

**CIRCULAR NO.SU/B.Sc./CBC&GS /67/2023**

It is hereby inform to all concerned that, the syllabi prepared by the Board of Studies, Ad-hoc Boards and recommended by the Dean, Faculty of Science & Technology, the Hon'ble Vice-Chancellor has accepted the **following syllabi of Bachelor of Science with Practical Pattern of Question Paper under the scheme of Choice Based Credit & Grading System** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

Sr.No.	Courses	Semester
1.	B.Sc. Biotechnology (Degree)	IIIrd & IVth semester
2.	B.Sc. Automobile Technology (Degree)	IIIrd & IVth semester
3.	B.Sc. Workshop Technology (Degree)	IIIrd & IVth semester
4.	B.Sc. Refrigeration and Air Conditioning (Degree)	IIIrd & IVth semester
5.	B.Sc. Physics (Optional)	IIIrd & IVth semester
6.	B.Sc. Chemistry (Optional)	IIIrd & IVth semester
7.	B.Sc. Analytical Chemistry (Optional)	IIIrd & IVth semester
8.	B.Sc. Statistics (Optional)	IIIrd & IVth semester

This is effective from the Academic Year 2023-24 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus,
Aurangabad-431 004.

REF.NO.SU/2023/670-77
Date:- 03.06.2023.

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*Deputy Registrar,
Academic Section*

Copy forwarded with compliments to :-

- 1] **The Principal of all concerned Colleges,**
Dr. Babasaheb Ambedkar Marathwada University,
- 2] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

Copy to :-

- 1] **The Director, Board of Examinations & Evaluation, Dr.BAMU,A'bad.**
- 2] The Section Officer,[B.Sc.Unit] Examination Branch,Dr.BAMU,A'bad.
- 3] The Programmer [Computer Unit-1] Examinations, Dr.BAMU,A'bad.
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**DR. BABASAHEB AMBEDKAR
MARATHWADA UNIVERSITY,
AURANGABAD.**



Revised Syllabus of
B . SC . BIOTECHNOLOGY
FIRST TO THIRD YEAR
THREE YEAR DEGREE COURSE
Semester-III to IV

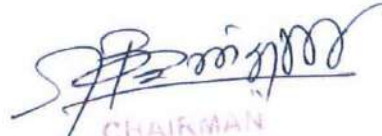
[Effective for 2023-24]

CHAIRMAN
Ad-Hoc Board of Studies Biotechnology
Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad

Semester III								
	Course Code	Course Title	Total periods (Teaching periods/ week)	Credits	Scheme of Examination			
					Max Marks	CIA	UA	Min Marks
Optional I Developmental Biology and Inheritance (DSC-III C) Core Courses	BIOT -311	Developmental Biology	45(3/wk)	2	50	10	40	20
	BIOT-312	Inheritance	45(3/wk)	2	50	10	40	20
	BIOTP - 313	Lab course 31 (based on BIOT -311)	45(3/wk)	1.5	50	10	40	20
	BIOTP- 314	Lab course 32 (based on BIOT-312)	45(3/wk)	1.5	50	10	40	20
Optional II Microbiology (DSC-III C) Core Courses	BIOT -321	General Virology	45(3/wk)	2	50	10	40	20
	BIOT-322	Basics of Immunology	45(3/wk)	2	50	10	40	20
	BIOTP - 323	Lab course 33 (based on BIOT-321)	45(3/wk)	1.5	50	10	40	20
	BIOTP- 324	Lab course 34 (based on BIOT-322)	45(3/wk)	1.5	50	10	40	20
Optional III Biochemistry (DSC-III C) Core Courses	BIOT -331	Basics of Enzymology	45(3/wk)	2	50	10	40	20
	BIOT-332	Animal physiology	45(3/wk)	2	50	10	40	20
	BIOTP - 333	Lab course 35 (based on BIOT-331)	45(3/wk)	1.5	50	10	40	20
	BIOTP- 334	Lab course 36 (based on BIOT-334)	45(3/wk)	1.5	50	10	40	20
Skill Enhancement course (SEC-1)	BIOTS- 341	SEC-1 A-Mushroom Cultivation SEC-1 (B)- Culturing and Maintenance of Microorganism Any one skill to be chosen out of two SEC-1(A), SEC-1 (B)	45(3/wk)	2	50	10	40	20
Ability Enhancement compulsory courses (AECC-3)	BIOT-351	Communication skills in English- III	45(5/wk)	3	50	10	40	20
	BIOT - 361	Marathi/Hindi/Urdu/Sanskrit A student can opt for any one of these languages (SL-III)	45(4/wk)	3	50	10	40	20
			675	29	750	150	600	750
Total Credits for Semester III : 29 (Theory : 20 ; Laboratory : 9)								


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Semester IV								
	Course Code	Course Title	Teaching time/week	Credits	Scheme of Examination			
					Max Marks	CIA	UA	Min Marks
Optional I Cell biology and Plant Physiology (DSC-1D) Core Courses	BIOT-411	Cell Biology	45(3/wk)	2	50	10	40	20
	BIOT-412	Plant Physiology	45(3/wk)	2	50	10	40	20
	BIOT P-423	Lab course 41 (based on BIOT-411)	45(3/wk)	1.5	50	10	40	20
	BIOT P-424	Lab course 42 (based on BIOT-412)	45(3/wk)	1.5	50	10	40	20
Optional II Genetics and Molecular Biology (DSC-IIID) Core Courses	BIOT -421	Genetics	45(3/wk)	2	50	10	40	20
	BIOT- 422	Central Dogma	45(3/wk)	2	50	10	40	20
	BIOTP-423	Lab course 43 (based on BIOT-411)	45(3/wk)	1.5	50	10	40	20
	BIOTP-424	Lab course 44 (based on BIOT-412)	45(3/wk)	1.5	50	10	40	20
Optional III Advanced Biology (DSC-IIID) Core Courses	BIOT-431	Advanced Enzymology	45(3/wk)	2	50	10	40	20
	BIOT-432	Advanced Immunology	45(3/wk)	2	50	10	40	20
	BIOTP-433	Lab course 45 (based on BIOT-411)	45(3/wk)	1.5	50	10	40	20
	BIOTP-434	Lab course 46 (based on BIOT-412)	45(3/wk)	1.5	50	10	40	20
Skill Enhancement course (SEC-2)	BIOTS-441	SEC-2 (C) Diagnostic Biology SEC- 2 (D)Agriculture Biotechnology Any one skill to be chosen out of two SEC-2(C) , SEC-2 (D)	45(3/wk)	2	50	10	40	20
Ability Enhancement compulsory courses (AECC-4)	BIOT-451	Communication skills in English-IV	45(5/wk)	3	50	10	40	20
	BIOT-461	Marathi/Hindi/Urdu/Sanskrit A student can opt for any one of these languages (SL-IV)	45(4/wk)	3	50	10	40	20
Additional credits	BIOT 471	Environmental Studies	45(3/wk)	2*	50	10	40	20
			675	29	750	150	60	750
Total Credits for Semester IV : 29 (Theory : 20 ; Laboratory : 9)								


