcript profiling: microarrays, transcriptome sequencing, RNA seq analysis.
3.3 Genome annotation: open reading frames, finding repeats, finding genes in Prokaryotic and eukaryotic genomes, finding promoters and regulatory motifs.
3.4 Bioinformatics for Genome maps and markers
3.5 Bioinformatics for Genome variation studies

Credit IV: Proteomic and Metabolomic Applications of Bioinformatics

4.1 Medical applications of Bioinformatics: pharmacogenomics, drug designing
4.2 Protein structure prediction and classification, Bioinformatics in support of Proteomic research
4.3 Protein Structural biology – Homology modeling
4.4 Bioinformatics for metabolic networks: pathways & reconstruction
4.5 Bioinformatics for phylogenetic analysis
4.6 Molecular modelling and molecular docking.

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Dichpally, Nizamabad-503 322

SEMESTER III – BIOINFORMATICS (BT352P)

PRACTICALS

1. Using NCBI & other web resources (EMBL, Genbank, Entrez, Swissprot/TrEMBL, Uniprot).
2. Introduction and use of various genome databases.
3. Dot-matrix comparison – understanding sliding window, window size (word size) and stringency
4. Pairwise alignment using algorithms
5. Multiple sequence alignment using Clustal Omega
6. Sequence similarity searching of DNA& protein sequences using tools like FASTA and BLAST
7. Downloading DNA sequence data (Genbank/DDBJ/EBI).
8. Downloading protein sequence data (Uniprot).
9. Downloading protein structure data (PDB/MMDB) and visualisation.
10. Construction of phylogenetic tree using MEGA software
11. Understanding & using ORF and gene prediction methods (Genscan, Glimmer).
12. Primer designing & restriction site prediction tools (primer 3 software).
13. Using RNA structure prediction tools.
14. Using various protein structure prediction tools & databases (CATH, SCOP, PDB).
15. Molecular docking by using Swiss Dock tool.

SPOTTERS: NCBI, PDB, EXPASY, BLAST, wheat genome, Rice genome, microarrays, phylogeny: distance tree, maximum parsimony, CLUSTAL omega, FASTA, Bioinformatic web portals.

Recommended Books:

1. Bioinformatics: Sequence and Genome Analysis by David W. Mount, Cold Spring Harbor Laboratory Press
2. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids by Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison, Cambridge University Press.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Second Edition by Andreas D. Baxevanis, B. F. Francis Ouellette, Wiley- Inter science
4. Foundations to bioinformatics – Evolution, similar macromolecular components, constancy of gene Number and core proteome in closely related organisms
5. Bioinformatics data – nucleic acid sequence, protein sequence, protein structure, genomic, proteomic and Metabolomic information
6. Bioinformatics databases – types, design, file formats, access tools with examples
7. Bioinformatics tools and Resources – free online tools, downloadable free tools, software packages, internet, Bioinformatics books and Journals, Bioinformatics web-portals.

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Dichpally, Nizamabad-503 322

SEMESTER III: PAPER III – BIOPROCESS ENGINEERING (BT303T)

Credit I: Fundamentals of Bioprocess Engineering

1.1 Introduction to bioprocess engineering
1.2 Bioprocess kinetics: Quantitative description of cellular process, Kinetic modelling, Model structures
1.3 Material balances and energy balances: Mass balances for ideal bioreactors
1.4 Cell immobilization, production of biomass and applications

Credit II: Upstream Processing

2.1 Designing of bioreactors: Bioreactor types, design configurations, design features for sterile operation
2.2 Transport phenomenon in bioprocess system: Mass transfer, heat transfer, Oxygen transfer
2.3 Shear stress effects and energy inputs in bioreactors
2.4 Sterilization of bioreactor: Design of sterilization process (batch and continuous),
2.5 Sterilization of air: sterilization of air, exhaust air; Sterilization of media: feed and liquid waste, sterilization by membrane filters.

