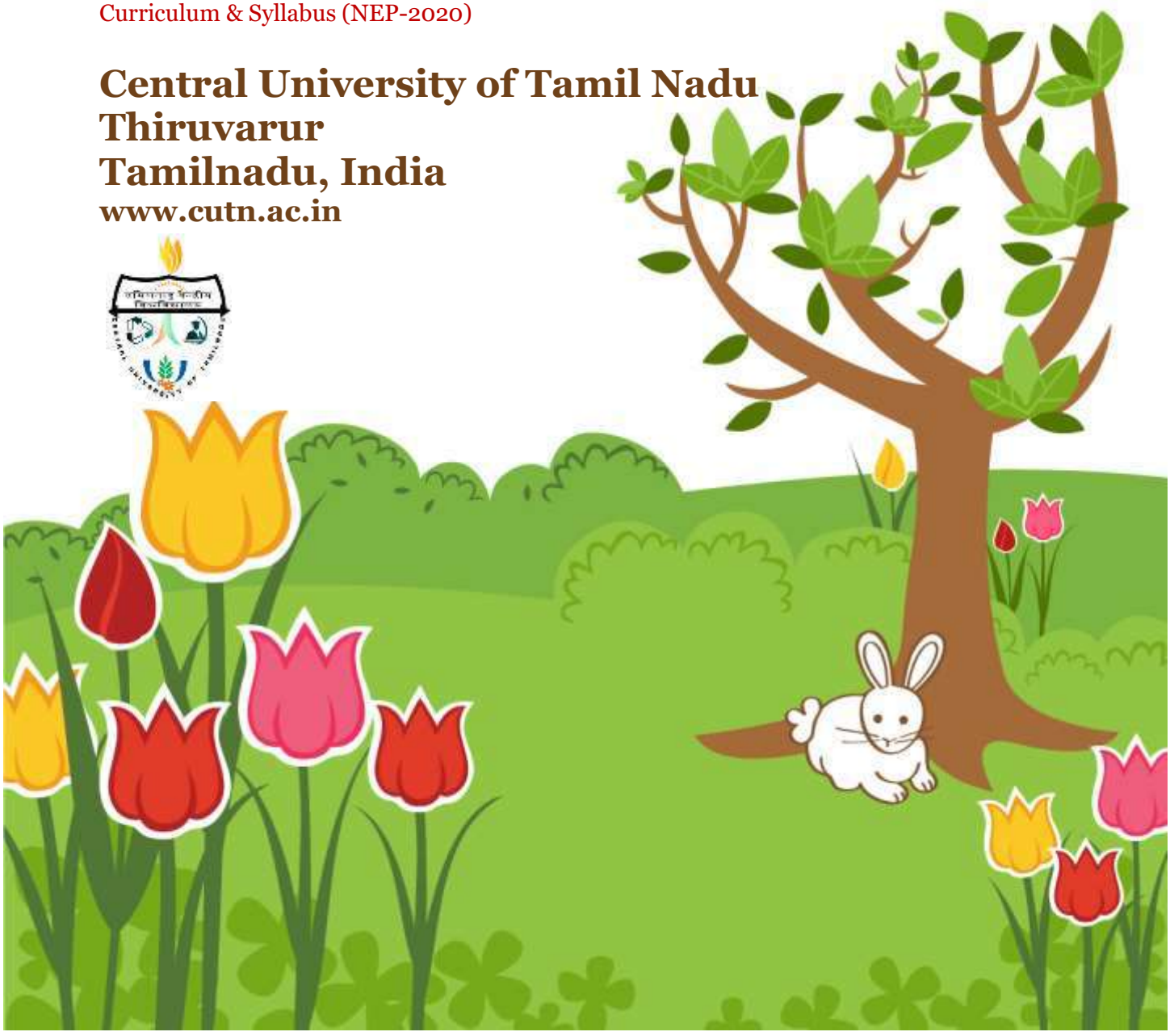
School of Integrative Biology

Department of Biotechnology
(DST-FIST Sponsored Department)

IMSc Biotechnology

Curriculum & Syllabus (NEP-2020)

Central University of Tamil Nadu
Thiruvarur
Tamilnadu, India
www.cutn.ac.in



तमिलनाडुकेन्द्रीयविश्वविद्यालय
(संसदद्वारापारितअधिनियम 2009केअंतर्गतस्थापित)
CENTRAL UNIVERSITY OF TAMIL NADU
(Established by an Act of Parliament, 2009)
नीलक्कुड़ीपरिसर/Neelakudi Campus, कंगलान्चेरी/Kangalancherry,
तिरुवारूर/Thiruvarur- 610 005, Tamilnadu
www.cutn.ac.in

5-YEAR INTEGRATED MSc BIOTECHNOLOGY PROGRAM

Curriculum and Syllabus – 2023

(NEP-2020)

Department of Biotechnology
(DST-FIST Sponsored Department)
School of Integrative Biology
Central University of Tamil Nadu
Thiruvarur 610005

Department of Biotechnology

School of Integrative Biology

Central University of Tamil Nadu

Established in 2012, as the Department of Life Sciences is now rechristened as the Department of Biotechnology (DBT) is a DST-FIST sponsored department. The department offers three programs, a 5-year-integrated MSc, a 2-year MSc and PhD for aspirants of Biotechnology. The 2-year MSc Biotechnology program is supported by Department of Biotechnology, Government of India. DBT is strengthened by a team of faculty members who commit themselves to the highest standards both in academics and research. It is one of the most vibrant and visible departments in terms of competition for admission among its aspirants. The department boasts of its internationally-trained faculty members with vast teaching experience, high-impact publications, extra-mural research grants and in terms of cutting-edge infra-structure facilities standing as a testimony to its success.

Vision of the Department

Enlighten the potential of biotechnology to achieve newer heights in multi-disciplinary education, research and entrepreneurship, and instil human values and welfare via promoting innovation in biotechnology for nation-building.

Mission of the Department

M1	• To provide an academic ambience that emphasizes creativity and critical thinking among students
M2	• To promote multi-disciplinary education, research and creative analysis among the students across diversified areas in biotechnology
M3	• To display leadership qualities in pedagogy and learning for better understanding of mechanistic concepts in biotechnology

Choice Based Credit System Curriculum and Syllabus
5-year Integrated M.Sc. Biotechnology Degree Program

Program Structure (234 Credits)

A. Program Specific Objectives (PSO)

After five years of successful completion of the program, the students will be able to

PEO1	Evolve into post graduates with knowledge and understanding of concepts across diverse areas in biotechnology
PEO2	Serve as skilled human resource tailored to formulate, analyze, and resolve complex problems in biotechnology
PEO3	Apply the knowledge and skills acquired to cater to the needs of the industry, academia, research and the society for contributing to nation-building
PEO4	Inculcate ethical values and quality for providing sustained constructive services to the community
PEO5	Understand the importance of continuous learning to overcome challenges in professional career

B. PSO to Mission Statement Mapping

	PEO1	PEO2	PEO3	PEO4	PEO5
M1	x	x	x	x	-
M2	x	x	x	-	x
M3	x	x	x	x	x

C. Graduate Attributes of Integrated M.Sc. (Biotechnology) Program

1. **Disciplinary Knowledge:** Understand the diverse aspects of biotechnology and apply tools and techniques for industrial advancement, progress and innovation.
2. **Communication Skills:** Develop verbal and written communication skills to convey the mechanistic concepts with clarity.
3. **Critical Thinking:** Capacity to generate hypotheses, design and conduct experiments, mining, analysis and interpretation of data, and reporting the findings.
4. **Problem-Solving:** Design and execute processes to find solutions for biological problems to meet the needs of the global society.
5. **Cooperation:** Ability to work independently, yet cooperate and function effectively as a member (team player) or leader of a team.
6. **Biotechniques & ICT Skills:** Apply biological concepts and appropriate ICT tools (technique) to solve complex biological problems.
7. **Ethics:** Demonstrate and endorse the universal standards of ethics and responsibilities.
8. **Self-Directed Learning:** Access and update current information and literature in science.
9. **Reasoning:** Develop the ability to critically and systematically analyze scientific data to be able to draw unbiased conclusions for fulfilling the objectives.
10. **Creativity:** Develop the ability to harness out-of-the-box (divergent and convergent) thinking, and by innovative means overcome technical challenges in biotechnology.
11. **Societal and Environmental Concern:** Appreciate and contribute to improvement of the quality of environment and sustainability of life.
12. **Harnessing Longevity of Learning:** Understand the importance of continuous learning and practice it through life.

D. Program Outcomes (PO)

On the successful completion of the program, the student will be able to

PO1	Gain knowledge across various areas in biotechnology and acquire the necessary skills on modern tools and techniques in the field.
PO2	Apply the gained knowledge and skills in research and development and contribute significantly to societal benefits.
PO3	Endorse an interdisciplinary approach for providing better solutions and innovative ideas towards sustainable development and engage in continuous learning.
PO4	Serve as an ingredient of the pool of skilled manpower and is able to apply the knowledge for harnessing bioentrepreneurship skills.
PO5	Imbibe ethical and moral values in both personal as well as social life for improving individual personality.

E. PO to PSO Mapping

	PO1	PO2	PO3	PO4	PO5
PSO1	x	x	x	x	-
PSO2	x	x	x	-	-
PSO3	x	x	x	x	x
PSO4	-	x	-	x	x
PSO5	-	-	x	x	x

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Department of Biotechnology Regulation – 2023

Choice Based Credit System Curriculum and Syllabus 5-year Integrated M.Sc. Biotechnology Degree Program

Types of Courses	Short Form
Major Course	MAC
Discipline Specific Elective Course	DSE
Minor Course – Multidisciplinary	MIC
Ability Enhancement Compulsory Course	AECC
Skill Enhancement Course	SEC
Open Elective Course – Interdisciplinary	OE
Value Added Course	VAC
Summer Internship	SI
Online Course	OC
Research Project/Dissertation	RP
Add-on Course	AOC
Audit Course	AUC
Extension Activity	EA

IMSc BIOTECHNOLOGY

Department of Biotechnology

School of Integrative Biology

SEMESTER I

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1011	Basics of Biology	MAC	4	4
2	CHE1011	Basics of Chemistry	MAC	4	4
3	XXXXX	Health Education and Nutrition	SEC	3	3
4	ENG1011	English I	AECC	3	3
5	XXXXX	Yoga and Fitness	VAC	2	2
6	XXXXX	Open Elective	OE	3	3
7	BTY1012	Biology Lab.	MAC	4	2
8	CHE1012	Chemistry Lab.	MAC	4	2
		Total		**27**	**23**

SEMESTER II

S.No.	Code	Course Title	Category	Hrs	Credits
1	PHY1011	Basics of Physics	MIC	4	4
2	MAT1011	Basics of Mathematics	MIC	4	4
3	XXXXX	Disaster Risk Reduction	SEC	3	3
4	TAM1011/ HIN1011	Language I (Tamil/Hindi)	AECC	3	3
5	XXXXX	Environmental Studies	VAC	2	2
6	XXXXX	Open Elective	OE	3	3
7	PHY1012	Physics Lab.	MIC	4	2
8	MAT1012	Mathematics Lab.	MIC	4	2
		Total		**27**	**23**

*Students who have successfully completed all 1st year courses can opt to slide to other related disciplines (Chemistry/Physics/Mathematics) provided fulfilment of all the stipulated conditions

** Students who have successfully completed all 1st year courses can opt to leave the program with a UG Certificate

*** Those who opt to leave the program with a UG Certificate should complete an approved 4-credit Vocational Course at the end of 2nd Sem.

**** Total Credit requirement for UG Certificate is 50 (46 + 4 = 50)

SEMESTER III

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1031	Biochemistry	MAC	4	4
2	CHE1031	Organic Chemistry	MIC	4	4
3	BTYSE01	Analytical Techniques	SEC	3	3
4	TAM1031/ HIN1031	Language II (Tamil/Hindi)	AECC	3	3
5	BTYVA01	Biopython	VAC	2	2
6	XXXXX	Open Elective	OE	3	3
7	BTY1032	Biochemistry Lab.	MAC	4	2
8	CHE1031	Organic Chemistry Lab.	MIC	4	2
		Total		**27**	**23**

SEMESTER IV

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1041	Microbiology	MAC	4	4
2	BTY1042	Cell Biology	MAC	4	4
3	BTYECXX	Biofertilizer/Vector Biology/ Plant Pathology/On-line Course	DSE	4	4
4	ENG1041	English II	AECC	3	3
5	XXXXX	Open Elective	OE	3	3
6	XXXXX	Extension Activity (NSS/NCC/Etc.)	EA	0	1
7	BTY1043	Microbiology Lab.	MAC	4	2
8	BTY1044	Cell Biology Lab.	MAC	4	2
		Total		**26**	**23**

*Students who have successfully completed all 4 Sem. (1st + 2nd year) can opt to leave the program with a UG Diploma

** Those who opt to leave the program with a UG Diploma should complete an approved 4-credit Vocational Course at the end of 4th Sem.

*** Total Credit requirement for UG Diploma is 96 (92 + 4 = 96)

SEMESTER V

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1051	Molecular Biology	MAC	4	4
2	BTY1052	Plant and Animal Biotechnology	MAC	4	4
3	BTY1053	Microbial Biotechnology	MAC	4	4
4	BTYECXX	Neurobiology/Drug Discovery and Development /Virology/On-line Course	DSE	4	4
5	BTYSE02	Genetics	SEC	2	2
6	BTY1054	Molecular Biology Lab.	MAC	4	2
7	BTY1055	Plant and Animal Biotechnology Lab.	MAC	4	2
8	BTY1056	Microbial Biotechnology Lab.	MAC	4	2
		Total		**30**	**24**

SEMESTER VI

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1061	Genetic Engineering	MAC	4	4
2	BTY1062	Immunology	MAC	4	4
3	BTY1063	Bioinformatics	MAC	4	4
4	BTYECXX	Clinical Biochemistry/Cell Signaling/Plant Functional Genomics/On-line Course	DSE	4	4
5	BTYSI01	Summer Internship*	SI	0	2
6	BTY1064	Genetic Engineering Lab.	MAC	4	2
7	BTY1065	Immunology Lab.	MAC	4	2
8	BTY1066	Bioinformatics Lab.	MAC	4	2
		Total		**28**	**24**

* Summer Internship must be completed during the summer vocation after 4th Sem.

** Students who have successfully completed all 6 Sem. (1st + 2nd + 3rd year) can opt to leave the program with BSc Degree.

*** Total Credit requirement for BSc Degree is 140

Students who have successfully completed all 6 Sem. (1st + 2nd + 3rd year) can opt to continue for 4-Yr BSc (Honours/ Honours with Research) Degree or continue for 5-Yr Integrated MSc Degree

Only those students who have scored ≥75% Marks are eligible for 4-Yr BSc (Honours with Research) Degree

SEMESTER VII

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1071	Bioprocess Engineering and Technology	MAC	4	4
2	BTY1072	Systems and Synthetic Biology	MAC	4	4
3	BTY1073	Gene Expression and Transgenics	MIC	4	4
4	BTY1074	Cell and Gene Therapy	MAC	4	4
5	BTYECXX	Cancer Genomics/ Vaccines/ Nanobiotechnology/On-line Course	DSE	4	4
6	BTYSE03	Research Methodology & Scientific Communication Skills	SEC	2	2
7	BTY1075	Bioprocess Engineering and Technology Lab.	MAC	4	2
8	BTY1076	Systems and Synthetic Biology Lab.	MAC	4	2
		Total		**30**	**26**

SEMESTER VIII

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1081	Omics Technologies	MAC	4	4
2	BTY1082	Molecular Diagnostics	MAC	4	4
3	BTY1083	Protein Engineering	MAC	4	4
4	BTY1084	Environmental Biotechnology	MAC	4	4
5	BTYECXX	Regenerative Medicine/ Epigenetics/ Pathogenesis of Infectious Diseases/On-line Course	DSE	4	4
6	BTYSE04	Biostatics and R Programing	SEC	3	3
7	BTYSE05	Intellectual Property Rights, Biosafety and Bioethics	SEC	3	2
8	BTYSE06	Seminar	SEC	1	1
9	BTYVAXX	VAC	VAC	2	0
		Total		**29**	**26**

* Students who have successfully completed 7th and 8th Sem. can opt to leave the program with a PG Diploma

** Those who opt to leave the program with a PG Diploma should complete a 2-credit Summer Internship at the end of 8th Sem.

*** Total Credit requirement for a PG Diploma is 192

SEMESTER IX

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1091	Bio-Devices	MAC	4	4
2	BTY1092	Emerging Technologies & Critical Analysis of Classical Papers	SEC	4	4
3	BTY1093	Bioentrepreneurship, Project Proposal Preparation and Presentation	SEC	5	4
4	BTYECXX	Biosimilars/ Biological Imaging/ Probiotics and Prebiotics/ On-line Course	DSE	4	4
5	XXXXXX	OE	OE	3	3
6	BTYSE07	Seminar	SEC	1	1
7	BTYPR01	Dissertation – Phase I	SEC	-	4
		Total		21	24

SEMESTER X

S.No.	Code	Course Title	Category	Hrs	Credits
1	XXXXX	Self-Study Course (On-line)	MAC	-	4
2	BTYSI02	Summer Internship	SI	-	2
3	BTYPR02	Dissertation – Phase II	SEC	-	12
		Total		**24**	18

* Summer Internship must be completed during the summer vocation at the end of 8th Sem.

#Self-Study Course will be assessed by presentation mode

** Total Credit requirement for IMSc Degree is 234

BSc BIOTECHNOLOGY
(HONOURS) DEGREE

SEMESTER VII

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1071	Bioprocess Engineering and Technology	MAC	4	4
2	BTY1072	Systems and Synthetic Biology	MAC	4	4
3	BTY1073	Gene Expression and Transgenics	MIC	4	4
4	BTY1074	Cell and Gene Therapy	MAC	4	4
5	BTYECXX	Cancer Genomics/ Vaccines/ Nanobiotechnology/On-line Course	DSE	4	4
6	BTYSE03	Research Methodology & Scientific Communication Skills	SEC	2	2
7	BTY1075	Bioprocess Engineering and Technology Lab.	MAC	4	2
8	BTY1076	Systems and Synthetic Biology Lab.	MAC	4	2
		Total		**30**	**26**

SEMESTER VIII

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1081	Omics Technologies	MAC	4	4
2	BTY1082	Molecular Diagnostics	MAC	4	4
3	BTY1083	Protein Engineering	MAC	4	4
4	BTY1084	Environmental Biotechnology	MAC	4	4
5	BTYPR01	Dissertation	SEC	8	4
		Total		**24**	**20**

* Total Credit requirement for BSc (Honours) Degree is 186

BSc BIOTECHNOLOGY
(HONOURS WITH RESEARCH) DEGREE

SEMESTER VII

S.No.	Code	Course Title	Category	Hrs	Credits
1	BTY1071	Bioprocess Engineering and Technology	MAC	4	4
2	BTY1072	Systems and Synthetic Biology	MAC	4	4
3	BTY1073	Gene Expression and Transgenics	MIC	4	4
4	BTY1074	Cell and Gene Therapy	MAC	4	4
5	BTYECXX	Cancer Genomics/ Vaccines/ Nanobiotechnology/On-line Course	DSE	4	4
6	BTYSE03	Research Methodology & Scientific Communication Skills	SEC	2	2
7	BTY1075	Bioprocess Engineering and Technology Lab.	MAC	4	2
8	BTY1076	Systems and Synthetic Biology Lab.	MAC	4	2
		Total		**30**	**26**

SEMESTER VIII

S.No.	Code	Course Title	Category	Hrs	Credits
		Any TWO among following courses		**8**	**8**
1	BTY1081	Omics Technologies	MAC	4	4
2	BTY1082	Molecular Diagnostics	MAC	4	4
3	BTY1083	Protein Engineering	MAC	4	4
4	BTY1084	Environmental Biotechnology	MAC	4	4
5	BTYPR01	Dissertation	SEC	12	12
		Total		**8**	**20**

* Total Credit requirement for BSc (Honours with Research) Degree is 186

Open Elective courses offered to other discipline

Code	Course Title	Code	Course Title
Elective I		Elective II	
BTYOE01	Introductory Biotechnology	BTYOE02	Economic Biology

Elective courses offered to Biotechnology

S.No.	Code	Course Title	Category	Hrs	Credits
SEMESTER IV					
1	BTYEC41	Biofertilizer	DSE	4	4
2	BTYEC42	Vector Biology	DSE	4	4
3	BTYEC43	Plant Pathology	DSE	4	4
4	BTYEC44	On-Line	DSE	4	4
SEMESTER V					
1	BTYEC51	Neurobiology	DSE	4	4
2	BTYEC52	Drug Discovery and Development	DSE	4	4
3	BTYEC53	Virology	DSE	4	4
4	BTYEC54	On-Line	DSE	4	4
SEMESTER VI					
1	BTYEC61	Clinical Biochemistry	DSE	4	4
2	BTYEC62	Cell Signalling	DSE	4	4
3	BTYEC63	Plant Functional Genomics	DSE	4	4
4	BTYEC64	On-Line	DSE	4	4
SEMESTER VII					
1	BTYEC71	Cancer Genomics	DSE	4	4
2	BTYEC72	Vaccines	DSE	4	4
3	BTYEC73	Nanobiotechnology	DSE	4	4
4	BTYEC74	On-Line	DSE	4	4
SEMESTER VIII					
1	BTYEC81	Regenerative Medicine	DSE	4	4
2	BTYEC82	Epigenetics	DSE	4	4
3	BTYEC83	Pathogenesis of Infectious Diseases	DSE	4	4
4	BTYEC84	On-Line	DSE	4	4
SEMESTER IX					
1	BTYEC91	Biosimilars	DSE	4	4
2	BTYEC92	Biological Imaging	DSE	4	4
3	BTYEC93	Probiotics and Prebiotics	DSE	4	4
4	BTYEC94	On-Line	DSE	4	4

EVALUATION

Theory Courses:

Internal Assessment : 40 marks
End Sem. Exam : 60 marks
Total : 100 marks

Requirement for pass in the course:

1. Minimum 50% (ie. 30 marks out of 60 marks) in the End Semester Examination
2. Minimum 50 marks out of 100 marks (Internal Assessment + End Semester Examination)

Internal Evaluation – 40 Marks

S. No.	Item	Marks
1	90 min Written Test – 2 x 15	30
2	Seminar/Assignment/Quiz	05
3	Attendance	05
Total		**40**

Question Paper Pattern for Internal Evaluation

S. No.		Item	Marks
1	Part A – 10 marks (MCQ)	Answer ALL Questions 1 x 10 = 10	10
2	Part B – 20 marks (Essay)	Answer any FOUR Questions 5 x 4 = 20 (4 questions from SIX questions)	20
Total			**30**

End Semester Examination (3 Hrs) – 60 marks

Question Paper Pattern for End Semester Examination

S.No.		Item	Marks
1	Part A – 10 marks (MCQ)	Answer ALL Questions 1 x 10 = 10 (2 Questions from each unit)	10
2	Part B – 15 marks (Short notes)	Answer ALL Questions 3 x 5 = 15 (1 Question from each unit)	15
3	Part C – 35 marks (Essay)	Answer ALL Question 7 x 5 = 35 (1 Question from each unit with internal choice)	35
Total			**60**

Practical Courses: Assessment of the practical courses shall be done for 100 marks by continuous internal assessment on the basis of the students' performance in the laboratory classes, on-time submission of results/observation/records, attendance, and written/viva-voce examinations.

