Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous)

Ganeshkhind, Pune 411 016

Three-Year BSc Biotechnology and

Four-Year BSc (Hons. With Research) Biotechnology

Degree Programs

Skeleton and Detailed Syllabus

(As per NEP Version 1 pattern; to be implemented from 2023-24)

Introduction:

Biotechnology has expanded and established as an advanced interdisciplinary applied science. The study of Life itself is at the core of it and the interdisciplinary networking potential of biotechnology has given it a separate status in fundamental research as well as in modern industrial enterprise. Global and local focus has slowly shifted to not only current "Century of Knowledge" but also on to technology development and application in life sciences. In the milieu of research and industrialization for economic development and social change, biotechnology is an ideal platform to work.

The interdisciplinary nature of biotechnology integrates living systems including animal, plant and microbes and their studies from molecular biology to cell biology, from biochemistry to biophysics, from genetic engineering to stem cell research, from bioinformatics to genomics-proteomics, from environmental biology to biodiversity, from microbiology to bioprocess engineering, from bioremediation to material transformation and so on. The relevance and application of these studies on living organisms and their bioprocesses is extensively covered in this field with the help of technology. Green revolution and white revolution was possible in India thanks to the deeper and intrinsic understanding of biotechnology. Economic and social renaissance is staged on biotechnology especially, since it' s biomedical and cutting-edge technological applications are tremendously powerful in shaping this century and exciting future. Biotechnologists are always in demand as an efficient work force in fundamental research and industries. Education and research sectors require such interdisciplinary trained work force to develop future generations of science leaders. Career opportunities for graduate students are created and expanding at the biotechnology parks and in manufacturing industries, teaching, research institutes and IT industry.

The newly developed syllabus is a choice-based credit system with semester pattern. Biotechnology has grown extensively in last couple of decades. With the changing scenario at local and global level, we feel that the syllabus orientation should be altered to keep pace with developments in the education and industrial sector. The need of the hour is to design appropriate syllabi that emphasize on teaching of technological as well as the economic aspects of modern biology. The proposed credit-based curriculum ensures the requirement of academia and industry. Theory supplemented with extensive practical skill sets will help a graduate student to avail the opportunities in the applied fields (research, industry or institutions) without any additional training. Thus, the college itself will be developing the trained and skilled man-power. Biotechnology being an interdisciplinary subject, this restructured syllabus will combine the principles of different sciences along with developing advanced technology

Biotechnology curricula are operated at two levels viz. undergraduate and postgraduate. The undergraduate curricula are prepared to impart primarily basic knowledge of the respective subject from all possible angles while postgraduate syllabus emphasizes on more applied courses. In addition, students are to be trained to apply this knowledge particularly in day-to-day applications of biotechnology and to get a glimpse of research. The basic aim of the revised course curriculum is to integrate various disciplines of life sciences which will cater the needs of human resources in academia and industry. The Overall objective of the Program is to promote education and research in biotechnology and provide academic and professional excellence for immediate productivity in academics, government organization, biomedical sectors, health and nutrition settings for ultimate benefit of society and sustainable development.

Program Objectives:

- To introduce the concepts in various allied subjects
- To enrich students' knowledge in basic and applied aspects of life sciences.

- To help the students to build interdisciplinary approach in teaching/learning & in research.
- To inculcate the sense of scientific responsibilities and social awareness
- To help the students build-up progressive and successful careers in academia and industry.

Program Specific Outcomes (PSOs):

Program Outcomes:

After successful completion of B.Sc. Biotechnology program, the students should be able:

PO1: to have competencies in the area of basic and applied biological sciences.

PO2: to learn and explore various fields and specializations of Biotechnology such as molecular biology, genetic engineering, large-scale manufacturing processes, environmental biotechnology and tissue culture

PO3: to get engaged and carry out biotechnological research independently and in team

PO4: to develop and explore the biotechnological tools with keeping in mind the social and ethical responsibilities

PO5: to prepare and pass competitive exams like GAT-B for higher studies

Examination Pattern

40:60 [Continuous Internal Evaluation: Formative, Summative and End semester exam (ESE)]

Evaluation of Students:

1) The Internal evaluation will be in form of continuous assesement format of 20 marks and End-Semester examinations will be of 30 marks making total to 50.

2) Student has to obtain 40% marks in the examination of In-Semester and End-Semester assessment. Separate passing is mandatory

4) Internal marks remain unchanged and internal assessment cannot be repeated. If student remain absent during internal assessment examination, he/she will have chance with the permission of the competent authority. But it will not be right of the student. It will be under the discretion of the competent authority and internal departmental assessment committee. In case he/she wants to repeat Internal, he/she can do so only by registering for the said courses.

In-semester Examination: Internal assessment for each course would be continuous and dates for each tutorials/practical tests etc. will be pre-notified in the time table for teaching or placed separately as a part of time table. Department/ College Internal Assessment Committee will coordinate this activity.

Suggested internal assessment tools for courses:

The concerned teacher shall announce the units for which internal assessment will take place. A teacher may choose one of the methods given below for the assessment.

1. Students Seminar
2. Short Quizzes / MCQ Test
3. Home Assignments
4. Tutorials/ Practical
5. Oral test
6. Research Project
7. Group Discussion
8. Open Book Test
9. Study Tour
10. Written Test
11. PPT presentation
12. Field Visit
13. Industrial Visit
14. Viva

Teaching Methodology:

1. Classroom Teaching
2. Guest Lectures
3. Group Discussions
4. Surveys
5. Power Point Presentations
6. Visit to Institutions / Industries
7. Research Papers & Projects
8. E-content

Department of Biotechnology

Detailed structure of TY BSc Biotechnology (NEP v.01) for implementation in A.Y. 2025-26

Course Code	Course Title	Theory/Practical (T/P)	No. of Credits	CIE+ESE (40:60)
TY BSc SEM V				
BIO3511	Plant and Animal Tissue Culture	T	4	40+60=100
BIO3512	Recombinant DNA Technology	T	4	40+60=100
BIO3513	Recombinant DNA Technology Lab	P	2	20+30=50
BIO3514	Microbial Biotechnology	T	2	20+30=50
BIO3515	Microbial Biotechnology Lab	P	2	20+30=50
BIO3526	Immunology	T	2	20+30=50
BIO3527	Immunology Lab	P	2	20+30=50
BIO3548	VSC: Plant and Animal Tissue Culture Lab	P	2	20+30=50
BIO3569	Field Project (FP)/Community Engagement Project (CEP)	P	2	20+30=50
		Total	**22**	**550**
TY BSc SEM VI				
BIO3611	Industrial Microbiology	T	4	40+60=100
BIO3612	Industrial Microbiology Lab	P	2	20+30=50
BIO3613	Applied Biotechnology	T	2	20+30=50
BIO3614	Biotechnology in The Indian Perspective (IKS Based Major)	T	2	20+30=50
BIO3615	Biostatistics and Bioinformatics	T	2	20+30=50
BIO3616	Biostatistics and Bioinformatics Lab	P	2	20+30=50
BIO3627	Enzyme Biotechnology	T	2	20+30=50
BIO3628	Enzyme Biotechnology Lab	P	2	20+30=50
BIO3669	On-Job-Training (OJT)	P	4	40+60=100
		Total	**22**	**550**

Detailed syllabus of TY BSc Biotechnology (NEP pattern) Semester V
For implementation in A.Y. 2025-26

Course Code:	**BIO3511**		**Course Name:**	**Plant and Animal Tissue Culture**
Total Credits:	**4**		**Total Lectures:**	**60**

On successful completion, the student should be able to:

CO1: Understand the basic concepts and terminology used in tissue culture.