Credit III: Downstream Process and Product Recovery

3.1 Downstream processing: A multi stage operation, Unit operations: solid liquid separation: filtration, centrifugation, filter aids, flocculation, foam separation (theory and equipment)
3.2 Recovery of intracellular components: Mechanical and non-mechanical (chemical and enzymatic methods)
3.3 Concentration of biological products: Evaporation, liquid-liquid extraction, Aqueous two-phase System (ATPS), membrane filtration, pervaporation, perstraction, precipitation, adsorption etc.
3.4 Purification of product: chromatography methods: Size exclusion chromatography, ion exchange, column-chromatography, chromato-focusing, hydrophobic interaction chromatography, affinity chromatography, immobilized ion metal chromatography, covalent chromatography.
3.5 Product formulation: Principles and equipment, crystallization, drying, use of different types of Dryers and lyophilization. Monitoring of downstream process and process integration

Credit IV: Bioprocess Control Measurement and Automation

4.1 Classes of sensors: In-line, on-line and off-line sensors
4.2 Physical and chemical sensors for media and gases: Instrumentation and principles for measurement of temperature, flow rate, pressure, agitation shaft power, foam sensing, biomass, dissolve oxygen, pH, carbon dioxide etc.
4.3 Automation and control system: manual control, automatic control, PID control and complex control systems.
4.4 Application of computers in bioprocess engineering: Data logging, analysis and control
4.5 Process economics: Cost benefit analysis

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SEMESTER III – BIOPROCESS ENGINEERING (BT353P)

PRACTICALS

1. Bioprocess description in quantitative terms, calculation of doubling time, estimating specific growth rate of target organism using kinetic models.
2. Determination of yield co-efficient and evaluation of Monod model.
3. Cell/tissue immobilization, production of biomass and harvesting of biological organism for analysis.
4. Development of laboratory scale bioreactors: knowhow.
5. Production of biotechnological products from immobilized yeast cells in packed bed bioreactor.
6. Recovery of product from fermentation broth and optimization of parameters.
7. Extraction of protein from a crude bioprocess homogenate using Aqueous Two-Phase System (ATPS)
8. Purification and identification of unknown compounds from a mixture of compounds using column chromatography and TLC

SPOTTERS:

Cell immobilization; Bioreactor; CSTR; Column chromatography; Up & down streaming; Depth filer; Batch Fed batch and continuous culturing; Centrifuge; Biomass production.

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SEMESTER III: PAPER IV -
INTELLECTUAL PROPERTY RIGHTS-ETHICS, ENTREPRENEURSHIP, LABORATORY MANAGEMENT-BIOSAFETY & RESEARCH METHODOLOGY (BT304T)

Credit I: Intellectual Property Rights & Ethics

1.1 Intellectual property rights: types (patents, trademarks, copyright related rights, industrial design, traditional knowledge, geographical indications),

1.2 IPs relevant to biotechnology and case studies, agreements and treaties, Rationale of IPRs in the fields of science and technology, protection of GMOs.

1.3 Patents – Concepts and principles of patenting, Procedure of obtaining patents, types of patent applications, patent filing procedure: national & PCT filing, Rights of patents, Infringement of patent rights, Patentability and emerging issues.

1.4 Ethics: Introduction – causes of unethical acts, Professional ethics, Ethical decision making, ethical dilemmas.

1.5 Bio ethics; ethical implications of biotechnological products and techniques, Teaching ethical values to scientists.

Credit II: Entrepreneurship

2.1 Introduction: Concept, definition, structure, types and theories of entrepreneurship.

2.2 Fundamentals of marketing, start-ups: setting of a small industry, location of an enterprise, steps, incentives & subsidies.

2.3 Process of entrepreneurial development: training, institution in aid of entrepreneur, entrepreneurial culture, entrepreneurial leadership, problems of entrepreneurship, risk and benefit, the art of negotiation, workable market and the strength of distribution.

2.4 Product planning and development: Project management, Search for business idea, Concept of projects, Project identification, formulation, Design and network analysis, Project report and project appraisal.

2.5 Bio entrepreneurship: Steps involved in the commercialization of a biotechnological product: establishment and marketing of biotechnology company, effective advertising, case studies.

Credit III: Laboratory Management & Biosafety

3.1 Administration of laboratories, laboratory design, security measures, laboratory bio security concepts, laboratory information management system (LIMS).

3.2 Laboratory safety: Good Laboratory Practices, Good Manufacturing Practices, Laboratory Accreditation.

3.3 Biosafety: introduction to biological safety cabinets, biosafety levels of specific microorganisms, handling & disposal of biological strains (fungal & bacterial).