Attendance: In each semester, the minimum attendance for a student to get eligible for appearing in the end semester examination is 75%. Upon failing the minimum requirement, the student shall abide by the University norms for eligibility.

Summer Internship: Assessment of the Summer Internship (SI) shall be done for 100 marks. Out of 100 marks, the Supervisor under whom SI was done will evaluate for 50 marks and SI/training evaluation committee of the department shall evaluate for 50 marks; out of which 25 marks are allotted for the report and 25 for the presentation.

Project/Dissertation: Assessment pattern of the Project (Phase I & II) is given below.

	Supervisor/Guide	Review	Total Marks
Internal Assessment	20	20 (2 x 10 = 20)	40
End Sem. Assessment	30	30	60
Total			**100**

- Review of the project shall be done by the Department Project Review Committee comprised of the Supervisor, one senior faculty member and one faculty member nominated by HoD.

BASICS OF BIOLOGY

Year 1 | Semester I | BTY1011 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the concept of origins of life from an abiotic world	x				
CO 2	Evaluate and preserve the biodiversity for sustainable utilization			x		
CO 3	Illustrate the importance of microbial world for the benefits of humans		x	x		
CO 4	Describe general characters of various phyla of plants and animals	x	x			
CO 5	Using the general characters, able to identify different species of plants and animals				x	x

UNIT I: ORIGIN OF LIFE AND EVOLUTION: 12 Hrs

Early earth and the origin of life; Theories of origin of life; Major events in the history of life; Mechanism of macroevolution; Phylogeny and the tree of life; Evidences for evolution, Biological evolution, Mechanism of evolution, Hardy-Weinberg principle,

UNIT II: BIODIVERSITY: 12 Hrs

Classifying the diversity of life, Kingdoms of Life –Prokaryotes, Eukaryotes, Archaea, Components of Biodiversity. Importance of biodiversity in daily life, Types of Ecosystems, Biodiversity and Ecosystem functioning, Plant and Animal systematics, Species concept in biodiversity studies. IUCN; Germplasm banks, National Parks, Botanical Gardens; Wildlife Sanctuaries, Bioresources.

UNIT III: INTRODUCTION TO MICROBIAL WORLD AND TO STUDY ITS DIVERSITY: 10 Hrs

Viruses: Discovery, General Structure, Replication, DNA Virus (T-phage), Lytic & Lysogenic Cycle (TMV). Economic Importance, Bacteria: Discovery, Ecology, Distribution, General Characteristics & Cell Structure, Vegetative, Asexual & Recombination (Conjugation, Transformation & Transduction), Economic Importance.

UNIT IV: PLANT DIVERSITY: 12 Hrs

General characteristics, Ecology and distribution, Organization and reproduction of algae, bryophytes, pteridophytes, gymnosperms and angiosperms Ecological & Economical Importance, General Account of Adaptations in Xerophytes & Hydrophytes, Importance of water, Water potential and its components; Transpiration and its significance.

UNIT V: ANIMAL DIVERSITY: 14 Hrs

General characters and classification up to class level with distinctive and adaptive features of Phylum Protozoa, Porifera, Coelenterata, Platyhelminthes, Nemathelminths, Annelida, Arthropoda, Mollusca and Echinodermata with the suitable examples of each category. General characters of Protochordata and Vertebrata: Reptiles - General Features & Classification up to Orders; Poisonous & Non-Poisonous Snakes, Biting Mechanism in Snakes, Aves - General Features & Classification up to Orders; Flight Adaptations in Birds, Mammalia - Classification up to Orders; Origin of Mammals.

REFERENCES

1. Taiz L, Zeiger E (2010) Plant Physiology. Sinauer Associates Inc., USA.
2. Singh G. (2012) Plant Systematics: Theory & Practice. Oxford & IBH Pvt. Ltd., New Delhi.
3. Kumar HD. (1999) Introductory Phycology. Affiliated EastWest. Press Pvt. Ltd. Delhi.
4. Raven PH, Johnson GB, Losos JB & Singer SR. (2005) Biology. Tata McGraw Hill, Delhi, India.
5. Kotpal RL (2019), Modern Text Book of Zoology (Invertebrate and Vertebrates), Rastogi Publications.

BASICS OF BIOLOGY LAB.

Year 1 | Semester I | BTY1012 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Recognize and understand the structural details of different species of microorganisms, plants and animals	x				

CO 2	Understand the classification & distribution of microbes and primitive plant species	x	x			
CO 3	Demonstrate and differentiate the morphology and sexual reproductive structures of different plants			x		
CO 4	Distinguish the differences in life cycles of microbes, algae, bryophytes, pteridophytes and gymnosperms.		x			
CO 5	Correlate and assemble the knowledge for understanding the mechanisms of evolution				x	x

EXPERIMENTS

1. EMs/Models of Viruses: T-Phage & TMV, Line Drawing/Photograph of Lytic & Lysogenic cycle
2. Types of Bacteria from Temporary/Permanent Slides/Photographs; EM bacterium; Binary Fission; Conjugation; Structure of Root Nodule
3. Gram Staining
4. Use of micropipettes, preparation of normal, molar and standard solutions, phosphate buffers, serial dilutions
5. Study of Vegetative & Reproductive Structures of Nostoc, Chlamydomonas (EM Images), Oedogonium, Vaucheria, Fucus* & Polysiphonia through Temporary Preparations & Permanent Slides. (*Fucus - Specimen & Permanent Slides)
6. Tissues (Parenchyma, Collenchyma & Sclerenchyma); Macerated Xylary Elements, Phloem (Permanent Slides, Photographs)
7. Study of Meristems through Permanent Slides & Photographs.
8. Study of Specimens from Protozoa to Annelida: Amoeba, Euglena, Plasmodium, Paramecium, Sycon, Hyalonema, &Euplectella, Obelia, Physalia, Aurelia, Tubipora, Metridium, Taenia solium, Male & female Ascaris lumbricoides, Aphrodite, Nereis, Pheretima, Hirudinaria
9. Study of Specimens from Arthropoda to Echinodermata: Palaemon, Cancer, Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Apis, Chiton, Dentalium, Pila, Unio, Loligo, Sepia, Octopus, Pentaceros, Ophiura, Echinus, Cucumaria & Antedon
10. Study of Specimens from Protochordata to Amphibia : Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo, Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla
11. Study of Specimens: Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis, Any Six Common Birds from Different Orders, Sorex, Bat, Funambulus, Loris
12. Study of Permanent Slides: TS & LS of Sycon, Study of Life History Stages of *Taenia*, TS of Male & Female *Ascaris*
13. Key for Identification of Poisonous & Non-Poisonous Snakes

REFERENCES

1. Alexopoulos CJ, Mims CW& Blackwell M. (1996) Introductory Mycology. Wiley &Sons, Singapore.
2. Bhatnagar SP&Moitra A. (1996) Gymnosperms. New Age International (P) Ltd Publishers, New Delhi.
3. Kumar HD. (1999) Introductory Phycology. Affiliated EastWest. Press Pvt. Ltd. Delhi.
4. Raven PH, Johnson GB, Losos JB& Singer SR. (2005) Biology. Tata McGraw Hill, Delhi, India.
5. Kotpal RL (2019), Modern Text Book of Zoology (Invertebrate and Vertebrates), Rastogi Publications.

BIOCHEMISTRY

Year 2 | Semester III | BTY1031 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the structures and functions of biomolecules	x	x			
CO 2	Demonstrate an understanding of fundamental principles of biomolecules	x	x			
CO 3	Able to distinguish macromolecules from small molecules	x	x			
CO 4	Formulate causes of pathway defects			x	x	
CO 5	Utilize the skillsets required to extrapolate the mechanisms for human applications with appropriate experimental tools				x	x

UNIT I: CHEMICAL BASIS OF LIFE: 10 Hrs

Historical Basis and overview of Biochemistry, Biochemical basis of life, Water – properties of water, essential role of water for life on earth, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different

enzymes (pepsin, trypsin and alkaline phosphatase), Biomolecular hierarchy, Molecular assemblies and Molecular interactions in understanding cellular processes.

UNIT II: BIOMOLECULES: 14 Hrs

Overview of Biomolecules, Carbohydrates- Definition, Classification, Properties, Structure &Importance; Different Types of Polysaccharides (Homo, Hetero & Mucopolysaccharides). Derivatives of Sugars. Amino acids and Proteins: Definition, Classification & Properties of Amino Acids and Proteins- Peptide Bond, Structure, Classification Based on the Function, Solubility & Nutritional Value; Proteoglycans, Protein Glycosylations& its Significance-Blood Grouping, Structure & Functions of Hemoglobin. Lipids- Classification & Properties of Lipids; Lipoproteins-Chylomicrons, HDL, LDL & VLDL. Sphingophospholipids, Cholesterol, Steroids, Bile Acids & Bile Salts; Lipid Bilayers. Glycolipids, Lipopolysaccharides. Nucleic Acids- Nucleosides & Nucleotides; Composition & Structure, DNA- Types, Primary & Secondary Structure, Denaturation & Renaturation; RNA- Types, Structure & Functions of tRNA, rRNA & mRNA.

UNIT III: METABOLISM 1: 12 Hrs

Basic Concepts- Anabolism & Catabolism, Role of ATP in Metabolism, High Energy Compounds & Intermediates, Common Types of Reactions Involved in Metabolism. Carbohydrate Metabolism- Glycolysis- Aerobic & Anaerobic, Regulation of Glycolysis, TCA Cycle & its Regulation; Glycogen Metabolism- Glycogenesis & Glycogenolysis, Glycogen Storage Diseases; Gluconeogenesis, Pentose Phosphate Pathway (HMP Shunt) & Glyoxylate Cycle; Metabolism of Lipids-Fatty Acid Oxidation, Biosynthesis of Fatty Acids, Elongation & Unsaturation of Fatty Acids, Comparison of Fatty Acid Oxidation with Synthesis; Triacyl Glycerol Biosynthesis, Cholesterol Biosynthesis & its Regulation, Ketone Bodies.

UNIT IV: METABOLISM 2: 12 Hrs

Nucleic Acid Metabolism- Purine- Biosynthesis, Regulation & Degradation of Purine and Pyrimidine nucleotides; Formation of Uric Acid; Gout; Disorders Associated with Nucleic Acid Metabolism; Protein Metabolism- Catabolism of Amino Acid Nitrogen- Transamination, Deamination, Ammonia Formation & the Urea Cycle. Catabolism of Carbon Skeletons of Amino Acids. Conversion of Amino Acids to Special Products. Disorders of Amino Acid Metabolism.

UNIT V: ROLE OF VITAMINS AND ENZYMES IN METABOLISM: 12 Hrs

Vitamins- Classification, General Sources, Functions, Deficiency Symptoms & Structural Aspects. Enzymes- Nomenclature, Classifications, Factors Affecting Enzymes, Enzyme Kinetics, Significance of V_{max}& K_m, Enzyme Inhibition - Competitive, Non-Competitive & Uncompetitive, Enzyme Regulation-Product Inhibition, Feedback Control, Covalent Modification & Allosteric Regulation.

REFERENCES

1. Nelson DL & Cox MM. (2021) Lehninger Principles of Biochemistry. 8th Ed. Publisher: W H Freeman
2. Stryer L, Berg J, Tymoczko J & Gatto G. (2019) Biochemistry. 9th Ed. Publisher: WH Freeman
3. Voet D & Voet G. (2016) Fundamentals of Biochemistry. 5th Ed. Publisher: Wiley
4. Zubay G. (2000) Principles of Biochemistry. 5th Ed. Publisher: Medtech Scientific International

ANALYTICAL TECHNIQUES

Year 2 | Semester III | BTYSE01 | Credits 3

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the concepts of analytical techniques	x				
CO 2	Apply various analytical techniques in biotechnology	x			x	
CO 3	Evaluate the applications of various analytical techniques for biomolecule analysis		x	x		
CO 4	Design and develop methods for characterization of biomolecules			x	x	
CO 5	Gain skills to perform, monitor and modify analytical methods				x	x

UNIT I: SPECTROSCOPY: 9 Hrs

Infrared Spectroscopy - Principle, mechanisms of measurements, selection rules, fundamental vibration modes, Factors influencing the band position and intensities, some characteristic frequencies and co-relation of IR spectra with molecular structures (applications), the effect of Hydrogen bonding on vibrational frequencies. Raman

Spectroscopy-Introduction theory of Raman Spectroscopy, Mechanism of Raman and Rayleigh scattering, Rule of Mutual exclusion, correlation with the molecular structure, difference between Raman and IR spectra, Resonance Raman effect, Application of Raman Spectroscopy. Inductively coupled plasma-Introduction, Principle, and applications of IC-AES or OES.

UNIT II: NMR/MS/ESR: 12 Hrs

Nuclear Magnetic Resonance Spectroscopy - Introduction, basic principles, mechanics of measurements, chemical shift, band multiples, spin-spin splitting, shielding and deshielding effect, spin-spin coupling and coupling constant (J), some characteristics of NMR positions, Application in elucidation of molecular structure, Elementary idea of NOE, DEPT NMR, C^{13} NMR, P^{31} NMR, F^{19} NMR. Mass Spectroscopy-Introduction, basic principles, instrumentation, fragmentation patterns, nitrogen rule, Mc Lafferty Rearrangement, interpretation of mass spectra and applications. ESR (Electron Spin Resonance) – Basic Principles, Instrumentation and Applications.

UNIT III: POTENTIOMETRY, CONDUCTOMETRY & POLAROGRAPHY: 6 Hrs

General principles, reference and indicator electrodes, potentiometric and conductometric titrations. Polarography - Basic principles, dropping mercury electrode (DME), half wave potential, polarographic currents and applications.

UNIT IV: CHROMATOGRAPHIC METHODS: 9 Hrs

Introduction to chromatographic methods: Paper, TLC, Column and Gas chromatography, Principles, Instrumentation, GC column, Detectors and stationary phases and applications, Hyphenated techniques (GC-MS). Liquid Chromatography LC/HPLC, Column efficiency in LC, Detectors, Instrumentation, Partition/Adsorption/Ion Exchange Chromatography and applications.

UNIT V: THERMAL & X-RAY METHODS, AND ELECTRON MICROSCOPY: 9 Hrs

Thermal Methods of Analysis- Thermogravimetric analysis, differential thermal analysis, and differential scanning calorimetry and applications. Electron Microscopy - Introduction and Applications of Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM). X-ray methods - Introduction and applications of XRD.

REFERENCES

1. Infrared and Raman Spectroscopy: Principles and Spectral Interpretation. P. Larkin: 3rd Ed. (2017) Elsevier.
2. Inductively Coupled Plasma Mass Spectrometry. S.J. Hill: 2nd Ed. (2018) Wiley
3. Nuclear Magnetic Resonance Spectroscopy: Principles and Applications. P. Hore : 2nd Ed. (2014) Oxford University Press
4. Mass Spectrometry: Principles and Applications. E. de Hoffmann & V. Stroobant: 3rd Ed. (2017) Wiley
5. Thermal Methods of Analysis: Principles and Applications. P. Gabbott: 1st Ed. (2013) Royal Society of Chemistry
6. Scanning Electron Microscopy and X-ray Microanalysis. J. Goldstein, D. Newbury, D. Joy, & C. Lyman: 4th Ed. (2018) Springer

BIOPYTHON

Year 2 | Semester III | BTYVA01 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Use Python as a programming tool for bioinformatics	x			x	
CO 2	Parsers various bioinformatics file formats and also able to access to online services		x			
CO 3	Appreciate to investigate specific contemporary biological questions through python programming			x	x	
CO 4	Interfaces to various common programs and documentation		x	x		
CO 5	Develop the skill of sequence manipulation & the ability to plotting genomic data in Biopython.				x	x

UNIT I: INTRODUCTION TO PYTHON AND BIOPYTHON: 9 Hrs

Conceptual introduction: topics in computer science, algorithms; modern computer systems: hardware architecture, data representation in computers, software and operating system; installing Python; basic syntax, interactive shell, editing, saving, and running a script.

UNIT II: DATA TYPES, EXPRESSIONS, AND STATEMENTS: 9 Hrs

Python interpreter and interactive mode, debugging; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments.

UNIT III: CONTROL FLOW, FUNCTIONS, STRINGS: 9 Hrs

Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays.

UNIT IV: LISTS, TUPLES, DICTIONARIES: 9 Hrs

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing – list comprehension.

UNIT V: BIOPYTHON PACKAGE, SEQUENCE MANIPULATION AND PLOTTING: 9 Hrs

Biopython – Introduction, Installation, Creating Simple Application, Sequence, Advanced Sequence Operations, Sequence I/O Operations, Sequence Alignments, Overview of BLAST, Entrez Database, PDB Module, Motif Objects, BioSQL Module, Population Genetics, Genome Analysis, Phenotype Microarray-Plotting, Cluster Analysis, Machine Learning and Biopython-Testing Techniques.

REFERENCES

1. Matthes E (2019) Python Crash Course: A Hands-On, Project-Based Introduction to Programming (2nd Ed.). No Starch Press.
2. Jones B (2013) Python Cookbook: Recipes for Mastering Python 3 (3rd Ed.). O'Reilly Media.
3. Antao T (2018) Bioinformatics with Python Cookbook (2nd Ed.). Ingram short title.
4. Jones M (2013) Python for Biologists: A Complete Programming Course for Beginners (1st Ed.). Independent Publishing Platform
5. https://docs.python.org/3/tutorial/index.html
6. http://biopython.org/DIST/docs/tutorial/Tutorial.pdf

BIOCHEMISTRY LAB.

Year 2 | Semester III | BTY1032 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the basic biochemical techniques	x	x			
CO 2	Demonstrate an understanding of experiments related to biochemistry		x	x		
CO 3	Able to analyze defects using biochemical techniques			x	x	
CO 4	Preparation of samples for the biochemical analysis		x		x	
CO 5	Utilize the skillsets required to extrapolate the mechanisms for human applications with appropriate experimental tools				x	x

EXPERIMENTS

1. Preparation of stock solutions, and buffers
2. Qualitative/quantitative Analysis of Carbohydrates, Proteins & Lipids
3. Separation and analysis of Amino Acids using TLC
4. Enzyme reactions- endpoint, kinetic
5. Separation of proteins by Chromatography, salting out, dialysis
6. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer.
7. Effect of PH and Temperature on Enzyme activity
8. Fluorometric method for the determination of cholesterol

REFERENCES

1. Sawhney SK & Singh R. (2014) Introductory Practical Biochemistry. Narosa Publishers, India.
2. Nelson DL & Cox MM. (2021) Lehninger Principles of Biochemistry. 8th Ed.
3. Stryer L, Berg J, Tymoczko J & Gatto G. (2019) Biochemistry. 9th Ed.
4. Voet D & Voet G. (2016) Fundamentals of Biochemistry. 5th Ed

MICROBIOLOGY

Year 2 | Semester IV | BTY1041 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the major categories of microorganisms and analyze their classification, diversity, and ubiquity	x				
CO 2	Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms	x	x			
CO 3	Analyse the importance of microorganisms in the biotechnology		x	x		
CO 4	Develop methods to produce bioproducts using microorganisms				x	x
CO 5	Acquire necessary skillsets to identify and employ associated with human welfare			x	x	x

UNIT I: MICROBIAL CHARACTERISTICS: 12 Hrs

Introduction to microbiology and microbes, history and scope of microbiology, morphology, cell structure, growth and nutrition of bacteria, microscopy, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

UNIT II: MICROBIAL DIVERSITY: 12 Hrs

Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilicarchae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

UNIT III: BACTERIAL CHARACTERIZATION: 12 Hrs

Bacterial isolation, purification, preservation, colony characteristics. Microbial staining. Nutritional requirements and groups. Preparation of artificial media and types. Control of microorganisms: Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

UNIT IV: BASIC VIROLOGY: 12 Hrs

Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.

UNIT V: HOST-MICROBE INTERACTIONS: 12 Hrs

Medical microbiology: Host-pathogen interaction, Koch's postulates for infectious diseases. Normal microbiota in humans. Comparative study of some infectious diseases caused by bacteria, fungi and viruses., ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

REFERENCES

1. Tortora, Funke, & Case. (2013) Microbiology: An Introduction. Pearson Publishers, USA.
2. Willey JM, Sherwood L, Woolverton CJ, Prescott LM, & Willey JM (2011). Prescott's Microbiology. New York: McGraw-Hill
3. Schaechter M & Leaderberg J (2009). The Desk Encyclopaedia of Microbiology. Elsevier Academic Press.
4. Woolverton CJ, et al. (2016) Microbiology. McGraw-Hill Education.
5. Nester EW, Roberts CV & Nester MT. (2015) Microbiology - A Human Perspective. McGraw-Hill Education.

