ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION

Model Syllabus for Biotechnology (Minor) in consonance with Curriculum framework w.e.f. AY 2025-26

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COURSE STRUCTURE

Year	Semester	Course	Title of the Course	No. of Hrs /Week	No. of Credits
II	III	1	Cell Biology & Biological Chemistry	3	3
			Cell Biology & Biological Chemistry-Practical	2	1
	IV	2	Microbiology & Immunology	3	3
			Microbiology & Immunology-Practical	2	1
III	V	3	Introduction to Biophysical Techniques, Bioinformatics & Biostatistics	3	3
			Introduction to Biophysical Techniques, Bioinformatics & Biostatistics-Practical	2	1
		4	Molecular Biology & Genetic Engineering	3	3
			Molecular Biology & Genetic Engineering-Practical	2	1
	VI	5	Plant & Animal Biotechnology	3	3
			Plant & Animal Biotechnology-Practical	2	1
		6	Industrial & Food Biotechnology	3	3
			Industrial & Food Biotechnology-Practical	2	1

SEMESTER-III

COURSE 1: CELL BIOLOGY & BIOLOGICAL CHEMISTRY

Theory **Credits: 3** **3 hrs/week**

Course Objectives

1. To explain that the cell is the basic unit of life in all organisms.
2. To study the structure and functions of prokaryotic and eukaryotic cells.
3. To describe cell organelles, cell cycle, and cell division.
4. To understand the structure and importance of nucleic acids, proteins, carbohydrates, and lipids.
5. To learn about enzymes, energy metabolism, and how cells use energy.

Learning Outcomes

After completing this course, students will be able to:

1. Describe the structure and role of different types of cells.
2. Explain how organelles work and how cells divide.
3. Identify the structure and function of nucleic acids, proteins, carbohydrates, and lipids.
4. Understand how enzymes work and how energy is produced in cells.
5. Relate cell structure and biochemistry to the overall working of living organisms.

Syllabus

UNIT I – Cell as the Basic Unit of Life

Cell as a basic unit of living organisms. Ultra-structure of prokaryotic cell. Brief description of viral, bacterial, fungal, plant and animal cells. Cell wall and plasma membrane.

UNIT II – Sub-cellular Organization & Cell Division

Sub-cellular organelles: Nucleus, cytosol, endoplasmic reticulum, chloroplast, mitochondria, vacuoles, ribosomes, peroxisomes, lysosomes, Golgi complex. Cell Division: Mitosis and Meiosis. Cell Cycle – phases and regulation.

UNIT III – Nucleic Acids & Proteins

Nucleic acids: Chemical structure and base composition; Chargaff's rules. Watson-Crick Model (B-DNA), deviations, and alternate forms of DNA (A- DNA and Z-DNA). Organization of chromosome in eukaryotes. acids: Structure, classification (pH-based, polarity-based, nutrition-based).Proteins: Levels of organization – primary, secondary, tertiary, and quaternary structures.

UNIT IV – Carbohydrates & Lipids

Carbohydrates: Definition, classification, nomenclature. Structures of monosaccharides, disaccharides, and polysaccharides. Concept and examples of heteropolysaccharides. Lipids: Structure of saturated and unsaturated fatty acids, triglycerides, phospholipids. Chemistry of porphyrins – heme and chlorophylls.

UNIT V – Enzymes & Bioenergetics

Enzymes: Classification and nomenclature. Factors affecting enzyme activity – substrate concentration, enzyme concentration, pH, and temperature. Enzyme inhibition – reversible inhibition (competitive, uncompetitive, non-competitive).Bioenergetics: Concepts of free energy, entropy, enthalpy, and redox potential. High-energy bonds – structure and role of ATP. Energy metabolism – glycolysis and Kreb's cycle.