CO2: Understand and evaluate cell cultures constraints and possibilities as an in vitro model.

CO3: Learn the concept and calculations for media preparation very well learnt as the media used for different types of culture were prepared by the students.

CO4: Design research projects, practical and large-scale micropropagation

CO5: Demonstrates knowledge on design and how to use the cell culture facilities.

CO6: Know the advantages and limitations of primary cell culture compared to immortalized or transformed cell lines.

Units	**Topic**	**Lectures**
I	**Concept of Plant Tissue culture (PTC):** Concepts of Cell theory & Cellular totipotency, major milestones and contributions in the field of plant cell, tissue and organ culture.	1
II	**Pre-requisite Facilities of Plant Tissue Culture:** Laboratory design of plant tissue culture laboratory – Research lab and Commercial Lab, Different work areas, Principle and Working of equipment & instruments required in PTC.	3
III	**Aseptic Techniques:** Washing & preparation of glassware, Packing & sterilization of Glassware, plastic ware and instruments, Media sterilization and surface sterilization, Precautions to maintain aseptic conditions in PTC Lab	2
IV	**Artificial Media and Media Preparation:** Media Composition, General methodology for medium preparation. Different types of media used in PTC, Plant growth regulators and their roles for growth and development in PTC	4
V	**Techniques of Plant Tissue Culture** **Organ culture**: Introduction, Protocol, factors affecting w.r.t. Root tip culture, Leaf culture, Shoot tip &Meristem culture, Importance of Organ culture	**2**
	Micropropagation: Concept of differentiation, Dedifferentiation and redifferentiation Different Stages of Micropropagation, Applications of Micropropagation	**3**

	Callus culture: Introduction, Types of callus, Factors affecting, protocol, Morphology & internal structure of callus, Maintenance of callus, Applications and limitations	**2**
	Suspension culture: Introduction, Types, Culture medium, Protocol, Synchronization, maintenance of cultures. Assessment of growth measurements and Viability, Applications and limitations	**2**
	Organogenesis: Introduction, Types of organogenesis (direct and indirect), Protocol, Factors affecting Organogenesis, Applications and limitations	**2**
	Somatic embryogenesis: Introduction, types of embryogenesis (direct and indirect), Stages of somatic embryogenesis. Induction, development and maturation of SE. Factors affecting somatic embryogenesis Advantages and disadvantages	**2**
	Anther and pollen culture: Introduction, Pre-treatments and Protocol, Pathways of development, Factors affecting, Advantages and disadvantages	**2**
	Ovary, Ovule, embryo and endosperm culture: Introduction, Types of culture, Protocol, Factors affecting, Applications and limitations	**2**
	Protoplast –Isolation, Culture and Fusion: Introduction, Different methods, Protocol, Factors affecting, Applications and limitations	**2**
VI	**Applications of plant tissue culture in research and commercial industry**	**1**
VII	**Introduction to Animal Tissue Culture** • History and development of Animal Tissue Culture • Scientists contributions to Animal Tissue Culture	**3**
VIII	**Basic concepts in Animal Tissue Culture and Types of cultures** • Primary Culture • Secondary Culture • Cell lines • Organ Culture, Organotypic culture/Histotypic Culture • Concept of monolayer culture/suspension culture	**5**
IX	**ATC Laboratory and Equipment** • Laboratory design • Equipment • Lab wares	**2**
X	**Nutrition and Physiology of cultured cells** • Nutritional requirement and physiology of cultured cells • Principles of media formulation	**4**

	• Serum containing medium and serum-free medium: Advantages and Disadvantages	
XI	**Aseptic conditions** • Maintenance of aseptic conditions. • Contamination, types of contaminants • Methods of detection of contaminants • Cross-contamination	**3**
XII	**Primary cell culture** • Methods of establishing primary cell culture • Source selection and establishment of fibroblast and lymphocyte culture	**3**
XIII	**Cell lines** • Evolution of cell line • Finite and transformed cell lines • Mammalian and insect cell line growth conditions • Subculture and characterization of cell line • Cell passage number and significance	**3**
XIV	**Organ Culture** • Types of organ culture • Organotypic and Histotypic culture	**3**
XV	**Cell Repositories and Cell banks** • Cryopreservation of cells • Cell repositories and cell distribution	**2**
XVI	**Applications of Animal cell cultures in different fields**	**2**

References Books:

1. Razdan M.K. (2009) - Introduction to Plant Tissue culture (Oxford & IBH Publ, New Delhi)
2. Bhojwani S.S. & Razdan M.K. (1996) (2016)- Plant Tissue Culture: Theory & Practice (Elsevier, New Delhi)
3. Jha TB & Ghosh B (2017) – Plant tissue culture: Basic and applied (Universities Press, Hyderabad) and latest editions
4. Plant Tissue culture (2010) – Kalyan Kumar De (New Central Book Agency, Calcutta)
5. Methods In Plant Tissue Culture – (2003) U Kumar Agrobios India
6. Plant cell culture Technology—MM Yeomen (2012) Blackwell
7. Freshney R.I. Culture of Animal Cells: A Manual of Basic Techniques and Specialized Applications. 7th Edition. Wiley Blackwell; USA: 2015
8. Principles and Practice of Animal Tissue Culture by Sudha Gangal, 2nd Edition.
9. Shenoy M 2007 Animal cell culture Animal Biotechnology ch 1, p (New Delhi: Firewall)
10. Bhat S.M. Animal Cell Culture Concept and Application. Alpha Science InternationalLimited; Oxford: 2011.
11. Walsh G. Biopharmaceuticals – Biochemistry and Biotechnology. 2nd ed. John Wiley andSons; Chichester: 2003

12. Castilho L.R., Moraes A.M., Augusto E.F.P. Animal Cell Technology. Taylor & FrancisGroup; New York: 2008. From Biopharmaceuticals to Gene Therapy.

Course Code:	**BIO3548**		**Course Name:**	**VSC: Plant and Animal Tissue Culture Lab**
Total Credits:	**2**		**Total Practical:**	**15**

On successful completion, the student should be able to:

CO1: Learn practical aspects of cell culture such as design and layout of the laboratory, aseptic technique, contamination, methods for measuring viability.

CO2: Acquire knowledge and hands on training on design and how to use the cell culture facilities.

CO3: Get practical hands on to establish a cell line and its maintenance.

