FOUR YEAR UNDER GRADUATE (FYUG) PROGRAMME UNDER NATIONAL EDUCATION POLICY, 2020

BIOTECHNOLOGY

NORTH-EASTERN HILL UNIVERSITY, SHILLONG

उत्तर-प ी पर्वतीय वर्वश्ववर्वद्यालय, शिलांग

Date of approval in Academic Council: 30th May and 21st June 2024.

Preface

The four years under Graduate Biotechnology Programme is aimed at providing platform for students to get trained to become a scientist, researcher, or entrepreneur to work in the fields of medicine, agriculture, and food production as well as prepare them for industries R & D. The course covers aspects from fundamentals and principles of cellular systems, bioprocess engineering to advancement in genetic engineering and recombinant DNA technology.

Programme outcomes (POs):

At the end of the B.Sc Biotechnology Programme, the graduates will be able to:

1. Apply knowledge of Bio-techniques and experiments at an appropriate level to the discipline

2. Analyse a problem and define the Biological requirements, appropriate to its solution

3. Understand new concepts and be articulate while executing knowledge with peers

4. Acquire knowledge in domain of biotechnology enabling their applications in industry and research

5. Recognize social and ethical responsibilities of a professional working in the discipline.

6. Acquire technological knowhow by connecting disciplinary and interdisciplinary aspects of biotechnology

7. Apply written and oral communication skills to communicate effectively in healthcare, industry, academia and research.
8. The students will learn to perform research following ethical guidelines

1st Semester					
Course Code	**Course Title**	**Credits**			**Total contact hours**
		Theory	**Practical**	**Total**	
BIT-100	Cell Biology & Genetics(Major)	3	1	4	(45+30)=75
BIT-101	Cell Biology & Genetics (Minor)	3	1	4	(45+30)=75
MDC - 110-119	Any of the available course as notified by the University from time to time	3	-	3	45
AEC – 120-129	Any of the available course as notified by the University from time to time	3	-	3	45
SEC – 130-139	Any of the available course as notified by the University from time to time	3	-	3	45
VAC - 140	EnvironmentalSciences	3	-	3	45
Total				**20**	**330**

2nd Semester					
CourseCode	**Course Title**	**Credits**			**Total contact hours**
		Theory	**Practical**	**Total**	
BIT-150	Biochemistry (Major)	3	1	4	(45+30)=75
BIT - 151	Biochemistry (Minor)	3	1	4	(45+30)=75
MDC – 160-169	Any of the available course as notified by the University from time to time	3	-	3	45
AEC – 170-179	Any of the available course as notified by the University from time to time	3	-	3	45
SEC – 180-189	Any of the available course as notified by the University from time to time	3	-	3	45
VAC – 190-199	Any of the available course as notified by the University from time to time	3	-	3	45
Total				**20**	**330**

3rd Semester					
Course Code	**Course Title**	**Credits**			**Total contact hours**
		Theory	**Practical**	**Total**	
BIT- 200	Biological Techniques (Major)	3	1	4	75
BIT-201	Biostatistics (Major)	3	1	4	75
MDC – 210-219	Any of the available course as notified by the University from time to time	3	-	3	45
AEC – 220-229	Any of the available course as notified by the University from time to time	2	-	2	30
SEC – 230-239	Any of the available course as notified by the University from time to time	3	-	3	45
VTC – 240-249	Any of the available course as notified by the University from time to time	3	1	4	75
Total		**17**	**3**	**20**	**345**

4th Semester					
CourseCode	**Course Title**	**Credits**			**Total contact hours**
		Theory	**Practical**	**Total**	
BIT - 250	Microbiology (Major)	4	-	4	60
BIT - 251	Molecular Biology (Major)	4	-	4	60
BIT - 252	Microbiological methods and Techniques (Major)	-	4	4	120
BIT - 253	Techniques in Molecular Biology (Major)	-	4	4	120
VTC -- 260-269	Any of the available course as notified by the University from time to time	3	1	4	75
Total		**11**	**9**	**20**	**435**

5th Semester					
CourseCode	**Course Title**	**Credits**			**Total contact hours**
		Theory	**Practical**	**Total**	
BIT - 300	Immunology (Major)	3	1	4	75
BIT - 301	Genetic Engineering (Major)	3	1	4	75
BIT - 302	Bioethics/IPR & Bioentreprenuership (Major)	4	-	4	60
BIT- 302	Food Technology (Minor)	4	-	4	60
BIT-303	Internship	-	4	4	120
Total		14	6	**20**	**390**

6th Semester					
CourseCode	**Course Title**	**Credits**			**Total contact hours**
		Theory	**Practical**	**Total**	
BIT - 350	Environmental Biotechnology(Major)	4	-	4	60
BIT - 351	Plant & Animal Biotechnology (Major)	4	-	4	60
BIT - 352	Techniques in Plant & Animal Environmental Biotechnology (Major)	-	4	4	120
BIT - 353	Computer Application & Bioinformatics (Major)	3	1	4	75
VTC – 360-369	Any of the available course as notified by the University from time to time	-	4	4	120
Total		11	9	**20**	**435**

BIT – Biotechnology; MDC – Multi Disciplinary Course; AEC – Ability Enhancement Course; SEC – Skill Enhancement Course; VAC – Value Added Course; VTC – Vocational Education & Training Course

SEMESTER III

Code: BIT-200 Biological Techniques

Credits: 4
(Contact Hours: 75)
Total Marks: 100

Course Objective (CO):

The students will be taught to understand the concept and gain understanding on the principles and applications of various instruments.