Reference Books:

1. Bruce Alberts et al. – Molecular Biology of the Cell
2. Lodish, Berk, Kaiser, Krieger et al. – Molecular Cell Biology
3. Verma & Agarwal – Cell Biology, Genetics, Molecular Biology, Evolution and Ecology
4. Lehninger Principles of Biochemistry
5. Biochemistry – Donald Voet & Judith Voet
6. Satyanarayana & Chakrapani – Biochemistry

SEMESTER-III

COURSE 1: CELL BIOLOGY & BIOLOGICAL CHEMISTRY

Practical **Credits: 1** **2 hrs/week**

Practical Component:

1. Principle and utilization of microscope
2. Preparation of blood smear and observation of cells
3. Study of divisional stages in mitosis
4. Study of divisional stages in meiosis
5. Observation of permanent slides of bacterial, fungal, plant and animal cells
6. Calculation of molarity, normality, and molecular weight of compounds.
7. Qualitative analysis of carbohydrates (sugars)
8. Quantitative analysis of carbohydrates
9. Quantitative estimation of protein - Lowery method
10. Estimation of DNA by diphenylamine reagent
11. Estimation of RNA by orcinol reagent

SEMESTER-IV

COURSE 2: MICROBIOLOGY & IMMUNOLOGY

Theory **Credits: 3** **3 hrs/week**

Course Objectives

1. To introduce the history and development of microbiology and immunology.
2. To study the structure of microorganisms and their nutritional and growth requirements.
3. To understand microbial control methods such as sterilization and disinfection.
4. To learn the basic principles of immunity, immune cells, organs, antigens, and antibodies.
5. To explain antigen–antibody reactions, immunoassays, and applications like vaccines and monoclonal antibodies.

Learning Outcomes

After completing this course, students will be able to:

1. Describe the contributions of early microbiologists and immunologists.
2. Identify the structure of bacteria and viruses, and explain their growth and nutritional needs.
3. Explain methods of microbial control through sterilization and disinfection.
4. Describe the cells, organs, antigens, and antibodies of the immune system.
5. Apply knowledge of antigen–antibody reactions in understanding immunoassays, monoclonal antibodies, and vaccines.

Syllabus

UNIT I – Microbiology: History, Staining & Structure
History and development of microbiology – contributions of Louis Pasteur, Robert Koch, and Edward Jenner. Stains and staining procedures – acidic, basic, neutral, Gram staining, acid-fast staining. Bacteria – general morphology and ultra-structure. Viruses – general characteristics, classification, structure of Lambda Phage.

UNIT II – Microbial Nutrition, Growth & Control
Basic bacterial nutritional requirements and classification (nutrition & temperature-based). Types of media. Selective and Differential media, Enriched media, Enrichment media. Bacterial growth curve. Sterilization and disinfection – methods and principles.

UNIT III – Immunology: History, Immunity & Immune System
History and scope of immunology. Immunity and its classification – innate and acquired. Cells of the immune system – T cells, B cells, NK cells. Organs of the immune system – bone marrow, thymus, spleen, lymph node, MALT.

UNIT IV – Antigens, Antibodies & Immune Mechanisms
Antibodies – structure, classes (IgG, IgM, IgA, IgE, IgD), diversity. Antigens – types, factors affecting antigenicity, epitopes, adjuvants, haptens. Immune responses – humoral and cell-mediated immunity (T-cell, NK-cell, ADCC). MHC and hypersensitivity.

UNIT V – Antigen-Antibody Reactions & Applications
Antigen–antibody reactions – precipitation, agglutination, complement fixation, immunodiffusion. Hybridoma technology – monoclonal antibodies and applications. Immunoassays – ELISA. Vaccination – discovery, principles, significance, and types (live, attenuated, killed, recombinant, subunit).