CELL BIOLOGY

Year 2 | Semester IV | BTY1042 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the structure and functions of cells and cellular components	x	x			
CO 2	Acquire knowledge on basic cell structures, and membrane dynamics	x				
CO 3	Able to characterize various types of cells		x	x		
CO 4	Develop the strategies to use the functioning of different types of cells			x	x	
CO 5	Conduct investigations based on skills related to cytology			x	x	x

UNIT I: DYNAMIC ORGANIZATION OF CELL: 12 Hrs

Basic properties of cell, Major types of cell: Prokaryotic, animal and plant cell, their characteristics, cell wall, composition, function of bacterial cell wall. Plasma membrane, structure, function, fluid mosaic model, membranes, lipids and proteins transport across the membrane – passive and active, Nature of Cytoskeleton, Intermediate Filaments, Microtubules, Actin Filaments, Cilia & Centrioles, Organization of the Cytoskeleton.

UNIT II: CELL ORGANELLES AND CHROMATIN STRUCTURE: 12 Hrs

Endoplasmic reticulum, Golgi complex – exocytosis; Lysosomes: phagocytosis, endocytosis, autophagy, Peroxisomes, Role of clatherin coated vesicles, Plant cell vacuoles; Structure of mitochondria and organization of respiratory chain; Structure of chloroplast and photophosphorylation; Structure of nucleus, nucleolus, nuclear membrane, transport across nuclear membrane. Chromatin organization - histone and DNA interaction.

UNIT III: CELLULAR PROCESSES: 12 Hrs

Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; Extracellular matrix, collagen, proteoglycans, fibronectin, laminins, integrin, selectin, cadherin, role of tight junctions and gap junctions, Cell-ECM and cell-cell interactions.

UNIT IV: CELLULAR SIGNALLING, TRANSPORT AND TRAFFICKING: 12 Hrs

Necrosis & Apoptosis - Mitochondrial & Death Receptor Pathway. Autophagy, Cell Signalling - Signalling Molecules & their Receptors, Functions of Cell Surface Receptors, Pathways of Intracellular Signal Transduction, cAMP, G Protein-Coupled Receptors, Receptors Tyrosine Kinases, Role of Ras & Raf in Oncogenesis, MAP Kinase Pathways, cell receptors and trans-membrane signalling; cell motility and migration.

UNIT V: CYTOLOGY: 12 Hrs

Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; Insitu-analysis of DNA, RNA and proteins in tissues. Cell Fixation - Fluid Fixatives, Freezing & Section Drying, Fixation for Electron Microscopy - Buffered Osmium Solutions, Fixation of Organic & Inorganic Substances, Staining Techniques Acid & Basic, Fluorescent & Radioactive Dyes, Staining of Lipids, Steroids, Nucleic Acids, Proteins & Enzymatic Reaction Products.

REFERENCES

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science
2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
3. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM; Sunderland.
4. Cell Biology. 7th Ed. 2013. Wiley. Gerald Karp. International Student version
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's world of the cell. Boston: Benjamin Cummings
6. Watson, J.D. (2008) Molecular Biology of the Gene (5th Ed.). Menlo Park, CA: Benjamin/ Cummings

MICROBIOLOGY LAB.

Year 2 | Semester IV | BTY1043 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the basic microbiological techniques	x	x			
CO 2	Demonstrate an understanding of experiments related to microbiology		x	x		
CO 3	Able to analyze the role of microorganisms for human applications			x	x	
CO 4	Conduct investigations using microbes for translational applications				x	x
CO 5	Utilize the skillsets required to extrapolate findings for human applications with appropriate experimental tools			x	x	x

EXPERIMENTS

1. Direct microscopic observations of bacterial shape – Cocci, rods, chains, fungal spores, mycelium, yeast budding
2. Staining methods: Simple, negative, gram staining, spore, capsule staining
3. Lactophenol cotton blue staining - Fungal slide culture
4. Biochemical tests for bacterial identification: Catalase, oxidase, urease, IMViC test
5. Sugar fermentation tests, Triple sugar iron, O/F, gelatin hydrolysis, DNAse test
6. Bacterial motility by hanging drop method, enumeration of bacterial/yeast cells-viable count (plate count)
7. Preparation of media: Broth and agar media, basal, selective and differential culture media, plates, slants
8. Pure culture techniques: Streak/spread/pour plate methods, bacterial & fungal cultivations.
9. Determination of bacterial growth: Growth curve
10. Bacterial DNA – Bacterial protein extractions and estimations

REFERENCES

1. Nester EW, Roberts CV & Nester MT. (2015) Microbiology - A Human Perspective. McGraw-Hill.
2. Mara D & Horan N. (2013) The Handbook of Water & Waste-Water Microbiology. Academic Press.
3. Tortora, Funke & Case. (2013) Microbiology: An Introduction. Pearson Publishers, USA.
4. Webster J. (2007). Introduction to Fungi. Cambridge University Press, Cambridge, UK

CELL BIOLOGY LAB.

Year 2 | Semester IV | BTY1044 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the concepts of cell division	x				
CO 2	Acquire knowledge of cell cycle and functional application of microscope	x	x			
CO 3	Explain the concepts of separation between live and dead cells			x		
CO 4	Acquire laboratory skill to understand the structure and function of different cell types			x	x	
CO 5	Remember the key features of different types of cells				x	x

EXPERIMENTS

1. Introduction to principles of sterile techniques and cell propagation
2. Principles of Bright field microscopy, phase contrast and fluorescent microscopy
3. Identification of given plant, animal and bacterial cells and their components by microscopy
4. Preparation of cell culture media.
5. Determination of Osmotic Potential of Plant Cell Sap by Plasmolytic Method
6. Staining for different stages of mitosis in *Allium cepa*
7. Identification of different types of cells in mammalian blood, liver, kidney, ovary, pancreas, lung, and testis tissue section under microscope
8. Observation of eukaryotic cancer cell lines under microscope; live, dead, starved, etc. and staining methods; trypan blue and DAPI, etc.
9. Apoptosis detection by DNA Ladder Pattern and staining
10. Histochemical techniques: Tissue processing, tissue embedding, and Immunohistochemistry

REFERENCES

1. Current protocols in Cell biology- Wiley
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor Laboratory Press.

3. https://www.microscopyu.com/tutorials (by Nikon)
http://zeisscampus.magnet.fsu.edu/tutorials/index.html (by Carl Zeiss) and
http://olympus.magnet.fsu.edu/primer/resources/tutorials.html (by Olympus).

MOLECULAR BIOLOGY

Year 3 | Semester V | BTY1051 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the basic concepts of molecular biology	x	x			
CO 2	Demonstrate fundamental principles of molecular biology	x	x			
CO 3	Able to analyze defects involved in molecular regulatory mechanisms			x		
CO 4	Formulate causes of molecular defects	x	x			x
CO 5	Utilize the skillsets required to extrapolate the mechanisms for human applications with appropriate experimental tools			x	x	x

UNIT I: INTRODUCTION TO MOLECULAR BIOLOGY: 12 Hrs

Discovery of DNA- Evidence for DNA as the Genetic Material; Central Dogma of Molecular Biology; DNA Replication- Types of Replication, Evidence for Semiconservative Replication - Meselson & Stahl Experiment. Enzymes & Necessary Proteins Involved in DNA Replication.

UNIT II: DNA REPLICATION: 12 Hrs

Replication in Prokaryotes- Replication Bubble, Bidirectional Replication, Replicon, DNA Polymerases, Lagging & Leading Strand Synthesis, Okazaki Fragments, Mechanism of Replication, Action of SSB, Primase, DNA Gyrase. The Fidelity of DNA Replication, Overview Mechanism of Eukaryotic Replication. Telomeres, Telomerase & End Replication. Inhibitors of Replication.

UNIT III: TRANSCRIPTION AND RNA PROCESSING: 12 Hrs

Definitions of Coding Strand, Template Strand, Sense Strand & Antisense Strand, Promotor, Transcription in Prokaryotes- RNA Polymerases, Mechanism of Transcription- Initiation, Elongation & Termination (Rho-Dependent & Independent Termination), Housekeeping Genes. Transcription in Eukaryotes- Mechanism, Posttranscriptional Processing & its Significance- Capping, Tailing, Splicing, Processing of rRNA & tRNA. RNA Editing. Regulation of eukaryotic transcription.

UNIT IV: PROTEIN BIOSYNTHESIS: 12 Hrs

Genetic Code, Wobble Mechanism & its Significance, Types of RNA Molecules, Structure of tRNA, Composition of Prokaryotic & Eukaryotic Ribosomes, Protein Biosynthesis in Prokaryotes & Eukaryotes- Activation of Amino Acids, Initiation, Chain Elongation, Translocation & Termination. Translational Machinery- Mechanism of Initiation- Elongation & Termination.

UNIT V: POST-TRANSLATIONAL MODIFICATIONS: 12 Hrs

Regulation of Protein Synthesis, Post-Translational Modifications in Prokaryotes & Eukaryotes, Inhibitors of Protein Synthesis. Protein Modifications, Folding & Export of Proteins; Gene Mutations & DNA Repair.

REFERENCES

1. Krebs JE, Goldstein ES & Kilpatrick ST. (2018)Lewin's Genes XII. 12th Ed. Publisher: Jones and Bartlett Publishers
2. Alberts B,Heald R, Johnson A, Morgan D, Raff M, Roberts K, Walter P, Wilson J, Hunt T. (2022)Molecular Biology of the Cell. 7th Ed. Publisher: WW Norton
3. Freifelder D. (2004) Molecular Biology. Narosa Publishing House, India.
4. Watson J, Baker T, Bell S, Gann A, Levine M, Losick R. (2013) Molecular Biology of the Gene. 7th Ed. Publisher: Pearson
5. Karp G, Iwasa J, Marshall J (2019) Cell & Molecular Biology. 9th Ed. Publisher: Wiley

PLANT AND ANIMAL BIOTECHNOLOGY

Year 3 | Semester V | BTY1052 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Summarize the concepts and components of plant and animal biotechnology	x	x			
CO 2	Appreciate the different methods of animal/plant cell culture	x	x			
CO 3	Differentiate between conventional and biotechnological methods of analysis of traits of plants and animals		x	x		
CO 4	Able to improve the plant and animal traits for better quality and quantity character using biotech approaches				x	x
CO 5	Perform biotechnological techniques like gene cloning and transfer			x	x	x

UNIT I: INTRODUCTION TO PLANT BIOTECHNOLOGY AND TISSUE CULTURE: 12 Hrs

Scope and importance of plant biotechnology - Plant cell tissue and organ culture – Totipotency - Tissue culture media - composition and preparation. Callus and suspension culture; Micropropagation; Somaclonal variation; Organogenesis; Somatic embryogenesis; Embryo culture. Artificial seeds. Protoplast fusion and somatic hybridization; cybrids; anther, pollen and ovary culture for production of haploid plants - Secondary metabolite production.

UNIT II: GENETIC TRANSFORMATION METHODS: 12 Hrs

Gene transfer methods in plants: Direct and indirect DNA transfer. Electroporation, microinjection and particle bombardment. Agrobacterium infection - Ti and Ri plasmids; opines *Agrobacterium* mediated gene transfer, Plasmids - Ti plasmids and Ri plasmids, Vectors viral vectors and their applications. Characterization of transgenics - screenable and selectable markers. Marker free methodologies and gene targeting.

UNIT III: BIOTECHNOLOGY FOR CROP IMPROVEMENT: 12 Hrs

Herbicide resistance: phosphoinothricin - weeds. Insect resistance: *Bt* genes, non-*Bt* genes like protease inhibitors. Disease resistance: chitinase, antifungal proteins, thionins, PR proteins; Virus resistance: coat protein mediated, nucleocapsid gene. Nematode resistance. Abiotic stress tolerance: drought and flooding, salt and temperature. Post-harvest losses: long shelf life of fruits and flowers, use of ACC synthase, polygalacturanase, carbohydrate composition and storage, ADP glucose pyrophosphatase.

UNIT IV: ANIMAL CELL CULTURE AND REPRODUCTIVE BIOTECHNOLOGY: 12 Hrs

Brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins. Structure of sperms and ovum; cryopreservation; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; embryo transfer technology; transgenic manipulation of animal embryos; Animal cloning - basic concept - Applications of transgenic animal technology.

UNIT V: MOLECULAR MAPPING AND MARKER ASSISTED SELECTION: 12 Hrs

Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker-assisted selection - strategies for Introducing genes of biotic and abiotic stress resistance: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in Food using DNA based methods.

REFERENCES

1. Slater A., Scott N.W. and Fowler, M.R. (2008). Plant Biotechnology – The genetic manipulation of plants. 2nd Edition. Oxford University press, USA.
2. H.S. Chawla, (2002). Introduction to Plant Biotechnology. Oxford and IBH P Publishing Co. Pvt. Ltd. New Delhi.
3. Brown, T. A. (2010) Gene Cloning and DNA analysis: An Introduction 6th edition, Wiley Blackwell.
4. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
5. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.

MICROBIAL BIOTECHNOLOGY

Year 3 | Semester V | BTY1053 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand applications of microbial biotechnology for the welfare of mankind	x	x			
CO 2	Apply microbial biotechnology to solve problems in different sectors		x	x		
CO 3	Analyze the potential of biotechnological tools for industrial applications		x	x		
CO 4	Create models to address the emerging problems using modern biotechnological tools			x	x	x
CO 5	Acquire skills in the area of modern biotechnological tools				x	x

UNIT I: INTRODUCTION: 12 Hrs

Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (e.g., engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 system as nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/ strains and their applications; Strain improvement to increase yield of selected molecules, e.g., antibiotics, enzymes, biofuels.

UNIT II: ENVIRONMENTAL APPLICATION OF MICROBIAL BIOTECHNOLOGY: 12 Hrs

Environmental application of microbes; Ore leaching; Biodegradation - biomass recycle and removal; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.

UNIT III: PHARMACEUTICAL APPLICATION OF MICROBIAL BIOTECHNOLOGY: 12 Hrs

Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical /operational, commercial and ethical); Attributes required in industrial microbes (Streptomyces sp., Yeast) to be used as efficient cloning and expression hosts (biologicals production); Generating diversity and introduction of desirable properties in industrially important microbes (Streptomyces/Yeast); Microbial cell factories; Downstream processing approaches used in industrial production process (Streptomyces sp., Yeast).

UNIT IV: FOOD APPLICATION OF MICROBIAL BIOTECHNOLOGY: 12 Hrs

Application of microbes and microbial processes in food and healthcare industries - food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Non recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (e.g., Yeast) - exploiting the existing natural diversity or the artificially introduced diversity through conventional acceptable techniques (mutagenesis, protoplast fusion, breeding, genome shuffling, directed evolution etc.).

UNIT V: ADVANCES IN MICROBIAL BIOTECHNOLOGY: 12 Hrs

Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (e.g., protease, antibiotic) etc.

REFERENCES

1. Lee, Y. K. (2013). Microbial Biotechnology: Principles and Applications.
2. Hackensack, NJ: World Scientific. 2. Moo-Young, M. (2011). Comprehensive Biotechnology. Amsterdam: Elsevier.
3. Nelson, K. E. (2015). Encyclopedia of Metagenomics. Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools. Boston, MA: Springer US.
4. The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet. (2007). Washington, D.C.: National Academies Press

GENETICS

Year 3 | Semester V | BTYSE02 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the relationship between phenotype and genotype in organisms' genetic traits	x	x			
CO 2	Describe the basics of genetic mapping	x	x			
CO 3	Understand how gene expression is regulated		x	x		
CO 4	Appreciate the fundamental molecular principles of genetics		x	x		
CO 5	Exposed to concepts of population and evolutionary genetics				x	x

UNIT I: GENETICS OF BACTERIA AND BACTERIOPHAGES: 10 Hrs

Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.

UNIT II: YEAST GENETICS: 6 Hrs

Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.

UNIT III: DROSOPHILA GENETICS AS A MODEL OF HIGHER EUKARYOTES: 12 Hrs

Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.

UNIT IV: POPULATION GENETICS AND GENETICS OF EVOLUTION: 4 Hrs

Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy- Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.

UNIT V: QUANTITATIVE GENETICS OF COMPLEX TRAITS & PLANT GENETICS: 4 Hrs

Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs. Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.

REFERENCES

1. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett.
2. Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman.
3. Tamarin, R. H., & Leavitt, R. W. (1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown.
4. Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press.

MOLECULAR BIOLOGY LAB.

Year 2 | Semester V | BTY1054 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the basic molecular techniques	x				
CO 2	Demonstrate experiments related to molecular biology	x	x			
CO 3	Able to analyze defects using molecular techniques		x	x		
CO 4	Preparation of samples for the molecular analysis		x	x	x	
CO 5	Utilize the skillsets required to extrapolate the mechanisms for human applications with appropriate experimental tools			x	x	x

EXPERIMENTS

1. Isolation and purification of genomic DNA/RNA from animal, plant and bacterial cells
2. Quantification of DNA Using Spectrophotometer
3. Primer Designing and PCR amplification of target DNA
4. Agarose gel electrophoresis
5. Purification of DNA and PCR products using gel extraction method
6. Quantification of gene expression using Real Time PCR
7. Polymorphism – RFLP, RAPD, ISSR, SNP
8. Polyacrylamide Gel Electrophoresis & Silver Staining of Protein
9. Western Blot Analysis; ELISA

REFERENCES

1. Cox M, O' Donnell M, Dounda J (2015). Molecular Biology: Principles and Practice. 2nd Ed. Publisher: WH Freeman
2. Krebs JE, Goldstein ES & Kilpatrick ST. (2018) Lewin's Genes XII. 12th Edition. Publisher: Jones and Bartlett Publishers
3. Alberts B, Heald R, Johnson A, Morgan D, Raff M, Roberts K, Walter P, Wilson J, Hunt T, . (2022) Molecular Biology of the Cell. 7th Ed. Publisher: WW Norton
4. Watson J, Baker T, Bell S, Gann A, Levine M, Losick R. (2013) Molecular Biology of the Gene. 7th Ed. Publisher: Pearson
5. Karp G, Iwasa J, Marshall J (2019) Cell & Molecular Biology. 9th Ed. Publisher: Wiley

PLANT AND ANIMAL BIOTECHNOLOGY LAB.

Year 2 | Semester V | BTY1055 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Formulation of plant tissue culture and animal cell culture media	x	x			
CO 2	Learn cell suspension cultures, organogenesis and embryogenesis	x	x			
CO 3	Understand the role of culture medium related to secondary metabolite production		x	x		
CO 4	Demonstrate genomic DNA isolation and its quantification from plants and animal tissues			x	x	
CO 5	Able to perform cloning and genetic transformation methods involved in plants and animals				x	x

EXPERIMENTS

1. Preparation of stocks - Preparation of Murashige and Skoog medium- Micropropagation of plants by nodal and shoot tip culture
2. Induction and maintenance of callus - Regeneration of plants from callus, anther and pollen culture
3. *Agrobacterium*-mediated plant transformation by co-cultivation method
4. Analysis of transgene expression in plants using selection media – GUS and GFP assays and other molecular confirmation
5. Preparation of culture media with various supplements for animal tissue culture.
6. Preparation of single cell suspension from spleen and thymus.
7. Cell counting and viability assay
8. Monitor and measure doubling time of animal cells
9. Chromosome preparations from cultured animal cells
10. Animal cell fusion using PEG

REFERENCES

1. Sambrook J and Green MR (2012) Molecular Cloning – A Laboratory Manual. 4th Ed 2012, Cold Spring Harbor Laboratory Press
2. Chawla, H.S. (2020). Introduction to Plant Biotechnology. Oxford and IBH P Publishing Co. Pvt. Ltd. New Delhi.
3. Jeffrey W. Pollard & John M. Walker (2014) Plant Cell and Tissue Culture (Methods in Molecular Biology)
4. Jan Freshney. R. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. 6th Ed. 2010. Wiley & Sons.
5. John Davis (2011) Animal Cell Culture: Essential Methods (1st Ed.) Wiley Blackwell and Sons.

MICROBIAL BIOTECHNOLOGY LAB.

Year 2 | Semester V | BTY1056 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the industrial applications of microbes	x	x			
CO 2	Able to produce biofertilizers in the lab		x	x		
CO 3	Develop hands on experience to advance analytical instruments		x	x		
CO 4	Capable of resource recovery from waste			x	x	x
CO 5	Acquire skills in the area of modern biotechnological tools			x	x	x

EXPERIMENTS

1. Production of Taq polymerase using recombinant E. coli
2. Different methods of antimicrobial susceptibility testing
3. Isolation of antagonistic bacteria for growth suppression of pathogens
4. Isolation and characterization of Nitrogen fixers
5. Microbial bioconversion of agricultural wastes using fungi and/or bacteria
6. Microbial degradation agricultural pollutants, fungicides and insecticides
7. Microbial degradation of hydrocarbons.
8. Analysis of microbial intermediates: VFA using HPLC
9. Gas chromotography analysis of microbial products – Methane, ethylene, Ethanol, H_2
10. Biochar production and its application
11. Microbial fermentation of food products.

REFERENCES

1. Verma, S., Das, S. and Singh, A. (2014). Laboratory Manual for Biotechnology Students. S. Chand.
2. Das, S. and Dash, H.R. (2015). Microbial Biotechnology – A Laboratory Manual for Bacterial Systems. Springer
3. Gupta, V.K., Tuohy, M.G., Ayyachamy, M., Turner, K.M. and O'Donovan, A. (2013). Laboratory Protocols in Fungal Biology. Current Methods in Fungal Biology. Springer.
4. Aneja, K.R. (2014). Laboratory Manual of Microbiology and Biotechnology. Medtech. 424 pp.
5. Harisha, S. (2007). Biotechnology procedures and experiments handbook. Infinity Science Press LLC. New Delhi.

GENETIC ENGINEERING

Year 3 | Semester VI | BTY1061 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Acquaint the concepts, tools and techniques employed in genetic engineering	x	x			
CO 2	Know the different cloning strategies employed in genetic engineering	x	x			
CO 3	Apply most appropriate recombinant-DNA techniques and other contemporary techniques to make a gene functional		x	x	x	
CO 4	Able to produce a recombinant organism for the improvement of quality and quantity characters			x	x	
CO 5	Gain knowledge in gene and genome engineering in an organism				x	x

UNIT I: CONCEPTS AND TOOLS IN GENETIC ENGINEERING: 12 Hrs

Scope and importance - Tools in genetic engineering - restriction endonuclease - DNA ligase, phosphatase and other DNA modifying enzymes – methylases, DNA ligase, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; Linkers & Adapters - Labelling of DNA: Radioactive and non-radioactive probes, Hybridization techniques: Southern Blotting – Northern, Western - Colony hybridization, fluorescence *in situ* hybridization.