3.4 Biosafety guidelines: definition of GMO's & LMO's, roles of institutional biosafety committee, applications in food and agriculture, environmental release of GMOs, risk analysis, risk management and communication,

3.5 National regulations and relevant international agreements, Cartagena Protocol.

Credit IV: Research Methodology

4.1 Introduction- Basic, applied & need based research

4.2 Identification of the problem, defining the problem, Research project planning

4.3 Literature search – information sources, library resources, online literature search, Design of the experimental programme – variables in the experiments, materials and methods, evaluation of methods

4.4 Progress of research – evaluation of results, statistical approach, comparison with existing methodologies, validation of findings, scientific publication writing, research communications, impact factor of journals, peer review process

4.5 Research ethics and plagiarism

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SEMESTER IV: PAPER I –PLANT BIOTECHNOLOGY (BT401T)

Credit I: Clonal Propagation of Plants

1.1 Plant Tissue Culture: historical perspective, sterilization techniques, media preparation, role of nutrients & hormones, terms used in tissue culture.

1.2 Establishment of *in vitro* cultures: callus culture, cell suspension culture, organogenesis, somatic embryogenesis.

1.3 Micro propagation: stages & applications, methods to detect pathogens in propagated sources, procedures to eliminate pathogens from plant parts.

1.4 Production of haploids: anther, pollen, embryo & ovule culture and their applications.

1.5 Protoplast isolation, culture and fusion& its applications.

1.6 Technology of freeze preservations and crop improvement.

Credit II: Production of Commercially Useful Compounds by Cell Cultures

2.1 Introduction, types and industrial importance of plant secondary metabolites.

2.2 Advantages of cultured plant cells and tissues as a source for commercial production of secondary Plant products

2.3 Physical and chemical factors (permeabilization, elicitation and immobilization of cells) that influence the production of secondary metabolites through cell culture *invitro*

2.4 Induction of hairy root cultures and their uses

2.5 Somatic hybridization: methods & applications, cybrids, soma clonal variations, synthetic seeds & germplasm conservation.

Credit III: Transgenic Technology

3.1 Methods of gene transfer in plants: *Agrobacterium* mediated (Ti& Ri plasmids, T-DNA (vector mediated transfer), direct gene transfer, PEG mediated, particle bombardment gene gun transformation.

3.2 Advanced methodologies: cisgenesis, intragenesis and genome editing.

3.3 Genetically modified value-added crops and social issues, Identification of transgenic plants.

3.4 Transgenic technology: development of herbicide resistant, insect resistance (Bt toxin, protease inhibitor), disease resistant (bacterial, fungal, viral) & genetic improvement of abiotic stress tolerance (Drought, Flooding Salt, High and low (cold) temperature, Photooxidative (light) & Metal Stress tolerance).

3.5 Gene editing with TALEN and CRISPER technology.

Credit IV: Applications of Plant Biotechnology

4.1 Molecular markers (RFLP, RAPD, AFLP & SSR) and their applications in crop improvement, Marker assisted selection (MAS)- strategies for introducing genes of agronomic importance, use of molecular markers for development of crops adaptable to stresses.

4.2 Molecular pharming: production & applications of edible vaccines, pharmaceuticals& plantibodies in plants.

4.3 Engineering for nutritional quality: improved seed storage proteins, improving and altering the composition of starch and plant oils. Enhancement of micro nutrients- beta carotene, and iron.

4.4 Types of nitrogen fixing microorganisms – Rhizobium, Azotobacter, Azolla, Cyanobacteria and fungal biofertilizers, *nif* gene.

4.5 Mode of action of bio fungicides (*Trichoderma, Pseudomonas flourescens*) and bioinsecticides (*Bacillus thuringiensis*, Baculoviruses).

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SEMESTER IV –PLANT BIOTECHNOLOGY (BT451P)

PRACTICALS

1. Preparation of media for plant tissue culture (MS & B5) & inoculation of sterilised explants
2. Establishment of callus culture from carrot cambial tissue
3. Embryo culture of Maize/Crotolaria
4. Direct and callus mediated organogenesis (tobacco/medicinal plants)
5. Induction of somatic embryos and preparation of synthetic seeds
6. Induction of hairy root cultures for the production of secondary metabolites
7. Genetic transformation of plants using *Agrobacterium tumefaciens.*
8. Confirmation of transgenics by PCR and Southern blotting
9. CRISPR/Cas-9 mediated gene editing in *Arabidopsis thaliana*

SPOTTERS: Totipotency; Protoplast technology; Elicitation; Biotransformation; Cell line selection; BT-cotton; Golden rice; RAPD & RFLP; Abiotic stress; Synthetic seeds.