CO4: Understand the basic techniques to establish different types of in vitro cultures

Sr. No.	**Title of Experiment**	**No. of Practical**
	Plant Tissue Culture	
1	**Lab-ware Preparation for Aseptic transfer** • Washing of Glassware/plasticware • Glassware preparation for sterilization capping, packing & sterilization, safety precautions • Discarding of contaminated glassware and washing of it	**1**
2	**Stock solution preparation** • Stock solutions calculations and preparation • Growth hormone calculation and preparation	**1**
3	**Media Preparation** • Calculation for media Preparation • Media preparation	**1**
4	**Callus culture Technique** • Callus culture technique-Initiation of culture, callus morphology & internal structure.	**1**
5	**Meristem Culture** • Initiation of shoot tip & axillary bud culture	**1**
6	**Embryo culture** • To germinate in vitro monocot and dicot embryo	**2**
	Animal Tissue Culture	
7	**ATC laboratory design and equipment used in ATC** • Structure and design ATC Laboratory • Equipment used: Laminar Air Flow, CO_2 incubator, Inverted microscope, Autoclave, Filter sterilization assembly, Centrifuge, • Refrigerator, pH meter, etc.	**1**
8	**Introduction to Aseptic Conditions** • Importance maintaining aseptic conditions.	**3**

	• Glassware washing, packing and sterilization • (Filter sterilization assembly, forceps, glass pipettes, petri plates, beakers, conical flasks etc.) • Media preparation and Sterilization (Demo using filter sterilization assembly)	
9	**Initiation of Primary Culture from chick embryo by trypsinization**	**2**
10	**Maintenance of cell line** • Observation of cell line and feeding of media • Sub-culturing: viable cell count, split ratio	**2**

Reference Books:

1. Razdan M.K. (2009) - Introduction to Plant Tissue culture (Oxford & IBH Publ, New Delhi)
2. Bhojwani S.S. & Razdan M.K. (1996) (2016)- Plant Tissue Culture: Theory & Practice (Elsevier, New Delhi
3. Plant tissue culture: Basic and applied Jha TB &Ghosh B (2017) – (Universities Press, Hyderabad) and latest editions
4. Plant Tissue culture (2010) – Kalyan Kumar De (New central Book Agency Calactta)
5. Methods In Plant Tissue culture – (2003) U Kumar Agrobios India
6. Plant cell culture Technology—MM Yeomen (2012) Blackwell
7. A Laboratory Mannual of Plant Biotechnology (2009) –S S Purohit Agrobias India
8. Freshney R.I. Culture of Animal Cells: A Manual of Basic Techniques and Specialized Applications. 7th Edition. Wiley Blackwell; USA: 2015
9. Principles and Practice of Animal Tissue Culture by Sudha Gangal, 2nd Edition.

Course Code:	BIO3512		Course Name:	Recombinant DNA Technology
Total Credits:	4		Total Lectures:	60

On successful completion, the student should be able to:

CO1: Comprehend the principles of recombinant DNA technology and the tools used in genetic manipulation.

CO2: Learn how to construct recombinant DNA molecules by inserting foreign genes into plasmids or other vectors.

CO3: Explore the diverse applications of recombinant DNA technology in biotechnology and medicine, including developing therapeutic proteins and vaccines.

CO4: Understand the principles and applications of DNA sequencing technologies.

CO5: Explore advanced techniques such as CRISPR-Cas genome editing and its applications in modifying specific genes.

CO6: Evaluation of ethical concerns related to recombinant DNA technology will be inculcated.

Units	Topic	Lectures
I	• Major milestones and breakthroughs in Recombinant DNA Technology • Contributions of Boyer and Cohen, Karry Mullis, Alec Jeffreys Craig Venter, *Jennifer Doudna* and *Emmanuelle Charpentier*.	8
II	• **Tools and techniques used in Recombinant DNA Technology** Mechanism of action, application, sources of: Restriction enzymes, Ligases, Polymerases, Alkaline Phosphatases, Nucleases, Kinases.	
II	**Vectors used in Recombinant DNA Technology:** • Plasmid and Bacteriophages- λ (Lambda) and M13 Vectors. • Overview of Expression vectors • Agro bacterial Vectors – Ti plasmid • Chimeric Vectors - Cosmid, Plasmids, Phagemids • Introduction of YAC & BAC • Selection and screening markers in vectors using techniques (Southern, Northern, Northwestern, Western blotting)	14
III	**Gene Cloning and Expression** • Steps in gene cloning. • Host organisms: Prokaryotic and eukaryotic systems. • Production of recombinant proteins and therapeutic products. • PCR: modifications and applications.	12

IV	**Next generation techniques in r DNA technology:** • DNA sequencing: Sanger sequencing, next-generation sequencing • Gene editing tools: CRISPR-Cas9, TALENs, and ZFNs. • Genomic and cDNA libraries: Construction, screening and applications. • Site-directed mutagenesis.	**14**
V	**Applications of Recombinant DNA Technology:** • Pharming- recombinant proteins from live animals and plants. (Insulin production, Vaccine production, antibody production) • Gene therapy: Strategies and challenges. • Development of transgenic plants and animals. • Diagnostic applications: r-DNA in disease detection **Ethical and Biosafety Considerations** • Ethical concerns in genetic engineering. • Biosafety levels and guidelines.	**12**

Reference Books:

1. Gene Cloning and DNA Analysis –An Introduction. T.A. Brown. Eighth Edition(2020). Wiley Blackwell.
2. Genetic Engineering. By Smita Rastogi and Neelam Pathak. Oxford University Press 2009).
3. Principles of Gene Manipulation & Genomics, 7th Edition (2006), Primrose and Twyman, Blackwell Publishing, USA.
4. Molecular Biology of the Gene, 7th Edition (2013), James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick, Pearson Education, Inc.
5. Genomes 3. T.A. Brown. Third Edition (2008). Garland Science Taylor and FrancisGroup, New York and London.
6. Sambrook, J., & Russell, D. W. (2001). *Molecular cloning: A laboratory manual* (3rd ed.). Cold Spring Harbor Laboratory press.
7. Doudna, J. A., & Charpentier, E. (2014). "The new frontier of genome engineering with CRISPR-Cas9." *Science*, **346**(6213), 1258096.

Web resources:

1. National Center for Biotechnology Information (NCBI): https://www.ncbi.nlm.nih.gov
2. Nature Reviews Genetics: https://www.nature.com/nrg/

Course Code:	BIO3513		Course Name:	Recombinant DNA Technology Lab
Total Credits:	2		Total Practical:	15

On successful completion, the student should be able to:

CO1: Students will acquire hands-on experience in recombinant DNA techniques.

CO2: The course will help students to understand setting up a polymerase chain reaction

CO3: The students will acquire practical skills on casting electrophoresis for nucleic acids.

CO4: The students will be able to transform bacterial cultures.

CO5: The students will hone practical knowledge for gene cloning experiments.

Sr. No.	Title of Experiment	No. of Practical
1	Plasmid DNA isolation and gel electrophoresis	2
2	Spectroscopic quantitation using UV-VIS spectrophotometer and Nanodrop	2
3	Restriction Digestion of DNA sample and gel electrophoresis Restriction Mapping	3
4	DNA ligation and gel electrophoresis	2
5	Transformation of *E.Coli* cells • Preparation of competent cells • Transformation • Selection of recombinants	3
6	PCR reaction and gel electrophoresis	2
7	Demonstration of Q- PCR	1

Reference Books:

1. Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J. G. Seidman, John A. Smith, Kevin Struhl, Short Protocols in Molecular Biology, Wiley.2002
2. Brenda D. Spangler, Methods in Molecular Biology and Protein Chemistry: Cloning and Characterization of an Enterotoxin Subunit, Wiley, 2002
3. Molecular cloning – A laboratory manual-(Vol. 1-3), 4 th edition, (2012), Green and Sambrook, Cold Spring Harbor Laboratory Press, USA
4. Federick M. Ausubel, Current Protocols in Molecular Biology, John Wiley and Sons,2014

Course Code:	BIO3514		Course Name:	Microbial Biotechnology
Total Credits:	2		Total Lectures:	30

On successful completion, the student should be able to:

CO1: The significance of microorganisms in food and milk processing, food spoilage, and the factors influencing microbial growth, along with preservation principles.