Learning Outcome (LO):

At the end of the course, the students will be able to :

LO1	Able to understand the various concepts in microscopy, spectroscopy, chromatography, and DNA based techniques.
LO2	Evaluate proficiency in specific biological techniques such as DNA extraction, PCR, gel electrophoresis, and chromatography.
LO3	Ability to design and plan experiments, including selecting appropriate techniques for specific research questions.

(Theory) **Credits: 3**
(Contact Hours: 45)

UNIT 1

Basic optical theory - the nature of light, lenses, ray diagrams, polarization. Theory of image formation. Conjugate image and aperture planes. Principles & applications of bright field, darkfield light microscopy, Phase contrast microscopy, differential interference contrast microscopy and fluorescence Microscopy. Electron Microscopy: TEM & SEM.

UNIT 2

Basic of electromagnetic radiation, energy, wavelength, wave numbers and frequency, absorption and emission spectra. Beer-Lambert law. Theory and Applications of UV and visible spectrophotometry, fluorescence spectroscopy, Infrared spectroscopy, circular dichroism, optical rotatory dispersion. Principle of centrifugation, preparative and analytical centrifugation

UNIT 3

Principle of Chromatography, size exclusion chromatography, ion exchange chromatography, Thin layer chromatography, High-performance liquid chromatography (HPLC), Gas Chromatography, Principle of electrophoresis (SDS & agarose gel),

UNIT 4: **(Practical)**

Credits: 1
(Contact Hours: 30)

1. Verification of Beer's Lambert Law and determination of molar extinction coefficient
2. Pipetting Technique and measurement
3. Separation of biological samples (amino acids) using Paper Chromatography
4. Separation of plant extracts using Thin Layer Chromatography (TLC)
5. Demonstration of GAS Chromatography/HPLC/PCR/Electrophoresis/microscopy/DNA based techniques/spectroscopy/pH instruments.

SUGGESTED READING:

1. Donald L. Pavia Introduction to Spectroscopy 2015, Cengage India Private Limited
2. Keith Wilson, John Walker Principles and Techniques of Biochemistry and Molecular
3. Biology Cambridge University Press, 21-Mar-2005
4. William Bialek Biophysics: Searching for Principles, Princeton University Press
5. K. Wilson and J. Walker, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2013. 2)
6. B Sivasankar, Instrumental Methods of Analysis, Oxford University Press, 2012
7. Biophysical Chemistry, Principles & Techniques – Upadhyay, Upadhyay and Nath –Himalaya Publ. House.
8. Chromatography – G. Abbott.
9. Physical Biochemistry- Application to biochemistry and molecular biology by David Freifelder. W. H. Freeman & Co. San Francisco. 2nd Edition
10. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
11. Analytical Biotechnology-Methods and Tools in Biosciences and Medicine, Thomas GM & Schalk Hammer
12. Tripathi, Timir (2023) Introduction to Spectroscopic Methods. Astral International (P) Ltd, New Delhi. ISBN: 978-93-5461-699-0
13. Tripathi, Timir (2024) Chromatography and Centrifugation Methods: A Beginner's Handbook. Astral International (P) Ltd, New Delhi. ISBN: 978-93-5461-731-7
14. Tripathi, Timir (2024) Electrophoresis and Immunology Methods: A Beginner's Handbook. Astral International (P) Ltd, New Delhi.

SEMESTER III

Code: BIT-201 **Biostatistics** **Credits: 4**

(Contact Hours: 75)

Total Marks: 100

Course Objective (CO):

The students will be taught to understand the theory and practical applications of statistics in biological studies.

Learning Outcome (LO):

At the end of the course, the students will be able to:

LO1	Define and understand fundamental statistical concepts
LO2	Comprehend and evaluate the basic principles of descriptive and inferential statistics.
LO3	Calculate and interpret descriptive statistics and their applications.
LO4	Analyze data and generate graphical representation.
LO5	Practically solve problems using statistical approach.

(Theory)

Credits: 3

(Contact Hours: 45)

UNIT 1

Sampling and Data Collection, Data Presentation: numerical data types – nominal, ordinal, ranked, discrete and continuous data. Graphical representation of data – Bar charts, histograms, frequency polygon, line graphs, one-way scatter plots. Measures of Central tendency- Arithmetic, Harmonic and Geometric Mean, Mode and Median and their applications, merits, and demerits; Measures of dispersion-Range, Variance, Standard Deviation Coefficient of variance, their applications, merits and demerits.

UNIT 2

Probability and Conditional probability, Theoretical distributions- Binomial and Poisson Distribution and their Properties; Normal distribution and its properties, Skewness and kurtosis.

UNIT 3

Significance tests: t–test, z-test, f-test and chi-square test, analysis of variance (ANOVA). Correlation and Regression analysis emphasising examples from Biological Sciences: Linear, bivariate regression analysis.

UNIT 4: **(Practical)**

Credits: 1

(Contact Hours: 30)

1. Measures of Location.
2. Measures of Dispersion.
3. Correlation Analysis.
4. Regression Analysis.
5. Student Paired t-Test.
6. X^2- Test of Independence of Attributes.
7. Use of MS Excel for statistical calculations.