UNIT II: MOLECULAR CLONING: 12 Hrs

Plasmids; Bacteriophages; M13, MP vectors; PUC19, Bluescript & Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Gene expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Mammalian expression and

replicating vectors; Baculovirus and pichia vectors system, plant-based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors. Cloning - Uni-directional and Bidirectional.

UNIT III: TECHNIQUES IN GENETIC ENGINEERING: 12 Hrs

PCR and its Types – Primer design - Applications of PCR in genetic engineering and molecular diagnostics; viral and bacterial detection; DNA sequencing - Maxam-Gilbert's and Sanger's methods - chemical sequencing of DNA - RNA sequencing; chemical synthesis of oligonucleotides; Mutation detection: SSCP, DGGE, RAPD, RFLP. DNA mapping - Physical and Molecular - DNA fingerprinting.

UNIT IV: GENE AND GENOME ENGINEERING: 12 Hrs

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy. Messenger RNA and cDNA synthesis; cDNA and Genomic Library- construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNA foot printing, Primer extension, S1 mapping, Reporter assays – Two hybrid system - Phage display.

UNIT V: APPLICATIONS OF GENETIC ENGINEERING: 12 Hrs

Genetic improvement of plant, microbes and animals using genetic engineering strategies. Creation of transgenic plants; Debate over GM crops; Genetic manipulation in different model systems e.g., fruit flies (drosophila), worms (*C. elegans*), frogs (xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; Introduction to genome editing - ZFN, TALENS and CRISPR-Cas with specific emphasis on clinical trials.

REFERENCES

1. Brown, T A (2018). Genomes 4. New York: Garland Science Pub.
2. Eugene Rosenberg (2017). Genetic Engineering in It's in Your DNA.
3. Primose SB &Twyman RM. (2006). Principles of Gene Manipulation and Genomics.7th Ed. Wiley-Blackwell Publishing.
4. Green, M. R., & Sambrook, J. (2012). *Molecular cloning: A laboratory manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

IMMUNOLOGY

Year 3 | Semester VI | BTY1062 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Able to identify the cellular and molecular basis of immune responsiveness	x				
CO 2	Describe the roles of the immune system in maintaining health	x	x			
CO 3	Analyse immunological response and how it is triggered and regulated		x	x		
CO 4	Transfer knowledge of immunology into clinical decision-making		x		x	x
CO 5	Demonstrate skills in the use of tools & technologies in immunology			x	x	x

UNIT I: COMPONENTS OF INNATE AND ACQUIRED IMMUNITY: 12 Hrs

Phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.

UNIT II: IMMUNOGLOBULINS: 12 Hrs

Basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self-discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.

UNIT III: IMMUNOTECHNOLOGY: 12 Hrs

Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.

UNIT IV: IMMUNITY TO INFECTION: 12 Hrs

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy. Messenger RNA and cDNA synthesis; cDNA and Genomic Library- construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNA foot printing, Primer extension, S1 mapping, Reporter assays – Two hybrid system - Phage display.

UNIT V: MAJOR HISTOCOMPATIBILITY COMPLEX: 12 Hrs

Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

REFERENCES

1. Abbas AK, Lichtman AH & Pillai S. (2014) Cellular & Molecular Immunology. Elsevier, USA.
2. Delves PJ, Martin SJ, Burton DR & Roitt IM. (2016) Essential Immunology. Wiley-Blackwell, UK.
3. Janeway CA, Travers P, Walport M & Shlomchik MJ. (2016) Janeway Immunobiology. Garland Science.
4. Paul WE. (2012) Fundamental Immunology. Lippincott Williams & Wilkins, USA.
5. Brostoff J, Seaddin JK, Male D & Roitt IM (2002). Clinical Immunology. London: Gower Medical Pub.

BIOINFORMATICS

Year 3 | Semester VI | BTY1063 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Develop an understanding of basic theory of bioinformatics tools	x	x			
CO 2	Demonstrate the knowledge of various biological databases and tools	x				
CO 3	Appreciate their relevance in investigating specific contemporary biological questions		x	x		
CO 4	Evolutionary relationships based on sequence comparisons and molecular phylogenetics		x	x		
CO 5	Critically analyse and interpret the results of bioinformatics study				x	x

UNIT I: BIOINFORMATICS BASICS: 12 Hrs

Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on the web; database mining tools.

UNIT II: DNA SEQUENCE ANALYSIS: 12 Hrs

Gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

UNIT III: MULTIPLE SEQUENCE ANALYSIS: 12 Hrs

Multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where how to submit, SEQUIN, genome centers; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

UNIT IV: PROTEIN MODELLING: 12 Hrs

Introduction; for Multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where how to submit, SEQUIN, genome centers; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis field methods; energy, buried and exposed residues; side chains and neighbors; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structure; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.

UNIT V: PROTEIN STRUCTURE PREDICTION: 12 Hrs

Protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of *in silico* drug design.

REFERENCES

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ: Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford University Press.

GENETIC ENGINEERING LAB.

Year 3 | Semester VI | BTY1064 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Gain hands-on experience with the plasmids, cloning vectors for the recombinant DNA research work	x	x			
CO 2	Explain the basic principles and practice in molecular cloning, design and genetic transformation	x	x			
CO 3	Analyse molecular data and interpret the results			x	x	
CO 4	Able to differentiate and confirm the cloned plasmid/vector using different molecular methods		x	x		
CO 5	Apply the most appropriate rDNA and other contemporary molecular techniques to engineer an organism		x		x	x

EXPERIMENTS

1. Isolation of plasmids (pBR322/pUC/pXCM) and purification
2. Various clonig techniques
3. Cloning of fragment in pBR322 / pBluescript – insertional inactivation / Blue white selection
4. Re-isolation of plasmid from the recombinant clone, Restriction digestion and agarose gel electrophoresis– confirmation of the size of insert
5. Preparation of competent *E.coli* cells and plasmid DNA for bacterial transformation
6. Genetic Transformation of *E.coli* with a recombinant Plasmid using $CaCl_2$, electrophoration
7. Expression of the cloned gene in *E.coli;* Blue White screening - IPTG induction.
8. Genomic and cDNA library construction methods
9. Blotting technique-DNA transfer by nylon membrane- Probe preparation - Southern, Northern, Western blotting
10. Identification of recombinant DNA and its expression

REFERENCES

1. Sambrook J and Green MR (2012) Molecular Cloning – A Laboratory Manual. 4th Ed 2012 by Cold Spring Harbor Laboratory Press.
2. Cseke J.L, Kirakosay A, Kaufman P.B, Westfall M.V. (2016) Handbook of Molecular and Cellular Methods in Biology and Medicine. Taylor and Francis Group.
3. Verma A.S, Das S and Singh A (2014). Laboratory Manual for Biotechnology. S Chand & Company Pvt Ltd, New Delhi.
4. Technical manual/literature from Sigma, Invtrogen, Thermo Scientific, Stratagene, Promega, Novagen, New England Biolab etc.

IMMUNOLOGY LAB.

Year 3 | Semester VI | BTY1065 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the basic immunological techniques	x	x			
CO 2	Demonstrate an understanding of experiments related to immunology	x	x			
CO 3	Able to analyze the role of the immune system for human applications		x	x		
CO 4	Conduct investigations in immunology for translational applications			x	x	x
CO 5	Utilize the skill sets required to extrapolate findings for human applications with appropriate experimental tools				x	x

EXPERIMENTS

1. Extraction of Human PBMCs by Ficoll-Hypaque Overlay Method.
2. Quantification of Immune Cells in PBMCs by Haemocytometer
3. Antigen-antibody reactions: ABO blood grouping and Rh compatibility testing
4. WIDAL test for enteric fever
5. VDRL test for syphilis
6. ELISA for antibody/antigen detection and immunoblotting
7. Latex agglutination test for diagnosis of infectious agents
8. Microparticle agglutination test for infectious agents
9. Immunoelectrophoresis and immunofluorescence test
10. Flow Cytometry & Data Analysis (FlowJo)

REFERENCES

1. Abbas AK, Lichtman AH & Pillai S. (2014) Cellular & Molecular Immunology. Elsevier, USA.
2. Delves PJ, Martin SJ, Burton DR & Roitt IM. (2016) Essential Immunology. Wiley-Blackwell, UK.
3. Janeway CA, Travers P, Walport M & Shlomchik MJ. (2016) Janeway Immunobiology. Garland Science.
4. Paul WE. (2012) Fundamental Immunology. Lippincott Williams & Wilkins, USA.

BIOINFORMATICS LAB.

Year 3 | Semester VI | BTY1066 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Sequence-based searches and analyze and discuss results in light of molecular biological knowledge	x	x	x		
CO 2	Apply available biological databases to understand function of genes	x	x	x		
CO 3	Explain major steps in pairwise and multiple sequence alignment			x		
CO 4	Execute pairwise sequence alignment by dynamic programming				x	x
CO 5	Predict secondary and tertiary structures of protein sequences				x	x

EXPERIMENTS

1. Using NCBI and Uniprot web resources
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.

6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, and CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins& molecular docking
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.

REFERENCES

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford University Press.

BIOPROCESS ENGINEERING

Year 4 | Semester VII | BTY1071 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Give an account of important microbial/enzymatic industrial processes	x	x			
CO 2	Estimate yield and production rates in a biological production process, and also interpret data	x	x			
CO 3	Carry out stoichiometric evaluations and specify models of their growth		x	x		
CO 4	Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research			x	x	x
CO 5	Analyze and interpret data, and apply the laboratory skills to solve complex bioprocess			x	x	x

UNIT I: BASIC PROCESS IN BIOPROCESS ENGINEERING: 12 Hrs

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics. Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

UNIT II: BIOREACTOR DESIGN AND ANALYSIS: 12 Hrs

Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

UNIT III: FERMENTATION ECONOMICS: 12 Hrs

Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

UNIT IV: ENZYMES IN BIOPROCESS: 12 Hrs

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

UNIT V: APPLICATION OF BIOPROCESS ENGINEERING: 12 Hrs

Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation.

REFERENCES

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
4. Bailey JE, & Ollis DF. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill

SYSTEMS AND SYNTHETIC BIOLOGY

Year 4 | Semester VII | BTY1072 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Describe the comprehensive measurements of biological systems	x				
CO 2	Discuss the details on the factors involved in Biological System Design		x	x		
CO 3	Find the networking of genes and protein interaction networks		x	x		
CO 4	Illustrate the modelling of the prokaryotic gene expression			x	x	
CO 5	Relate the engineering principles in Synthetic Biology and its applications				x	x

UNIT I: INTRODUCTION TO SYSTEMS BIOLOGY AND BIOLOGICAL NETWORKS: 12 Hrs

Introduction to Systems Biology - System-level Understanding of Biological Systems - Advanced Measurement Systems - Introduction to Biological Networks and Basic Concepts – Metabolic, Signaling and Regulatory networks - Why build and study models? - Characterizing dynamic states - Formulating and studying dynamic network models - Properties of dynamic states - Network structure versus dynamics.

UNIT II: STANDARD MODELS AND APPROACHES IN SYSTEMS BIOLOGY: 12 Hrs

Metabolism- enzyme kinetics and thermodynamics- Michaelis-Menten Kinetics - metabolic networks- metabolic control analysis - Signal transduction- introduction- function and structures- interactions- structural components - Signalling selected biological processes - mathematical models - prediction of biological systems.

UNIT III: SYSTEMS BIOLOGY SOFTWARE: 12 Hrs

Systems biology software project: About the project-model inter change-code use-bio-models- online services-SBML Layout viewer-SBML validation-simulation translator-model repository- SBW broker - Jurnac-J-designer-BioSpice – BioUMC - CellDesigner – Cytoscape - Dizzy- Oscillator- Virtual cell - virtual rice project – E-CELL: numerical simulation algorithm - mathematical analysis methods-software environment-projects models-applications chemotaxis - molecular clock-circadian rhythms-oxidation stress-multi- enzyme systems.

UNIT IV: NEXT GENERATION SEQUENCING (NGS) DATA ANALYSIS: 12 Hrs

Introduction to Next Generation Sequencing (NGS) – Sequencing Technologies - Using Galaxy for NGS Analyses - Experimental Design and Sample Preparation - From Generating Sequence Data to FASTQ - Genome Assembly - Sequence Alignment - The SAM/BAM Format and SAM tools - Variant Calling: Single-Nucleotide Variants and Indels - Variant Calling: Structural Variants - Summarizing Variation: The VCF Format and VCF tools - Visualizing and Tabulating Next Generation Sequence Data - Interpreting the Biological Significance of Variants - Storing Data in Repositories - Specialized Applications of NGS.

UNIT V: INTRODUCTION TO SYNTHETIC BIOLOGY: 12 Hrs

Introduction – Definition – Synthetic Biology versus Systems Biology - Synthesis and Engineering Tools - DNA Synthesis - Protein Engineering - Pathway Engineering - Genome Engineering - Computational and Theoretical Tools – Genomics, Proteomics and Metabolomics Tools - Applications in Synthetic Biology – Molecular, Pathway and Whole Cell Levels - Challenges and Future Perspectives.

REFERENCES

1. Hiroaki Kitano (Editor), Foundations of Systems Biology, MIT Press, 2001.
2. Bernhard Ø. Palsson, Systems Biology – Simulation of Dynamic Network States, Cambridge Univ. Press, UK, 2011.
3. E.Klipp, et al. Systems Biology in Practice, Wiley-VCH, Weinheim, 2005.
4. Huimin Zhao (Ed.), Synthetic Biology: Tools and Applications, Academic Press, Elsevier, 2013.
5. Arthur M. Lesk, Introduction to Bioinformatics 2nd Ed. Oxford University Press, New Delhi, 2005.
6. Jing Liang, Yunzi Luo, and Huimin Zhao, Synthetic biology: putting synthesis into biology, *Wiley Interdiscip Rev Syst Biol Med*, 3, 7-20, 2011.
7. Jonathan Pevsner, Bioinformatics and Functional Genomics, 3rd Edn, John Wiley, New York, 2015.
8. www.systems-biology.org/
9. https://www.sysbiol.cam.ac.uk/
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GENE EXPRESSION AND TRANSGENICS

Year 4 | Semester VII | BTY1073 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the genetic architecture of prokaryotes and eukaryotes	x		x		
CO 2	Appreciate the regulation of transcription and translation	x	x			
CO 3	Recognize the significance of post transcriptional/translational modifications in cells	x	x			
CO 4	Demonstrate the transduction of chemical signals to gene expression			x	x	
CO 5	Generate GM bioproducts and describe their role in food security, sustainable environment and medicine				x	x

UNIT I: GENOME ORGANIZATION IN PROKARYOTES AND EUKARYOTES: 12 Hrs

Genome organization, chromatin structure, nucleosomes, heterochromatin, euchromatin repeat sequences, cot curve analysis, structural DNA sequences, complexity frequency of repetition. Eukaryotic gene regulation, process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls, Coordinated genetic regulation-examples.

UNIT II: GENE EXPRESSION: 12 Hrs

Transcription, precursor, polyadenylation, capping, processing, splicing, editing - Regulation of transcription, promoters, cis regulatory elements. enhancers, activators, transacting proteins. Role of polyadenylation, maternal stored messengers. Translation, genetic code, Eukaryotic ribosomes and ribosomal RNA translational apparatus, polysomes.

UNIT III: POST TRANSLATIONAL MODIFICATION: 12 Hrs

Secretory proteins, Signal hypothesis, glycosylation. Modulators of eukaryotic gene expression, signal transduction mechanisms oncogenes, hormones, Ca2+, cyclic AMP, metal, heat shock proteins. Translational and post-translational regulation; Signal transduction; Stress-induced gene expression; Gene traps and enhancer traps.

UNIT IV: HOMEOBOX GENES: 12 Hrs

Vertebrate, nomenclature, axial patterning functional comparison between Hox – C genes – Hom – C genes Hom – C/ Hox C at differential development stages in different tissues Hom C/ Hox C or Hox genes in *C.elegans*. Homeobox gene, gsc controlled cell migration in Xenopus embryos. Genetic and molecular basis depending on tissue specificity.

UNIT V: TRANSGENE EXPRESSION AND GENE SILENCING MECHANISMS: 12 Hrs

Horizontal and vertical homology; Transformation-regulatory genes as visible markers; Reporter systems to study gene expression; Combinatorial gene control. Production of Transgenic organisms – GMOs – Plant, animal and Microbes – Their applications in medicine, agriculture, industries and environment. HGP & its impact – impact of Human Genome project in Plant, Animal & Human, High-throughput analysis gene functions / Single Nucleotide Polymorphisms.

REFERENCES

1. Carp G & Puritt NL. (2013) Cell & Molecular Biology - Concepts & Experiment. John Wiley & Sons.
2. Karp G, Iwasa J, Marshall W. (2019) Cell & Molecular Biology, 9th Ed. John Wiley & Sons Inc.
3. Krebs JE, Goldstein ES, Kilpatrick ST. (2018) Lewin's Genes XII, 12th Ed. Jones and Bartlett Publishers.
4. Alberts B, Johnson A, Lewis J, Morgan D, Raff M. (2015) Molecular Biology of the Cell, 6th Ed. Garland Science.

CELL AND GENE THERAPY

Year 4 | Semester VII | BTY1074 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Gain basic knowledge on technology used for cell and gene therapy	x				
CO 2	Know the approaches in translating into clinical applications of these therapies		x	x		x
CO 3	Understanding the commercial and regulatory elements of this area				x	x
CO 4	Apprehend on key regulatory issues, technical considerations and preclinical aspects of therapeutic applications			x		x
CO 5	Develop the skills on the gene therapy by using various models			x	x	

UNIT I: OVERVIEW OF GENE AND CELL THERAPY: 12 Hrs

The concepts of cell and gene therapy, History of gene therapy, types of gene therapy, gene therapy strategies, choice of the therapeutic target, administration routes, delivery systems, cell targeting, immune response to the therapy, Bone Marrow Transplantation as The First Cellular Therapy, Ethical questions and concerns about gene and cell therapy.

UNIT II: GENE TARGETING: 12 Hrs

Gene targeting, principles, and practice in mammalian cells, Site-specific recombination in cells and mice, Production of targeted embryonic stem cell clones, Production of chimeras by blastocyst and morula injection of targeted ES cells, Production and analysis of ES cell aggregation chimeras, Gene trap strategies in ES cells.

UNIT III: NON -VIRAL AND VIRAL VECTORS OF GENE THERAPY: 12 Hrs

Non-viral: Physical methods –Hydrodynamic delivery, Microinjection, electroporation, Nucleofection, ultrasound and sonoporation, Ballistic gene delivery, gene gun, magenetofection and magnetoporation, microneedles. Chemical systems – polimer-based nanocarriers, lipid-based systems, inorganic materials. Viral vectors of gene therapy: lentiviral vectors, adenoviral vectors, adeno-associated virus, Herpes simplex virus, vaccinia, Baculovirus.

UNIT V: STEM CELLS AND TISSUE REGENERATION: 12 Hrs

Adult and fetal neural stem cells, embryonic stem cells, stem cells generated through tissue cell reprogramming, induced pluripotent stem cells, chemically induced pluripotent stem cells (iPSC), CAR-T Cell therapy, epigenetic, metabolic, and cellular pathway modulation by small molecules, iPSC and iPSC derived neural progenitors issues, organoids, three dimensional bioprinting.

UNIT IV: GENE THERAPY STRATEGIES AND APPLICATIONS: 12 Hrs

Gene replacement, gene addition, the basis of gene editing, DNA double strand break repair mechanisms, programmable nucleases used in gene editing,editing genes using CRISPR-Cas. Gene therapy for cancer, Gene therapy for eye conditions, Gene therapy for cardio vascular conditions, Gene therapy for neurodegenerative diseases, Gene therapy for Beta hemoglobinopathies, Hemophlilia A and B, Gene therapy for muscular diseases: Duchenne Muscular Dystrophy.

REFERENCES

1. Gene and cell gene therapy, therapeutic mechanisms and strategies, 2nd ed.i, Nancy smith Templeton, 2015. Taylor and Francis Group
2. Gene targeting, a practical approach , 2nd edition, AL JOYNER , 2020, oxford university press
3. A handbook of gene and cell therapy, C Nobrega, L Mendonca, CA Matos, Springer, 2020.
4. Advanced Textbook on Gene Transfer, Gene Therapy And Genetic Pharmacology: Principles, Delivery And Pharmacological And Biomedical Applications Of Nucleotide-based Therapies: 2013, Daniel Scherman, World Scientific Publishing company.

RESEARCH METHODOLOGY & SCIENTIFIC COMMUNICATION SKILLS

Year 4 | Semester VII | BTYSE03 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Develop understanding of the basic framework of research process	x				
CO 2	Understand various research designs and techniques	x				
CO 3	Identify various sources of information for literature review and data collection	x	x	x		
CO 4	Appreciate scholarly writing and evaluate its quality				x	x
CO 5	Gain knowledge on understanding effective lab practices and scientific communication and appreciate scientific ethics			x		x

UNIT I: RESEARCH OBJECTIVES AND FORMULATION: 6 Hrs

Motivation and objectives – Research methods vs. Methodology; Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical; Research Formulation – Defining and formulating the research problem; Selecting the problem; Necessity of defining the problem; Importance of literature review in defining a problem; Literature review – Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web; Critical literature review; Identifying gap areas from literature review – Research question - Development of working hypothesis.

UNIT II: RESEARCH DESIGN AND METHODS: 6 Hrs

Research design – Basic Principles, Need of research design, Features of good research design; Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models; Developing a research plan - Exploration, Description, Diagnosis, Experimentation; determining experimental and sample designs.

UNIT III: DATA COLLECTION AND ANALYSIS: 6 Hrs

Execution of the research - Observation and Collection of data; Methods of data collection – Sampling Methods- Data Processing and Analysis strategies; Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation; Maintaining a lab notebook with date-wise entry.