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 University, Aurangabad

Course Code	BIOT -311
Course Title	Developmental Biology
Marks	50
Credits	2
Total periods	45(3/wk)
contact hours	30

Unit 1 Developmental Biology an overview

Introduction of animal development: Development among unicellular eukaryotes – *Acetabularis*, *Naegleria*. The origins of sexual reproduction. Fertilization: structure of gametes, recognition of sperm and egg –action at distance and contact of gametes. Cleavage: Patterns of embryonic cleavage, radial holoblastic cleavage, spiral holoblastic cleavage, mechanisms of cleavage –regulation of cleavage cycles.

Unit2 Early Embryonic Development

Gametogenesis, Fertilization, Embryo sac development and double fertilization in plants, blastula formation, Types of Cleavage, Gastrulation and formation of germ layers in animals.

Unit3 Morphogenesis and organogenesis in animals

Cell aggregation and differential in *Dictyostelium*; axes and pattern formation in *Drosophila*, organogenesis –vulva formation in *Caenorhabditis elegans*; eye lens induction, limb development in vertebrates, neuron differentiation, -larval formation, metamorphosis; environmental regulation of normal development.

Unit4 Extra embryonic membrane, Cell death and regeneration

Study of extra-embryonic membrane in chick, concept of regeneration programmed cell death aging and senescence.

References:

1. Developmental Biology by Scott Gilbert -9th edition
2. Balinsky –An introduction to embryology CBS college Publishers
3. Lodish H, *et. al.*, Molecular Cell Biology
4. Alberts Bruce, *et. al.*, Molecular Biology of the Cell Sinauer
5. Grant –Biology of Development systems, Holt. Reihart, Winston.
6. Developmental Biology website companion to Gilbert -
<http://www.devbio.com/contents.php>

Course Code	BIOT-312
Course Title	Inheritance
Marks	50
Credits	2
Total periods	45(3/wk)
contact hours	30

UNIT-1: Gene Concept, Mendelism and Extension of Mendelian Principles

A. **Concept of Gene:** Allele, Multiple Alleles, Pseudoallele, Complementation tests.

B. **Mendelian Principles:** Dominance, Segregation, Independent Assortment, Deviation from Mendelian Inheritance.

C. **Extensions of Mendelian Principles:** Codominance, Incomplete Dominance (Partial Dominance), Gene Interactions, Pleiotrophy, Genomic Imprinting, Penetrance and Expressivity, Phenocopy, Linkage and Crossing over, Sex determination, Sex Differentiation, Sex Linkage, Sex limited and Sex influenced characters.

UNIT 2: Chromosomes and Structural Alterations of Chromosome

A. **Chromosome:** Structure of a typical circular and linear chromosomes, molecular nature and functioning of centromeres and telomeres, Giant chromosome, Polytene chromosome. Chromatin Organization: Euchromatin, Heterochromatin, Nucleosome as a subunit of chromatin, organization of histone octamer, acetylation and deacetylation of histones, roles of methylation and demethylation of DNA in CpG islands.

B. **Structural and Numerical alterations of Chromosome:** Deletion, Duplication, Inversion, Translocation, Ploidy and their genetic implications.

UNIT 3: Gene Mapping Methods

Linkage maps, Tetrad analysis, Mapping with molecular markers, Mapping by using somatic cell hybrids, development of mapping population in plants.

UNIT 4: Extra Chromosomal Inheritance

Inheritance of mitochondrial and chloroplast genes, Maternal Inheritance, Plasmid inheritance.

Calculation of autosomal recombination frequencies by backcrossing to homozygous recessives, recombination frequencies for Sex-linked genes, recombination frequencies in $F_1 \times F_1$ crosses.

Brief mention of following points (not more than 2 hours)

The balance concept of sex determination in *Drosophila*.

Haplodiploidy and sex determination in Hymenoptera, mosaics and gynandromorphs.

Sex linked dominance,

sex limited gene expression and sex linked inheritance.

Sex linkage, Bridges' demonstration of Non-disjunction, attached-X,

Sex Linkage in Moths and Birds, Reptiles (Snake), , Sex ratio,

X-inactivation,

dosage compensation.

X-linked disorder –females as carriers, hemophilia, sickle cell anemia, fragile-X-syndrome, Huntingtons disease, (only introductory).

References:

1. Genetics, Third edition by Monroe W. Strickberger First Indian Impression 2006.
 2. Principles of Genetics, Eighth edition, Gardner, Simmons and Snustad. 2001.
 3. Molecular Genetics An introductory Narrative. Second edition, by Gunther S. Stent and Richard Calendar –University of California Berkley 1986 first Indian edition
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Course Code	BIOTP -313
Course Title	Lab course 31 (based on BIOT -311)
Marks	50
Credits	1.5
Total periods	45(3/wk)
contact hours	45

PRACTICALS

Developmental Biology

1. Microscopic observation of permanent slides of different developmental stages embryo
2. Study of meiosis in Grass hopper testis
3. Study of development of frog embryo from permanent slides (at least five)
4. study of different types of cancer cell

Course Code	BIOTP-314
Course Title	Lab course 32 (based on BIOT-312)
Marks	50
Credits	1.5
Total periods	45(3/wk)
contact hours	45

Practicals based on BIOT-312 Inheritance

1. Determination of nucleic acid by Feulgen reaction
 2. Isolation of Giant chromosome
 3. Isolation of Polytene chromosome
 4. Estimation of temperature melting
 5. Problems based on monohybrid and backcross
 6. Problems based on di-hybrid
 7. Problems based on tri-hybrid
 8. Problems based on pedigree analysis
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Course Code	BIOT -321
Course Title	General Virology
Marks	50
Credits	2
Total periods	45(3/wk)
contact hours	30

Unit1. General aspects

Classification and nomenclature of viruses in general, their properties, morphology and structure of typical bacteriophage(brief mention), animal virus and plant virus, types of envelope, their composition, Viroids and Prions.