SUGGESTED READING:

1. Biostatistics – Daniel. (Wiley).
2. Statistics by S.C.Gupta.
3. Statistical Methods by G.W.Snedecor & W.G.Cochran.
4. Fundamentals of Biostatistics – Khan & Khanum.
5. Fundamentals of Biostatistics by U.B.Rastogi (Ame Books Ltd).
6. Fundamentals of Biostatistics – Khan & Khanum.
7. Fundamentals of Biostatistics by U.B.Rastogi (Ame Books Ltd).
8. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press.
9. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley
10. Mariappan P. (2013) Biostatistics. Pearson
11. Rastogi VB.(2015). Biostatistics (3rd Edition). MedTec

SEMESTER IV

Code: BIT-250 **Microbiology** **Credits: 4**
(Contact Hours: 60)
Total Marks: 100

Course Objetive (CO):
The students will be taught to understand the theoretical aspects of microbiology which will enhance their knowledge of the domain

Learning Outcome (LO):
At the end of the course, the students will be able to :

LO1	Understand the classification system for microbes.
LO2	Understand the various sterilisation techniques and media preparation for microbes.
LO3	Identify and summarize the major virulence factors that contribute to microbial pathogenicity. .
LO4	Understand the applications of microbiology in various industries, including medicine, agriculture, and environmental science

UNIT 1
Spontaneous generation, Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Germ theory of disease, Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems, different forms of acellular microorganisms (Viruses, Viroid's, Prions) and Cellular microorganisms (Archaea and Bacteria, Eukarya, Algae, Fungi and Protozoa).

UNIT 2
Concept and different sterilisation methods – Physical, Chemical and radiation, Filtration – Diatomaceous earth filter, Seitz filter, a membrane filter and HEPA. Components of media, natural and synthetic media, selective, differential, indicator, enriched and enrichment media, Serial dilution and plating methods (pour, spread, streak); maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, Principles of staining, Types of stains-simple stains, structural stains and differential stains.

UNIT 3
Spontaneous and induced mutation in microbes; isolation of bacterial auxotrophic mutants; genetic recombination in microbes (conjugation, transduction, transformation); Growth curve with mathematical formulation and generation time. symbiosis and antibiosis among microbial populations.

UNIT 4:
Probiotics: Health benefits, types of microorganisms used, Quality Control using Microbiological Criteria- Control at Source and good manufacturing practices, role of microbes in bio-geo chemical cycling

SUGGESTED READING:

- Atlas RM. (1997). Principles of Microbiology. 2nd edition. Wm C Brown Publishers.
- Black JG. (2008). Microbiology: Principles and Explorations. 7th Ed., Prentice Hall
- Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Micro-organisms. 14th
- Ed., Prentice Hall International, Inc.
- Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology, 5th Ed., Tata McGraw Hill.
- Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
- Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th Ed., McMillan.
- Ketchum, P. A. (1984) Microbiology- Concepts and applications, Wiley Publications
- Frobisher M. (1957) Fundamentals of Microbiology, 6th Ed., W.B. Saunders Toppan Publications
- Singh, R.B (1990) Introductory Biotechnology, C.B.D. India
- Salle AJ (2007) Fundamentals of Bacteriology, Dodo Press, USA
- Bison P.S., (1994) Frontiers in Microbial technology, CBS Publishers.
- Bull AT, Holt G, Lilly MD. Biotechnology, International Trends and Perspectives, OECD
- Powar C.B. (2010) General Microbiology, Himalaya Publishing Co.

SEMESTER IV

Code: BIT-251 **Molecular Biology** **Credits: 4**
(Contact Hours: 60)
Total Marks: 100

Course Objective (CO):
The students will be taught to understand the theoretical aspects in molecular biology which will enhance their knowledge of the domain

Learning Outcome (LO): At the end of the course, the students will be able to:

LO1	Define and understand fundamental molecular biology concepts, including DNA replication, transcription, translation, and the central dogma
LO2	Identify and summarize the gene expression regulation at the transcriptional and post-transcriptional levels, including the role of transcription factor
LO3	Communicate scientific concepts effectively through written reports, oral presentations, and scientific discussions
LO4	Gain an understanding of chemical and molecular processes that occur within and between cells

UNIT 1
Nucleic acids as genetic information carriers- experimental evidence, Basic concepts about the secondary structure of nucleic acids, base pairings and base stacking in DNA molecule, RNA. DNA structures & types, Chemical and physical properties of DNA, chromatin organisation, T_m and buoyant density and the relationship with GC content in DNA. Structure and properties of RNA – mRNA, tRNA and rRNA.

UNIT 2
DNA replication – semiconservative replication, DNA polymerases and other enzymes and protein factors involved in replication; Mechanism of replication in prokaryotes and eukaryotes, its differences with eukaryotes;

UNIT 3
Transcription: RNA polymerases, promoter, initiation, elongation and termination of RNA synthesis in prokaryotes and its difference with eukaryotes. Reverse transcriptase; Eukaryotic post-transcriptional processing of RNA. Genetic code- triplet nature, degeneracy and universality Translation- mechanism in prokaryotes and eukaryotes.

UNIT 4:
Regulation of Gene expression in prokaryotes – enzyme induction and repression, Operon Concept (Lac and Trp Operon), Principle and application of Southern, Northern blotting. PCR and its application.

SUGGESTED READING:

1. Molecular Biology of the Cell, Alberts B, Johnson A, Lewis J, Raff M, Roberts K & Walter P, 4th Edition, New York & London, Garland Science, 2002.
2. Molecular Biology of the Gene, James W, Richard L, Michael L, Alexander G, Tania B &Stephen B, 5th Edition, Benjamin-Cummings Publishing Company, 2003.
3. Genetic Engineering: Concepts, Tools and Techniques, Mann R, Syrawood Publishing House, USA, 2016.
4. Molecular Biology. 2"13 ed. 1994. D. Freifelder. Springer.
5. Molecular Biology by G. Padmanabhan, K. Sivaram Sastry, C. Subramanyam, 1995,Mac Millan.
6. Molecular Biology and Biotechnology 2na ed. J.M. Walker and E.B. Gingold. Panima Publications. PP 434.
7. Dictionary of microbiology and molecular biology. 2nd ed. 1994. Sigleton. P. and Sainsbury, D. Sciential Publication.
8. Molecular Biology of the Gene, 1S87. 4th Ed. J.D. Watson, N.H.Hopkins, J.W. Roberts, J.A. Steitzand A.M. Weiner, 2 Vol. Benjmin/Cummings.