UNIT IV: REPORTING AND THESIS WRITING: 6 Hrs

Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes – software; Oral presentation – Planning – Preparation – Practice – Making presentation – Use of visual aids - Importance of effective communication - Concept of effective communication; Setting goals for communication; Determining outcomes and results; Initiating communication; Creating value in conversation; Barriers to effective communication; Non-verbal communication. Interpreting non-verbal cues; Importance of body language, Power of effective listening; recognizing cultural differences.

UNIT V: APPLICATION OF RESULTS AND ETHICS: 6 Hrs

Ethical issues, ethical committees; Commercialization; Intellectual property rights, patent law Copyright, royalty; Calculations of Impact factor of a journal, citation Index, ISBN & ISSN; Reproduction of published material; Plagiarism; Citation and acknowledgement - Reproducibility and accountability.

REFERENCES

1. Garg BL, Karadia R, Agarwal F & Agarwal UK (2002). An Introduction to Research Methodology, RBSA Publishers.
2. JW Creswell (2006). Designing and Conducting Mixed Method Research. Sage Publication. (CA) 275 pages.
3. Sinha SC & Dhiman AK. (2002). Research Methodology, EssEss Publications. 2 volumes.
4. Trochim WMK. (2005). Research Methods: the Concise Knowledge Base, Atomic Dog Publishing. 270p.
5. Movie: Naturally Obsessed, The Making of a Scientist. (imdb – tt1470891).
6. Research Methods for Communication Science -http://www.cios.org/readbook/rmcs/rmcs.htm
7. Scientific Writing for Agricultural Research Scientists-http://www.authoraid.info/uploads/resources/scientific-writing-for-agricultural-research-scientists-a-training-resource-manual.pdf
8. Scientific Communication and Research Methodology - http://www.academia.edu/5318451/Scientific_Communication_and_Research_Methodology

BIOPROCESS ENGINEERING LAB.

Year 4 | Semester VII | BTY1075 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Provide hands-on training to students in upstream and downstream unit operations	x				
CO 2	Explain major steps in industrial production of bioproducts	x				
CO 3	Execute theoretical aspects of bioprocess into practice	x				
CO 4	Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research		x	x	x	
CO 5	Analyze and interpret data, and apply the laboratory skills to solve complex bioprocess				x	x

EXPERIMENTS

1. Scale up from frozen vial to agar plate to shake flask culture.
2. Instrumentation: Microplate reader, spectrophotometer, microscopy.
3. Isolation of microorganisms from soil samples.
4. Immobilization of bacteria.
5. Production of ethanol by yeast
6. Extraction of flavanoids from plants.
7. Assembly of bioreactor and sterilization.
8. Growth kinetics.
9. Substrate and product inhibitions.
10. Measurement of residual substrates.
11. Introduction to Metabolic Flux Analysis (MFA).
12. Batch, Fed-batch, Continuous fermentation.

REFERENCES

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York.
4. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

SYSTEMS AND SYNTHETIC BIOLOGY LAB.

Year 4 | Semester VII | BTY1075 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand systems and synthetic biology prototypes	x				

CO 2	Exposure to bottom-up and top-down design and analysis strategies for systems and synthetic biology	x		x		
CO 3	Explore the basic circuitry in transcription regulation, signal transduction, and developmental networks	x	x	x		
CO 4	Able to design biological circuits based on simple mathematical framework		x		x	
CO 5	Able to design and synthesis of biomolecules with novel properties		x		x	x

EXPERIMENTS

1. Transcription networks, basic concepts
2. Auto-regulation, a network motif
3. The feed forward loop network motif
4. Temporal programs and the global structure of transcription networks
5. Network motifs in developmental, signal-transduction and neuronal networks
6. Robustness of protein circuits, the example of bacterial chemotaxis
7. Robust patterning in development
8. Kinetic proofreading
9. Optimal gene circuit design
10. Rules for gene regulation based on error minimization

REFERENCES

1. Uri Alon, Chapman & Hall (2020). An Introduction to Systems Biology: Design Principles of Biological Circuits. 2nd Ed. Routledge and CRC Press.
2. Huimin Zhao. (2013). Synthetic Biology: Tools and Applications. Academic Press.

OMICS TECHNOLOGIES

Year 4 | Semester VIII | BTY1081 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Structure and organization of genes and other DNA elements in a genome	x				
CO 2	Applications of genomics, proteomics, transcriptomics and metabolomics in various areas of biology		x	x		
CO 3	Significance of studying global gene expression profile.		x	x		
CO 4	Importance of comparing any two or more genomes.			x	x	
CO 5	Able to utilize advanced techniques and methods for genome analysis				x	x

UNIT I: INTRODUCTION TO BASICS OF GENOMICS AND PROTEOMICS: 12 Hrs

Introduction to prokaryotic and eukaryotic genome organization; Genome Sizes, c- Value Paradox, extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast. Central Dogma of Molecular Biology, Significance of studying genomes and Proteomes with Respect to Basic and applied sciences.

UNIT II: GENOME SEQUENCE DATA ANALYSES: 12 Hrs

Introduction to sequencing: Maxam and Gilbert method, Sanger Sequencing techniques and applications; Next Generation sequencing (NGS), Experimental protocol (Isolation of DNA/RNA), quality check, Library Preparations, sequencing reaction); Types of NGS, Platform overview and comparison (Illumina, 454 (Roche), SOLiD (Life technology), Specific Biosciences, Ion Torrent, Nanopore, PacBio); Whole genome sequencing, exome sequencing, Deep sequencing, ChIP sequencing, RNA-sequencing and the types (small RNA sequencing, non-coding RNA sequencing); Data Processing and Analysis: Data Quality Check, filtering and Genome assembly and mapping to reference genomes, mapping tools (bowtie, maqetc,), Sequence Alignment formats: Sequence Alignment/ Map (SAM) format, Binary Alignment/Map (BAM) format, Functional Analysis: Pathway analysis, Gene Ontology analysis; Application of different sequencing technique, methylomics, in vivo protein binding, genome wide association studies (GWAS), Histone modification, microbial sequencing, case studies.

UNIT III: FUNCTIONAL GENOMICS AND TRANSCRIPTOMICS: 12 Hrs

Whole Transcriptome Analysis: Introduction, Basic principles and design, cDNA and oligonucleotide arrays, DNA microarray, Instrumentation and structure; Designing a microarray experiment - The basic steps, Types of

microarray - expression arrays, protein arrays, Comparative Genomic Hybridization (CGH) arrays, Resequencing arrays; Different platforms (Affymetrix, Agilent etc.); Data Processing and Normalization - Algorithms of data processing and Normalization; Tools used to normalize; Microarray databases – NCBI; GEO (Gene Expression Omnibus), ArrayExpres (EBI); Functional Analysis: Differential gene expression; Gene Ontology functional enrichment tools, Pathway analysis (KEGG Database); Applications of Microarray technology; case studies; RNA-Seq Approach. Identification and validation of functional annotation of gene, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function forward and reverse genetics.

UNIT IV: PROTEOMICS: 12 Hrs

Overview of protein structure-primary, secondary, tertiary and quarternary structure, Relationship between protein structure and function; Outline of a typical proteomics experiment, Identification and analysis of proteins by 2D analysis, Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting, Mass spectrometry : ion source (MALDI, spray sources), analyzer (ToF, quadrupole, quadruple ion trap) and detector; Post translational Modifications: Quantitative proteomics, clinical proteomics and disease biomarkers, mass spectral tissue imaging and profiling; Proteinprotein interactions: Surfaceomes and Secretomes, Solid phase ELISA, pull-down assays (using GST-tagged protein) tandem affinity purification, far western analysis, by surface plasmon resonance technique; Yeast two hybrid system, Phage display, Protein interaction maps, Protein arrays-definition; applications- diagnostics, expression profiling..

UNIT V: METABOLOMICS AND METAGENOMICS: 12 Hrs

Introduction and overview of metabolites, sample collection and processing, Non tracer and tracer (radio labelled)-based techniques in metabolomics (HPLC, NMR, LC-MS and GC-MS); Metabolome data processing derived by various techniques, analysis of databases (MetaboLight, Meta Cyc, MMCD etc.), Analysis tools, Metabolic pathways and network analysis Metabolic flux analysis (TCA, Amino acids, fatty acids, intermediary metabolites), Stoichiometric metabolic flux analysis, 13C metabolic flux analysis (MFA), Metabolic control analysis (MCA); Applications of metabolomics; Integration of metabolomics data sets with other data (eg. Transcriptomics, enzyme activity. Metagenomics and its applications, Metagenomics in animal gastro intestinal ecosystems, Methods of studying microbial diversity and microbiome of production animals, Prospects of biome engineering in enhancing animal health and production

REFERENCES

1. Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
2. Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press.
3. Brown TA (2023): An Introduction to Genomes, Taylor and Francis Group
4. Jamil Momand, Alison McCurdy (2016): Concepts in Bioinformatics and Genomics, Oxford University Press
5. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). Principles of gene manipulation and genomics. Malden, MA: Blackwell Pub.

MOLECULAR DIAGNOSTICS

Year 4 | Semester VIII | BTY1082 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the concepts and applications of components of Molecular Diagnostics	x				
CO 2	Know the different types of disease diagnostic methods	x	x			
CO 3	Analyse the basic concept of medical important and how to detect the diseases by diagnostic techniques	x	x			
CO 4	Develop modern molecular techniques for detecting/monitoring diseases			x	x	x
CO 5	Able to improve the new diagnostic techniques for disease identification		x		x	x

UNIT I: MOLECULAR DIAGNOSIS, GENOME BIOLOGY IN HEALTH AND DISEASE: 12 Hrs

Biochemistry in Diagnostics and Molecular Biology Biochemistry in Diagnostics, what is molecular diagnostics? Why use molecular diagnosis? DNA, RNA, and Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs.

UNIT II: GENOME: RESOLUTION, DETECTION & ANALYSIS: 12 Hrs

PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16s rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis.

UNIT III: DIAGNOSTIC METABOLOMICS: 12 Hrs

Metabolites profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.

UNIT IV: DETECTION AND IDENTITY OF MICROBIAL DISEASES: 12 Hrs

Direct detection and identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

UNIT V: DETECTION OF INHERITED DISEASES AND MOLECULAR ONCOLOGY: 12 Hrs

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes. Molecular Oncology: Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

REFERENCES

1. Brooker RJ (2009). Genetics: Analysis & Principles. McGraw-Hill.
2. Glick BR, Pasternak JJ & Patten CL (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.
3. Coleman WB, & Tsongalis GJ (2010). Molecular Diagnostics: for the Clinical Laboratorian. Humana Press.
4. Molecular Diagnostics: Fundamentals, Methods & Clinical applications (2012). 2nd Ed. Lele Buckingham. F.A. Davis Co.
5. Fundamentals of Molecular Diagnostics (2007). David E. Bruns, Edward R. Ashwood, Carl A. Burtis. Saunders Group.

PROTEIN ENGINEERING

Year 4 | Semester VIII | BTY1083 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand methods and strategies used in protein engineering	x				
CO 2	Construction of protein structures by computer-based methods	x				
CO 3	Describe structure and classification of proteins		x	x		
CO 4	Analyse purity and stability of proteins and its storage methods		x	x		
CO 5	Explain the uses of proteins for industrial and academic purposes			x	x	x

UNIT I: INTRODUCTION TO PROTEIN ENGINEERING: 12 Hrs

Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc. Protein engineering with unnatural amino acids and its applications.

UNIT II: STABILITY OF PROTEIN STRUCTURE: 12 Hrs

Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be

Measured / obtained from NMR and their interpretation.

UNIT III: APPLICATIONS: 12 Hrs

Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, etc., Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens etc., Application to devices with bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery.

UNIT IV: ENZYME KINETICS AND ENGINEERING: 12 Hrs

Enzyme as biological catalysts; Enzyme action, active site, functional group, enzyme substrate complex, cofactors, Michaelis-Menten equation, Km and Vmax, enzyme inhibition; order of reaction, methods of plotting enzyme kinetics data; Enzyme turnover number, competitive, non-competitive, uncompetitive, irreversible; order of reaction, methods of plotting enzyme kinetics data; determination of Kcat, Km, Vmax, Ki, Half life, activation and deactivation energy *etc.* Cross-linked enzyme aggregates, Cross linked enzymes, enzyme crystals, their use and preparation. Solution of numerical problems; Energy yielding and energy-requiring reactions; Calculation of equilibrium constants; Activation energy *etc.*; Multisubstrate enzymes and kinetics mechanisms; Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects. Random and rational approach of protein engineering; Directed evolution and its application in the biocatalysis; various approaches of creating variant enzyme molecules; Future of Biocatalysis; Ideal biocatalyst.

UNIT V: IMMOBILIZED ENZYME TECHNOLOGY: 12 Hrs

Different techniques of immobilization of enzymes and whole cells; Advantages and disadvantages of immobilization; Kinetics of immobilized enzymes, design and operation of immobilized enzymes reactors; Types of reactors, classification, retention of enzymes in a reactor, kinetics of enzyme reactors; Reactor performance with inhibition, operation of enzyme reactors; case studies; starch conversion; 6APA production, biotransformations using soluble as well as immobilized enzymes; Calculations of diffusional resistances and Thiele's modulus, multi-step immobilized enzyme systems; Solution of numerical problems; Application and future of immobilized enzyme technology.

REFERENCES

1. Edited by T E Creighton, (1997), Protein Structure: a Practical Approach, 2nd Edition, Oxford university press.
2. Cleland and Craik, (2006), Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands.
3. Mueller and Arndt, Protein Engineering Protocols, 1st Edition, Humana Press.
4. Ed. Robertson DE, Noel JP, (2004), Protein Engineering Methods in Enzymology, Elsevier Academic Press.
5. J. Kyte; (2006), Structure in Protein Chemistry, 2nd Edition, Garland publishers.

ENVIRONMENTAL BIOTECHNOLOGY

Year 4 | Semester VIII | BTY1084 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the nature of various problems in environment	x				
CO 2	Apply biotechnological methods to solve problems in water, air and soil environment		x	x		
CO 3	Analyze the impact of pollution on environment		x	x		
CO 4	Create mitigation methods for environmental problems				x	x
CO 5	Acquire biotechnological skills for abating environmental problems				x	x

UNIT I: INTRODUCTION TO ENVIRONMENT: 12 Hrs

Introduction to environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; Nutrient removal in wastewater: Nitrification, denitrification, reactors employed; Anamox process - Aerobic and Anaerobic treatment of wastewater; kinetics and modelling of aerobic suspended growth reactor, suspended and attached growth anaerobic reactor.

UNIT II: BIOREMEDIATION: 12 Hrs

Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ).

UNIT III: ROLE OF MICROORGANIMS IN BIOREMEDIATION: 12 Hrs

Application of bacteria and fungi in bioremediation: White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization).

UNIT IV: MARINE ENVIRONMENT: 12 Hrs

Marine life forms Role of microorganisms in ocean processes; Biomimetic materials Marine pollution and its control – Biosensors, oil spills and remediation Biofouling and bio-deterioration; Compounds obtained from marine environment – industrial products and processes, sea and land based cultivation of seaweeds and their products, Microalgae –Potential species –application in air and wastewater water treatment – biorefinery route and valorization of microalgae.

UNIT V: BIOFUELS: 12 Hrs

Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

REFERENCES

1. Bruce Rittmann and P.L. McCarty, Environmental Biotechnology. McGraw-Hill publication
2. Alan Scragg. Environmental Biotechnology, Oxford University Press, USA.
3. Kaliappan and Rajesh Banu, 2022, Biofuel production using anaerobic digestion, Springer.

BIOSTATISTICS AND R PROGRAMMING

Year 4 | Semester VIII | BTYSE04 | Credits 3

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understanding the central concepts of modern statistical theory	x				
CO 2	Interpret results of descriptive statistical methods & tools		x	x		
CO 3	Analyse the results of statistical analyses accurately and make appropriate inference			x	x	
CO 4	Create basic programming concepts in R	x			x	x
CO 5	Develop the statistical analysis with R and data visualization				x	x

UNIT I: INTRODUCTION TO BIOSTATISTICS: 9 Hrs

Sampling, Qualitative & Quantitative Data, Cross-Sectional & Time Series Data, Discrete & Continuous Data, Nominal, Ordinal, Ratio & Interval Scales; Data Presentation: Frequency Distribution & Cumulative Frequency Distribution, Measures of Variability Z-Score & Standard Normal Distribution, Graphical Presentation of Data, Bar, Pie Diagrams, Histograms & Frequency Curve.

UNIT II: BASICS OF BIOSTATISTICS DATA ANALYSIS: 9 Hrs

T-Statistic (One Sample), Independent & Dependent (Paired) Samples T-Test, One-Way ANOVA, Simple Linear Regression Analysis, Chi-Square & Other Non-Parametric Tests, Introduction to Multivariate Analysis.

UNIT III: BASIC PROGRAMMING CONCEPTS IN R: 12 Hrs

Install R & R Studio, List of R Packages, DataSet in R, R Operators, R Data Frame. Write and execute R code. R Data Types, R Operators, R Data Frame, R Tree Package, Vectors in R. Control statement in R – If, If Else, Else if and Switch Statement. Loops in R – For Loop, Nested For Loop, While, Next in R.

UNIT IV: DATA STRUCTURE, MANIPULATION, & PROGRAMS IN R: 12 Hrs

Data Structure - List, Arrays, Data Frames, Factors, and Vector. Read data from a file, write data to a file. Format data from tables. Functions in R. R Program Functions, Factorial in R, Random Number Generator in R.

UNIT V: STATISTICAL ANALYSIS WITH R & DATA VISUALIZATION: 12 Hrs

Statistical analysis with R – T-test, Standard deviation, ANOVA, and Regression analysis. Create plots/chart/graphs from data (Visualization) - Graphs in R - Bar Charts, Pie Chart, Histogram, Line Graph, Plot Function, Scatterplots, R Boxplot labels.

REFERENCES

1. Gupta SP (2000) Statistical Methods (43rdEdition). S Chand & Sons, India.
2. Braun WJ (2007) A First Course in Statistical Programming with R (3rd Edition). Cambridge University Press.
3. Davies TM (2016) The Book of R A First Course in Programming and Statistics (1st Edition). No Starch Press.
4. Beckerman AP (2017) Getting Started with R: An Introduction for Biologists (2nd Edition), Oxford University Press.

INTELLECTUAL PROPERTYRIGHTS, BIOSAFETY AND BIOETHICS

Year 4 | Semester VIII | BTYSE05 | Credits 2

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the rationale for and against IPR and especially patents	x				x
CO 2	Familiarize with broad outline of patent regulations	x				x
CO 3	Appreciate ethical aspects related to biological, biomedical, health care and biotechnology research		x	x		x
CO 4	Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research	x		x		x
CO 5	Learn biosafety and risk assessment of products derived from biotechnology and regulation of such products				x	x

UNIT I: INTRODUCTION TO IPR: 6 Hrs

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

UNIT II: PATENTING: 6 Hrs

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure – patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

UNIT III: BIOSAFETY: 6 Hrs

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.

UNIT IV: NATIONAL AND INTERNATIONAL REGULATIONS: 6 Hrs

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

UNIT V: BIOETHICS: 6 Hrs

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care – patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. 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. Sharing benefits and protecting future generations - Protection of environment and biodiversity – bio piracy.

REFERENCES

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata
2. McGraw-Hill Pub.
3. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
4. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
5. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
6. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy &
7. Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
8. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy
9. Challenges from New Technologies, MIT Press
10. World Trade Organisation. http://www.wto.org
11. World Intellectual Property Organisation. http://www.wipo.int
12. International Union for the Protection of New Varieties of Plants. http://www.upov.int
13. National Portal of India. http://www.archive.india.gov.in
14. National Biodiversity Authority. http://www.nbaindia.org
15. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf.

BIO-DEVICES

Year 5 | Semester IX | BTY1091 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Familiarize with emerging trends in biomedical devices	x				
CO 2	Understand the concepts of microfluidics and its application	x				
CO 3	Able to choose appropriate biomedical technique for disease surveillance		x	x		
CO 4	Extend principles of engineering to the development of medical devices and design of sensors		x	x	x	x
CO 5	Appreciate basic configuration and distinction among biosensor systems			x	x	

UNIT I: SENSORS: 9 Hrs

Rationale of electronic biosensors; Essence of three types of electronic biosensors (*i.e.*, potentiometric, amperometric, and cantilever-based sensors); Three essential metrics that define modern electronic sensors; detection time, sensitivity, and selectivity; Physics of detection time that allows one to organize every available sensor in a systematic way; Fundamental limits of detection of various classes of sensors; Opportunities and challenges of integrating sensors in a system platform.

UNIT II: TRANSDUCERS AND OPTICAL SENSORS: 12 Hrs

Principles and applications of Calorimetric, Piezoelectric, semiconductor, impedimetric, based transducers; Biochemical Transducers: Electrode theory: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity of electrode jellies and creams. Photo detectors, optical fiber sensors, indicator mediated transducers; General principles of optical sensing, optical fiber temperature sensors; Pulse sensor: photoelectric pulse transducer, strain gauge pulse transducer.

UNIT III: BIO RECOGNITION ELECTRODES AND IMMOBILIZATION, SYSTEMS: 12 Hrs

Enzymes; Oligonucleotides Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors; Chemoreceptors. Microelectrodes, body surface electrodes, needle electrodes, pH electrode, specific ion electrodes/ Ion exchange membrane electrodes, enzyme electrodes; Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes; Enzyme immobilization; Peptide immobilization; Antibody immobilization; Oligonucleotides and Nucleic Acid immobilization; Cell immobilization; Mono-enzyme electrodes; Bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes.

UNIT IV: FUNDAMENTALS AND APPLICATIONS OF MICROFLUIDICS: 12 Hrs

Capillary flow and electro kinetics; Micro pump, Micro mixers, Micro reactors, Micro droplets, Micro particle separators; Micro fabrication techniques (different types of lithography methods); Application of micro-fluidics (*e.g.* Lab- in –Chip).

UNIT V: APPLICATIONS: 12 Hrs

Biomarkers: Disease and pathogen specific information, availability by sample type (blood, serum, urine, sputum, saliva, stool, mucus); Specificity, sensitivity, shelf life, portability; Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable Sensors for long-term monitoring; Drug development and detection; Environmental monitoring; Examples of various diseases (Cancer, HIV/AIDS, Tuberculosis, Malaria, Lymphatic Filariasis, Schistosomiasis, Dengue, Chikungunya).