CO2: Understand the significance and activities of microorganisms in various food and factors affecting microbial growth in food leading to spoilage and understand the principles underlying the preservation methods.

CO3: Understand the mechanisms of microbial pathogenesis and prevention, wastewater treatment processes, and methods for assessing water potability.

CO4: Gain insights into the applications of microorganisms in metal bioleaching, agriculture, and production of biosynthetic materials.

Units	Topic	Lectures
I	**History and Scope of Microbial Biotechnology**	1
II	**Food Microbiology** • Role of microorganisms in food spoilage, Factors affecting growth of microbes in food (intrinsic and extrinsic factors), • Spoilage of meat and poultry, Fruits and vegetable, Canned food. • Principles of Food Preservation. • Methods of preservation chemical and Physical methods. **Dairy Microbiology** • Milk: Definition, Composition of milk, Normal and abnormal microflora of milk, Sources of contamination of milk, International standards of Milk. • Milk Spoilage- Flavour and colour defects, Stormy fermentation, Sweet curdling, Ropiness. • Grading of milk- Direct and Indirect Tests • Preservation of Milk- Pasteurization and efficiency of pasteurization. • Microbial processing of milk- Curd, Yogurt, Butter, Kefir,Cheese. • Food borne diseases- Food infection and intoxication	7
III	**Medical Microbiology** • Medical Microbiology: Normal flora,	7

	• Diseases of various systems Tuberculosis, Leprosy, Typhoid, Polio, Syphilis, Tetanus (causative agent, symptoms, morphology, pathogenesis, diagnosis • and treatment.)	
IV	**Microbes in Waste treatment Processes** • Water borne diseases: Indicators of fecal pollution, Routine bacteriological analysis of water for potability: Presumptive,Confirmed, Completed test, Membrane Filter Technique andEijkman tests. • Bacteriological standards of drinking water. (WHO, BSI) • Sewage and Industrial waste water: Types of wastes, relevance ofCOD and BOD determination in analysis of waste water • Methods and principles of treatment of sewage (primary,secondary and tertiary treatment methods • Microbial consortium for effluent treatment.	8
V	**Applications of Microbial Biotechnology** • Geomicrobiology-Ore leaching (methods and examples), MEOR. • Bioweapons • Biofertilizers and Biopesticides and Microbial plant growth Promoters (gibberellins and IAA) • GMOs-Norms and applications • Microbial Sweeteners (Thaumatin, Monellin) • Microbial toxins and their applications • Microbial Polysaccharide production: any 2 examples • Concept of Synthetic Biology and Bio-metabolite Production	7

References Books:

1. Food Microbiology, Frazier & Westhoff, 4th edition, Tata McGraw Hill Publications
2. Modern Food Microbiology, James Jay, 7th edition, Springer Publications
3. Advances in Biotechnology, S. N. Jogdand, Himalaya Publishing House
4. Milk & Milk Products, C. Eckles, 4th edition, Tata McGraw Hill Publications
5. Prescott, S.C. and Dunn, C.G., (1983) Industrial Microbiology, Reed G. AVI tech books
6. General Microbiology - Stanier R.Y., 5th edition, (1987)Macmillan Publication, UK.
7. Tortora, G.J., Funke, B.R., Case, C.L, 1992. Microbiology: An introduction 5th Edition,Benjamin Pub. Co. NY
8. Davis B.D., Delbacco, 1990 Microbiology 4th edition, J.B. Lippincott Co. NY

9. Wolfgang K. Joklik, 1992, Zinsser Microbiology 20th Edition, McGraw-Hill ProfessionalPublishers
10. Dey, N.C and Dey, TK. 1988, Medical Bacteriology, Allied Agency, Calcutta, 17thEdition
11. Ananthnarayana, R. and C.E, Jayaram Panikar, 1996 Text book of microbiology, 5th edition, Orient Longman. .Park and Park, Preventive and Social medicine. 2013, Publisher: Banarsidas Bhanot, Jabalpur
12. Ingraham J.L. and Ingraham C.A. (2004) Introduction to Microbiology. 3nd Edition. Thomson Brooks / Cole.
13. Madigan M.T, Martinko J.M. (2006) Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.
14. Salle A.J. (1971) Fundamental Principles of Bacteriology. 7th Edition. Tata MacGraw Publishing Co.
15. Standard Methods for the Examination of Water and Wastewater (2005) 21st edition, Publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF); edited by Andrew D. Eaton, Mary Ann H. Franson. Satyanarayan, U. Biotechnology (2008), Books and Allied Ltd. Kolkata
16. Sing, B. D. Biotechnology, (2010), Kalyani Publishers, New Delhi

Course Code:	BIO3515		Course Name:	Microbial Biotechnology Lab
Total Credits:	2		Total Practical:	15

On successful completion, the student should be able to:

CO1: Learn technique for isolation and identification of spoilage causing microorganisms and detection of pathogen from food sample.

CO2: Assess microbiological quality of milk and milk product.

CO3: Obtain hands on experience of various test used to determine potability of water

CO4: Experience the biotechnological aspects of wastewater treatment and commercial processing of dairy products

CO5: Evaluate ethical concerns in applications of genetically modified organisms.

Sr. No.	Title of Experiment	No. of Practical
1	Food and Dairy Microbiology: Grading of raw milk (Dye reduction test, DMC) Determination of efficiency of Pasteurization byphosphatase test	**2**
2	Isolation and identification (up to Genus level) of spoilage causing microorganisms from spoiled foods	**2**
3	Detection of pathogenic bacteria from packaged food sample	**1**
4	Isolation and identification (upto Genus level) of probiotics from curd sample	**1**
5	Study of Normal flora of humans (Skin and oral cavity)	**1**
6	Assessment of potability of water: Presumptive Confirmed and Completed test Eijkman's test IMViC tests	**5**
7	Enumeration of fecal coliforms by Membrane Filtration Technique	**2**
8	Visit to Dairy/ Effluent treatment plant / Sewage Treatment /Biofertilizer plant/ any other relevant industry and reportwriting.	**1**

Reference Books:

1. Milk & Milk Products, C. Eckles, 4th edition, Tata McGraw Hill Publications

2. Prescott, S.C. and Dunn, C.G., (1983) Industrial Microbiology, Reed G. AVI tech books

3. Standard Methods for the Examination of Water and Wastewater (2005) 21st edition, Publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the

Water Environment Federation (WEF); edited by Andrew D. Eaton, Mary Ann H. Franson. Satyanarayan, U. Biotechnology (2008), Books and Allied Ltd. Kolkata

Course Code:	BIO3526		Course Name:	Immunology
Total Credits:	2		Total Lectures:	30

On successful completion, the student should be able to:

CO1: Understand and demonstrate thebasic knowledge of immunological processes at a cellular and molecular level.

CO2: Demonstrate a capacity for problem-solving about immune-responsiveness

CO3: Apply basic techniques for identifying antigen-antibody interactions.

CO4: Identify the cellular and molecular basis of immune-responsiveness

CO5: Elucidate the reasons for immunization and aware of vaccination techniques

CO6: Describe the roles of the immune system in both maintaining health and contributing to disease.