SEMESTER IV

Code: BIT-252 Microbiological methods and Techniques (Practical)

Credits: 4
(Contact Hours: 120)
Total Marks: 100

Course Objective (CO):
The students will be taught to understand the practical aspects to be used in Microbiology which will enhance their knowledge of the domain

Learning Outcome (LO): At the end of the course, the students will be able to:

LO1	Apply and analyze various microbiological tools for identification of microorganisms and interpret the results.
LO2	To understand, learn and isolate, culture and maintenance of pure culture
LO3	Understand the safety protocols involved in handling microorganisms and demonstrate ethical aspects in the collection, handling, and dissemination of microbial data
LO4	Understand the method for estimating the quality of environmental samples.

1. Introduction to aseptic techniques
2. Preparation of cotton plug
3. Preparation of Culture media, slants, plates and deep tubes
4. Isolation of microorganisms from air.
5. Isolation of microorganisms from water and soil using serial dilution techniques.
6. Isolation of pure cultures of bacteria by streak plate.
7. Methods of preservation of cultures – low temperature, storage in liquid nitrogen, storage in mineral oil and maintenance by subculturing.
8. Calibration and standardization of microscope by using an Ocular micrometre and stage micrometre and measurement of dimension (size) of the given microorganism.
9. Staining techniques- Simple staining, Negative staining, Gram staining, Capsule staining, Endospore staining, and cotton blue staining.
10. Growth curve of E. coli by turbidimetric method and calculate the generation time.
11. Examination of water: (Drinking water, Supply water, Pond water) - for coliform
12. Antibiotic sensitivity test

SUGGESTED READING:

1. Microbiology: A laboratory manual by J. Cappucino and C.T. Welsh. 11th edition, Pearson Education, USA. 2016
2. Aneja K.R., Experiments in Microbiology, plant pathology, Tissue culture and Mushroom Cultivation, New Age International, New Delhi.
3. Dubey R.C.. and Maheshwari D.K., Textbook of practical microbiology, S Chand Publications.
4. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology, 5th edition McMillan.

SEMESTER IV

Code: BIT-253 **Techniques in Molecular Biology (Practical)** **Credits: 4 (Contact Hours: 120) Total Marks: 100**

Course Objective (CO):
The students will be able to understand and interpret the techniques used in molecular biology.

Learning Outcome (LO): At the end of the course, the students will be able to:

LO1	Design and execute experiments in molecular biology.
LO2	Develop skills to analyze scientific problems and design appropriate molecular biology experiments.
LO3	Develop and conclude effective communication skills for presenting experimental results towards dissemination of knowledge.
LO4	Prepare molecular biology reagents for practical purposes.
LO5	Isolate genomic DNA and estimate protein along with performing electrophoresis experiment

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1. Preparation of Molecular Biology reagents relevant to the practical's
2. Spectrposcopic estimation of DNA by DPA method
3. Estimation of RNA by Orcinol Method
4. Estimation of protein by Bradford's method
5. Isolation of genomic DNA from animal tissue
6. Agarose gel electrophoresis of DNA
7. DNA hyperchromicity
8. Isolation of protein using ammonium sulphate fractionation
9. SDS PAGE of protein

SUGGESTED READING:

- H. Miller, et al., Molecular Biology Techniques, Elsevier Academic Press, 2011, 3rdedition
- W. Ream and K. G. Field, Molecular Biology Techniques: An Intensive Laboratory Course, Elsevirer Academic Press, 1998, 1stedition
- David Plummer, An Introduction to Practical Biochemistry, Tata McGraw Hill Education; 3rd edition (2006)
- M. R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual (3 Volumes), Cols Spring Harbor Laboratory Press, 2012, 4th edition.

SEMESTER V

Code: BIT-300 Immunology & Immunological Techniques **Credits: 4**

(Contact Hours: 75)

Total Marks: 100

Course Objective (CO):

The students will be taught to understand the theoretical and experimental aspects of immunology.

Learning Outcome (LO):

At the end of the course, the students will be able to:

LO1	Illustrate and identify the processes and mechanisms involved in immune responses, including antigen recognition, immune cell activation, and the functioning of antibodies.
LO2	Interpret and explain key terms and concepts related to immunology.
LO3	Understand the concepts in immunology including humoral and cell mediated immunity
LO4	Understand antibody interactions and agglutination reactions
LO5	Perform practical experiments on immunological aspects.

(Theory)

Credits: 3

(Contact Hours: 45)

UNIT 1

History of immunology; Innate & adaptive, humoral and cell-mediated immunity; Lymphoid organs, primary and secondary lymphoid organs- Immune cells, antigen-presenting cells (professional and non-professional)and their importance in antigen recognition, structure and functions of immunoglobulins.

UNIT 2

Antigens-Nature of antigens; Immunogens, haptens & Adjuvants. Antigen – Antibody interactions: Antibody affinity, antibody avidity, precipitation reactions – radian immune diffusion, double immune diffusion, immune electrophoresis. Agglutination reactions – hemagglutination, ELISA- dot blot & sandwich.

UNIT 3

MHC and types, Antigen processing and presentation by Class I and Class II MHC molecules, Structure and function of BCR and TCR, generation of antibody diversity, Complement system and their activation, Polyclonal and monoclonal antibodies and their applications, hypersensitive reactions- Type I, II III & IV.