Books Recommended

1. Plant Tissue Culture and its Biotechnological Applications By W. Barz, E. Reinhard, M.H.Zenk
2. Plant Tissue Culture By AkioFujiwara
3. Frontiers of Plant Tissue CultureBy Trevor A.Thorpe
4. In Vitro Haploid Production of Higher Plants By S. Mohan Jain, S.K. Sopory, R.E.Veilleux
5. Plant Tissue Culture : Theory and Practice By S.S. Bhojwani and A.Razdan
6. Plant Cell, Tissue and Organ Culture Applied AND Fundamental Aspects By Y.P.S. Bajaj and A.Reinhard

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SEMESTER IV: PAPER II –ANIMAL BIOTECHNOLOGY (BT402T)

Credit I: Animal Tissue Culture

1.1 Basic techniques in cell, tissue and organ culture; Media for culturing cells & tissues – natural media, BSS, MEM and serum free media and its sterilization
1.2 Different methods for the estimation of cell viability and cytotoxicity, kinetics of cell growth.
1.3 Development & maintenance of cell lines, sources of cell culture contamination and eradication, Cryopreservation and transport of germplasm, Applications of cell culture, bioethics and biosafety.
1.4 Cell hybridization, hybridoma & monoclonal antibodies production
1.5 Stem cells: types, isolation, culture& sorting. applications of stem cells in medicine, Apoptosis – mechanism and significance with reference to neuro degenerative diseases - Parkinson's disease and stroke.

Credit II: Animal Improvement

2.1 Conventional methods of animal Improvement – Selective Breeding, Cross Breeding
2.2 Embryo Biotechniques for augmentation of replication efficiency and faster multiplication of superior Germplasm.
2.3 In vitro culture of Oocyte /embryo, Super ovulation, Oestrus Synchronization, embryo collection and transfer, In vitro maturation of oocytes, in vitro fertilization, embryo culture & preservation
2.4 Micromanipulation and cloning, Somatic cell cloning, Embryo sexing
2.5 Gene mapping in farm animals; Marker assisted selection and genetic improvement of live stocks

Credit III: Development and Use of Transgenic Animals

3.1 Designer/ Transgenic animals as different disease models comparable to human system.
3.2 Production of transgenic animals: mouse, sheep, cattle and fish by microinjection, retro viral and embryonic stem cell methods; Transgenesis for animal improvement and production of animals as bioreactors for proteins
3.3 Gene therapy and its utilization.
3.4 Animal Cloning and xenotransplantation; Chemical and electrochemical gene transfection methods: microinjection, viral and other methods.
3.5 Newly emerging transgenic tools; Ethical issues related to animal biotechnology.

Credit IV: Vaccines and Therapeutic Agents

4.1 Sub-unit Vaccines, Live recombinant vaccines, Attenuated Vaccines, Anti-idiotypic vaccines
4.2 Monoclonal antibodies as therapeutic agents (transplant rejection),
4.3 Genetically engineered Immuno therapeutic agents
4.4 Tissue engineering: general process of bioengineering artificial tissue, design principles, 2D Vs 3D culture. Bioartificial skin, liver and pancreas.
4.5 Biopharming and gene knock out.

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SEMESTER IV –ANIMAL BIOTECHNOLOGY (BT452P)

PRACTICALS

1. Laboratory design and instrumentation in animal culture lab.
2. Quality assurance in animal tissue culture facility
3. Sterilization techniques used in ACTL
4. Preparation of animal cell culture media and membrane filtration
5. Isolation and culturing peripheral blood lymphocytes using ficoll gradiant.
6. Cell counting, viability assay, cryopreservation technique.
7. Subculturing and maintenance of cell lines.
8. In vitro anticancer assay (MTT assay).
9. Preparation of glycerol stocks and preservation of cell lines.
10. Developing animal models for diseases like, diabetes, cataract or nutritional deficiency

SPOTTERS: MABs; Mouse and *Caenorhabditis elegans* (Model Organisms); Superovulation; IVF technology: Xenotransplantation: Genetically engineered Vaccines and hormones; Bioartificial skin & liver; Immuno therapeutic agents; Gene therapy

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SEMESTER IV –ELECTIVE-I: MEDICAL BIOTECHNOLOGY (BT403T/A)

Credit I: Classification of Genetic Diseases

1.1 Chromosomal disorders – Numerical disorders e.g. trisomy & monosomy, Structural disorders e.g. deletions, duplications, translocations & inversions, Chromosomal instability syndromes.