REFERENCES

1. Alice Cunningham, (1998), Introduction to Bio Analytical Sensors, John Wiley & Sons.
2. Jiri Janata, (2009), Principles of Chemical Sensors, 2nd Ed., Plenum Press.
3. F. Schellr, F. Schubert, J. Fedrowitz, (1997), Frontiers in Biosensors, Birkhauser.
4. F. Ligler, C. Rowe Taitt, (2002), Optical Biosensors. Present & Future. Elsevier.
5. Brian Eggins, (2002), Chemical Sensors and Biosensors, John Willey & Sons.
6. Berthier Jean, and Silberzan Pascal, (2010), Microfluidics for Biotechnology, 2nd Ed. Artech House.
10. Frank A Gomez, (2008), Biological Applications of Microfluidics, Wiley.
7. Gareth Jenkins, Colin D. Mansfield, (2013), Microfluidic Diagnostics: Methods and Protocols, Springer.
8. J G. Webster, (1998), Encyclopedia of Medical Devices and Instrumentation. Vol I, II, III, IV, Wiley-Blackwell.

EMERGING TECHNOLOGIES & CRITICAL ANALYSIS OF CLASSICAL PAPERS

Year 5 | Semester IX | BTY1092 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Familiarize with classic scientific literature	x				
CO 2	Appreciate how ground-breaking discoveries were made without, necessarily, use of high-end technologies	x				
CO 3	Analyse about various applications of emerging technologies		x	x		
CO 4	Exercise of hypothesis building and methods of addressing the hypothesis with readily available technology			x	x	x
CO 5	Learning and developing skills on latest technologies in biotechnology				x	x

In this course, for the classical paper section, students may be divided in groups and each group may be responsible for one classical paper. Each week there may be a 1.5 hour presentation cum discussion for each of the papers. At the end of the semester each student will be asked to write a mini-review (2-3 pages long) on any one classical paper, other than the one he/she presented/discussed. This section will be assessed for 50 marks through 100% internal assessment and no end semester examination will be conducted.

The Emerging Technologies section will be assessed for 50 marks through 40% internal and 60% end semester examination.

UNIT I: GENOME EDITING TECHNIQUES: 12 Hrs

Restriction Enzymes, Zinc Finger Nucleases (ZFNs), Transcription activator-like effector-based nucleases (TALENs) Gene Editing, Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR-Cas9); Gene Editing: site-specific Double-Strand Breaks (DSBs) and nonhomologous end-joining (NHEJ) or homologous recombination (HR), Editing by Nucleobase Modification (BASE Editing), Homing Endonucleases (meganucleases), artificial restriction DNA cutter (ARCUT), Multiplex Automated Genomic Engineering (MAGE). Applications, prospects, limitations, and, risks of genome editing technology.

UNIT II: 3D BIOPRINTING: 12 Hrs

Types of 3D printing - Stereolithography (SLA), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), Digital Light Process (DLP), Multi Jet Fusion (MJF), PolyJet, Direct Metal Laser Sintering (DMLS), Electron Beam Melting (EBM). Three basic processes of bioprinting - Pre-bioprinting, Bioprinting, and Post-bioprinting. Bioprinting approach – Biomimicry, Autonomous self-assembly, and Mini-tissue. Printers - Extrusion-Based Methods and Other Printing Methods. Post-printing bioreactor maturation, cell, tissue, and biological factor patterning, biofabrication, and tissue engineering. Advantages of magnetic 3D bioprinting. Bioinks, 3D & 4D bioprinting technology applications - Transplantable organs and organs for research, cultured meat for medical and biotechnology applications.

UNIT III: MICROPHYSIOLOGICAL SYSTEMS: 12 Hrs

The problems with animal use in research-FDA Modernization Act 2.0- alternatives- 3Rs principle- 2Dculture – 3D culture – tissue explants - 3D organoids-stem cell-derived organoids- pros and cons. Artificial organ - Organ-on-chip (Ooc) – simplicity – physiological relevance Microfluidic & devices/chipset and its types: (Plasma bonding, Replica molding, Capillary molding, Microcontact printing); Materials used: (Silicon, Glass, Ceramic, PDMS, Polystyrene, Polycarbonate, Polyurethane, Paper); Choices of cells in building Ooc (actual tissue slices[brain, blood vessel], cell lines, IPSCs & patient-derived stem cells). A typical Ooc system - a lung/bone/skin/retina/heart-on-a-chip system-. Multi-organ-on-chip systems: animal-on-a-chip, Human-on-a-chip- Applications of Ooc on personalized, precision medicine, drug development, and Screening.

UNIT IV: CRITICAL ANALYSIS OF CLASSICAL PAPERS IN MOLECULAR & DEVELOPMENTAL BIOLOGY /GENETICS : 12 Hrs

1. Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from Pneumococcus type III. Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.
2. Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56. Note: Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.
3. Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid. Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8 Note: In this one page paper Watson and Crick first described the structure of DNA double helix Study help - Watson_Crick_Nature_1953_annotated.
4. Transposable mating type genes in Saccharomyces cerevisiae James Hicks, Jeffrey N. Strathern & Amar J.S. Klar; Nature 282, 478-483, 1979 Note: This paper provided evidence for 'cassette hypothesis' of yeast mating type switches i.e. interconversion of mating types in yeast (S. cerevisiae) occurs by DNA rearrangement.
5. Messelson & Stahl experiment demonstrating semi-conservative replication of DNA. Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82 Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology".
6. In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi& Elizabeth H. Blackburn; Nature 344, 126-132, 1990 Note: This paper demonstrates that the telomerase contains the template for telomere synthesis
7. Mutations affecting segment number and polarity in Drosophila Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980 Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.
8. Information for the dorsal--ventral pattern of the Drosophila embryo is stored as maternal mRNA Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7 Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes.

9. Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7 Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cillia in it. Suggested Reference paper - Design and execution of a embryonic lethal mutation screen in mouse.

UNIT V: CRITICAL ANALYSIS OF CLASSICAL PAPERS IN CELL BIOLOGY: 12 Hrs

1. A protein-conducting channel in the endoplasmic reticulum Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371-80 Note: This paper demonstrates the existence of a protein conducting channel Study help - A brief history of Signal Hypothesis
2. Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15 Note: In this groundbreaking paper Randy Schekman'sgroup used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion
3. A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug; 105(2):633-45 Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC) Suggested reference paper - A biochemical assay for identification of PCC.
4. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16 Note: This paper describes setting up of an in vitro reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP etc.
5. A complete immunoglobulin gene is created by somatic recombination Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14 Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.
6. A novel multigene family may encode odorant receptors: a molecular basis for odor recognition Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87 Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in Drosophila olfactory epithelium where a large family of odorat receptors is expressed.
7. Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 Note: This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.

REFERENCES

BIOENTREPRENEURSHIP, PROJECT PROPOSAL PREPERATION AND PRESENTATION

Year 5 | Semester IX | BTY1093 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences	x				
CO 2	Gain entrepreneurial skills & project proposal preparation		x		x	x
CO 3	Formulate a scientific question; Present scientific approach to solve the problem; Interpret, discuss and communicate scientific results in written form		x	x		x
CO 4	Able to build up a strong network with the scientific community and industry			x	x	x

CO 5	Gain experience in writing a scientific proposal; Learn how to present and explain their research findings to the audience effectively				x	x

In this course, for the project preparation and presentation section, each student has to prepare a project one each in R&D and in commercial sections. Each week there may be a 1.5hour presentation cum discussion for each of the projects. The feasibility and viability of the projects will be presented/discussed. This section will be assessed for 50 marks through 100% internal assessment and no end semester examination will be conducted.

The Bioentrepreneurship section will be assessed for 50 marks through 40% internal and 60% end semester examination.

UNIT I: INNOVATION AND ENTREPRENEURSHIP IN BIO-BUSINESS: 12 Hrs

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

UNIT II: BIO MARKETS - BUSINESS STRATEGY AND MARKETING: 12 Hrs

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills. Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

UNIT III: PROJECT PROPOSAL PREPARATION: 12 Hrs

Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources. Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

UNIT IV: POSTER PRESENTATION: 12 Hrs

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

UNIT V: ORAL PRESENTATION: 12 Hrs

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

REFERENCES

1. Adams D J & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.
2. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., &Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
4. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.

DISSERTATION PHASE 1 & 2

Year 5 | Semester IX & X | BTYPR01 & 02 | Credits 4 & 12

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	In-depth knowledge of the chosen area of research	x	x			
CO 2	Adapt to the research environment and understand how projects are executed in a research laboratory		x	x		
CO 3	Capability to critically and systematically integrate knowledge			x	x	
CO 4	Identify issues that must be addressed within framework of specific thesis				x	x
CO 5	Competence in research design				x	x

PLANNING & PERFORMING EXPERIMENTS:

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

THESIS WRITING:

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

RECOMMENDED ELECTIVE COURSES

BIOFERTILIZER

Year 2 | Semester IV | BTYEC41 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the role of biofertilizers in solving the fertilizer problem in India	x		x		
CO 2	Apply the biotechnique for alleviating nutrient deficiency in soils		x	x		
CO 3	Analyze and choose choose the best biofertilizer for the given soil		x	x	x	x
CO 4	Able to produce biofertilizers to improve the soil productivity		x	x	x	
CO 5	Prepare inoculum and carrier material for biofertilizer production		x	x	x	

UNIT I: INTRODUCTION : 12 Hrs

Status of Indian agriculture – fertilizer manufacturing process- usage – its effect to crops and environment; Biofertilizers – Transporter constitutents, method of actions, biochemistry, benefits, variances among organic and biofertilizers, Types. Microorganisms used as biofertilizers; Nitrogen fixation, Phosphorous solubilizing microorganisms, microbial mechanisms of phosphorous solubilisation.

UNIT II: MICROBES AS BIOFERTILIZERS: 12 Hrs

Azospirillum & Azotobacter Azospirillum: Isolation & Mass Multiplication – Carrier Based Inoculant, Associative Effect of Different Microorganisms. Rhizobium – Isolation, Identification, Mass Multiplication, Carrier-Based Inoculants, Actinorrhizal Symbiosis.

UNIT III: ALGAE AS BIOFERTILIZERS: 12 Hrs

Azotobacter: Classification, Characteristics – Crop Response to Azotobacter Inoculum, Maintenance & Mass Multiplication Distribution of nitrogen fixing microalgae in environment; Cyanobacteria, Azolla & Anabaena Cyanobacteria (Blue Green Algae), Azolla & Anabaena Association, Nitrogen Fixation, Factors Affecting Growth, Blue Green Algae & Azolla in Rice Cultivation- Mass cultivation of algae – Field application – case studies.

UNIT IV: FUNGI AS BIOFERTILIZERS: 12 Hrs

Importance and distribution of fungal species as biofertilizers; Mycorrhizae: Mycorrhizal Association, Types of Mycorrhizal Association, Taxonomy, Occurrence & Distribution, Phosphorus Nutrition, Growth & Yield – Colonization of VAM – Isolation & Inoculum Production of VAM, & its Influence on Growth & Yield of Crop Plants – Case studies.

UNIT V: ORGANIC FRAMING: 12 Hrs

Organic Farming – Green Manuring & Organic Fertilizers, Recycling of Biodegradable Municipal, Agricultural & Industrial Wastes; Composting of organic wastes- different types – Methods – factors affecting composting – Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens).

REFERENCES

1. Inamuddin, M.I. Ahamed, R. Boddula, M. Rezakazemi. 2020. Biofertilizers: Study and Impact, Wiley publisher
2. Biofertilizers. Vol. 1: Advances in Bio-inoculants. A Rakshit, VS Meena, M Parihar, HB Singh, AK Singh. 2021. Elsevier.
3. Biofertilizers for Sustainable Agriculture and Environment. 2019. B. Giri, R. Prasad, Q.S. Wu. Springer.
4. Biofertilizers and Biopesticide in Sustainable Agriculture and Environment. 2019. Krishnendu Acharya. CRC Press.

VECTOR BIOLOGY

Year 2 | Semester IV | BTYEC42 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the dynamics of vector borne disease transmission	x				

CO 2	Epidemiology of the current disease pattern and implement on field studies	x	x	x		
CO 3	Able to Identify the major environmental methods used for the control of vector-borne diseases		x	x		
CO 4	Develop an understanding of the sampling, testing, and data				x	x
CO 5	Identification of various public health important vectors on using the taxonomical keys					x

UNIT I: INTRODUCTION TO VECTOR BORNE DISEASES: 12 Hrs

Introduction to vector borne diseases, Vector taxonomy (mosquitoes, sand flies, fleas, ticks and mites etc), Diagnosis of important vector borne diseases, Epidemiology and Climate change impact on vector borne diseases.

UNIT II: TRANSMISSION BIOLOGY: 12 Hrs

Vector biology, Vector character, Disease transmission, Identification of pathogens in vectors.

UNIT III: VECTOR MANAGEMENT: 12 Hrs

Vector control methods, integrated vector management, Insecticide resistance, New vector control methods.

UNIT IV: PARASITIC VECTOR BORNE DISEASES: 12 Hrs

Malaria, Lymphatic Filarasis, Visceral Leishmaniasis, life cycle, disease transmission, diagnosis and disease management.

UNIT V: OTHER VECTOR BORNE DISEASES: 12 Hrs

Dengue, Chickungunya, Japanese encephalitis, Kyasanur Forest disease, life cycle, disease transmission, diagnosis and disease management. Genetically engineered mosquitoes, release in the environment, *Wolbachia* bacteria for control of mosquito.

REFERENCES

1. Grafton-Cardwell, E. E., Stelinski, L. L., & Stansly, P. A. (2013). Biology andmanagement of Asian citrus psyllid, vector of the huanglongbing pathogens. AnnualReviewof Entomology, 58, 413-432.
2. Luckhart, S., Lindsay, S. W., James, A. A., & Scott, T. W. (2010). Reframingcritical needs in vector biology and management of vector-borne disease. PLoSNeglTropDis, 4(2), e566.
3. Beier, J. C., Keating, J., Githure, J. I., Macdonald, M. B., Impoinvil, D. E., & Novak,R. J. (2008). Integrated vector management for malaria control. Malaria journal, 7(1), 1.

PLANT PATHOLOGY

Year 2 | Semester IV | BTYEC43 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Introduce and familiarize the students with basic terminologies, principles and concepts of plant pathology	x				
CO 2	Appreciate various methods and techniques to diagnosis the plant diseases/pathogens	x	x			
CO 3	Gain knowledge on plant diseases with the pathogens involved		x	x		
CO 4	Distinguish different diseases of crop plants and their symptoms		x	x		
CO 5	Develop skill to control the plant diseases using biological, chemical and Integrated disease management methods				x	x

UNIT I: INTRODUCTION AND IMPORTANCE: 12 Hrs

Plant diseases and its importance - Definitions and concepts - History of plant pathology, biotic and abiotic causes of plant diseases. Classification of plant diseases based on spread or occurrence, symptoms, host and causal factor - plant infection – inoculum potential – infection and dissemination of plant pathogens.

UNIT II: PLANT DISEASE EPIDEMIOLOGY: 12 Hrs

Growth, reproduction, survival and dispersal of important plant pathogens – Fungi, Bacteria, Virus and other agents - Elements of epidemics and their interaction. Role of environment and host nutrition on disease development. Infection process – Pre-penetration, Penetration and Post penetration activities of pathogens,

development inside host tissue. Effects of pathogens on plant physiological functions. Host parasite interaction, symptomatology and disease development.

UNIT III: CONCEPT IN PLANT PATHOLOGY: 12 Hrs

Pathogen infection, role of enzymes, toxins, growth regulators; Defense strategies- Phenolics, Phytoalexins, PR proteins, Elicitors. Classes of 'R' Gene proteins, Recognition of pathogen Avr proteins by the host. Defence through plantibodies, SAR and ISR etc. Genetics of resistance - mechanism of genetic variation in pathogens; molecular basis for resistance- Gene for Gene concept, Signal transduction between pathogenecity genes and resistance genes.

UNIT IV: MAJOR DISEASES OF CROP PLANTS: 12 Hrs

Cereal Crops - Rice, wheat, sorghum, maize, Ragi; Pulses, Oilseed and Cash crops – Cotton, Sugarcane. Diseases of Major Vegetables, Fruits; Spices, and plantation crops. Their distribution - importance - causative agents - diagnostic symptoms - pathogen characters - favourable conditions - mode of infection - mode of Survival and spread – integrated management strategies.

UNIT V: PLANT DISEASE MANAGEMENT: 12 Hrs

Principles of plant disease management – Methods of plant disease control -by exclusion, cultural, physical, biological, chemical, organic amendments and botanicals - Integrated Disease Management (IDM) - Concept and tools of disease management, Components of integrated disease management- Quarantine regulations & Procedures - their limitations and implication. Development of disease resistance plants using genetic engineering approaches- Fungal, Bacterial and Virus resistance.

REFERENCES

1. Singh, R .S. (2017). Plant Diseases. 10th Ed. Med Tech, New Delhi.
2. Parker J. (2008). Molecular Aspects of plant disease resistance. Annual Plant Reviews, Vol.34, Willey-Blackwell P.400.
3. Dube, H.C. (2018). Modern Plant Pathology Second Ed. Publisher: Agrobios
4. Mehrotra RS &Aggarwal A. (2003). Plant Pathology. 2nd Ed. Oxford & IBH

NEUROBIOLOGY

Year 3 | Semester V | BTYEC51 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Divisions of Nervous System, Anatomy of Brain & Spinal Cord, Structure & Types of Neurons, Types of Glial Cells & their Functions	x				
CO 2	Understanding on Synthesis, Storage & Function of neurotransmitters	x				
CO 3	Knowledge of diseases of nervous system through case studies		x	x		x
CO 4	Creating the awareness on state of art technologies & research methods in basic and applied neurobiology				x	x
CO 5	Exposed to the concepts in the use of diagnostic tools in neurobiology				x	x

UNIT I: INTRODUCTION TO THE NERVOUS SYSTEM: 12 Hrs

Divisions of Nervous System, Anatomy of Brain & Spinal Cord, Structure & Types of Neurons, Types of Glial Cells & their Functions.

UNIT II: CEREBRAL CIRCULATION: 12 Hrs

Blood Brain Barrier Formation & Function, Cerebrospinal Fluid Secretion & Function, Blood Flow to Brain, Formation of Synapse, Synaptic Transmission, Electrical & Chemical Transmission, Membrane Potentials (Resting & Action Potentials).

UNIT III: NEUROTRANSMITTERS: 12 Hrs

Synthesis, Storage & Function of Acetylcholine, GABA, Glutamate, Serotonin, Dopamine, Norepinephrine, Epinephrine in Brain.

UNIT IV: COGNITIVE NEUROSCIENCE AND TECHNOLOGICAL ADVANCEMENT: 12 Hrs

Types of Memory, Limbic System, Structure of Hippocampus & Associated Structures, Mechanisms of Long Term Potentiation & Memory Formation.

UNIT V: DISEASES OF THE NERVOUS SYSTEM AND TECHNOLOGIES FOR IDENTIFICATION: 12 Hrs

Neuronal Dysfunction & Mechanisms Underlying Alzheimer's Disease, Multiple Sclerosis, Parkinson Disease, Epilepsy, Amyotrophic Lateral Sclerosis. Gene therapy for the neurodegenerative diseases, Neuroengineering, computational models of neural systems, in vivo clinical and pre-clinical neuroimaging, neurotrauma and repair research, and neuronal tissue engineering.

REFERENCES

1. Guyton AC & Hall JE. (2010) Textbook of Medical Physiology.
2. Saunders, USA. Krebs C, Weinberg J &Akesson E. (2012) Neuroscience.
3. Lippincott Williams & Wilkins, USA. Robbins &Cortan. (2004) Pathologic Basis of Disease.
4. Saunders, USA. Sherwood L. (2016) Human Physiology - From Cells to Systems. Pearson India. Squire L, et al. (2012) Fundamental Neurosciences. Academic Press, USA.

DRUG DISCOVERY AND DEVELOPMENT

Year 3 | Semester V | BTYEC52 | Credits 4

COURSE OUTCOME

		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the basics of drug and drugable target	x				
CO 2	Gain knowledge on various methods of drug designing	x	x			
CO 3	Describe the general steps involved in drug discovery	x	x	x		
CO 4	Explain the methods of target and lead identification and validation in drug discovery			x		x
CO 5	Know about drugs including ADME, Drug-Drug Interactions, Drug-Food Interactions, Drug toxicity and Safety				x	x

UNIT I: INTRODUCTION TO DRUG DESIGNING: 12 Hrs

Introduction, Drug-Like Properties & Drugable Targets. Definition, importance, and objectives of drug designing. Phases and key steps involved in drug discovery. Introduction to various target classes and disease categories.

UNIT II: *IN SILICO* PHARMACOLOGY: 12 Hrs

In silico Pharmacology, Docking, Molecular Simulation, Medium Throughput, High Throughput & Ultrahigh Throughput Assay Platforms, *In vitro* &*In vivo* Pharmacological Assays.

UNIT III: MOLECULAR DYNAMICS: 12 Hrs

Target Identification, Target Validation, Lead; Identification & Lead Identification. Economics of Drug Discovery, Structure-Related Drug-Like Criteria of Global Approved Drugs.

UNIT IV: DRUG PREDICTION: 12 Hrs

Anti-Microbial, Anti-Obesity, Anti-Inflammatory, Anti-Viral Anti-Cancer, Anti-Angina, Anti-Atherosclerotic, Anti-Hypersensitive Anti-Alzheimer's & Parkinson's, Anti-Depressive, Anti-Epileptic Drug Discovery.

UNIT V: DRUG METABOLISM AND INTERACTIONS: 12 Hrs

Pharmacokinetics & Pharmacodynamics, Mode of Drug Administration, Drug-Drug Interactions, Drug-Food Interactions, Drug Metabolism, Toxicological Studies, Drug Safety, Modern Pharmaceutical & Analytical Techniques, Small Molecule Discovery in Academia, Intellectual Property Rights.

REFERENCES

1. Goodman& Gilman. The Pharmacological Basis of Therapeutics. Mc Graw Hill Ed.
2. Kalueff AV, et al. (20012) Experimental Animal Models in Neurobehavioral Research. Nova Science Publishers.
3. Kreitzer G, et al. Cell Biology Assays: Essential Methods. Elsevier.
4. Salmon DM. Practical Pharmacology for the Pharmaceutical Sciences. Wiley & Sons.