Unit2. Animal Viruses

Classification of animal viruses,

Genome organization and replication of typical DNA viruses (SV40, Adeno virus,) and RNA viruses (Poliovirus, Corona virus)

Diagrammatic representation of structure of Pox virus, Hepatitis B virus, Vaccinia, Lentivirus. life cycle, pathogenicity Clinical diagnosis and treatment of important viruses [HIV, Influenza and Hepatitis]

Unit3. Plant Viruses

Classification plant viruses,.

Genome organization and replication of common plant viruses; TMV, CaMV,

Transmission of plant viruses by vectors and other means.

Diganostic techniques in seed, seed stocks and diseased plants.

Unit4. Bacteriophages

Structure and genomic organization of bacteriophages, lytic and lysogenic life cycles –T4 and lambad. Genetic switch for control of lytic and lysogony of lambda phage. Genome organization, infection and multiplication of T odd and T even phages. Lambda phage, M13, Mu phage.

Course Code	BIOT-322
Course Title	Basics of Immunology
Marks	50
Credits	2
Total periods	45(3/wk)
contact hours	30

UNIT 1

Types of immunity : innate, acquired, active and passive. Elements of immune system: Hematopoiesis, T-cells, B-cells, myeloid cells, antigen presenting cells, cell mediated subset of T-Cells, helper and suppressor cells, cell mediated and humoral immunity, antibody dependent cell mediated cytotoxicity, natural killer cells. Primary and Secondary organs of immune system

UNIT 2

Cellular and molecular aspects:

Antigens :- Immunogenicity Vs antigenicity, factors affecting antigenicity, epitopes, haptens, adjuvants.

Antigen antibody interactions :- forces of antigen antibody interaction, principle, methods and applications of precipitation and agglutination.

Antibody structure, function and diversity antigen-antibody reactions, T-Cells receptors, cell activation complement, lymphokines, regulation of immune response, immunological tolerance. Recognition of antigen: MHC, antigen processing and presentation, T-cell and B - cell activation.

UNIT 3

Hypersensitivity: An allergy, types of hypersensitivity. Immunology of hypersensitivity. Secondary immune response. Autoantibodies – Autoimmune diseases. Examples such as; Rheumatoid Arthritis, Myasthenia Gravis, Systemic Lupus Erythematus, Rhesus incompatibility, Protection of fetus from immuneresponse.

UNIT 4

Immunotechniques: Immunodiffusion, immunoelectrophoresis ELISA, RIA, fluorescence activated cell sorter, PBMC, immunoblotting.

REFERENCE BOOKS

1. Immunology Kuby, R.A. Goldsby, T.J. Kind 1997, 4th Edition B.A.Osborne.
2. Essential of immunology Ivan Riot-Blakswel 1997, 4th Edition B.A.Osborne
3. Fundamentals of Immunology Paul W.E. (Eds.) 1998 Raven press, NewYork.
4. Text Book of Microbiology by Panikar and Anantnarayan2009.
5. General Microbiology byDavis
6. Medical Microbiology by Duguid andCruikshank

Course Code	BIOTP -323
Course Title	Lab course 33 (based on BIOT-321)
Marks	50
Credits	1.5
Total periods	45(3/wk)
contact hours	30

PRACTICALS ON Virology

1. Isolation of coliphages
2. Titration of bacteriophages
3. One step growth curve
4. Viral DNA extraction
5. Demonstration of nucleic acid type of viral sample
6. Isolation of plant virus from clinical specimen
7. Isolation of animal virus from clinical specimen

Course Code	BIOTP-324
Course Title	Lab course 34 (based on BIOT-322)
Marks	50
Credits	1.5
Total periods	45(3/wk)
contact hours	45

PRACTICALS ON –Basic Immunology

1. Blood film preparation and identification of immune cells
2. Lymphoid organs and their microscopic organization
3. Immunization and collection of serum
4. Double Diffusion
5. Hemagglutination
6. Detection of antigen
7. Separation of monoclonal cells by Ficoll-Hypaque

Course Code	BIOT -331
Course Title	Basics of Enzymology
Marks	50
Credits	2
Total periods	45(3/wk)

Unit1. Introduction to enzymes

Definition of enzymes, importance of enzymes: Physiological and industrial, enzyme classification, chemical nature of enzymes, structure of enzyme proteins determination of enzyme structure by X-ray crystallography.

Unit2. Enzyme Action

Concept of activation energy, active site of an enzyme, Enzyme specificity : Group specificity Substrate specificity Stereo-Specificity & product specificity. Hypotheses of enzyme action- Hypotheses lock and key Hypothesis, induced fit Hypothesis, Hypotheses involving strain or transition state stabilization Uni-Uni, Bi-Bi, enzyme reactions involving one and two substrate molecules, Ping-pong Bi-Bi mechanism, Random Order mechanism, compulsory order mechanism.

Unit3. Types of Enzymes

Monomeric Enzymes (Serine Proteases)

Oligomeric Enzymes (lactate Dehydrogenase)

Metalloenzyme Complex (Pyruvate Dehydrogenase)

Metalloenzymes & Metal activated enzymes Isozymes Ribozymes, Abzymes & Extremozymes & allosteric Enzymes.

Unit4. Co-Enzymes & Co-factors

Introduction : NAD, NADP, FMN, FAD, Adenosine Phosphates Co-enzyme A, Thiamine Pyrophosphate, Pyridoxal Phosphate, Lipoic Acid Tetrahydro folate & Vitamin B12.

Reference Books

- 1) Biochemistry – by A.lehninger
- 2) Enzymes – Biochemistry, Biotechnology, Clinical chemistry, 2004 by Trevor Palmer, East – West PressEdition.

- 3) Fundamentals of Enzymology 2003 by Nicholas C. Price and Lewis Stevens Oxford University Press.
 - 4) Enzyme kinetics by Paul Engal. 1977, John Willey and Sons Inc.
 - 5) Enzymes by Dixon and Web. Acad. Press.
 - 6) Principles of enzyme kinetics by Athel Cornish. 1976. Bowden and Butterworth and Co.
 - 7) Laboratory manual in Biochemistry by J. Jayaraman. 2006, New Age International.
 - 8) Source book of Microbiology by Primrose.
 - 9) A.L. Lehninger, D. L. Nelson & M M Cox – Principles of Biochemistry.
 - 10) Cohn & Stump – Outline of Biochemistry; Wiley Eastern Ltd.
 - 11) Lubert Stryer – Biochemistry
 - 12) R.L. Foster – The nature of Enzymology; Croom-Helm London
 - 13) Harpers -Review of biochemistry –; Prentice Hall New York
 - 14) R.A. Copeland -Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis,; John Wiley and Sons Inc.
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Course Code	BIOT-332
Course Title	Animal physiology
Marks	50
Credits	2
Total periods	45(3/wk)
contact hours	30

Unit1. Physiology of digestion and excretion

Definition of digestion and types of digestion–extra and intracellular.