Reference Books:

1. Prescott's Microbiology – Willey, Sherwood & Woolverton
2. Microbiology – Pelczar, Chan & Krieg
3. Ananthanarayanan & Paniker – Textbook of Microbiology
4. R.C. Dubey & D.K. Maheshwari – A Textbook of Microbiology
5. R.C. Dubey & D.K. Maheshwari – A Textbook of Microbiology
6. R.C. Dubey – Immunology
7. K. D. Tripathi – Essentials of Immunology

SEMESTER-IV

COURSE 2: MICROBIOLOGY & IMMUNOLOGY

Practical **Credits: 1** **2 hrs/week**

Practical Component:

1. Observation of permanent slides using microscope
2. Preparation of nutrient agar medium for bacteria
3. Preparation of PDA medium for fungi
4. Sterilization techniques (autoclave, hot air oven, filter)
5. Isolation of bacteria from soil
6. Simple staining technique
7. Differential staining technique
8. Antigen–antibody reaction–determination of Blood group, Cross reactivity
9. Pregnancy test
10. Widal test
11. Ouchterlony immunodiffusion
12. Radial immunodiffusion
13. ELISA (Demonstration)

SEMESTER-V

COURSE 3: INTRODUCTION TO BIOPHYSICAL TECHNIQUES, BIOINFORMATICS & BIOSTATISTICS

Theory **Credits: 3** **3 hrs/week**

Course Objectives

1. To introduce the principles and applications of spectroscopy, chromatography, and separation techniques used in biology.
2. To explain analytical and imaging techniques like electrophoresis, isotopic methods, and microscopy.
3. To understand centrifugation principles and its use in isolating biomolecules and organelles.
4. To provide knowledge of bioinformatics databases, tools, and their applications in genomics, proteomics, and drug design.
5. To develop skills in statistical analysis of biological data using probability, distributions, and hypothesis testing.

Learning Outcomes

After completing this course, students will be able to:

1. Apply spectroscopic and chromatographic methods for analyzing biological samples.
2. Demonstrate the use of electrophoresis, isotopic labeling, and microscopy for studying biomolecules and cells.
3. Explain how centrifugation is used to separate and study cellular components.
4. Use bioinformatics tools and databases to analyze DNA, RNA, and protein sequences.
5. Perform basic biostatistical tests, interpret results, and apply them in biological research.

Syllabus

UNIT I – Spectroscopy & Separation Techniques
Spectrophotometry – spectrum of light, Beer–Lambert's law, instrumentation (UV-Vis, colorimeter), applications. Chromatography – principles and applications of Paper, Thin Layer, Gel filtration, Ion-exchange, and Affinity chromatography. HPLC – principle, instrumentation, and applications.

UNIT II – Analytical & Imaging Techniques
Electrophoresis – Agarose, SDS-PAGE, isoelectric focusing, PFGE, applications. Isotopic techniques – radioactive isotopes, GM counter, autoradiography. Non-radioactive Compounds: Fluorescein, Biotin, Digoxigenin and their applications in Biotechnology.

UNIT III – Centrifugation & Microscopy
Centrifugation – principles, rotors, types of centrifuges (clinical, high speed, ultracentrifuge). Differential and density gradient centrifugation – principles and applications. Microscopy – compound, phase contrast, fluorescence, electron microscopy (TEM, SEM).

UNIT IV – Bioinformatics
Introduction – scope, branches, genomics and proteomics. Databases & tools – nucleic acid databases, protein databases, BLAST searching, visualization of protein structures. Applications – computational phylogenetics, computer-aided drug design, systems biology basics.

UNIT V – Biostatistics
Data analysis – measures of central tendency (mean, mode), dispersion (SD, SE). Probability & distributions – binomial, Poisson, normal distribution. Tests of significance – hypothesis testing, Student's t-test, ANOVA, Chi-square test, correlation & regression.

Reference Books:

1. Plummer, David T. – An Introduction to Practical Biochemistry
2. O. P. Agarwal – Practical Biochemistry
3. S. C. Rastogi, Namita Mendiratta & Parag Rastogi – Bioinformatics: Methods and Applications
4. R.C. Gupta – Textbook of Bioinformatics
5. Khan & Khanum – Fundamentals of Biostatistics
6. P.N. Arora & P.K. Malhan – Biostatistics

SEMESTER-V

COURSE 3: INTRODUCTION TO BIOPHYSICAL TECHNIQUES, BIOINFORMATICS & BIOSTATISTICS

Practical **Credits: 1** **2 hrs/week**

Practical Component:

1. Separation of plant pigments and amino acids by paper chromatography
2. Separation of lipids of TLC
3. Quantification of DNA, RNA using Spectrophotometer
4. Agarose gel electrophoresis
5. Mean, Median, Mode
6. Standard deviation, Standard error
7. Chi-square test
8. Sequence retrieval (protein and gene) from NCBI
9. Similarity search using BLASTN, BLASTP

SEMESTER-V

COURSE 4: MOLECULAR BIOLOGY & GENETIC ENGINEERING

Theory **Credits: 3** **3 hrs/week**

Course Objectives

1. To explain the structure and organization of genomes and the process of DNA replication.
2. To describe transcription, gene regulation, and control of gene expression in prokaryotes and eukaryotes.
3. To study the genetic code, protein synthesis, and post-translational modifications.
4. To introduce tools, vectors, and methods used in recombinant DNA technology.
5. To understand molecular techniques such as PCR, hybridization, blotting, sequencing, and their applications in biotechnology.

Learning Outcomes

After completing this course, students will be able to:

1. Explain how genetic material is organized, replicated, and expressed.
2. Describe transcription, operon models, and regulation of gene expression.
3. Interpret the genetic code and outline the steps of protein synthesis.
4. Demonstrate knowledge of enzymes, vectors, and methods used in gene cloning and recombinant selection.
5. Apply molecular biology techniques such as PCR, blotting, sequencing, and gene editing in research and biotechnology.

Syllabus

UNIT I – Genome Structure & DNA Replication
DNA as genetic material – Griffith and Hershey–Chase experiments. Genome organization – prokaryotic vs. eukaryotic genomes; concepts of gene, chromosome, and genome.DNA replication – enzymes (DNA polymerases, helicases, topoisomerases, primase), origins of replication, rolling circle model, semi-conservative proof.

UNIT II – Transcription & Gene Regulation
Transcription – prokaryotic RNA polymerase, promoters (Pribnow box, -10/-35), steps of initiation, elongation, termination; reverse transcription. Gene regulation – operon models (lac operon, trp operon), negative and positive control. Control of gene expression – polycistronic vs. mono-cistronic mRNA; regulation in prokaryotes and eukaryotes (overview).

UNIT III – Genetic Code & Protein Synthesis
Genetic code – features, degeneracy, wobble hypothesis. Translation – structure of mRNA and tRNA; adaptor hypothesis. Protein synthesis – initiation, elongation, termination; post-translational events (brief).

UNIT IV – Tools & Vectors in rDNA Technology
Molecular tools – restriction enzymes, modifying enzymes, ligation (linkers, adaptors). Vectors – plasmids (pBR322, pUC19), phages (λ, M13), cosmids, shuttle and expression vectors, YAC & BAC. Recombinant selection – gene transfer methods, screening and selection techniques.

UNIT V – Molecular Techniques & Applications
PCR – principle, types, and applications; DNA labeling methods (nick translation, random priming).Hybridization techniques – probes (radioactive/non-radioactive), detection methods. Southern Blotting. Genomic and cDNA libraries; vector engineering, codon optimization. Advanced applications – gene editing (site-directed mutagenesis, silencing), DNA sequencing (Sanger and Maxam–Gilbert).

Reference Books

1. Molecular Biology of the Gene – James D. Watson, Tania Baker, Stephen Bell, et al.
2. Molecular Cell Biology – Lodish, Berk, Kaiser, Krieger, et al.
3. P.S. Verma & V.K. Agarwal – Cell Biology, Molecular Biology, Genetics (S. Chand)
4. R.C. Dubey – A Textbook of Biotechnology
5. S.C. Rastogi – Genetic Engineering
6. Molecular Cloning: A Laboratory Manual – Sambrook & Russell

SEMESTER-V

COURSE 4: MOLECULAR BIOLOGY & GENETIC ENGINEERING

Practical **Credits: 3** **3 hrs/week**

Practical Component:

1. Determination of absorption maxima of DNA and RNA and their quantification
2. Quantitative estimation of RNA
3. Quantitative estimation of DNA
4. Isolation of plasmid DNA from bacteria
5. Isolation of genomic DNA from *E.coli*
6. Separation of DNA by Agarose gel Electrophoresis
7. Problem solving related to restriction enzymes sites in Genetic engineering.
8. Transformation in Bacteria using plasmid
9. Restriction digestion of DNA and its electrophoretic separation.
10. Ligation of DNA molecules and their testing using electrophoresis.
11. Demonstration of PCR

SEMESTER-VI

COURSE 5: PLANT & ANIMAL BIOTECHNOLOGY

Theory **Credits: 3** **3 hrs/week**

Course Objectives

1. To explain basic plant tissue culture techniques and their applications in agriculture and industry.
2. To introduce methods of plant transgenesis and molecular markers for crop improvement.
3. To describe animal cell and tissue culture methods, including stem cell culture and transfection techniques.
4. To study the production of transgenic animals, gene therapy, and their medical applications.
5. To make students aware of bioethics, biosafety, and intellectual property rights in biotechnology.

Learning Outcomes

After completing this course, students will be able to:

1. Demonstrate knowledge of plant tissue culture, micropropagation, synthetic seeds, and production of secondary metabolites.
2. Explain transgenic plant technology, molecular markers, and their applications in agriculture.
3. Describe animal tissue culture methods, cell lines, stem cells, and transfection techniques.
4. Understand the production and applications of transgenic animals and gene therapy.
5. Apply concepts of bioethics, biosafety, and IPR in biotechnology research and practice.

Syllabus

UNIT I – Plant Tissue Culture Techniques & Secondary Metabolites Production
Totipotency, media preparation – nutrients and plant hormones; sterilization techniques; establishment of cultures (callus culture, cell suspension culture). Applications of tissue culture – micropropagation, somatic embryogenesis. Synthetic seed production; protoplast culture and somatic hybridization – applications; cryopreservation. Plant secondary metabolites – concept and importance.

UNIT II – Transgenesis and Molecular Markers
Plant transformation technology – Agrobacterium-mediated gene transfer (Ti plasmid), hairy root features of Ri plasmid, transgenic plants as bioreactors. Development of resistance traits – herbicide resistance (glyphosate), insect resistance (Bt cotton). Molecular markers – RAPD, RFLP and DNA fingerprinting: principles and applications.

UNIT III – Animal Tissue Culture Techniques
Cell culture media and reagents; culture of mammalian cells, tissues, and organs. Types of cultures – primary culture, secondary culture, cell lines, stem cell cultures. Tests for cell viability and cytotoxicity; cryopreservation. Transfection methods – calcium phosphate precipitation, electroporation, microinjection; applications.

UNIT IV – Transgenic Animals & Gene Therapy
Production of vaccines, diagnostics, hormones, and other recombinant DNA products in medicine (e.g., insulin, somatostatin, vaccines); IVF. Concept of gene therapy. Transgenic animals – merits and demerits; ethical issues in animal biotechnology.

UNIT V – Bioethics, Biosafety and IPR
Bioethics – cloning and stem cell research, human and animal experimentation, animal rights/welfare. Biosafety – introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GLP. Introduction to Intellectual Property Rights (IPR) – patents, trademarks, copyrights.

Reference Books:

1. Plant Tissue Culture: Theory and Practice – S.S. Bhojwani & M.K. Razdan
2. B.D. Singh – Plant Biotechnology
3. R.C. Dubey – A Textbook of Biotechnology
4. Plant Biotechnology and Transgenic Plants – Kirsi Marja Oksman-Caldentey & Wolfgang H. Barz
5. Jatley & Jatley – Animal Biotechnology
6. Barnes & Freshney – Culture of Animal Cells: A Manual of Basic Technique

SEMESTER-VI

COURSE 5: PLANT & ANIMAL BIOTECHNOLOGY

Practical **Credits: 1** **2 hrs/week**

Practical Component:

1. Plant culture media and composition of MS media
2. Raising of aseptic seedlings
3. Induction of callus from different explants
4. Plant propagation through Tissue culture (shoot tip and Nodal culture)
5. Establishing primary cell culture of chicken embryo fibroblasts.
6. Animal tissue culture– maintenance of established cell lines (Demonstration).
7. Estimation of cell viability by dye exclusion (Trypan blue).