VIROLOGY

Year 3 | Semester V | BTYEC53 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Remember each virus family and its representative members	x				
CO 2	Apply concepts of virus structure to replication cycle	x	x			
CO 3	Predict replication strategy of viruses based on genome composition		x	x		
CO 4	Apply virology concepts to viral infectious disease control, prevention, and treatment				x	x
CO 5	Compare possibilities and limits of methods and techniques used in virology diagnosis and reference			x	x	

UNIT I: HISTORY: 12 Hrs

History, origin and evolution of viruses, pioneers of Virology. Nomenclature and classification of viruses: Criteria used for naming and classification, Current ICTV classification of viruses of bacteria, plants and animals and humans. Morphology and properties of viruses: Physical- morphology and structure, sedimentation, electrophoretic mobility, buoyant density; Biochemical- chemical composition, nucleic acids, proteins, enzymes, lipids, carbohydrates, polyamines, cations, virus stability; Biological- Host range, inclusion bodies and transmission. Transmission of viruses: Non-vector and vector mode of transmission of viruses.

UNIT II: *ISOLATION, CULTIVATION AND MAINTENANCE OF VIRUSES*: 12 Hrs

Isolation and cultivation of plant and animal viruses (experimental plants and tissue culture, experimental animals, embryonated eggs, organ cultures, primary and secondary cell cultures, suspension and monolayer cell cultures, cell strains, cell lines).Purification of viruses: Extraction of viruses from tissues, clarification, and concentration of viruses in clarified extracts by physical and chemical methods, further purification of viruses by rate zonal / equilibrium density gradient centrifugation, Criteria of virus purity, Quantitation and preservation of purified virus preparations.

UNIT III: ASSAY OF VIRUSES: 12 Hrs

Infectivity assay methods (plaque, pock, end point, local / systemic assay of plant viruses), physical (EM), serological (HA, HI, immunofluorescence, ELISA) and molecular (viral protein and nucleic acid based) approaches.

UNIT IV: MAJOR CHARACTERISTICS OF VIRUS FAMILIES: 12 Hrs

Adenoviridae, Bromoviridae, Bunyaviridae, Caulimoviridae, Flaviviridae, Geminiviridae, Hepadnaviridae, Herpesviridae, Orthomyxoviridae, Paramyxoviridae, Parvoviridae, Picornaviridae, Potyviridae, Poxviridae, Reoviridae, Retroviridae, Rhabdoviridae, Virgaviridae.

UNIT V: BACTERIOPHAGES: 12 Hrs

Biology of major RNA (MS2, Qβ) and DNA (T4, lambda, Øx174, M13) bacteriophages, replication of M13, T4 and lambda phages; biology of cyanophages. Algal and fungal viruses: Biology of viruses of Phycodnaviridae, Partitiviridae and Totiviridae. Biology of sub-viral agents: Satellite viruses, sat-RNAs, DI particles, viroids, virusoids and prions.

REFERENCES

1. Introduction to Modern Virology (2001). 5th ed. Dimmock et al., Blackwell Science Publishers.
2. Field's Virology, Fields BN, Knipe DM, Howley PM, ChanockRM, Melnick JL, Monath TP, Roizman B, Straus SE. (Eds.), (2007) 3rd Edition. Lippincott-Raven, Philadelphia, PA.
3. Principles of Virology (2000). SJ Flint et al., ASM Press.
4. Plant Virology (2001). 4th Edition, R. Hull. Academic Press.
5. Guide to Clinical and Diagnostic Virology (2019), (ASM Books) 1st Edition, ReetiKhare, ASM Press.

CLINICAL BIOCHEMISTRY

Year 3 | Semester VI | BTYEC61 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the basic concepts of clinical biochemistry	x				
CO 2	Demonstrate an understanding of the clinical importance of biomolecules	x	x	x		
CO 3	Able to distinguish various metabolic disorders	x	x	x		
CO 4	Formulate causes of pathway defects				x	x
CO 5	Utilize the skillsets required to extrapolate the mechanisms for human applications with appropriate experimental tools				x	x

UNIT I: BASIC CONCEPTS IN CLINICAL BIOCHEMISTRY: 12 Hrs

Role of Biochemistry in clinical diseases; Definition and scope of clinical biochemistry in diagnosis, collection and preservation of biological fluids (blood, urine & CSF), normal values of important constituents of blood, CSF and urine. Collection preparation, preservation, and handling of clinical samples, quality control, Safety measures in clinical laboratory.

UNIT II: CLINICAL IMPORTANCE OF BIOMOLECULES: 12 Hrs

Carbohydrates- Estimation of glucose, glycosurias, GTT's, hyper &hypoglycemia, blood glucose regulation and role of hormones; diabetic coma, Lipids- lipid profile estimation, hypercholesterolemia, atherosclerosis and its risk factors. Proteins -albumin, hypoalbuminemia, hypoproteinemia, Bence Jones proteins, proteins in CSF and their estimation.

UNIT III: DISORDERS OF METABOLISM: 12 Hrs

Basic concepts and diseases of metabolic disorders. Disorders of Carbohydrate metabolism- Diabetes Mellitus, Glycogen storage diseases; Disorders of amino acid metabolism- Albinism, Alkaptonuria, Maple-Syrup Urine Disease; Disorders of Lipid metabolism- Gaucher's disease and Tay-Sacch's disease; Disorders of Nucleic acid metabolism- Neimann Pick disease and ADA deficiency.

UNIT IV: PHYSIOLOGY AND DISORDERS OF BLOOD: 12 Hrs

Biochemistry of blood- Composition, blood group, Defects associated with blood; RBC formation and maturation, Iron metabolism (serum iron, iron binding capacity, transferrin and ferritin), Porphyrins; porphyrin and heme metabolism, regulation of heme biosynthesis, Blood disorders- Anemia and polycythemia. Blood coagulation; Platelet biochemistry; extrinsic, intrinsic, anticoagulants for clinical use and Blood coagulation tests.

UNIT V: ORGAN FUNCTION TESTS: 12 Hrs

Liver function test; kidney function test; pancreas function test; thyroid function test; cardiac function test.

REFERENCES

1. Marshall J. (2014) Clinical Biochemistry: Metabolic and Clinical Aspects. 3rd Edition. Publisher: Churchill Livingstone
2. Nelson DL & Cox MM. (2021) Lehninger Principles of Biochemistry. 8th Edition. Publisher: W H Freeman
3. Stryer L, Berg J, Tymoczko J &Gatto G. (2019) Biochemistry. 9th Edition. Publisher: WH Freeman
4. Voet D & Voet G. (2016) Fundamentals of Biochemistry. 5th Edition. Publisher: Wiley
5. Zubay G. (2000) Principles of Biochemistry. 5th Edition. Publisher: Medtech scientific international.

CELL SIGNALLING

Year 3 | Semester VI | BTYEC62 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the fundamental concepts of cell signaling, and mechanisms involved in cellular communication	x	x			
CO 2	Explore the key components of cell signalling cascades, and their roles in transmitting signals within cells		x	x		
CO 3	Analyze the diversity of cell signaling pathways in various cellular processes		x	x		
CO 4	Investigate the regulatory mechanisms and feedback loops that controlled cellular responses			x	x	

CO 5	Apply research and experimental techniques in cell signaling, and evaluate their implications in human health and disease				x	x

UNIT I: INTRODUCTION TO CELL SIGNALING: 12 Hrs

Overview of cell signaling principles and concepts, types of signaling molecules and their receptors, intracellular signaling pathways and their regulation, signal transduction mechanisms and cellular response. Signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing.

UNIT II: CELLULAR COMMUNICATION : 12 Hrs

General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation, regulation of haematopoiesis.

UNIT III: CELL SIGNALLING IN CANCER: 12 Hrs

Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth. Cell Cycle/Checkpoint and DNA Damage.

UNIT IV: SPECIFIC PATHWAYS OF CELL SIGNALING: 12 Hrs

Receptor Tyrosine kinase signaling (Ras-MAPK Signaling and PI3K/Akt Signaling),; Apoptosis/Autophagy, Ca, cAMP& Lipid Signaling, Jak/Stat Pathway, NF-κB Signaling, TGF-β/Smad Signaling, Tyrosine Kinase/Adaptors, Cytoskeletal Signaling, Wnt/Hedgehog/Notch, Nuclear Receptors.

UNIT V: EMERGING TOPICS IN CELL SIGNALING: 12 Hrs

Stem cell signalling, examination of signaling pathways governing stem cell self-renewal, differentiation, and tissue regeneration; Epigenetic regulation of signalling, study of epigenetic modifications, such as DNA methylation and histone modifications, and their impact on signaling pathway activity; Single-cell signaling analysis, introduction to advanced techniques for studying cell signaling at the single-cell level, including single-cell RNA sequencing and spatial transcriptomics; Therapeutic targeting of signaling pathways, analysis of strategies for modulating signaling pathways in disease treatment, including small molecule inhibitors and targeted therapies.

REFERENCES

1. GM. Cooper 2013. The Cell-A Molecular Approach, Sunderland (MA), Sinauer Associates, Inc. USA.
2. Gerald K., Cell and Molecular Biology, Concept and Experiment, 5th Edition, Wiley, 2007.
3. Lodish, H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., and Scott M.P. Molecular Cell Biology, 7th Edition, Freeman, W. H. and Co., 2013.
4. Alberts B., Walter P., Johnson A., Lewis J., Morgan D., and Raff. M., RobertsK., Walter P. Molecular Biology of the Cell, 6th Ed., Garland Publishing Inc., 2014.

PLANT FUNCTIONAL GENOMICS

Year 3 | Semester VI | BTYEC63 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Provide the comprehensive knowledge in the field of plant genomics that benefit in agricultural production, human health and nutrition	x	x			
CO 2	Identify the genes that regulates the specific function and mechanisms in plants	x	x			
CO 3	Genomic level assessment and its importance by correlating with their physiological processes in plants		x	x		
CO 4	Perform metabolic engineering by knowing the different functions of the genes involved in various biochemical pathways		x	x	x	
CO 5	Improve the genotype of the plants for better function of the genes and sustainable growth and development for metabolite production.				x	x

UNIT I: GENOME ORGANIZATION IN PLANTS: 12 Hrs

Genes from Nucleus, Chloroplast and Mitochondria – Endosymbiotic theory, C-Value paradox - Repetitive sequence, transposons in plant genome, chloroplast genome organization - Mitochondrial genome organization- Constructing of genomic libraries - *In silico* analysis of plant gene function.

UNIT II: PLANT GENE REGULATION: 12 Hrs

Transcription factors, epigenetic gene regulation, gene expression during plant development - Vegetative Growth and Organ Development- Physiological and Molecular aspects of growth and development - Genome analysis during *in vitro* responses &stress response - Gene over expression approaches – Transient expression - Transgenics -Targeted transgene expression - Co-expression analysis and Epigenetics.

UNIT III: PHYSIOLOGICAL AND MOLECULAR REGULATION BY LIGHT AND TEMPERATURE : 12 Hrs

Light control of plant development: Phytochromes and cryptochromes, phototropins - Chloroplast movement, Leaf Expansion, and Stomatal opening – Molecular mechanisms of light perception, signal transduction and gene regulation. Photoperiodism and its significance, vernalization and hormonal control. Thermo-morphogenesis- Thermo periodism. Circadian rhythms-biological clocks and their genetic and molecular determinants.

UNIT IV: GENOMICS OF PRIMARY AND SECONDARY METABOLITES: 12 Hrs

Introduction to various pathways - Biochemical pathways – Networks - Regulation in Primary metabolites - Carbohydrate, Protein Lipid and enzymes biosynthesis – Plant secondary metabolites and regulation in the pathway of Carotenoids, Alkaloids, Terpenoids, Flavonoids, Phenolics, and other therapeutic molecules -Value addition using pathway regulation. Engineering microbial pathways in plants.

UNIT V: CASE STUDIES OF GENES CONTROLLING PHYSIOLOGICAL PROCESS: 12 Hrs

Case studies specific to Genes and its function in various biochemical pathways - photosynthesis – respiration – photorespiration - fatty acid biosynthesis - Nutrient uptake – flowering - Seed germination -Senescence; Fruit ripening; Seed protein quality and quantity. Plant response to biotic and abiotic stress.

REFERENCES

1. Biochemistry and Molecular Biology of plants. (2015). Buchanan B, Gruissem W, Jones R (Eds). ASPP.
2. Plant Physiology and Development-6th edition (2015). Taiz , Zeiger E Ian M Møller, and Angus Murphy (Eds) published by Sinauer Associates
3. Plant Functional Genomics. 2003. E. Grotewold. Humana Press, Totowa
4. Alonso JM, Stepanova AN. (2015). Plant Functional Genomics: Methods and Protocols. Springer.

CANCER GENOMICS

Year 4 | Semester VII | BTYEC71 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understanding molecular mechanisms to solve the complexities involved in the apoptosis and cancer	x	x			
CO 2	Various facets of molecular procedures and genomics approaches that could be employed in early diagnosis and prognosis of human cancer	x	x			
CO 3	Able to identify genetic alteration in clinical samples		x	x		x
CO 4	Acquire knowledge on use of antibodies in cancer therapeutics		x	x		
CO 5	Gain laboratory skill in the molecular diagnosis of cancer				x	x

UNIT I: INTRODUCTION TO CANCER: 12 Hrs

Definition, Properties of a cancer cell, Normal cell versus Cancer cell, immortalization and transformation, cancer as a multifactorial and genetic disease, influential factors of carcinogenesis, brief overview of cancer treatment. Special emphasis on few important cancers which are prevalent in India- Breast cancer, Oral cancer, cervix cancer, prostate cancer, leukaemia, GBM.

UNIT II: GENOME INTEGRITY AND DEVELOPMENT OF CANCER: 12 Hrs

Mutations, DNA damaging agents, DNA repair and association of defective DNA repair pathways to development of cancer. Oncogenes and tumour suppressor genes: Definitions of proto-oncogenes, oncogenes and tumour suppressor genes. Characteristics of oncogenes and tumour suppressors. Gain of function and loss of function mutations. Knudson's two hit hypothesis, haploinsufficiency, LOH, Epigenetics and cancers, Role of promoter methylation and histone modifications in the development of cancer, glycosylation changes in cancer. p53, EGFR,

RB1, TGF, mTOR and Wnt pathways in cancer. Invasion and metastasis: Epithelial to mesenchymal transition. Circulating tumour cells. Molecular modulators of EMT.

UNIT III: APOPTOSIS AND CANCER : 12 Hrs

Programmed cell death, caspases, cell death receptor and apoptosis, pro and anti-apoptotic pathways and cell survival, autophagy in cancer biology, tumour viruses, Viruses and Cancer, Non-coding RNAs in cancer.

UNIT IV: MOLECULAR ONCOLOGY: 12 Hrs

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next generation sequencing of clinical isolates, Molecular profiling in cancer.

UNIT V: CANCER-RELATED BIOMARKERS: 12 Hrs

Predictive biomarkers for personalized oncotherapy of human diseases such as chronic myeloid leukaemia, colon, breast, lung cancer and melanoma, as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies, application of Nano-particles in in cancer therapy. Vaccine against cancer. Mechanism of action of few anti-cancer drugs such as Gleevec, gefitinib and imatinib. Brief overview on clinical trials. Gene therapy in cancer. Next generation sequencing and metabolomics approaches in cancer biomarker discovery.

REFERENCES

1. Molecular biology of cancer: Mechanisms, Targets and therapeutics. Pecorino L
2. The biology of cancer. Weinberg RA
3. Coleman W B, & Tsongalis GJ (2010). Molecular Diagnostics: for the Clinical Laboratorian. Humana Press

VACCINES

Year 4 | Semester VII | BTYEC72 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Exposed to current developments in different areas of vaccines	x	x			
CO 2	Develop fundamental concepts of human immune system and basic immunology	x	x			
CO 3	Differentiate and understand immune responses in relation to infection and vaccination		x	x		
CO 4	Able to understand requirement and designing of different types of vaccines			x	x	x
CO 5	Appreciate importance of conventional and new emerging vaccine technologies				x	x

UNIT I: FUNDAMENTALS OF IMMUNE SYSTEM: 12 Hrs

Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.

UNIT II: IMMUNE RESPONSE TO INFECTION: 12 Hrs

Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.

UNIT III: IMMUNE RESPONSE TO VACCINATION : 12 Hrs

Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.

UNIT IV: VACCINE TYPES & DESIGN: 12 Hrs

History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.

UNIT V: VACCINE TECHNOLOGIES: 12 Hrs

New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).

REFERENCES

1. Janeway CA, Travers P, Walport M, Shlomchik MJ (2005). Immuno Biology: the Immune System in Health and Disease. Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology. W.H. Freeman.
3. Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

NANOBIOTECHNOLOGY

Year 4 | Semester VII | BTYEC73 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Grasp the functional principles of nanobiotechnology	x	x			
CO 2	Apply knowledge to practical nanobiotechnological applications		x	x		
CO 3	Critically analyze methods and techniques in nanobiotechnology		x	x		x
CO 4	Design novel self-assembling nanostructures and nanodevices		x	x		x
CO 5	Develop essential skills for laboratory work and data analysis in nanobiotechnology				x	x

UNIT I: FUNCTIONAL PRINCIPLES OF NANOBIOTECHNOLOGY: 12 Hrs

Information-Driven Nanoassembly- Energetic- Chemical Transformation- Regulation- Traffic Across Membranes- Biomolecular Sensing- Self-Replication- Machine-Phase Nanobiotechnology.

UNIT II: SELF ASSEMBLING NANOSTRUCTURES: 12 Hrs

Self-Assembled Artificial Transmembrane Ion Channels-types, Methods, Self-Assembling Nanostructures from Coiled-Coil Peptides, Synthesis and Assembly using Bio-Derived Templates- Self-Assembling for Patterned Molecular Assembly.

UNIT III: PROTEIN AND PEPTIDE BASED NANOSTRUCTURES : 12 Hrs

S-layers-Chemistry and structure, Assembly, recrystalisation, diagnosis- Engineered Nanopores- Methods of production- Supported bilayers and membrane arrays- Genetic Approaches- Microbial nanoparticles production- Magnetosomes- Bacteriorhodopsins- Nanoproteomics.

UNIT IV: DNA BASED NANOSTRUCTURES: 12 Hrs

DNA-protein nanostructures-Methods- Self assembled DNA nanotubes—Nucleic acid Nanoparticles, DNA as a Biomolecular template-DNA branching-Metallization- Properties.

UNIT V: PHARMACEUTICALLY IMPORTANT NANOMATERIALS: 12 Hrs

Drug Nanoparticles- Structure and Preparation, Liposomes, Cubosomes and Hexosomes, Lipid based Nanoparticles-Liquid nanodispersions- Solid Lipid Nanoparticles (SLP) - Biofunctionalsiation of SLP, Charatcterisation- Nanoparticles for crossing biological membranes. Fundamentals- Physicochemical Principles of Nanosized Drug Delivery Systems-Nanotubes, Nanorods, Nanofibers, and Fullerenes for Nanoscale Drug Delivery, Carbon nanotubes biocompatibility and drug delivery.

REFERENCES

1. Claudio Nicolini, Nanobiotechnology & Nanobiosciences Pan Stanford Publishing Pte. Ltd, 2009.

2. CM Niemeyer & CA Mirkin, Nanobiotechnology, Concepts, Applications and perspectives, WILEY-VCH, 2004.
3. S. David Goodsell, Bionanotechnology, Lessons from Nature, Wiley-Liss, Inc, 2004.
4. deVilliers MM, Aramwit P, Kwon GS, Nanotechnology in Drug Delivery, Springer-American Association of Pharmaceutical Scientists Press 2009.

REGENERATIVE MEDICINE

Year 4 | Semester VIII | BTYEC81 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand basic concepts upon which various regenerative medicine techniques are developed	x	x			
CO 2	Various facets of procedures and approaches adapted in regenerative medicine	x	x	x		
CO 3	Able to identify suitable cell and tissue therapeutic methods for ailments		x	x		x
CO 4	Acquire knowledge on use of various regenerative therapeutics			x	x	x
CO 5	Gain technical skill require for regenerative medicine and therapeutics				x	x

UNIT I: BIOLOGIC AND MOLECULAR BASIS FOR REGENERATIVE MEDICINE: 12 Hrs

Molecular organisation of cells, Cell -extra- cellular matrix interactions in repair and regeneration, How cells change their phenotype, Somatic cloning and epigenetic reprogramming in mammals.

UNIT II: CELLS AND TISSUE DEVELOPMENT: 12 Hrs

Embryonic stem cells; derivation and properties, Induced pluripotent stem cells, Mesenchymal stem cells in regenerative medicine, Multipotent adult progenitor cells, Hematopoietic stem cell properties, markers, and therapeutics, Cardiac stem cells: biology and therapeutic applications, Skeletal muscle stem Cells, Stem cells derived from fat, Peripheral blood stem cells, Pancreatic stem cells, Determinants of tissue development, Angiogenesis, Morphogenesis of bone, Physical stress as a factor in tissue growth and remodeling, organoids.

UNIT III: INHERENT REGENERATIVE MECHANISMS : 12 Hrs

Blood regeneration, Wound healing and skin regeneration, Bone regeneration, Liver regeneration, Peripheral nerve regeneration, The multifactorial role of peripheral nervous system in bone growth.

UNIT IV: DECELLULARIZED SCAFFOLDS IN TISSUE REGENERATION: 12 Hrs

Decellularization of tissues and organs, Repopulation of decellularized scaffolds using stem cells, Decellularized scaffolds as a platform for regenerating tissues and organs.

UNIT V: THERAPEUTIC APPLICATIONS: 12 Hrs

Cell therapy for bone repair and regeneration, Cell therapy for articular cartilage regeneration, Cell therapy for heart diseases, Bone marrow transplantation, Myoblast transplantation in skeletal muscles, Islet transplantation, Stem cell derived secretome. Exosomes for regenerative medicine.