Digestion of Carbohydrates, proteins, lipids and cellulose .Absorption and assimilation of digested food materials. Gastrointestinal hormones-control of digestion.

Definition of excretion. Forms of nitrogenous waste material and their formation; classification of animals on the basis of excretory products. Structure and function of Nephron–Counter current mechanism.

Unit2. Physiology of respiration and circulation

Types of respiration – external and internal respiration. Transport of oxygen – formation of oxyhaemoglobin and affinity of haemoglobin for Oxygen, Oxygen dissociation curves.

Transport of CO₂–Chloride shift, Bohr effect.

Open and closed circulation Heart beat and cardiac cycle. Myogenic and neurogenic hearts.

Regulation of heart rate–Tachycardia and Bradycardia.

Unit3. Physiology of muscle contraction and nerve impulse

General structure and types of muscles. Ultrastructure of skeletal muscle. Sliding filament mechanism of muscle contraction. Chemical changes during muscle contraction – role of calcium, ATP utilization and its replenishment.

Structure of nerve cell. Nature of nerve impulse–resting potential and action potential. Properties of nerve impulse–threshold value, refractory period, all or none response. Conduction of nerve impulse along an axon – local circuit theory and saltatory conduction theory. Structure of synapse, mechanism of synaptic transmission – electrical and chemical transmissions.

Unit 4: Endocrine control of reproductive system-and mammary growth

Chemical signaling, Hormone from a neurosecretory cell, Antagonistic hormones and homeostasis, Feedback control loops regulating the secretion of thyroid hormones, Homeostasis

Hormonal control of mammary growth: Estrogen (Puberty), Progesterone (Adulthood estrous cycle), Prolactin (Pregnancy, Lactation).

Reference Books:

William O, Reece. 2004. *Duke's Physiology of Domestic Animals*. 12th Edition. Comstock Publishing Associates.

Keith Dyce & Wolfgang Sack & Wensing CJG. 2009. *Textbook of Veterinary Anatomy*, 4th Edition. Elsevier Health Sciences.

Rowen D. Frandson, W. Lee Wilke & Anna Dee Fails. 2009. *Anatomy and Physiology of Farm Animals*. 7th Edition. Wiley–Blackwell.

Sarad Subrahmanyam, K Madhavankutty & HD Singh Textbook of Human Physiology S Chand Publishing

Link for the book Anatomy & Physiology by Rice University 6100, Texas 77005

<https://assets.openstax.org/oscms-prodcms/media/documents/AnatomyandPhysiology-OP.pdf>

Link for the book grey's Anatomy

<https://mystudytown.in/grays-anatomy-41st-edition-pdf/>

Course Code	BIOTP -333
Course Title	Lab course 35 (based on BIOT-331)
Marks	50
Credits	1.5
Total periods	45(3/wk)
contact hours	45

PRACTICALS

Basic Enzymology

1. Detection of enzyme production by bacteria & Fungi: Proteases, alpha amylase, lipase, Cellulase.
2. Detection of β -Lactamase Production by *Staph. aureus* / E.coli.
3. Assay of urease.
4. Assay of alpha Amylase in terms of substrate consumption.
5. Assay of alkaline phosphatase in human serum.
6. Detection of extremozymes production by bacterial isolates from extreme environment
e.g. : salted fish.
7. Study of substrate specificity of enzymes.

Course Code BIOTP-	332
Course Title	Lab course 36 (based on BIOT-334)
Marks	50
Credits	1.5
Total periods	45(3/wk)
contact hours	45

PRACTICALS

Animal Physiology

1. Detection of normal and abnormal constituents of urine –
sugar, albumen bile and blood cells.
2. Demonstration of salivary amylase.
3. Effect of temperature and pH on salivary amylase

Course Code	BIOTS-341
Course Title	SEC-1 A-Mushroom Cultivation
Marks	50
Credits	2
Total periods	45(3/wk)
contact hours	30

Unit: I Mushroom morphology and Classification:

Different parts of a typical mushroom & variations in mushroom morphology. Key to differentiate Edible from Poisonous mushrooms

Classification of mushrooms:Based on occurrence-

Epigenous & Hypogenous,

Natural Habitats-Humicolous, Lignicolous & Coprophilous,

Color of spores- white,yellow ,pink, purple brown & black,

Morphology- fruiting layers exposed to air, fruiting layers not exposed to air, plants with predominantly pitted cap, cap saddled shape & saucer shape,

Structure and texture of fruit bodies-gilled fungal& pore fungal, Fruit bodies and spores-

Ainsworth et al (1973) classification.

Unit: II Biology and Nutrient Profile of Mushrooms:

Common edible mushrooms: Button mushroom (*Agaricus bisporus*), Milky mushroom (*Calocybe indica*), Oyster mushroom

(*Pleurotus sajorajju*) and paddy straw mushroom (*Volvariella volvcea*).

General morphology, distinguishing characteristics, spore germination and life cycle. ;

Protein, amino acids, calorific values, carbohydrates , fats, vitamins & minerals.

Unit: III Health benefits of Mushroom:

Antiviral value, antibacterial effect, antifungal effect, anti-tumour effect, haematological value cardiovascular & renal effect, in therapeutic diets, adolescence, for aged persons & diabetes mellitus.

Unit IV: Principles of mushroom cultivation (8 Hours)

Structure and construction of mushroom house.

Sterilization of substrates. Spawn production -

Culture media preparation- production of pure culture, mother spawn, and multiplication of spawn.

Composting technology, mushroom bed preparation. Spawning, spawn running, harvesting.

Cultivation of oyster and paddy straw mushroom.

Problems in cultivation - diseases, pests and nematodes, weed moulds and their management strategies.