UNIT 4 **(Practical)**

Credits: 1

(Contact Hours: 30)

1. ABO blood grouping and Rh factor
2. Identification of various immune cells by morphology and staining methods
3. Differential WBC count
4. Separation of mononuclear cells
5. Isolation of immunoglobulin from serum
6. ODD
7. ELISA

SUGGESTED READING:

1. Immunology – Kuby., J - 5 th Edition
2. Immunology – Ivan M. Roitt – Third Edition
3. Immunobiology – Janeway and Travers – 5th Edition
4. An Illustrated colour text of Clinical Biochemistry by Allen Gaw, Robert A.Cowan, illustrated by Robert Britton (1999, second edition, Churchill Living stone press).
5. Basic and Clinical Immunology. Peakman M and Vergani D, 2nd Edition Churchill Livingstone Publishers, Edinberg (2009)

SEMESTER V

Code: BIT-301 Genetic Engineering

Credits: 4
(Contact Hours: 75)
Total Marks: 100

Course Objective (CO):
The students will be taught to understand the concepts and applications of genetic engineering.

Learning Outcome (LO): At the end of the course, the students will be able to:

LO1	Analyse the use of genetic engineering in various fields, including medicine (gene therapy), agriculture (genetically modified organisms), and industry (production of biofuels).
LO2	Perform practical experiments and interpret the data
LO3	Apply recombinant DNA technology to produce genetically modified organisms (GMOs) with improved traits or for the production of therapeutic proteins.
LO4	Apply genetic engineering principles to solve real-world problems and address challenges in different contexts.

(Theory)

Credits: 3
(Contact Hours: 45)

UNIT 1

Safety measures in recombinant DNA technology, Restriction enzymes: Type I, II, III & IV, mode of action, nomenclature, DNA modifying enzymes & their applications – polymerase, nucleases, kinases, topoisomerase, gyrases, methylase and ligases, Vectors- Plasmid, bacteriophage, cosmids, expression vectors, retroviral vectors, artificial chromosomes.,

UNIT 2

Cloning strategies: production of defined DNA fragments, insertion of the DNA molecule into a vector, detection of recombinant molecules, cloning and expression of genes in prokaryotic and eukaryotic systems.

UNIT 3

Construction and screening of genomic and cDNA libraries, DNA sequencing techniques and its improvements, Gene transfer techniques: Vector and vector-mediated gene transfer plants and animals. Transgenic: Bt cotton, golden rice, transgenic sheep, transgenic cow, transgenic monkey. Knock in and knock out techniques

UNIT 4 **(Practical)**

Credits: 1
(Contact Hours: 30)

1. Extraction and visualization of Plasmids from bacterial culture
2. Bacterial transformation by $CaCl_2$ method and blue, white screening
3. Restriction digestion of lambda DNA
4. Ligation of DNA
5. PCR of 16S rRNA gene of *E. coli*
6. Display model preparation: pBR, Bacteriophage, phagemids, Gene cloning.

SUGGESTED READING:

1. Molecular Biology of the Cell, Alberts B, Johnson A, Lewis J, Raff M, Roberts K & Walter P, 4th Edition, New York & London, Garland Science, 2002.
2. Molecular Biology of the Gene, James W, Richard L, Michael L, Alexander G, Tania B &Stephen B, 5th Edition, Benjamin-Cummings Publishing Company, 2003.
3. Genetic Engineering: Concepts, Tools and Techniques, Mann R, Syrawood Publishing House, USA, 2016.
4. An Introduction to Genetic Engineering, Nicholl DST, Cambridge University Press, 2008.
5. Molecular cloning 3rd Edition, A laboratory Manual, 1st edition, Maniatis T, Fritch EF& Sambrook L, Cold Spring Harbour Laboratory, New York, 2006.
6. Molecular biotechnology, Principle and applications of recombinant DNA technology, Bernard R. Glick.
7. Principles of gene manipulation and genomics. 2016 .S.B. Primrose and R.M. Twyman 2 Gene Cloning and DNA Analysis: An Introduction .2010. Terry Brown
8. From Genes to clones. Ernst. L. Winnacker, (2003), 2nd edition, Panima publishing corporation, NewDelhi.
9. James. D. Watson (2001) Recombinant DNA technology, 2nd edition, WH Freeman and company, New York.
10. David T. Plummer. An Introduction to Practical Biochemistry
11. Wood W. B. Wilson J.H., Benbow R.M. and Hood L.E. 1981. Biochemistry- A Problem Approach, 2nd edition. The Benjamin/ Cummings Pub.co
12. Segel I.R., 2nd edition., 2004, Biochemical calculations, John Wiley and Sons
13. Irwin H. Segel, 2nd Edition, Biochemical Calculations, John Wiley & Sons
14. Molecular cloning 3rd Edition, A laboratory Manual, 1st edition, Maniatis T, Fritch EF& Sambrook L, Cold Spring Harbour Laboratory, New York, 2006.
15. Introduction to Practical Molecular Biology, DEabre P. John Wiley & Sons Ltd (1998)

SEMESTER V

Code: BIT-302 Bioethics, IPR & Bioentreprenuership Credits: 4

(Contact Hours: 60)
Total Marks: 100

Course Objective (CO):
The students will be taught to understand the concept of ethics, IPR for development and ethical management of advancements in the life sciences. Further, the students may augment their potential for Bioentreprenuership.

Learning Outcome (LO):
At the end of the course, the students will be able to :

LO1	Conceptualise IPR, and bioentrepreneur ship to create innovative solutions while upholding ethical standards.
LO2	Explore and connect the integration of ethical considerations, intellectual property protection, and sustainable business practices in the development and commercialization of bio-based technologies
LO3	Summarize and interpret strategies for managing intellectual property portfolios, including licensing, commercialization, and enforcement of rights

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UNIT 1
Bioethics: Introduction, ethical conflicts in biological sciences-interference with nature, Bioethics in research - cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology-genetically engineered food, environmental risk, labelling and public opinion, laboratory biosafety

UNIT 2
Introduction to Intellectual Property and History. Patents, Trademarks, Copyright, Trade secrets, Industrial Design and Rights, Traditional Knowledge, Geographical Indications – the importance of IPR – patentable and non-patentable, legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO),

UNIT 3
Introduction to Bioentreprenuership, Promotion of Bioentreprenuership. Introduction - Meaning, Needs and Scope of Bio-entrepreneurship, entrepreneurship, Types of Bio-Industries Entrepreneurship development programs of public and private agencies (MSME, BIRAC.). Definition of copyright, patents, trademarks, geographical indications, and industrial designs.