Units	Topic	Lectures
I	**Immunology: Basic definitions and fundamentals of the immunesystem** • Definitions - Infection, Invasion, Pathogen, Immunity, Antigen,Antibody • Concept of Host pathogen interaction • Organization of Immune system: Structure and function of the cells and tissues of immunesystem. Structure and function of Primary and Secondary lymphoidorgans • Types of immunity: Innate and Acquired immunity Cell mediated and Humoral immunity • Immune Response: Primary and Secondary • Phagocytosis	7
II	**Components of the immune system:** • Antigens: Types and properties of an antigen. Factors affecting immunogenicity. • Immunoglobulin: Structure and their types. Properties and functionof different Immunoglobulin classes. • Complement system: Components, function and pathways. • Major Histocompatibility Complex: Types, structure and function • Cytokines: Properties and their function	8
III	**Antigen-Antibody Interactions** • General characteristics of Antigen-Antibody reaction • Concept of Lattice hypothesis and Zone phenomenon **Principle and example of different diagnostic tests:** • Precipitation, Agglutination, Immunodiffusion and Complement fixation test • Radioimmunoassay, Immunofluorescence, ELISA • Western blotting	7
IV	**Clinical Immunology** • Hypersensitivity reactions: Types of Hypersensitivity and clinical manifestation. • Concept of Autoimmunity: Mechanisms, Types of autoimmune diseases • Concept of Immunotherapy	8

	Vaccine Technology • Adjuvant- Properties and role with suitable example • Concept with suitable example of Killed and Live attenuated vaccines, Combined vaccines • Modern Techniques: Concept of Subunit vaccines, Recombinant DNA Vaccines, Conjugate vaccines, Polyvalent vaccines, Monoclonal antibodies, Chimeric antibodies with suitable example	

Reference Books:

1. Ananthanarayan R and Paniker CKJ. Textbook of Microbiology. University PressPublication.
2. Roitt I. Essential Immunology. 10th Ed. Blackwell Science.
3. Kuby. Immunology. 4th edition. W. H. Freeman & company.
4. Sudha Gangal and ShubhangiSontakke, Textbook of basic and clinical immunology,1st edition (2013), University Press, India

Course Code:	BIO3527		Course Name:	Immunology Lab
Total Credits:	2		Total Practical:	15

On successful completion, the student should be able to:

CO1: Acquire the required laboratory skills to perform, interpret and analyze core/ widely used immunological techniques.

CO2: Conduct immunological and serological tests in diagnostics.

CO3: Integrate the skill into to research and development.

Sr. No.	Title of Experiment	No. of Practical
1	Determination of blood group using slide agglutination test	1
2	To determine total leukocyte count of the given blood sample	1
3	Determine Differential count of the given blood sample	2
4	Isolation of lymphocytes	1
5	Immunodiffusion: • Single Radial immunodiffusion • Ouchterlony double diffusion technique (pattern of identity)	2
6	Determination of antibody titer by tube agglutination test (Widal Test)	2
7	Detection of presence of antigen by qualitative ELISA (Dot ELISA)	1
8	Slide flocculation test- VDRL	1
9	Antigen preparation for bacterial vaccine production	2
10	Flow cytometry- Demonstration	1
11	Visit to Immunodiagnostic laboratory	1

Reference Books:

1. Ananthanarayan R and Paniker CKJ. Textbook of Microbiology. University Press Publication.
2. Roitt I. Essential Immunology. 10th Ed Blackwell Science.
3. Kuby. Immunology. 4th edition WH Freeman & company.

Course Code	Course Title	Theory/Practical (T/P)	No. of Credits	CIE+ESE (40:60)
TY BSc SEM V				
BIO3511	Plant and Animal Tissue Culture	T	4	40+60=100
BIO3512	Recombinant DNA Technology	T	4	40+60=100
BIO3513	Recombinant DNA Technology Lab	P	2	20+30=50
BIO3514	Microbial Biotechnology	T	2	20+30=50
BIO3515	Microbial Biotechnology Lab	P	2	20+30=50
BIO3526	Immunology	T	2	20+30=50
BIO3527	Immunology Lab	P	2	20+30=50
BIO3548	VSC: Plant and Animal Tissue Culture Lab	P	2	20+30=50
BIO3569	Field Project (FP)/Community Engagement Project (CEP)	P	2	20+30=50
		Total	**22**	**550**
TY BSc SEM VI				
BIO3611	Industrial Microbiology	T	4	40+60=100
BIO3612	Industrial Microbiology Lab	P	2	20+30=50
BIO3613	Applied Biotechnology	T	2	20+30=50
BIO3614	Biotechnology in The Indian Perspective (IKS Based Major)	T	2	20+30=50
BIO3615	Biostatistics and Bioinformatics	T	2	20+30=50
BIO3616	Biostatistics and Bioinformatics Lab	P	2	20+30=50
BIO3627	Enzyme Biotechnology	T	2	20+30=50
BIO3628	Enzyme Biotechnology Lab	P	2	20+30=50
BIO3669	On-Job-Training (OJT)	P	4	40+60=100
		Total	**22**	**550**

NEP 2020 (Version 1)
T.Y. B.Sc. Biotechnology (Semester VI)

For implementation in A.Y. 2025-26

Course Code:	**BIO3611**		**Course Name:**	**Industrial Microbiology**
Total Credits:	**4**		**Total Lectures:**	**60**

Course Outcomes:

- CO1: Students will learn about the different types of fermentation processes, Fermenter design, different types of equipment used and microbiological processes.
- CO2: Students attain knowledge of equipment and design of media sterilization process in fermentation industry.
- CO3: Application of microorganisms in technological operation, substrate preparation and control of fermentative process and purification of products.
- CO4: Understand concept and importance of good manufacturing practices, quality control and quality assurance and tests used in QA and QC used in fermentation industry.

Sr. No.	Topic	Lectures
1	a. **Fermentation**- Definition, Historical perspective, Lay out of a typical fermentation unit. b. Definition and Concept of Bioprocess Engineering, Various components of Bioprocess. c. Types of fermentations: Submerged, Surface, Solid State, Dual, Batch, Continuous, Fed Batch.	4
2	a. **Screening**- Definition and Objectives: Primary and Secondary Screening b. **Strain Improvement**: Objectives, Methods for strain improvement with examples (mutant selection, mutants with altered permeability, auxotrophic mutants, analogue resistant DNA technology)	5
3	a. **Bioreactor Design**: Characteristics of an ideal Fermenter, Construction material used, surface treatment of material Design of a typical Batch Fermenter Aerator and Agitator- types, Baffles, Seals and valves used, steam traps. Additional accessories and peripherals. b. **Different designs of bioreactors**: Mechanically agitated and non-mechanically agitated • Stirred Tank reactor • Air Lift (internal and external loop • Packed Bed reactor • Fluidized bed reactor • Animal and Plant cell Bioreactors	9