References

1. Marimuthu, T. et al. (1991). Oyster Mushroom. Department of Plant Pathology. Tamil Nadu Agricultural University, Coimbatore.
 2. Nita Bhal. (2000). Handbook on Mushrooms. 2nd ed. Vol. I and II. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi
 3. Pandey R.K, S. K Ghosh, 1996. A Hand Book on Mushroom Cultivation. Emkey Publications.
 4. Pathak, V. N. and Yadav, N. (1998). Mushroom Production and Processing Technology. Agrobios, Jodhpur.
 5. Tewari Pankaj Kapoor, S. C. (1988). Mushroom Cultivation. Mittal Publication, New Delhi.
 6. Tripathi, D.P. (2005) Mushroom Cultivation, Oxford & IBH Publishing Co. PVT.LTD, New Delhi.
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Course Code	BIOTS-341
Course Title	SEC-1 B- Culturing and Maintenance of Microorganism
Marks	50
Credits	2
Total periods	45(3/wk)
contact hours	30

Unit I: Different nutrient media used for isolation and culturing of microorganisms

Construction, ingredients, methods and uses of simple media, complex media, enrichment media, enriched media,

Special purpose media (names, key ingredient/s and uses of minimum 10 media that are commonly used in microbiology laboratory should be discussed) u

Unit II : isolation techniques for Microorganisms

Bacteria: Serial dilution method , pour plate method , streak plate methods

Fungi: soil plate method, soil washing method,soil dilution plate method

Isolation of VAM, and actinomycetes

Unit III :

Methods of Maintenance,

Methods of Preservation- • Short-term preservation ,Medium-term preservation , Long-term preservation

Unit IV:

Microbial culture collections - role of culture collections in microbiology,

Maintenance of Industrially Important Microorganisms

References: standard text and reference books in microbiology should be used.

Course Code	BIOT-351
Course Title	Communication skills in English-III
Marks	50
Credits	3
Total periods	45(5/wk)
contact hours	30

Details are to be made available from respective language (English) authorities

Course Code	BIOT -361
Course Title	Marathi/Hindi/Urdu/Sanskrit (A student can opt for any one of these languages (SL-III))
Marks	50
Credits	3
Total periods	45(4/wk)
contact hours	30

Details are to made available from respective language authorities

Course Code	BIOT-411
Course Title	Cell Biology
Teaching time/week	45(3/wk)
Credits	2
Max Marks	50

Unit1. Cell Structure and organelles

Cell theory. Organisation- prokaryotic and eukaryotic cells. Origin of eukaryotic cells- endosymbiotic theory, Giardia- a living fossil. Overview of cell specializations: Plants- epidermis, vascular tissue and cortex, Animals- epithelia, connective tissue, nervous tissue, muscle, blood, germ cells and sensory cells.

Structure and Functions of Organelles: Endoplasmic Reticulum, Lysosome, Golgi Complex, Peroxisome (Microbody), Centriole, Mitochondria, Cytoskeleton- microtubules, intermediate filaments, actin filaments, mechanism of muscle contraction, motors and movements, Cilia & Flagella, Nucleus, Special Properties of Plant Cells- cell wall, vacuoles and chloroplast.

Unit 2. Membrane Structure

Membrane models- Overton's lipid nature of membrane, Langmuir's lipid monolayer, Gorter and Grendel's lipid bilayer, Davson and Danielli's lipid bilayer plus protein sheet, Robertson's Unit membrane, Singer and Nicolson's fluid mosaic. Membrane structure- 2D Lipid bilayer, composition of lipid bilayer, asymmetric nature, fluidity, membrane proteins and their function.

Unit3. Membrane Transport

Movement across membranes- Passive transport: simple diffusion, facilitated diffusion- transporters (uniporters and co-transporters) and channel proteins. Active transport: Pumps, Group Translocation and Electrochemical Gradients

Unit 4. Cell Division and Cell Cycle

Mitosis, Meiosis, and Cytokinesis, role of protein kinases and Cyclin-Cdk complex in controlling cell cycle, control of cell proliferation in multicellular organisms, programmed cell death.

References:

1. Cell Biology by Sadava
2. Molecular Cell Biology, Lodish *et al.*, Freeman and Company, New York, 1999
3. Essential Cell Biology - An introduction to the molecular Biology of the cell - Alberts, Bray, Johnson, Lewis, Raff, Roberts, Walter, Garland Publishing.
4. Molecular Biology of the cell - Bruce Alberts, Garland Publishing Inc.
5. Cell Biology - A short course, Second edition, Stephen R. Bolsover, Wiley Publication
6. Genes IX - Benjamin - Lewin, Prentice Hall Publication
7. An introduction to Practical Biochemistry - David T Plummer, Tata-McGraw-Hill Edition
8. Developmental Biology, Ninth edition, S.F. Gilbert, Sinauer Associates Inc

Course Code	BIOT-412
Course Title	Plant Physiology
Teaching time/week	45(3/wk)
Credits	2
Max Marks	50

Unit1. Plant water relations:

Cell as a physiological unit. Osmosis, Imbibition. Diffusion, D.P.D. Water potential, Absorption of water, (active & passive). Plasmolysis, cohesion, tension and transpiration pull theory. Significance, factors affecting transpiration, mechanism of stomatal opening and closing, (k+transport theory).Guttation and anti-transpirants.

Unit2. Photosynthesis:

Significance, site of photosynthesis, pigments, photochemical phase. Electron transport chain. Photophosphorylation- cyclic and non-cyclic. Biosynthetic phase, Calvin cycle, C3 and C4 pathways. Crassulacean Acid Metabolism, factors affecting photosynthesis. Law of limiting factors, light, temperature, water, nutrient supply. Leaf factor. Photorespiration, Chemosynthesis- a brief account.

Essential, non- essential, macro and micro elements,(brief account only.)

Unit3. Plant Growth & Regulation:

Phases of growth, growth curve. Plant growth regulators - Auxins, Gibberillins, Cytokinins Ethylene, Absisic acid-physiological functions only. Senescence-(here brief account only.)

Unit4. StressPhysiology, Photoperiodism And Vernalization:

Responses of plants to biotic(pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; photoperiodism and biological clocks (Brief account only)

REFERENCES

1. Bilgrami K.S. & Dube - A text book on Modern Plant Pathology. Vikas Publishing House, New Delhi.
2. Develin & Witham - Plant Physiology - C.B.S. Publishers.
3. Fritsch F.E. - Structure and reproduction of Algae. Vol I and Vol II Cambridge University Press London.
4. Kumar & Purohith - Plant Physiology. Fundamentals - Agrobios.
5. Kumar. H.D. & Singh A.N. - A text book on Algae. Chand & Company.
6. Malik C.P. & Srivastava. - A text book of Plant Physiology Kalayani Publishing Co. New Delhi.
7. Pandae & Trivedi - A textbook of Fungi, Bacteria and Virus Vikas Publishing House New Delhi.
8. Parihar N.S. - An introduction to Bryophyta Central Book Depot Allahabad
9. Smith G.M. - Cryptogamic Botany Vol I McGraw Hill Co. New Delhi.
10. Smith K.M. - A textbook of Plant diseases S. Chand & Company.
11. Sporne K.R. - Morphology of Pteridophytes. - Hutchins university Library. London.
12. Vashista P.C. - Gymnosperms — S. Chand & Company. New Delhi
13. Vasistha B., - Bryophyta, S. Chand & Company.
14. Willam G. Hopkins. - Introduction to Plant Physiology John Wiley.
15. Robert A Wallace. Biology, The world of life. Harper Collins