UNIT 4
Sharing benefits and protecting future generations - Protection of environment and biodiversity - biopiracy. Ethics, Pros and Cons of IP protection. International patenting, requirements, fees and guidelines, provisional/complete, financial assistance for a patent, publication of patent gazette of India, credit sharing, power of attorney, patent infringement studies. Overview of intellectual property; Biotechnology Research and Intellectual Property Rights Management Licensing and Enforcing Intellectual Property.

SUGGESTED READING:

1. Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan K. Sell Cambridge University Press, 2000
2. Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I. Poltorak; Paul J. Lerner Wiley, 2011 (second edition)
3. Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4thEdition. ASM 2006
4. Entrepreneurial Development - S.S. Khanka
5. Entrepreneurial Development - Satish Taneja & Dr.S.L. Gupta
6. Entrepreneurial Development - P.C. Shejwalkar
7. Dynamics of Entrepreneurial Development - Vasant Desai.
8. Fundamental of Entrepreneurship – Dr. A.K. Gavai
9. Entrepreneurship: New Venture Creation : David H. Holt
10. Patterns of Entrepreneurship : Jack M. Kaplan
11. Entrepreneurship and Small Business Management: C.B. Gupta, S.S. Khanka, Sultan Chand & Sons.

SEMESTER V

Code: BIT-302 **Food Technology** **Credits: 4**

(Contact Hours: 60)

Total Marks: 100

Course Objective (CO):

The students will be able to develop the necessary skills and knowledge in Food Technology including quality assurance, and other related fields.

Learning Outcome (LO):

At the end of the course, the students will be able to :

LO1	Implement proper sanitation practices in food handling and processing.
LO2	Learn quality control measures to ensure the consistency and safety of food products.
LO3	Develop and modify recipes based on nutritional requirements, dietary restrictions, culinary preferences and food safety
.LO4	Demonstrate creativity and innovation in the development of new food products.

UNIT 1

Introduction to Nutrients - Carbohydrates, Protein, Lipids, Vitamins, Minerals. General outline, Composition & Nutritional value of Cereals: Structure of wheat and Rice. Millets – ragi, sorghum, maize, finger millet. Composition, Nutritive value, Antinutritional factors of Pulses and legumes. Changes during cooking, Factors affecting cooking time.

UNIT 2

Composition and nutritive value change during storage of eggs, and fish. Classification, composition, and nutritional value of Poultry. Introduction to Functional foods, Prebiotics, Probiotics, Nutraceutical. Organic Foods and GM foods**.**

UNIT 3

Introduction to food technology, definition, history, growth, and scope. Role of food technology in food processing industries. Food properties and significance - physical, rheological, thermal, mass transfer, and electrical properties. Introduction to food quality, food safety, factors affecting nutrient composition, food spoilage.

UNIT 4

Objectives, importance, and functions of quality control. Current challenges to food safety. Role of national and international regulatory agencies, Bureau of Indian Standards (BIS), AGMARK, Food Safety and Standards Authority of India (FSSAI), USFDA, International Organization for Standards (ISO), and its standards for food quality and safety (ISO 9000 series, ISO 22000, ISO 15161, ISO 14000).

SUGGESTED READING:

1. Motarjemi Y. Lelieveld H. (Ed.) Food Safety Management, A Practical Guide for the Food Industry, Academic Press, eBook ISBN: 9780123815057,
2. Forsythe S J, Hayes P R. Food Hygiene, Microbiology & HACCP. Springer, 2012.
3. Schmidt R.H., Rodrick G.E. Food Safety Handbook, John Wiley & Sons, Inc., 2003, Print
4. Srilakshmi, B. 2003 Food science, New Age International Publishers, India.
5. Shakuntalamanay, N. M., 2004 Foods: Facts and Principles - New Age Publishers.
6. Swaminathan M., 2003 Food Science, Chemistry & Experimental Foods, BAPPCO

SEMESTER V

Code: BIT-303 **Internship** **Credits: 4**
(Contact hours: 120)
Total Marks: 100

Course Objective:

- To provide a learning opportunity at the field level.
- To provide opportunity to manage biotechnology related activities.
- To equip them with technical skills as bio-enterpreneurs.

Learning Outcomes:

On completion of the course, students will be able to:

- Experience working in a biotechnology farm.
- Learn practical application to manage a biotechnology farm.
- Learn from the field experts about biotechnology tools and management.

S.No	Evaluation of Interns	Marks distribution	Credits
1	Field work 12 days x 6 hours = 72 hours	50	2
2	Report submission and preparation of presentation **(**Every intern must submit report after completion of internship program) 48 hours.	25	1
3	Presentation and Viva.	25	1
Total		**100**	**4**

Suggested Readings:

1. Aniket Singh. (2018). The complete book of internships in India: Intern abroad thissummer. Notion Press, Incorporated.
2. Woodard, E. (2015). The ultimate guide to internships: 100 steps to get a greatinternship and thrive in it. Allworth Press.
3. McLachlan, J. E., & Hess, P. F. (2015). Get an internship and make the most of it: Practical information for high school and community college students. Rowman & Littlefield Publishers.
4. Green, M. E. (1997). Internship success: Real-world, step-by-step advice on getting themost out of internships. VGM Career Horizons.
5. Khoury, R. J., & Selby, J. (2021). How to intern successfully: Insights and actions tooptimize your experience. Waterside Productions.
6. Shindell, R. (2019). Total internship management supervisor's handbook: A manager'sguide to delivering an amazing internship experience. Intern Bridge, Incorporated.