REFERENCES

1. Principles of Regenerative Medicine, Atala A, James RL, Nerem TR, 2nd Edition, Elsevier -2010
2. Essentials of Stem Cell Biology by Robert Lanza, Anthony Atala, and Deepak Srivastava
3. Stem Cell Biology and Regenerative Medicine by Rakesh Sharma
4. Regenerative Biology and Medicine edited by David L. Stocum
5. Decellularized Extracellular Matrix: Biology and Applications edited by Laura E. Niklason and David L. Kaplan
6. Exosomes: Biology, Therapeutic Potential, and Emerging Clinical Applications edited by Yusra Ahmad

EPIGENETICS

Year 4 | Semester VII | BTYEC82 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Enlighten the students about the epigenetic phenomena	x	x			
CO 2	Describe the role of epigenetic mechanisms in normal development and in diseases	x	x	x		
CO 3	Understand chromatin architecture and how gene expression is regulated	x	x			
CO 4	Evaluate functions of various types of epigenetic mechanisms			x		x
CO 5	Know the role of epigenetic modification plays in diseases			x	x	

UNIT I: INTRODUCTION: 12 Hrs

DNA transcription in eukaryotes; chromatin architecture; modifying chromatin structure; architectural proteins; polycomb repression; epigenetic inheritance; preservation of epigenetic marks during DNA replication.

UNIT II: DNA METHYLATION: 12 Hrs

DNA Methylation; Methylome; Demethylation; DNA Methylation Reprogramming; Intergenerational and Transgenerational Inheritance; Methylated CpG Islands; Functions of DNA Methylation; Epigenoprints; DNA Methylation as a Therapeutic Target.

UNIT III: HISTONE MODIFICATIONS : 12 Hrs

Post-translational modification of histone; histone modification machinery; Functions of histone modification; histone variants; histone modification as a Therapeutic Target.

UNIT IV: NONCODING RNAS: 12 Hrs

Noncoding RNAs – long and short; functions of Noncoding RNAs; Noncoding RNA, Epigenetics, and Diseases; Noncoding RNA–Based Therapies s.

UNIT V: EPIGENETIC CONTROL: 12 Hrs

Epigenetic control of cellular function – cell-specific gene expression, mitotic cell cycle, gene imprinting, cellular differentiation; epigenetic regulation and disease – disease predisposition and imprinting based disorders, cancer, neurodegeneration.

REFERENCES

1. L Armstrong L. (2014) Epigenetics. (1st Ed.). Taylor & Francis.
2. T O Tollefsbol (Ed.). (2016) Medical Epigeentics. Academic Press.
3. N Carey (2012) The Epigenetics Revolution: How Modern Biology is Rewriting Our Understanding of Genetics, Disease and Inheritance. Icon Books Ltd.

PATHOGENESIS OF INFECTIOUS DISEASES

Year 4 | Semester VII | BTYEC83 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the role of microorganisms in causing infectious diseases	x	x			
CO 2	Describe etiology, therapeutic and prevention measures against infectious diseases	x	x			
CO 3	Analyse the challenges & opportunities in preventing & controlling infectious diseases in diverse population settings		x	x		x
CO 4	Transfer knowledge of infectious diseases into decision-making through case studies				x	x
CO 5	Analyze & organize published literature on infectious diseases					x

UNIT I: INTRODUCTION TO INFECTIOUS DISEASES: 12 Hrs

Host-pathogen interactions, Molecular mechanisms of microbial pathogenesis, Immunization principles and vaccine use, Health advice for international travel, Microbial bioterrorism.

UNIT II: BACTERIAL PATHOGENESIS: 12 Hrs

Staphylococcal, streptococcal infections, diphtheria, listeriosis, tetanus, botulism, gas gangrene, pseudomembranous colitis, meningococcal & gonococcal infections, campylobacterioses, PUD, pseudomonas,

salmonella, shigella, cholera, brucellosis, anaerobic infections, tuberculosis, leprosy, syphilis, leptospirosis, mycoplasma & chlamydia.

UNIT III: VIRAL PATHOGENESIS: 12 Hrs

Poxviruses, herpes, parvovirus, HPV, influenza, coronaviruses, retroviruses, viral gastroenteritis, viral hepatitis, enteroviruses, reoviruses, MMR, rubella, mumps, rabies, ebola & marburg, prion diseases.

UNIT IV: PARASITIC AND FUNGAL PATHOGENESIS: 12 Hrs

Amebiasis & free-living amebae, toxoplasma, intestinal protozoa & trichomoniasis, trichinella, tissue & intestinal nematodes, schistosomiasis & trematodes, cestodes, dermatophytoses, histoplasmosis, blastomycosis, cryptococcosis, candidiasis, pneumocystosis, aspergillosis, mucormycosis, miscellaneous mycoses.

UNIT V: PATHOGENESIS OF VECTOR-BORNE INFECTIONS: 12 Hrs

Malaria, dengue, chikungunya, viral encephalitis, filariasis; visceral leishmaniasis, cutaneous leishmaniasis, plague, typhus fever; typhus fever; borrelioses, rickettsial, bartonellosis, Chagas disease, control & prevention.

REFERENCES

1. Anaissie EJ, McGinnis MR &Pfaller MA. (2009) Clinical Mycology. Elsevier, USA.
2. Bauman RW. (2009) Microbiology: Diseases by Body System. Benjamin Cummings, USA.
3. Brooks GF, et al. (2007) Jawetz, Melnick &Adelberg's Medical Microbiology. McGraw-Hill Professional.
4. Greenwood D, Slack R, Peutherer J & Barer M. (2007) Medical Microbiology. Churchill Livingstone.
5. Harvey RA, Champe PC & Fisher BD. (2007) Lippincott's Illustrated Reviews: Microbiology. Lippincott Williams & Wilkins, New Delhi/New York.

BIOSIMILAR

Year 5 | Semester IX | BTYEC91 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Introduce about the design and development of different kinds of biologics, biomimetics, and biosimilars and their applications	x	x			
CO 2	Apply knowledge on the regulatory framework about the biosimilars		x	x		
CO 3	Enlighten about various types of biologics and biosimilars	x	x	x		
CO 4	Understand the perspective of the complexity to establish biosimilars and biologics				x	x
CO 5	Develop essential skills for develop various biologics and biosimilars				x	x

UNIT I: INTRODUCTION TO BIOPHARMA: 12 Hrs

Generics in Biopharma, definition of biologics, biosimilars, super biologics, differences between chemical genetics and biosimilars, The developmental and regulatory challenges in biosimilar development, Prerequisites for Biosimilar development, Biosimilar market potential.

UNIT II: TYPES OF BIOSIMILAR DRUGS: 12 Hrs

Peptides, proteins, antibodies, Enzymes, Vaccines, Nucleic acid based therapies (DNA, RNA, etc), Cell based therapies (including stem cells).

UNIT III: CHARACTERIZATION METHODS: 12 Hrs

Aggregation- precipitation, floccule strength, precipitate ageing & kinetics, adsorption of proteins & peptides on surfaces, effect of temperature on protein structure, hydration & thermal stability of proteins - solid powders, suspension on non-aqueous solvents, reversed micelles, aqueous solution of polyols, analytical and spectrophotometric characterization of proteins, protein sequencing and structure determination.

UNIT IV: BIOEQUIVALENCE STUDIES: 12 Hrs

Immunogenicity & allergenicity of biosimilars; factors affecting immunogenicity - structural, post-translational modifications, formulations, impurities, manufacturing and formulation methods for biosimilars; types of bioequivalence (average, population, individual), experimental designs & statistical considerations for bioequivalence studies (Non-replicated designs – General Linear Model, Replicated crossover designs), introduction to "ORANGE BOOK" & "PURPLE BOOK".

UNIT V: CASE STUDIES: 12 Hrs

Indian companies working in this space & their product pipeline (Biocon, Intas, Dr Reddy's, Reliance, Bharat Biotech, Lupin, Cipla, Shanta, etc); products - Erythropoietin, growth hormone, granulocyte stimulating factors, interferons, streptokinase, monoclonal antibodies.

REFERENCES

1. Laszlo Endrenyi, Paul Declerck and Shein-Chung Chow, Biosimilar Drug Development, Drugs and Pharmaceutical Sciences, Vol 216, CRC Press.
2. Cheng Liu and K. John Morrow Jr., Biosimilars of Monoclonal Antibodies: A Practical Guide to Manufacturing, Preclinical and Clinical Development, Wiley, 2016.
3. https://www.drugs.com/medical-answers/many-biosimilars-approved-unitedstates-3463281/

BIOLOGICAL IMAGING

Year 5 | Semester IX | BTYEC92 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand various imaging techniques used in biomedical science	x				
CO 2	Able to compare and analyse advantages and disadvantages of various imaging techniques	x	x	x		
CO 3	Learn to increase their resolution to improve qualitative and quantitative improvement in their performance		x	x		
CO 4	Enlighten the perspectives and complexities of imaging techniques used in biomedical research		x	x		
CO 5	Gain knowledge and skill on various imaging techniques for biomedical applications				x	x

UNIT I: WIDEFIELD FLUORESCENT MICROSCOPY: 12 Hrs

One of the most basic techniques for live-cell imaging is widefield fluorescent microscopy. Standard inverted research grade microscopes can yield valuable results if you are imaging adherent cells, large regions of interest (such as organelles) or very thin tissue sections (less than 5 micrometer). In widefield, a CCD camera is usually used to capture images and the epi-fluorescence illumination source can be a mercury lamp, xenon lamp, LED's, etc. Each of light sources require carefully matched interference filters for specific excitation and emission wavelengths of your fluorophore of interest. With widefield microscopy, your specimen is only exposed to excitation light for relatively short time periods as the full aperture of emission light is collected by the objectives. Widefield fluorescence microscopy can be used in combination with other common contrast techniques such as phase contrast and differential interference contract (DIC) microscopy. This combination is useful when performing live-cell imaging to examine general cell morphology or viability while also imaging regions of interest within cells.

UNIT II: CONFOCAL LASER SCANNING MICROSCOPY (CLSM): 12 Hrs

CLSM has ability to eliminate out-of-focus light and information. It is also possible to obtain optical serial sections from thicker specimens. A conjugate pinhole in optical path of confocal microscope prevents fluorescence from outside of focal plane from being collected by photomultiplier detector or imaged by camera. In CLSM, a single pinhole (and single focused laser spot) is scanned across specimen by scanning system. This spot forms a reflected epi-fluorescence image back on original pinhole. When specimen is in focus, fluorescent light from it passes through pinhole to detector. Any out-of-focus light is defocused at pinhole and very little of this signal passes through to detector meaning that background fluorescence is greatly reduced. The pinhole acts as a spatial filter for emission light from the specimen.

UNIT III: SPINNING DISC CONFOCAL MICROSCOPY (SDCM): 12 Hrs

This method utilises a 'Nipkow Disc' which is a mechanical opaque disc which has a series of thousands of drilled or etched pinholes arranged in a spiral pattern. Each illuminated pinhole on disc is imaged by microscope objective to a diffraction-limited spot on region of interest on specimen. The emission from fluorophores passes back though Nipkow disc pinholes and can be observed and captured by a CCD camera. The effect of spinning disc is that many thousands of points on specimen are simultaneously illuminated. Using SDCM to examine a specimen

means that real-time imaging (30-frames-per-second or faster) can be achieved, which is extremely useful if you are looking at dynamic changes within living cells over a wide spectrum of time-scales.

UNIT IV: LIGHT-SHEET FLUORESCENCE MICROSCOPY (LSFM, OR SPIM): 12 Hrs

This method enables one to perform live-cell imaging on whole embryos, tissues and cell spheroids in vivo in a gentle manner with high temporal resolution and in three dimensions. One is able to track cell movement over extended periods of time and follow development of organs and tissues on a cellular level. The next evolution of light-sheet fluorescence microscopy, termed lattice light-sheet microscopy as developed by Eric Betzig (Nobel Prize Laureate 2014 for PALM super-resolution microscopy) will even allow live-cell imaging with super-resolved in vivo cellular localization capabilities.

UNIT V: SUPER-RESOLVED FLUORESCENCE MICROSCOPY: 12 Hrs

Super-Resolution in a Standard Microscope: From Fast Fluorescence Imaging to Molecular Diffusion Laws in Live Cells; Photoswitching Fluorophores in Super- Resolution Fluorescence Microscopy; Image Analysis for Single-Molecule Localization Microscopy Deconvolution of Nanoscopic Images; Super-Resolution Fluorescence Microscopy of the Nanoscale Organization in cells; Correlative Live-Cell and Super- Resolution Microscopy and Its Biological Applications; SAX Microscopy and Its Application to Imaging of 3D-Cultured Cells; Quantitative Super-Resolution Microscopy for Cancer Biology and Medicine.
Structured Illumination Microscopy; Correlative Nanoscopy: AFM Super-Resolution (STED/STORM) ; Stochastic Optical Fluctuation Imaging.

REFERENCES

1. Rajagopal Vadivambal, Digvir S. Jayas. (2015). Bio-Imaging: Principles, Techniques, and Applications. ISBN 9781466593671 - CAT# K20618.
2. Diaspro A, Marc AMJ. van Zandvoort. (2016). Super-Resolution Imaging in Biomedicine. ISBN 9781482244342 - CAT# K23483.
3. Taatjes, Douglas, Roth, Jürgen (Eds.). (2012). Cell Imaging Techniques Methods and Protocols. ISBN 978-1-62703-056-4.

PREBIOTICS AND PROBIOTICS

Year 5 | Semester IX | BTYEC93 | Credits 4

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Basic understanding of prebiotics, and probiotics	x	x			
CO 2	Biomedical application of prebiotics and probiotics		x	x		
CO 3	Probiotic characterization of culturable bacteria isolated from fermented food		x	x		
CO 4	Genetic modification of probiotic organisms and their use and adverse effect				x	x
CO 5	Fermentation technology for large scale production of probiotics			x	x	

UNIT I: INTRODUCTION, HISTORY, THE SCOPE OF PROBIOTICS: 12 Hrs

Probiotics and Feed Biotechnology, normal micro flora of GI tract; Introduction to feed processing and preservation, microbial bioconversion of lignin and cellulose rich feeds, factors affecting delignification; Role of microbes in rumen fermentation in ruminant animals; Methane gas production manipulation by biotechnology tools.

UNIT II: METHODS FOR ANALYSIS: 12 Hrs

Methods for analysis of intestinal micro flora, microorganisms and proteins used in probiotics, Mechanism of action of prebiotics and probiotics, immune response to probiotics, anti-mutagenic and anti-tumour activities of lactic acid bacteria, probiotics and immune system, lactic acid bacteria as live vaccines; Genetic modification of intestinal lactobacilli and bifidobacteria, recombinant probiotics; Genetic manipulation of organisms to enhance bioconversion ability, manipulation of rumen fermentation by selective removal of protozoa and fungi.

UNIT III: DIVERSITY OF ORGANISMS: 12 Hrs

Diversity of organisms involved, fermentation techniques, large scale bioconversion of substrates, pretreatment of feeds, chemicals, microbial treatment of feeds, anti-nutritional factors present in feeds, microbial detoxification of aflatoxins, mimosine and other anti-metabolites present. Role of probiotics and prebiotics in inducing gut immunity.

UNIT IV: APPLICATION OF PROBIOTICS: 12 Hrs

Application of probiotics for humans, farm animals and poultry, probiotics and intestinal infections, lactose intolerance, probiotics regulatory issues; Symbiotics, traditional probiotic products, probiotics-industrial perspective, contradictions, precautions and adverse reactions; Effect of feed additives like antibiotics, methane inhibitors, genetic manipulation of rumen micro flora to improve feed utilization, single cell protein as animal feed. Health hazards due to residual pesticides in feeds.

UNIT V: DIVERSITY OF ORGANISMS: 12 Hrs

Diversity of organisms involved, fermentation techniques, large scale bioconversion of substrates, pretreatment of feeds, chemicals, microbial treatment of feeds, anti-nutritional factors present in feeds, microbial detoxification of aflatoxins, mimosine and other anti-metabolites present. Role of probiotics and prebiotics in inducing gut immunity.

REFERENCES

1. Ana Paula do Carmo and Koen Venema Eds. (2015). Probiotics and Prebiotics: Current Research and Future Trends, Caister Academic Press.
2. Asa Ljungh and T. Wadstrom, Eds. (2009). Lactobacillus Molecular Biology: from Genomics to Probiotics, Caister Academic Press
3. Gerald W. Tannock, Caister, (2005). Probiotics and Prebiotics: Scientific Aspects Ed. Academic Press.
4. Huffnagle GB and Wernick S (2007). The Probiotics Revolution: the Definitive Guide to Safe, Natural Health, Bantam Books.
5. Perdigon G and Fuller R. (2000). Probiotics: Immunomodulation by the Gut Microflora and Probiotics, Springer.

RECOMMENDED OPEN ELECTIVE COURSES

INTRODUCTORY BIOTECHNOLOGY

Odd Semester | BTYOE01 | Credits 3

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Understand the concepts and application of different fields of biotechnology	x				
CO 2	Evaluate the importance of different fields of biotechnology		x	x		
CO 3	Analyze the basic concepts and applications of biotechnology			x		x
CO 4	Improve the description of biotechnology				x	x
CO 5	Able to develop novel concepts in biotechnology for society				x	x

UNIT I: INTRODUCTION TO BIOTECHNOLOGY: 9 Hrs

Scope & Importance of Biotechnology. Branches of Biotechnology, Present Status of Biotechnology in India and their research Disciplines. Branches of Biotechnology: Red Biotech, White/Grey Biotech, Green Biotech, Blue Biotech.

UNIT II: GENETIC ENGINEERING AND RECOMBINANT DNA TECHNOLOGY: 10 Hrs

History of Genetic Material, DNA as the genetic material, DNA Modifying Enzymes, DNA Replication in Prokaryotes & Eukaryotes, Polymerase Chain Reaction, Generalized cloning schemes and strategies, Genetic Engineering and Applications.

UNIT III: INDUSTRIAL BIOTECHNOLOGY: 10 Hrs

Production of useful compounds: ethanol, & lactic acid. Production of antibiotics: Penicillin & Streptomycin. Production of enzymes: α-amylase & proteases. Single cell proteins (SCP) from bacteria, yeast, fungi and algae for human feed and animals feed (as supplements). Biofuel & Bioenergy.

UNIT IV: PLANT& ANIMAL BIOTECHNOLOGY: 10 Hrs

Plant Tissue Culture & applications. Applications of Plant Genetic Engineering – crop improvement, herbicide resistance, insect resistance, virus resistance. Genetic modification in Agriculture – transgenic plants, genetically modified foods, application.

Animal Tissue Culture & applications. Animal Cloning and Transgenic animals. Stem cell technology and gene therapy. Biotherapy for viral diseases, bacterial diseases, and cancer. Vaccines.

UNIT V: ENVIRONMENTAL BIOTECHNOLOGY: 10 Hrs

Bioremediation and Biodegradation. Aerobic and Anaerobic degradation. Biohydrogen and biomethane, Biopesticides & Biofertilizers. Microbes in the treatment of Water and Wastewater. Environmental Safety,

REFERENCES

1. Crueger W & Crueger A. (2000). Biotechnology: A Textbook of Industrial Microbiology. 2nd Ed. Panima Pub. Co.
2. Griffiths AJF, JH Miller, Suzuki DT, Lewontin RC & Gelbart WM (2009). An introduction to genetic analysis. IX Edition. Freeman & Co.
3. Slater A, Scott NW & Fowler MR (2008) Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.
4. Jordening HJ and Winter J. (2004). Environmental Biotechnology –Concepts and Applications, 1st Edition.

ECONOMIC BIOLOGY

Even Semester | BTYOE02 | Credits 3

COURSE OUTCOME		PO1	PO2	PO3	PO4	PO5
CO 1	Explain the basics of plants and animals and their products	x				
CO 2	Identify the economically important biological organisms	x	x	x		
CO 3	Understand and compare the economically important plants and animals		x	x		
CO 4	Underline the applications of biotechnology in economically important plants and animals			x		x
CO 5	Explore the possible novel products from plants and animals		x	x	x	

UNIT I: INTRODUCTION TO ECONOMIC BIOLOGY: 9 Hrs

An overview of the economic importance of animals of various phyla and plants from various families. Introduction to aquaculture (prawn culture, pearl culture, and pisciculture). Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

UNIT II: BIOLOGY AND REARING OF SILKWORM: 9 Hrs

Life Cycle of Bombyx mori, Structure of Silk Gland & Secretion of Silk, Selection of Mulberry Variety & Establishment of Mulberry Garden, Rearing House & Rearing Appliances; Disinfectants: Formalin, Bleaching Powder, RKO, Silkworm Rearing Technology: Early Age & Late Age Rearing; Types of Mountages, Spinning, Harvesting & Storage of Cocoons.

UNIT III: APICULTURE: BIOLOGY AND REARING OF BEES: 9 Hrs

History, Classification & Biology of Honey Bees Social Organization of Bee Colony, Artificial Bee Rearing (Apiary), Beehives – Newton & Langstroth; Bee Pasturage, Selection of Bee Species for Apiculture; Bee Keeping Equipment; Methods of Extraction of Honey (Indigenous & Modern).

UNIT IV: CEREALS: 9 Hrs

Brief account of wheat, rice and millets. Legumes: General account, importance to man and ecosystem. Sugars & Starches: Morphology and processing of sugarcane, products and byproducts of sugarcane industry. Potato – morphology, propagation & uses. Oils & Fats: General description, classification, extraction, their uses and health implications Groundnut, coconut, linseed and Brassica (Botanical name, family & uses).

UNIT V: SPICES: 9 Hrs

Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper Beverages: Tea, Coffee (morphology, processing & uses) Tobacco: Tobacco (Morphology, processing, uses and health hazards) Drug-yielding plants: Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis.

REFERENCES

1. Kotpal RL (2019), Modern Text Book of Zoology (Invertebrate and Vertebrates), Rastogi Publications.
2. Aminul Islam (2020). A Textbook of Economic Zoology.
3. Simpson BB & Ogorzaly MC. (2001) Economic Botany: Plants in Our World. McGraw-Hill.
4. Kingsolver B. (2007) Animal, Vegetable, Miracle: A Year of Food Life. HarperCollins, New York, NY, USA.
5. Kochhar SL. (2011) Economic Botany in the Tropics. MacMillan Publishers India Ltd., New Delhi