Course Code	BIOT P-423
Course Title	Lab course 41 (based on BIOT-411)
Teaching time/week	45(3/wk)
Credits	1.5
Max Marks	50

Practical based on BIOT-411 Cell Biology

1. Visualization of Chromosomes in mitotic/ meiotic stages in onion root tips/ buds.
2. Isolation and confirmation of mitochondria from plant / animal cells.
3. Lipid solubility of membrane
4. Study of osmosis in blood cells
5. Isolation of Chloroplasts from Spinach leaves
6. Study of Hill reaction using isolated chloroplast
7. The effect of detergents on the erythrocyte membrane
8. Effect of lipid composition on membrane permeability.

Course Code	BIOT P-424
Course Title	Lab course 42 (based on BIOT-412)
Teaching time/week	45(3/wk)
Credits	1.5
Max Marks	50

Practices based on BIOT-412 Plant Physiology

1. Explain with suitable diagrams and working of experiments setup to demonstrate various physiological phenomena.
 - a) Osmosis - Thistle funnel osmoscope.
 - b) Effect of stomatal number on rate of transpiration. (Cobalt chloride test)
 - c) Effect of root pressure on ascent of sap.
 - d) Relation between absorption and transpiration. (Water balance)
 - e) Rate of transpiration by Ganong's potometer.
 - f) Separation of different photosynthetic pigment using paper chromatography.
 - g) Rate of photosynthesis by Wilмот's bubbler.

Course Code	BIOT -421
Course Title	Genetics
Teaching time/week	45(3/wk)
Credits	2
Max Marks	50

Unit1. Genes and Mutation

The enzyme cannot make enzyme paradox, The one gene –one enzyme hypothesis, Bacterial mutants, Temperature sensitive Mutants, Pathway analysis, gene protein relations. **Mutation:** Spontaneous and Induced Mutation. Types of mutations :- point mutations, frameshift mutations, inversion and deletion mutations, null mutation, lethal and conditional lethal mutation. **Mutagenic Suppression:** Reversion of mutation, true reversion, second site suppression. Drug resistant mutants, forward, reverse and suppressor mutations. Scoring of Mutations –Mutation frequencies and mutation rates (Fluctuation test, replica plating), Enrichment of mutant singletype,

Physical, Chemical and Biological mutagens.

Biological mutable agents: viruses, transposons. In vitro mutagenesis by transposons.

Unit2. Repair and genetic recombination,complementation

Repair: Base excision repair, Mismatch repair, Photoreactivation, Dark repair, SOS, post replication repair (only at concept level not at molecular level), DNA safeguarding systems. **Genetic Recombination:** Bacterial transformation, bacterial conjugation, bacterial transduction. Phage mutants, the map, mapping pool, heterozygotes, mechanism of recombination, correspondence between genetic map and DNA molecule, **Fine structure analysis:** early evidence that the gene is subdivisible, the *cis-trans* or complementation test for functional allelism, limitations of *cis-trans* test, Fine structure of the phage T4 *rII* locus.

Unit3. Genetic Code

Amino acid replacements, artificial messenger RNA, the code table, direction of the code, the anticodon and tRNA –structure and classes of tRNA, nonsense codons, nonsense suppression, suppression and anti-suppression at the ribosomal level,

intergenic frameshift suppressors, evolution of the code. Wobble pairing, code is degenerate, early evidences of *in vitro* amino acid synthesis, deciphering genetic code, codon usage, codon bias.

Unit4. Population Genetics

Gene frequencies and Equilibrium; gene frequencies, gene pool, conservation of gene frequencies, attainment of equilibrium at two or more loci, sex linkage. Estimation of equilibrium frequencies in natural populations; codominance in natural populations, dominance in natural populations, multiple alleles, mutation rates, selection, fitness, gametic selection, zygotic selection, heterozygous advantage, unstable equilibrium, equilibrium between mutation and selection, estimates of mutation rates and equilibrium frequencies, migration, random genetic drift.

References

1. Genetics, Third edition, by Monroe W. Strickberger, first Indian impression 2006
2. Microbial genetics, by, David Frifelder
3. Molecular Genetics: an introductory narrative, Second edition, by Gunter S. Stent and Richard Calendar, University of California, Berkley, First Indian print 1986, Reprint 2004
4. Principles of Genetics, Eight Edition, by Gardner, Simmons and Snustad, first Indian print 2001, second print 2007.
5. Principles of Genetics by Temin Baltimore
6. Genetics by Wintergreen.

Course Code	BIOT- 422
Course Title	Central Dogma
Teaching time/week	45(3/wk)
Credits	2
Max Marks	50

Unit1. Perpetuation and its connection with celldivision

Replicon: Definition, types of bacterial replicon, eukaryotic replicon, extrachromosomal replicon –plasmid, virus, mitochondria and chloroplast. Experimental evidences of bidirectional replication.

Replication in Prokaryotes–Escherichiacolireplicationasrolemodel,DNA polymerases–withreferencetotheirfunctionalproperties,formationofreplicationfork, primerformation,replicationonleadingandlaggingstrand,terminationofreplication.

Eukaryotic DNA replication: Origin Recognition Complex, Licensing factor, componentsofreplicaseandotherpolymerases.Replicationfork–experimentalprooffor multiplereplicationforksineukaryotes.Processofreplication,initiation,elongationand termination.

Replication of extrachromosomal material,plasmid replication–rolling circle, plasmid partitioning, plasmid incompatibility, mitochondrialDNAreplication,

Regulation of Replication connection of replication with cell division, segregation.

Consequences of mutations in replication assembly, mini-cells and maxi-cells.

Unit 2. Transcription

Prokaryotic transcription

Transcription in Escherichia coli a role model for prokaryotes–RNA polymerase:- structural components and assembly of core and holoenzyme. Transcription initiation- Bipartite structure of promoter, factors influencing promoter strength, consensus sequence, sigma mediated recognition of promoter,Formation of opencomplex, transcription bubble. Promoter clearance, Transcription elongation (inchworm mechanism),[what are road blocks and regions where polymerase will pause.]

Transcription termination –factor dependent and factor independent terminations.

Antiterminators from bacteria and bacteriophages – their applications in genetic engineering.