4	**Fermentation Media: Components and optimization**: Media used for large scale production: **Carbon sources:** Cane and Beet molasses, Malt, Corn, Starch, oils, hydrocarbons, alcohols. **Nitrogen sources**: Corn steep liquor, Soybean meal, peanut meal Buffers, Inoculum and Production media Media for animal cell culture. **Medium Optimization:** • Concept and importance • Classical Approach	5
5	**Air and Media Sterilization**: Concept of Aseptic Operations and Containment. **Air sterilization**: Principles, Mechanism of capture of particles in air, Fixed (absolute) and non-fixed pore (depth) filters, Filter sterilization of air, Theory of depth filter, Validation of air filters. **Media Sterilization**: Principles, Thermal Death time, Decimal reduction time, Del factor, Indicator organism, designing of sterilization cycle using thermal death of microbes, loss of nutrient quality during sterilization, Equipment used in sterilization: Batch and Continuous, Use of Non-sterilized media.	5
6	**Measurement and Control of different Bioprocess parameters**: (Physical and Chemical Parameters): • Temperature, pH, Dissolved oxygen, Microbial biomass, foam) • Oxygen Uptake rate, Oxygen transfer rate, Concept and importance of KLa, • Scale Up and Scale down.	6
7	**Methods and equipments used in Downstream processing:** • Definition: Unit operations and downstream processing, General strategy of product recovery. • Precipitation (Agents used: Salts, Organic solvents, polyelectrolytes, acids and bases) • Filtration (Plate Frame. Rotary Vacuum, Filter Aids, Flocculating agents) • Centrifugation (types used in Industry: basket, multi-chamber, disc bowl) • Cell Disruption (Physico – mechanical and chemical, enzymatic methods). • Liquid- Liquid extraction (Principle, Co and counter current extraction) • Chromatography (one example each of use of Adsorption, Ion exchange, Gel and Affinity in product recovery can be explained along with manufacturing process of antibiotics, enzymes and vaccines). • Drying (Drum and Spray Drying)	10
8	**Large Scale Manufacturing Process** of (Strain used, Inoculum medium, Production medium, Bioreactor type used, Optimum conditions w.r.t time, pH, temperature, aeration, agitation, Product recovery) • Enzymes: Extracellular and Intracellular enzyme- one example each • Antibiotics: Penicillin, Streptomycin • Vitamins: B12, Riboflavin • Amino acids: Glutamic acid • Vaccines: DPT, Polio	10
9	a. Concept of Good Manufacturing Practices (GMP), Standard Operating Practices (SOP) b. Quality Control and Quality Assurance (Definition, Functions and Responsibilities) c. Tests Used for Quality Assurance of finished product: • Sterility Testing • Pyrogen testing • Bacterial endotoxin (LAL test) • Ames Test	5
10	**Course-based One commercial Success**	1

Reference Books:

1. Principles of Fermentation Technology, 2nd edition, (2003), Whittaker & Stan bury, Butterworth-Heinemann, An imprint of Elsevier Science, UK
2. Practical fermentation technology, 1st edition, (2008), BRIAN MCNEIL & LINDA M. HARVEY, John Wiley & Sons, USA
3. Industrial Microbiology: An Introduction, 1st edition, (2007), Waits and Morgan, Blackwell Science Ltd USA.
4. Morden Industrial Microbiology and biotechnology, 1st edition, (2007), Nduka Okafor, Science Publishers, USA
5. Industrial Biotechnology, 1st edition, (2009), Abilasha Mathuriya, Ane books Pvt.Ltd, India

Course Code:	**BIO3612**		**Course Name:**	**Industrial Microbiology Lab**
Total Credits:	**2**		**Total Practical:**	**15**

Course Outcome:

On successful completion of the course the student is able to

CO1: Learn techniques for screening and isolation of antibiotic producer/auxotrophic mutant isolation

CO2: Design the process for production, recovery of industrially important primary and secondary metabolites produced by microorganisms.

CO3: Determine the efficacy of the process and learn techniques used for estimating the amount of product formed.

CO4: Apply the techniques to ascertain the quality of the produce.

Sr. No.	Name of the experiment	Practical (15P)
1	• Screening and isolation of antibiotic producing organism from soil (Crowded plate/ Giant colony method) • Isolation of auxotrophic mutants by Gradient plate technique.	3
2	Production, Recovery (Filtration, Precipitation) and Estimation (Titrimetric or colorimetric) of a Primary metabolite (Organic acid)	3
3	Production, Recovery (Filtration, Solvent extraction) and estimation (Bioassay) a of Secondary metabolite (Antibiotic)	3
4	Preparation of wine	2
5	Laboratory Scale Production, Recovery and estimation of Ethanol	2
6	Sterility testing of injectables	1
7	Visit to a Fermentation Unit	1

Course Code:	BIO3613		Course Name:	Applied Biotechnology
Total Credits:	2		Total Lectures:	30

Course Outcome:

On successful completion of the course the student is able to

CO1: Learn the contemporary fields of applications of biotechnology

CO2: Learn and apply the biotechnological tools for applications in Biomanufacturing

CO3: Learn and apply the biotechnological tools for applications in human welfare

CO4: Learn and apply the biotechnological tools for applications in human welfare, agriculture, therapeutics and environment

CO5: Learn the concepts of synthetic and systems biology

Units	Topics	Lectures
I	• Applied Biotechnology: Introduction and scope- in medicine, agriculture, industry, space and environment	1
II	**Biomanufacturing** • Introduction • Biotechnology for Economy, Environment, and Employment (BioE3) policy of Government of India • Biobased chemicals and enzymes • Functional foods and smart proteins • Biomanufacturing of novel biomimetic cell and tissue products for regenerative medicine, and cell therapy.	5
III	**Biotechnology for Human Welfare** • **Precision biotherapeutics** • **Biotechnology based Diagnostics:** Biomarkers in disease diagnosis with examples, use of PCR and microarrays in diagnostics, Cellular and functional genomics in diagnostics. • **Genome India Project:** Introduction, objectives and outcomes • **Agriculture:** Climate resilient agriculture • **Bioenergy production:** Production of first, second, third and fourth generation biofuels, Applications • **Circular economy:** Designing out waste and pollution; wastes as resources; waste minimization and recycling; Regenerating natural systems, with examples. Scope for bio-entrepreneurship / business models.	8
IV	**Nanobiotechnology** • Fundamentals of nanobiotechnology • Nanomaterials and their physico-chemical properties • Applications of nanobiotechnology in Therapeutics, Agriculture, Food industry and Environment, with examples.	3
V	**Space Biotechnology** • Space biology and biotechnology. Concept of microgravity. • Space radiation biology: Impact of space radiation on DNA, cells, and organisms.	5

	• Life Support Systems: bio-regenerative life support systems for long-duration space missions, including food production and waste management. • Microbial Detection in Air System for Space (MiDASS) • Space Agriculture • Biological processes, like protein crystal growth, to produce pharmaceuticals and other useful materials in space.	
VI	**Marine Biotechnology** • Introduction • The potential of marine organisms as food, feed and nutraceuticals • Marine organisms for fuel production • Production of Bio-inspired materials using marine organisms • Seaweeds for removal of metal pollutants • Drugs from marine origin • Marine micro-organisms and its applications	4
VI	**Systems Biology and Synthetic Biology** • **Systems biology**- Introduction and concept, tools used for systems biology, Applications of systems biology in drug discovery, Precision medicine, understanding disease mechanisms and crop improvement. • **Synthetic Biology**- Introduction and concept. Creating synthetic genetic systems, Applications of synthetic biology in Pharmaceuticals, Agriculture and industries	4
VII	**Course-based One commercial Success**	

References:

1. https://www.intechopen.com/books/biomass-volume-estimation-and-valorization-for energy/metal-removal-by-seaweed-biomass
2. Molecular Diagnostics: For the Clinical Laboratorian / Edition 2 William B. Coleman (Editor), Gregory J. Tsongalis (Editor) Publisher: Springer-Verlag New York, LLC.
3. Nanobiotechnology: Concepts, applications and Perspectives, Christof M. Niemeyer (editor), Clad AMirkin (Editor), Wiley VCH, First edition, 2004.
4. Nanobiotechnology: Bioinspired Devices and Material of Future by Oded Shoseyov and Ilan levy, Human Press, First edition, 2007.
5. Introduction to Nanotechnology, Charles Poole and Frank Owen, Wiley, First Edition, 2006
6. Systems and synthetic Biology by Vikram Singh and Pawan K. Dhar, Springer Publication. 2015 (Available as Google Book)
7. Advances in Synthetic Biology by Vijai Singh. Springer Publication. 2020. Springer handbook of marine biotechnology
8. Karouia, F., Peyvan, K., & Pohorille, A. (2017). Toward biotechnology in space: High-throughput instruments for in situ biological research beyond Earth. *Biotechnology advances*, *35*(7), 905-932. https://doi.org/10.1016/j.biotechadv.2017.04.003
9. Santomartino, R., Zea, L. & Cockell, C.S. The smallest space miners: principles of space biomining. *Extremophiles* **26**, 7 (2022). https://doi.org/10.1007/s00792-021-01253-w

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11. Benner, S. A., & Sismour, A. M. (2005). Synthetic biology. *Nature reviews genetics*, *6*(7), 533-543. https://doi.org/10.1038/nrg1637
12. Tebeje, A., Tadesse, H., & Mengesha, Y. (2021). Synthetic bio/techno/logy and its application. *Biotechnology & Biotechnological Equipment*, *35*(1), 1156-1162. https://doi.org/10.1080/13102818.2021.1960189
13. Rotter, A., Barbier, M., Bertoni, F., Bones, A. M., Cancela, M. L., Carlsson, J., ... & Vasquez, M. I. (2021). The essentials of marine biotechnology. *Frontiers in Marine Science*, *8*, 629629. https://doi.org/10.3389/fmars.2021.629629
14. Zhang, Y. H. P., Sun, J., & Ma, Y. (2017). Biomanufacturing: history and perspective. *Journal of Industrial Microbiology and Biotechnology*, *44*(4-5), 773-784. https://doi.org/10.1007/s10295-016-1863-2
15. Nath, S. (2024). Biotechnology and biofuels: paving the way towards a sustainable and equitable energy for the future. *Discover Energy*, *4*(1), 8. https://doi.org/10.1007/s43937-024-00032-w
16. Jaiswal, S. K., & Mukti, S. K. (2025). Prioritizing factors affecting e-waste recycling in India: A framework for achieving a circular economy. *Circular Economy and Sustainability*, *5*(1), 461-481.
17. BIOE3: www.dbtindia.gov.in

Course Code:	**BIO3614**		**Course Name:**	**IKS Based Major:** **Biotechnology: The Indian Perspective**
Total Credits:	**2**		**Total Lectures:**	**30**

Course Objectives:

CO1: To introduce students to rich traditional knowledge and history of Biotechnology in Indian context
CO2: To acquaint students with journey of biotechnology from traditional to modern biotechnology in India

Syllabus

Units	**Topics**	**Lectures**
I	History of Biotechnology Introduction to Indian Traditional Knowledge System	3
II	Traditional Biotechnology and Indian Context in Agriculture, Environment, Food and	10

	Medicine (e.g. domestication and breeding animals and crops, and using microorganisms to make cheese, yogurt, bread, beer and wine, production of medicines and medicinal products, etc.)	
III	Case Studies and Examples of Classical Indian Biotechnological Products	3
IV	Traditional or Classical Biotechnology in: Plant and Animal Breeding Fermentation	6
V	Traditional Indian Medicinal Systems	2
VI	Traditional to Modern Biotechnology – The Indian Story	4
VII	Traditional Indian Products Used in Modern Biotechnology (Turmeric, Cardamom, etc.)-	2
VIII	Course-based One commercial Success	

Course Code:	**BIO3615**		**Course Name:**	**Biostatistics & Bioinformatics**
Total Credits:	**2**		**Total Lectures:**	**30**

Course Outcomes:

CO1: To introduce a tankful of scientific discipline that merges biology, computer science, and information technology to analyse and interpret biological data using computational and statistical techniques.

CO2: Get familiar with the concept & types of databases, organization, and data mining techniques.

CO3: Developing basics of biological sequence alignment and operating of computational tools.

CO4: Better understanding of basics in statistics and their utilization for data management.

Unit	Topic	Lecture
I	**Introductory Biostatistics** • Concept, definition, Aim, and Scope in biosciences • Types of data (Raw data and Grouped data) • Data Representation using frequency distribution diagram (Simple/Multiple/Subdivided bar diagram, Pie diagram), Graphs (Histogram, polygon, curve) Stem and leaf diagram. • Tools and Databases used for data analysis	6
II	**Descriptive Statistics** • Measures of Central tendency (Mean, Median, Mode, Range, and Box Plot) • Measures of Dispersion (Variance and Standard Deviation), Standard Error	5
III	**Inferential Statistics** • Hypothesis- definition, types (one-tailed, two-tailed), Sampling distribution, and Types of errors (Type I, II) • Testing of hypothesis- T-test, Z-test, F-test, Chi-square test, and ANOVA (one-way and two-way).	4
IV	**Introductory Bioinformatics** • Concept, definition, Aim and branches of Bioinformatics	3

	• Application of Bioinformatics- Environment, biotechnology, agriculture, *in-silico* drug designing, and biomedical genome medicines. • New age concept- era of *Omics*, Big Biological Data, Artificial Intelligence, and Machine Learning	
V	**Biological Data and Databases** • Types of databases (Primary, Secondary, and Composite) • Literature databases (Google Scholar and PubMed) • Citation databases (Web of Science and Scopus) • Nucleic acid databases (NCBI, DDBJ, GenBank, and EMBL) • Protein databases (PDB, SwissProt, and UniProt) • Model organism Databases (MODs) (*Arabidopsis thaliana*, *Escherichia coli, Danio rerio, Saccharomyces cerevisiae*).	4
VI	**Data Organization and Mining System** • File format (GenBank, FASTA, SwissProt) • Types of Sequence: Nucleotide- Genomic DNA, Complementary DNA (cDNA), Recombinant DNA (rDNA), Expressed sequence tags (ESTs), Genomic survey sequences (GSSs), Complete coding sequences (cds) and Protein (ExPasy tools). • Text-based search tools – Entrez and Sequence Retrieval System (SRS). • Sequence submission tools- BankIT, Webin, and Sequin.	4
VII	**Sequence Alignment and Analysis** • Local (Smith-Waterman algorithm) and Global (Needleman-Wunsch algorithm) sequence alignment • Pairwise sequence alignment (BLAST), Gaps, Gap penalties, Scoring matrices (PAM250 and BLOSUM62) • Multiple sequence alignment (MSA) Tools- Clustal Omega/ClustalW/Muscle	3
VII	**Course based One commercial Success**	1

Reference Books

1. Molecular Cell Biology. 7th Edition, (2012) Lodish H., Berk A, Kaiser C., KReiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman and Co., USA.
2. Molecular Biology of the Cell, 5th Edition (2007) BruceAlberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA.
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA.
4. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA.
5. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
6. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.

7. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press& Sunderland, Washington, D.C.; Sinauer Associates, MA.
8. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition.
9. R.G. Bartle and D.R. Sherbert 2nd edition, (1992), Introduction to real analysis, John Wiley, USA
10. Introductory biostatistics. 1st edition. (2003), Chap T. Le. John Wiley, USA
11. High Yield TM Biostatistics. (2001) Antony N Glaser. Lippincott Williams and Wilkins, USA

Course Code:	**BIO3616**		**Course Name:**	**Biostatistics & Bioinformatics Lab**
Total Credits:	**2**		**Total Practical:**	**15**

Practical No.	List of Practical	Practical (15)
1	Introduction to MS Excel and use of spreadsheets for data organization	2
2	Data representation types: Pie chart, Bar graphs, Line diagram, frequency polygon, frequency curve, and histogram	2
3	Data analysis using t-test , chi-square and ANOVA (one way).	3
4	Use of Online literature sources: PubMed and Google Scholar	1
5	cessing biological databases (NCBI, DDBJ, GenBank, PDB, and SwissProt) and data mining (Retrieving nucleotide sequence and protein sequence from GenBank)	2
6	Handling Sequence submission tools- BankIT/Webin/Sequin	1
7	Similarity sequence search using BLASTp and BLASTn	2
8	To study closely related genes or proteins via Multiple Sequence alignment tools like ClustalW/MUSCLE	2

Course Code:	**BIO3627**		**Course Name:**	**Enzyme and Enzyme Technology**
Total Credits:	**2**		**Total Lecture**	**30**

Course Outcome:

- CO1: Students will learn the nature, properties and role of enzymes in biological system.
- CO2: Students will gain insight into mechanisms of enzyme catalysis by enzymes and basis of their specificity.
- CO3: Students will understand the kinetics of enzyme catalyzed reactions, regulation of enzyme catalyzed reaction and its application in metabolism studies.
- CO4: The course will introduce students to the applications of enzymes in research and medicine as well as in industry.

Units	Topic	Lectures
I	**Introduction to Enzymes:** • Properties of enzymes; definition of active sites, enzyme units, specific activity; purity of enzyme. • Protein nature of enzymes and Non-protein enzymes- Ribozymes and DNAzymes • Metalloenzymes and metal activated enzymes.	**2**
II	**Enzyme Catalysis:** • Mechanism of enzyme catalysis: Acid base catalysis, Covalent Catalysis, Metal ion catalysis, Proximity and orientation effect • Mechanism of action of Serine proteases: Chymotrypsin	**4**
III	**Enzyme Kinetics:** • Factors affecting the enzyme activity- Enzyme & Substrate Concentration, pH and Temperature. • Kinetics of Single substrate enzyme catalysed reaction. • Michealis- Menten equation, Km, Vmax, Lineweaver-Burk plot, Turnover number, Kcat • Enzyme Inhibition: Concept and Types • Case study on application of basic enzyme kinetics to metabolism studies	**7**
IV	**Enzyme Regulation:** • Regulation based on Activity: Feedback Regulation, Allosteric Regulation, Covalent modification, and Proteolytic activation of Zymogens. • Multienzyme complexes and Isoenzymes • Organization of enzymes in Cells: Compartmentation of metabolic pathways eg Fatty acid Catabolism & Anabolism, Enzymes in Membrane with suitable examples. • Mechanism of enzyme Degradation: Lysosomal and non-lysosomal pathways.	**8**
V	**Immobilization of Enzymes** • Carrier matrices & its properties. • Methods of enzyme immobilization. • Whole Enzyme/cells immobilization. • Applications of immobilized enzymes.	**3**
VI	**Industrial and clinical applications of enzymes** • **Industrial Enzymes:** Thermophilic enzymes (Reverse transcriptase), Amylases, Lipases, Proteolytic enzymes in Meat and leather industry, cellulose degrading enzymes, Metals degrading enzymes. • **Clinical Enzymes:** Enzymes as thrombolytic agent, Anti-inflammatory agents, Streptokinase, Asparaginase, LDH, Transaminases (AST), Amylases, Phosphatases, Cholinesterase. • **Biosensor:** Components of enzyme biosensor: e.g. Glucose oxidase.	**6**
VII	Course-based One commercial Success	**7**

References

1. Outlines of Biochemistry: 5th Edition, (2009), Erice Conn & Paul Stumpf ; John Wiley and Sons, USA
2. Fundamentals of Biochemistry. 3rd Edition, (2008), Donald Voet& Judith Voet, John Wiley and Sons, Inc. USA
3. Principles of Biochemistry, 4th edition (1997), Jeffory Zubey, McGraw-Hill College, USA
4. Biochemistry:7th Edition, (2012), Jeremy Berg, Lubert Stryer, W.H. Freeman and company, NY
5. Lehninger, Principles of Biochemistry. 5th Edition (2008), David Nelson & Michael Cox, W.H. Freeman and company, NY.
6. Biochemistry. 5th Edition, (copu right 2013), Reginald Garett and Charles Grisham, Brook/Cole, Cengage Learning, Boston, USA.
7. Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.
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9. Understanding Enzymes, 4th ed., Palmer, T. Prentice Hall/Ellis Horwood, London (1995).
10. Fundamentals of Enzymology. . Price, Nicholas C., and Lewis Stevens. Oxford Science Publications. Second edition. New York, 2001.
11. Biocatalysts and enzyme technology. . Buchholz, Klaus, Volker Kasche, and Uwe Theo Bornscheuer. John Wiley & Sons, 2012.
12. Enzymes: a practical introduction to structure, mechanism, and data analysis. Copeland, Robert A. John Wiley & Sons, 2004.

Course Code:	**BIO3628**		**Course Name:**	**Enzyme and Enzyme Technology Lab**
Total Credits:	**2**		**Total Practical:**	**15**

Sr. No.	Title of Experiment	No. of practical
1.	Isolation of Alpha / Beta Amylase from suitable sources.	1
2.	Partial purification of Amylase.	1
3.	Determination of Enzyme activity • Preparation of Std of graph of Maltose • Calculation of enzyme activity • Preparation of standard curve of protein (Albumin) by Folin' s-Lowry method • Calculation of specific activity	4
4.	Effect of following parameters on Enzyme activity • Temperature • pH • Time	3

5.	• Effect of Substrate concentration on enzyme activity and determination of Km and Vmax	2
6.	• Enzyme Immobilization using gel entrapment method	2
7.	• Detection of Serum enzymes: SGOT/SGPT /Alkaline phosphatase	2

Recommended References

1. An Introduction to Practical Biochemistry.3rd Edition, (2001), David Plummer, Tata McGraw Hill Edu.Pvt.Ltd. New Delhi, India
2. Biochemical Methods.1st , (1995), S.Sadashivam, A.Manickam, New Age International Publishers, India
3. Bisswanger, Hans. Practical enzymology. John Wiley & Sons, 2013. 2. Wilchek, Meir, and 4. Edward A. Bayer. "Methods in enzymology." (1990). 3. Sawhney, S. K., and Randhir Singh.
4. Introductory practical biochemistry. Alpha Science Int'l Ltd., 2000.
5. A textbook of practical biochemistry- Joshi A. Reshmi
6. Practical clinical biochemistry- Harold Varley