1.2 Single gene disorders- sickle cell anaemia, Thalassemia; polygenic disorders- Alzheimer's disease, Type I Diabetes; Mitochondrial diseases: MELAS, LHON, MERRF;

1.3 Identification of disease genes: Functional cloning –eg. Hemophilia gene, Positional cloning – eg. DMD and CGD genes, Candidate gene approach – eg. Marfan's syndrome.

1.4 Molecular basis of human diseases –Gain of function mutations (Oncogenes, Huntington's Disease, Pittsburg variant of alpha 1antitrypsin); Loss of function (Tumor Suppressor Genes, PAX- 3gene); Gene Dosage Effect - PMP22, Collagen gene, Dynamic Mutations - Fragile- X syndrome, Myotonic dystrophy; Genomic Imprinting -Mechanisms, Praderwilli / Angelman syndrome, WAGR syndrome, Beckwith Weideman Syndrome.

1.5 Gene controlled diseases – Autosomal and X-linked disorders, Multifactorial conditions; Infectious disorders- Hepatitis, HIV; Autoimmune disorders-SLE, RA.

Credit II: Diagnostics

2.1 Prenatal diagnosis - Invasive techniques - Amniocentesis, Fetoscopy, Chorionic Villi Sampling (CVS), Non- invasive techniques - Ultrasonography, X-ray, TIFA, maternal serum and fetal cells in maternal blood

2.2 Diagnosis using protein and enzyme markers (PKU-Guthrie test, Dystrophy-creatine kinase), Diagnosis using monoclonal antibodies (hormonal disorders & infectious diseases).

2.3 DNA/RNA based diagnosis Hepatitis, CML – bcr/abl, HIV - CD4 receptor

2.4 Microarray technology- genomic and c DNA arrays, application to disease diagnosis,

2.5 genetic counselling-calculating risk and discussing the options.

Credit III: Therapeutics

3.1 Gene therapy - Ex-vivo, In vivo, In situ gene therapy; Strategies of gene therapy: gene augmentation, CFTR Prodrug therapy/ suicide gene, TFO, Antisense therapy, Ribozymes, Protein Aptamers, Intrabodies, SmaRT. Vectors used in gene therapy: Biological vectors – retrovirus, adenoviruses, Herpes Synthetic vectors–liposomes, receptor mediated gene transfer, Gene therapy trials – Familial Hypercholesterolemia, ADA deficiency, Cystic Fibrosis, Parkinson's disease, HIV, Solid tumors.

3.2 RNA interference and its applications in prevention of cancer and generation of antiviral drugs.

3.3 Therapeutic genome editing: ZFN, CRISPR-Cas (HIV), TALENS (leukemia).

3.4 Enzyme therapy- Gaucher disease, hormone replacement therapy- diabetes, growth hormone deficiency; cytokine therapy- interferons.

3.5 DNA based vaccines: subunit vaccines – Herpes Simplex Virus Attenuated Vaccines– Cholera; Vector vaccines – Rabies.

Credit IV: Gene Products in Medicine

4.1 Regenerative medicine: Stem cell therapy - Embryonic and adult Stem Cells, Totipotent, Pluripotent and Multipotent Cells; Potential use of stem cells – Cell based therapies

4.2 Cell and tissue engineering: Encapsulation technology and therapeutics-Diabetes, Hypothyroidism, Haemophilia, biomaterials-characteristics

4.3 Bioartificial organs (liver, heart auricles, blood vessels & skin)

4.4 Nanomedicine – Nanomaterials in medicine-quantum dots, dendrimers, peptide nanotubes, smart drugs, nanopore sensors, nanopore immune isolation devices, nanorobots (microbivores, respirocyte), DNA based nanodevices, Nanomedicine and Nano surgery – for cancers, neurological disorders.