Eukaryotic transcription

RNA polymerases Pol I, Pol II and Pol III – structural components and their roles.

Transcription initiation Promoters, promoter like elements, downstream promoter elements, Up elements, Activators, enhancers. Activation of basal apparatus, pre-initiation and initiation. TAFs, transcription factors,

Transcription elongation specific mechanisms for each type of polymerase.

Transcription termination – processing, formation of 5' Cap, 3' polyadenylation.

Splicing, spliceosome, nucleoproteins, snRNA, hnRNA, and ribonucleoproteins.

Unit 3. mRNA Translation

Prokaryotic translation – translation initiation, ribosome assembly, RBS – Shine Dalgarno sequence, initiation codon, initiation complex, initiator tRNA, P site, A site and E site – their relevance in translation, translocation,

Translation elongation structural different between initiator tRNA and methionine tRNA during elongation, transpeptidation and chain elongation.

Translation fidelity.

Translation termination factors and release of ribosomes and their recycling.

Eukaryotic translation Pre mRNA and mature mRNA – their differences and translocation (–only review). Structural organization of functional ribosome and comparison with E. coli apparatus.

Cozaks sequence, initiator tRNA, formation of initiation complex, P site, A site and E site, their role during mRNA translation.

Translation elongation comparative studies of elongation with E. coli.

Translation termination factors, release of ribosomes and recycling, regulation.

Unit 4 Post translational/co-translational processing for functional aspect

Post translational modification Phosphorylation, Acetylation, Methylation, Glycosylation (introductory only with one popular example).

Protein Trafficking/ transport:types of transport :- cotranslational and post translational transport. Transport apparatus without carrier protein(s), with carrier protein, transport of proteins thru nuclear membrane. Endoplasmic reticulum mediated transport of proteins, need and significance of proteins involved in folding- unfolding of protein during translation, transport and after transport. Roles of chaperons, chaperonin with suitable examples. Protein transport across mitochondria and chloroplast.

References:

1. Molecular Biology –David Frifelder
2. Genes IX –Benjamin Lewin
3. Molecular biology of the gene J. D. Watson and *et.al.*,
4. Molecular Biology of the Cell –Bruce Alberts and *et.al.*,

Course Code	BIOTP-423
Course Title	Lab course 43 (based on BIOT-411)
Teaching time/week	45(3/wk)
Credits	1.5
Max Marks	50

Genetics

1. Determination of mutation rate
2. Fluctuation analysis
3. Spontaneous mutation –drug resistance phenotype
4. Mutations by UV rays
5. Mutations by chemical agents such as; base analogue, intercalating agents or Alkylating agents.
6. Bacterial transformation
7. Bacterial conjugation
8. Bacterial transduction
9. UV survival curve and Photo and/or Dark repair.

Course Code	BIOTP-424
Course Title	Lab course 44 (based on BIOT-412)
Teaching time/week	45(3/wk)
Credits	1.5
Max Marks	50

Section B –Central Dogma

1. Demonstration of Mitosis –onion root tips experiment
2. Meiosis slide demonstration (permanent slides)
3. Plasmid DNA isolation
4. Plasmid Curing
5. Isolation of total proteins from bacterial cell.

Course Code	BIOT-431
Course Title	Advanced Enzymology
Teaching time/week	45(3/wk)
Credits	2
Max Marks	50

Unit1. Extraction & Purification of Enzymes

Different sources of enzymes, Extraction of soluble enzymes Physical and chemical methods of cell disintegration to obtain enzymes. Extraction of membrane bound enzymes. Preliminary purification of enzymes by various fractionation methods – advanced purification methods : different electrophoresis and chromatographic methods.

Unit2. Enzyme Kinetics

Effect of pH, temperature, substrate concentration enzyme concentration, reaction time, metal ions on enzyme catalyzed reactions. Kinetics of single substrate enzyme catalyzed reactions (Derivation of Michaelis Mentan Equation and its significance). Transformation of MM plots into Lineweaver Burk plot and Eddle Hofstee plots. Enzyme inhibitors, Introduction to irreversible and reversible (competitive, uncompetitive and non competitive inhibitions with suitable examples.)
Allosteric enzymes, feed back inhibition and its significance in metabolic regulation. (Sequential and concerted).

Unit3. Enzyme Immobilization

Importance of enzyme immobilization, different methods of enzyme immobilization. Properties of immobilized enzymes and application of immobilized enzymes.

Unit4. Applications of Enzymes

Uses of enzymes in food and beverages, textile industries, leather industries and detergents. Enzymes in clinical diagnosis and therapeutic applications. Enzymes as environmental and therapeutic biosensors.

Reference Books

1. **Enzymes – Biochemistry, Biotechnology, Clinical chemistry**, 2004 by Trevor Palmer, East – West Press Edition.
2. **Fundamentals of Enzymology** 2003 by Nicholas C. Price and Lewis Stevens Oxford

University Press.

3. Enzyme kinetics by Paul Engal. 1977, John Willey and Sons Inc.
4. Enzymes by Dixon and Web. Acad. Press.
5. Principles of enzyme kinetics by Athel Cornish. 1976. Bowden and Butterworth and Co.
6. Laboratory manual in Biochemistry by J. Jayaraman. 2006, New Age International.
7. Source book of Microbiology by Primrose.

Course Code	BIOT-432
Course Title	Advanced Immunology
Teaching time/week	45(3/wk)
Credits	2
Max Marks	50

Unit 1. Graft and its fate: Types of graft, mechanism of graft rejection, prevention of graft rejection. Foetus as graft

Unit 2. Vaccines

Synthetic vaccines, autoimmunity, hyper- sensitivity, tumor immunity, tissue and organ transplant, ideotype network hypothesis, epitope mapping.

Vaccines: Live attenuated, Heat killed with suitable examples (Preparations, standardization and storage) Future developments- Recombinant Vaccines, Vaccines against alzheimers disease, Vaccines for AIDS, vaccine for Meningitis C, Super vaccine immunomodulators, vaccine against Cervical Cancer.

3. Fusion on myeloma cell with lymphocytes

Production of monoclonal antibodies. Chimeric antibody, humanized antibody. Methods of preparation, their clinical applications and applications in Research and development. immunodeficiency.

4. Cancer and immunology

Cancer terminology Basic proportion of a cancer cell, the causes of cancer, the genetics of cancer- tumor- Suppressor genes and oncogenes, Tumor antigens, Cancer immunotherapy).