SEMESTER VI

Code: BIT-350 Environmental Biotechnology

Credits: 4
(Contact Hours: 60)
Total Marks: 100

Course Objective (CO):

The students will be taught to understand the applications and importance of environmental biotechnology.

Learning Outcome (LO):

At the end of the course, the students will be able to :

LO1	Understand environmental challenges, including pollution, waste management, and the impact of human activities on ecosystems.
LO2	Apply and formulate biotechnological tools and techniques to address environmental problems.
LO3	Measure and infer bioremediation techniques for the clean-up of contaminated sites using various environment monitoring tools

UNIT 1

Scope of environmental biotechnology, Environmental Pollution: Classification of pollutants, Ecosystem structure and functions, abiotic and biotic components, Energy flow, food chain, food web, ecological pyramids-types, and biogeochemical cycles. Air, Water, Soil, Noise and Thermal pollution, the concept of Air quality index.

UNIT 2

Waste treatment and management - anaerobic digestion, aerobic treatment processes, composting and vermiculture, liquid waste management - Biological waste treatment, activated sludge treatment, microbial pollution in activated sludge, percolating filters, biofilms. Waste management of Dairy and fertilisers.

UNIT 3

Biofuel production (biogas, biodiesel, etc.), microbial fuel cells, and algal biofuel technology. Energy from Biomass, Biosensors and Biochips, molecular tools in environmental monitoring, and Biomarker identification, biofuels and biopesticides.

UNIT 4

Bioremediation & phytoremediation: Bio feasibility, bioreduction, microbial leaching and biomining, microbes in petroleum extraction, introduction to biodegradation of xenobiotics compounds, pesticides, oil spills and toxic industrial effluents.

Suggested Reading:

1. Textbook of environmental biotechnology by Pradeep Kumar Mohaptra.
2. Environmental Biotechnology by Alan Scragg.
3. Sharma, P.D. 1990. Ecology and environment. Rastogi publications, Meerut.
4. Applied Biotechnology and Plant Genetics, M Sudhir, Dominant Publishers & Distributors, 2016.
5. Intellectual Property Rights: Critical Concepts in Law, Vaver D, Taylor & Francis, 2006.
6. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and applications (2nd edition), Cambridge, University Press.
7. Divan Rosencraz, Environmental laws and policies in India, Oxford Publication.

SEMESTER VI

Code: BIT-351 Plant & Animal Biotechnology

Credits: 4
(Contact Hours: 60)
Total Marks: 100

Course Objective (CO):
The students will be taught the theoretical and practical aspects of plant and animal biotechnology, preparing them for careers in research, agriculture, biotechnology industries, and regulatory bodies.

Learning Outcome (LO):
At the end of the course, the students will be able to :

LO1	Demonstrate a comprehensive understanding of the fundamental principles of plant and animal biotechnology, including molecular biology, genetics, and cellular processes.
LO2	Gain practical skills in bioprocessing, including the cultivation of genetically modified organisms, downstream processing, and the production of biotechnological products.
LO3	Comprehend current trends and emerging technologies in plant and animal biotechnology, including advancements in genomics, synthetic biology, and other related fields.

UNIT 1
Scope and history of plant biotechnology, plant tissue culture –culture media, surface sterilization, callus and suspension cultures. Protoplast isolation and fusion for the development of cybrids and hybrids, Process of embryogenesis and organogenesis, different modes of plant regeneration, anther and ovary culture for production of haploid plants, micropropagation (Axillary buds, Shoot tip and meristem culture).

UNIT 2
Genetic fidelity of tissue culture-raised plants using RFLP, RAPD, and AFLP. Marker-assisted selection.

UNIT 3
Animal cell culture: History and background, advantages and limitations, the biology of cultured cells, basics concept of primary cell culture and established cell lines, maintenance of cell culture, high-density cell culture, types of media,.

UNIT 4
Vaccine development-DNA,RNA and mRRNA, Gene knockouts, Animal Cloning : retroviral vectors, adenoviral vectors, microinjection, Gene therapy: therapeutic methods of production and applications, stem cells concepts and applications.

Suggested Reading:

1. Sharma, P.D. 1990. Ecology and environment. Rsatogi publications, Meerut.
2. Applied Biotechnology and Plant Genetics, M Sudhir, Dominant Publishers & Distributors, 2016.
3. Plant Biotechnology: Current and Future Applications of Genetically Modified Crops, Nigel Halford, Wiley-Blackwell, 2013.
4. Mather and Barnes, Methods in Cell Biology, Academic Press, 1998.
5. Butler, Mammalian Cell Biotechnology: A Practical Approach, Oxford UNI Press, 1991.
6. Intellectual Property Rights: Critical Concepts in Law, Vaver D, Taylor & Francis, 2006.
7. Plants, Genes and Crop Biotechnology, Chrispeels MJ & Sadava DE, Jones and Bartlett Publishers, Inc., 2nd Edition, 2002.
8. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and applications (2nd edition), Cambridge, University Press.

SEMESTER VI

Code: BIT-352 Techniques in Plant, Animal & Environmental Biotechnology (Practical)

Credits: 4
(Contact Hours: 120)
Total Marks: 100

Course Objective (CO):
The students will be taught to acquire practical skills in the field of plant, animal, and environmental biotechnology techniques.

Learning Outcome (LO):
At the end of the course, the students will be able to :

LO1	Perform and understand basic laboratory techniques used in plant, animal, and environmental biotechnology.
LO2	Demonstrate proficiency in tissue culture methods for plant and animal cells.
LO3	Isolate and culture microorganisms of industrial importance.