4.5 Pharmacogenomics and drug delivery systems: controlled release mechanisms, administration routes.

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SEMESTER IV –ELECTIVE-I: MEDICAL BIOTECHNOLOGY (BT453P/A)

PRACTICALS

1. Genotyping of candidate genes for diseases by RFLP, Microsatellite and VNTR analysis
2. Screening for known mutations by ARMS PCR/ASO
3. Screening for unknown mutations by SSCP and sequencing
4. Detection for dynamic mutations - Trinucleotide repeat polymorphism
5. Identification of disease gene expression by RT-PCR
6. Sequencing of cDNA and cloning in expression vectors
7. Identification of foetal cells in maternal blood for detecting genetic defects
8. Detection of congenital abnormalities by triple test

SPOTTERS: Stem cell therapy; Nanomedicine; CRISPR-Cas 9; Autoimmune disorders, β-Thalassemia; Marfan's syndrome; Microarray; Cytokine therapy, CFTR; Antiviral drugs

References:

1. Introduction to Human Molecular Genetics – J.J Pasternak, John Wiley Publishers.
2. Human Molecular Genetics –Tom Strachen and A P Read, Bios Scientific Publishers
3. Human Genetics Molecular Evolution, McConkey,
4. Recombinant DNA Technology, AEHEmery
5. Principles and Practice of Medical Genetics, I, II, III Volumes by AEH Edts. Emery

SEMESTER IV –ELECTIVE-II: ENVIRONMENTAL BIOTECHNOLOGY (BT403T/B)

Credit I: Biomass and Bio-fuels

1.1 Plant biomass (Cellulose, starch, pectin, gum materials), Animal biomass (chitin, milk whey, Slaughter house wastes), Microbial biomass (algal blooms -in fresh and sea waters, Fungal- Mushrooms, yeasts and bacterial fermentation biomass wastes)
1.2 Concepts of single cell proteins, probiotics and their applications
1.3 Biomass feed stocks to fermentations
1.4 Microbial production of fuels: alcohols, hydrogen and methane
1.5 Microbial production of polymers (xanthan gums)

Credit II: Bioremediation and Phytoremediation

2.1 Types and sources of pollution - Inorganic, organic and biotic
2.2 Environmental Impact Assessment (EIA) of pollution and microbial bioremediation of oil spills
2.3 Concepts of bioremediation (in-situ and ex-situ), Bioremediation of toxic metal ions – biosorption and bioaccumulation principles
2.4 Concepts of improving phytoremediation and bioremediation
2.5 Microbial biotransformation of pesticides and xenobiotics, Microbial leaching of ores

Credit III: Biofertilizers and Biopesticides

3.1 Biofertilizers and their importance in crop productivity
3.2 Algal and fungal (mycorrhizae) biofertilizers
3.3 Bacterial biofertilizers (rhizobial, free living N2 fixers and phosphate solubilizing bacteria), their significance
3.4 Biopesticides: Bacterial (Bt pesticides), fungal (Trichoderma)
3.5 Viral biopesticides – Baculovirus, NPV insecticides
3.6 Production of biofertilizers and biopesticides for large scale application

Credit IV: Genetic Engineering in Environmental Biotechnology

4.1 Genetically engineered microorganisms in environmental health
4.2 Genetically engineered plants and microorganisms in agriculture and productivity
4.3 Genetically engineered bacteria in bioremediation of organic pesticides, insecticides oil spills
4.4 Hazards of genetically engineered microorganisms, plants and animals
4.5 Policies of genetic engineering research

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SEMESTER IV –ELECTIVE-II: ENVIRONMENTAL BIOTECHNOLOGY (BT453P/B)

PRACTICALS

1. Biomass estimation by different methods
2. Isolation of Biofertilizer microbes by biological enrichment method
3. Production of microbial biofertilizers
4. Estimation of BOD in sewage samples.
5. Estimation of COD in sewage samples.
6. Estimation of heavy metals in water/soil by atomic absorption sspectrophotometry.
7. Testing for microbiological quality of potable water (Coli form test)
8. Testing for effect of chemical pesticides on soil microbial respiration
9. Testing for microbial biodegradation of pesticides
10. Preparation of formulations of microbial biopesticide.

SPOTTERS: Microalgae-Biofuels; Biomass- Agricultural; Nif genes- RUBP-Case; Phytoremediation; Oil spills-superbug; Baculovirus-NPV insecticides; Sustainable development; GEMs in modern food; Microbial remediation.

Recommended Books

1. Comprehensive Biotechnology (All volumes) Ed. Young, M.Y. Pub: Pergmon Press
2. Environmental Microbiology. Grant, WD and Long PE. Publ: Blakie, Glasgow
3. Biotreatment systems Vol. 22. Ed. Wise, DL.
4. Microbial Ecology: Principles, Methods and Applications by Lavin, Seidler, Rogul
5. Laboratory Experiments in Microbiology by Gopal Reddy et al.

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