REFERENCE BOOKS

1. Immunology Kuby, R.A. Goldsby, T.J. Kind 1997, 4th Edition B.A.Osborne.
2. Essential of immunology Ivan Riot-Blakswel 1997, 4th Edition B.A.Osborne
3. Fundamentals of Immunology Paul W.E. (Eds.) 1998 Raven press, NewYork.
4. Text book of Microbiology , Panikar and Anantnarayan2009
5. General Microbiology byDavis
6. Medical Microbiology by Duguid andCruikshank.

Course Code	BIOTP-433
Course Title	Lab course 45 (based on BIOT-411)
Teaching time/week	45(3/wk)
Credits	1.5
Max Marks	50

Section A –Advanced Enzymology

1. Production of bacterial / fungal – alphaamylase.
2. Partial purification of – amylase by salt precipitationmethod.
3. Assay of alpha amylase in terms of reducing sugar produced & calculation of enzymeunit.
4. Extraction of unease from horse gram seed / jack bean meal & estimation of its activity in termsAmmonia.
5. Extraction of papain form papaya leaves. Estimation of its activity in terms of Ammonia.
6. Characterization of alpha Amylase, invertase usingPAGE.

Course Code	BIOTP-434
Course Title	Lab course 46 (based on BIOT-412)
Teaching time/week	45(3/wk)
Credits	1.5
Max Marks	50

Advanced Immunology

1. Diagnosis of R.A. by latex agglutination
2. Ames test
3. Visit to serum institute/Immunological institute or laboratory

Course Code	BIOTS-
Course Title	SEC-2 (C) Diagnostic Biology
Teaching time/week	45(3/wk)
Credits	2
Max Marks	50

Unit I: Blood analysis

Blood Typing, Types of Blood groups, rare blood groups, Importance of Blood grouping.

Reading and significance of different parameters tested in **Complete Blood Count (CBC)**

Differential WBC Count, Types of WBC, Biological role of Leucocytes, Importance of WBC Count

Haemoglobin : Biological role of Hemoglobin Estimation of Hemoglobin, Normal level, Significance of test.

Unit II: Antigen-Antibody reactions in diagnosis

VDRL Test

Definition of a STD; **Syphilis**- Causative agent, Symptoms, Diagnosis -Definition of VDRL, procedure of VDRL test .

Widal test

Introduction to typhoid, Causative agent, Symptoms, Tests for Diagnosis of Enteric fever, Widal test-types, procedure and interpretation

ELISA Types, ELISA as tool in Clinical Biology.

Unit III: Microbiological analysis

Introduction, Microbial culture methods (from biological samples), biochemical tests for diagnosis of enteric pathogens ,interpretation of test plates

Antibiotic sensitivity test: Introduction, different types of antibiotics, mode of action

Unit IV: Pathological parameters

Urine Creatinine: Biological role of creatinine, Diagnostic use, Estimation and Interpretation.

Serum cholesterol: Introduction, types, Functions, Dietary Sources, Estimation and Clinical significance.

Blood Sugar Introduction, Dietary Sources hyperglycemia, Hypoglycemia, Estimation, Clinical significance,

References

- 1 F. C. Hay, M. R. Olwyn, P. N. Westwood and N. L. Hudson, *Practical Immunology*, 4th ed. UK: Blackwell Company Ltd, 2002.
- 2 G. P. Talwar, *Hand Book of Practical and Clinical Immunology*, 2nd ed. Vol. II, New Delhi: CBS Publishers and Distributors, 2009.

Course Code	BIOTS-441
Course Title	SEC- 2 (D)Agriculture Biotechnology
Teaching time/week	45(3/wk)
Credits	2
Max Marks	50

UNIT I History of plant genetic transformation; Generation of gene construct and maintenance; Genetic transformation: Agrobacterium mediated, biolistics, electroporation, liposome, Polyethylene glycol, in plant methods.

UNIT II Selection and characterization of transgenic plants using selectable and reportable markers; PCR; qRT-PCR; Southern, Northern, ELISA and Western techniques; Application of genetic transformation: for quality, yield, biotic, and abiotic stresses; Biosafety aspects of transgenic plants and regulatory framework.

UNIT III History of plant tissue culture; concept of totipotency; Concept of aseptic culture practices; Components of in vitro culture media and role of different macro and micro nutrients, vitamins, plant growth regulators and growth supplements; Sterilization techniques.

UNIT IV Various plant cell, tissue and organ culture techniques and uses; Somatic cell cultures; morphogenesis: organogenesis and somatic embryogenesis; Micropropagation: In vitro grafting, meristem culture; Anther, pollen, embryo, ovule, ovary culture; Protoplast culture and somatic hybridization; Somaclonal variation.

Reference Books

1. Grierson D. 2012. Plant Genetic Engineering. Springer Netherlands.
2. Primose SB & Twyman RM. 2006. Principles of Gene Manipulation and Genomics, 7th Ed. Black Well Publishing.
3. Sambrook J, Russel D. 2001. Molecular Cloning: A Laboratory Manual. 3rd Ed Cold Spring Harbor Laboratory Press.:
4. Green & Sambrook. 2014. Molecular Cloning: A Laboratory Manual. 4th Ed. 3 Vol Sets. Cold Spring Harbor Laboratory Press.
5. Stewart NC Jr. 2008. Plant Biotechnology and Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc.

6. Bhojwani SS & Razdan MK. 1996. Plant Tissue Culture: Theory and Practice. Elsevier.
7. Bhojwani SS & Dantu PK. 2013. Plant Tissue Culture: An Introductory Text. Springer.
8. K.K. Dey. Plant Tissue Culture
9. H.S. Chawla. Introduction to Plant Biotechnology.
10. Dixon RA & Gonzales RA. 2003. Plant Cell Culture: A Practical Approach. Oxford University press.
11. Helgason CD & Miller CL. 2005. Basic Cell Culture Protocols. 3rd Ed. Humana Press

Course Code	BIOT-451
Course Title	Communication skills in English-IV
Teaching time/week	45(5/wk)
Credits	3
Max Marks	50

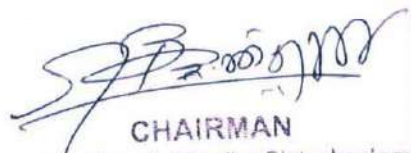
Details are to made available from respective language (English) authorities

Course Code	BIOT-461
Course Title	Marathi/Hindi/Urdu/Sanskrit A student can opt for any one of these languages (SL- IV)
Teaching time/week	45(4/wk)
Credits	3
Max Marks	50

Details are to made available from respective language authorities

Course Code	BIOT 471
Course Title	Environmental Studies
Teaching time/week	45(3/wk)
Credits	2*
Max Marks	50

Details are to made available from respective subject authorities


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