SEMESTER-VI

COURSE 6: INDUSTRIAL & FOOD BIOTECHNOLOGY

Theory **Credits: 3** **3 hrs/week**

Course Objectives

1. To introduce industrially important microorganisms and the basics of bioprocess technology.
2. To explain the design, operation, and applications of different types of bioreactors and fermentation systems.
3. To study the production of industrial products such as ethanol, enzymes, antibiotics, amino acids, vitamins, and recombinant products.
4. To provide knowledge of food microbiology, food spoilage, and different methods of food preservation.
5. To understand the importance of animal and seafoods, milk and milk products, vitamins, and deficiency disorders in nutrition.

Learning Outcomes

After completing this course, students will be able to:

1. Describe methods of isolation, screening, and improvement of industrial microorganisms and explain media and inoculum preparation.
2. Explain the working principles of different types of bioreactors and fermentation systems.
3. Demonstrate knowledge of industrial production processes for alcohols, acids, enzymes, antibiotics, and recombinant products.
4. Identify microorganisms associated with foods and describe methods of food preservation and food safety.
5. Explain the nutritional value of animal and seafoods, milk products, vitamins, and understand deficiency-related disorders.

Syllabus

UNIT I – Industrially Important Microorganisms & Bioprocess Basics
Isolation, screening, preservation, and improvement of industrially important microorganisms. Media preparation – synthetic and natural media, precursors, antifoams. Sterilization methods and inoculum preparation.

UNIT II – Bioreactors and Fermentation Systems
Definition, design, and basic principles of bioreactors. Classification of bioreactors – batch, continuous, fed-batch, and semi-continuous. Analysis of bioprocesses and their applications in industry.

UNIT III – Industrial Products & Applications
Ethanol production (molasses, starchy substrates), production of beer and wine. Citric acid fermentation (submerged & solid state). Production of enzymes (amylase, protease), SCP, baker's yeast. Antibiotics (penicillin), amino acids (glutamic acid), vitamins (B12), recombinant products (insulin, vaccines).

Unit -IV
Principles of food preservation. Microorganisms associated with foods. Infection, food intoxication, definition of shelf-life, perishable foods. Food preservation by freezing, refrigeration. Storage at high temperature: sterilization, pasteurization, blanching, drying, dehydration, evaporation, salting, smoking and irradiation. Food adulteration. Food additives.

Unit- V
Animal and sea foods-their importance, nutritional values, and preservation methods. Microbiology of milk, milk products–cheese, yoghurt, butter and their preparation. Deficiency disorders: Protein deficiency disorders, Calorie maintenance diet, Malnutrition, Kwashiarkar, Maranus, Starvation. Vitamins: types of vitamins, sources of various vitamins. Essential vitamins and their biological role and deficiency disorders.

Reference Books:

1. Industrial Microbiology – L.E. Casida Jr.
2. Biotechnology: Principles and Applications – Smith
3. R.C. Dubey – A Textbook of Biotechnology
4. Fundamentals of Food Biotechnology – Byung H. Kim
5. U. Satyanarayana – Biotechnology
6. B. Singh – Food Biotechnology

SEMESTER-VI

COURSE 6: INDUSTRIAL & FOOD BIOTECHNOLOGY

Practical **Credits: 1** **2 hrs/week**

Practical Component:

1. Isolation of industrially important microorganisms from soil.
2. Isolation of amylase producing organisms from soil.
3. Production of α– amylase from *Bacillus Spp.* By shake flask culture.
4. Production of alcohol or wine using different substrates
5. Study of food preservation method
6. Nutritional labelling of food
7. Preparation of yoghurt
8. Isolation and identification food spoiling microorganisms