1. Preparation of Tissue Culture Media.
2. Micropropagation by vegetative bud proliferation
3. Callus Culture.
4. Organogenesis.
5. Preparation of media & Surface sterilization for animal cell culture, Culture, and maintenance of animal cell lines
6. Preparation of cell culture media: Preparation of basic cell culture media, such as Dulbecco's Modified Eagle Medium (DMEM), supplemented with foetal bovine serum (FBS), antibiotics, and other required additives.
7. Count cells using a haemocytometer, and perform viability assays (e.g., trypan blue exclusion) to determine the percentage of viable cells.
8. Cell staining and microscopy: Staining the cultured cells using dyes such as haematoxylin and eosin (H&E) and observe them under a light microscope to study cell morphology and structure.
9. Production of wine.
10. Estimating the percentage of alcohol, total acidity & volatile acidity in wine.
8. Isolation of industrially important microorganisms from natural resources.
9. NPM of water analysis
10. Demonstration on vermicomposting.

Suggested Reading:

1. Plant tissue culture – theory and practice by Bhojwani S.S.
2. Plant cell culture – A practical approach by Dixion R.A.
3. Plant Cell, Tissue, and Organ Culture, By Reinert, J. and YPS Bajaj (Springer – Verlag).
4. Plant tissue and cell culture, by Street, HE (Blackwell).
5. Introduction to Plant Biotechnology, Chawla, H. S. (2000), Enfield, NH: Science.
6. Introduction to Plant Tissue Culture, Razdan, M. K. (2003), Enfield, NH: Science.
7. Plant Biotechnology: an Introduction to Genetic Engineering, Slater, A., Scott, N. W., &Fowler, M. R. (2008), Oxford: Oxford University Press.
8. Biochemistry & Molecular Biology of Plants, Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015), Chichester, West Sussex: John Wiley & Sons.
9. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs,
10. 1991.
11. Paulins, M. D. Bioprocess Engineering Principles. John Wiley Publishers.2003.Prentice Hall, Englewood Cliffs, 2002.
12. Prescott, Sc and Dunn, C. Industrial Microbiology, McGraw Hill, New York. 1984.
13. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (2014). Environmental engineering. McGraw-Hill Education.
14. Banerjee, S., & Santhosh, C. (2019). Environmental biotechnology: Concepts and applications. CRC Press

SEMESTER VI

Code: BIT-353 Computer Application & Bioinformatics Credits: 4

(Contact Hours: 75)
Total Marks: 100

Course Objective (CO):
The students will develop theoretical knowledge and practical application in both computer applications and bioinformatics

Learning Outcome (LO):
At the end of the course, the students will be able to :

LO1	Differentiate and discuss the relevant computer applications and software tools commonly used in the field.
LO2	Gain knowledge and hands-on experience in analysing genomic and proteomic data, including the interpretation of DNA and protein sequences.
LO3	Understand the algorithms and computational methods behind common bioinformatics tools, enabling students to make informed choices and potentially contribute to the development of new tools

.

(Theory) **Credits: 3**
(Contact Hours: 45)

UNIT 1

Basic architecture of Operating System- WINDOWS & LINUX (UBUNTU), Mainframe & Mini Frame- computers, CPU & GPU based system, Introduction to networks topology, Types of networks: LAN, MAN, WAN. Network Devices: modem, hub, switch, repeater, router, gateway, Star, Bus, Tree, Mesh. Introduction to Internet, URL, WWW, and its applications- Web, email, Chat, VoIP, Web Browsers: Introduction, commonly used browsers. Software licensingand copyright, free and open-source software (FOSS).

UNIT 2

Introduction to Biological databases, classification of biological databases, introduction to NCBI website- history and applications, major resources for Bioinformatics (NCBI, EBI, DDBJ, ENA, PDB, SWISS-PROT, TREMBL,), database similarity search- BLAST & FASTA, introduction to sequence alignment, introduction to different file formats in biological databases.

UNIT 3

Introduction to proteomics, the concept of protein folding, protein structure-function relationship, and protein interactions (protein-protein, protein -DNA and protein-ligand). Computational approaches to protein interaction (molecular docking and analysis): Protein primary structure determination – homology modelling and structure validation.

UNIT 4 **(Practical)**

Credits: 1
(Contact Hours: 30)

1. Retrieval of protein and nucleotide sequences from biological databases – NCBI – protein and nucleotide databases, DDBJ, EMBL, Uniprot and KEGG
2. Retrieval of three-dimensional structures of biomolecules from PDB and its analysis.
3. Sequence similarity search using BLAST and FASTA
4. Primer designing and troubleshooting.
5. Retrieval of research articles from PubMed/MEDLINE

Suggested Reading:

1. Proteomics- Pennigton & Dunn (2002) Viva books publishers, New Delhi
2. Discovering Genomics, Proteomics, and Bioinformatics, 2nd Edition, Campbell AM & Heyer LJ,Pearson, 2007.
3. Bioinformatics: Sequence and Genome Analysis, 2nd Edition, Mount D, CSHL Press, 2004.
4. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition, Baxevanis AD & Francis BF, Wiley, 2004
5. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.\
6. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
7. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.
8. Marcello Pagano, Kimberlee Gauvreau, Principles of Biostatistics, Second Edition. 2018 by Chapman and Hall/CRC

9 . R.K. Taxali, PC Software for Windows Made Simple, Tata McGrawHill Publishing Company,1998.

10. Sinha, P.K.(2007). Computer Fundamentals. New Delhi: BPB Publications.
11. Rajaraman, V. (2014). Fundamental of Computer. New Delhi: Prentice Hall India Pvt. Limited.