THE ASSAM
ROYAL GLOBAL UNIVERSITY
GUWAHATI

Guidelines for framing
Curriculum and Credit Framework
for
Postgraduate Programmes in Biotechnology

W.E.F

AY-2025-26

(Based on National Education Policy 2020)

1. Introduction:

India is one of the fastest-growing economies globally, with knowledge creation and research playing a pivotal role in sustaining this momentum. As the nation aspires to establish itself as a leading knowledge society and one of the largest economies, there is an urgent need to expand research capabilities and outputs across disciplines.

At Royal Global University, we align ourselves with this national vision by fostering a robust ecosystem of research and innovation, nurturing a vast talent pool that is critical for achieving these ambitious goals.

The National Education Policy (NEP) 2020 emphasizes the transformation of higher education to support India's transition to a knowledge-driven economy. Key initiatives such as multidisciplinary education with multiple entry and exit options, undergraduate research opportunities, and a learning outcomes-based curriculum are at the fore front of this transformation.

The postgraduate (PG) programmes at Royal Global University are designed to advance students' expertise in their chosen fields and equip them for higher research pursuits. These programmes provide the advanced knowledge and specialized skills necessary for students to evolve from learners to innovators, contributing meaningfully to the nation's knowledge economy.

In line with NEP 2020, Royal Global University offers restructured degree programmes to provide flexible and holistic education. The policy envisions undergraduate programmes with various certification options, including:

- AUG certificate after completing 1 year of study,
- AUG diploma after 2 years,
- A Bachelor's degree after a 3-year programme, or
- A preferred 4-year multidisciplinary Bachelor's degree, offering students the opportunity to explore holistic and multidisciplinary education alongside their chosen major and minors.

Similarly, postgraduate programmes at Royal Global University are designed with flexibility to cater to diverse academic and professional aspirations, fostering a new generation of knowledge creators who will shape India's future as a global leader.

Royal Global University remains committed to empowering students and creating an educational environment that embodies the principles of NEP 2020, driving innovation and excellence in higher education.

2. Recommendations of NEP 2020 Pertinent to Postgraduate Education

- A **2-year PG programme** may be offered, with the second year exclusively dedicated to research for students who have completed a 3-year Bachelor's programme.
- For students who have completed a **4-year Bachelor's programme with Honours or Honours with Research**, a **1-year PG programme** could be introduced.
- An **integrated 5-year Bachelor's/Master's programme** may also be offered.
- Universities are encouraged to provide PG programmes in core areas such as **Machine Learning**, multidisciplinary fields like **AI+X**, and professional domains such as **healthcare**, **agriculture**, and **law**.
- A **National Higher Education Qualifications Framework (NHEQF)** will define higher education qualifications in terms of learning out comes. The PG programme levels will correspond to **Levels 6, 6.5, and 7** under the NHEQF.
- The PG framework must align with the **National Credit Framework (NCrF)** to facilitate the creditization of learning, including the assignment, accumulation, storage, transfer, and redemption of credits, subject to appropriate assessment.

3. Key Features of the Postgraduate Curriculum Framework

- **Interdisciplinary Flexibility**: Students can transition between different disciplines of study.
- **Choice of Specialization**: Students with a UG qualification, including a major and minor(s), have the flexibility to pursue their PG programme in their major, minor(s), or any other subject, provided they demonstrate the required competence.
- **Learner-Centric Options**: Opportunities are provided for students to select courses aligned with their interests.
- **Diverse Learning Modes**: Flexibility to adopt alternative learning methods, including offline, Open and Distance Learning (ODL), online, and hybrid modes.
- **Mobility and Credit Flexibility**: In line with the UGC (Establishment and Operation of Academic Bank of Credits in Higher Education) Regulations, 2021, and the UGC Guidelines for Multiple Entry and Exit in Academic Programmes, students benefit from greater academic mobility. These frameworks support the implementation of the proposed **"Curriculum and Credit Framework for Postgraduate Programmes"**.

4. Credit Requirements and Eligibility Criteria for PG Programmes

- A 1-year (2-semester) PG programme at level 6.5 on the NHEQF requires a Bachelor's degree with Honours or Honours with Research and a minimum of 160 credits.
- A2-year (4-semester) PG programme at level 6.5 on the NHEQ Frequires a 3-year (6-semester) Bachelor's degree with a minimum of 120 credits.
- For professional PG programmes such as M.E., M.Tech., etc., a 2-year (4-semester) PG programme at level 7 of the NHEQF requires a 4-year Bachelor's degree (e.g., B.E., B.Tech.) with a minimum of 160 credits.
- A student is eligible for a PG programme in a discipline corresponding to either their major or minor(s) from their UG programme. Admission may be granted based on performance in the UG programme.
- Regardless of the major or minor disciplines pursued during UG, a student can seek admission to any discipline of a PG programme if they qualify through a National level entrance examination in the relevant discipline.

5. Generic Learning Outcomes at the Postgraduate Level

Under the **National Higher Education Qualifications Framework (NHEQF)**, higher education qualifications are classified across levels ranging from **Level 4.5 to Level 8**. These levels represent sequential stages of learning, defined through a set of learning outcomes that outline what learners are expected to **know, understand, and demonstrate** upon successfully completing a programme of study at a specific level.

Learning outcomes are articulated as measurable graduate attributes, which students must achieve and demonstrate upon completing their programme. For postgraduate studies, these outcomes ensure students are equipped with advanced knowledge, skills, and competencies essential for their academic and professional growth.

- **NHEQF Level 4.5** corresponds to the learning outcomes expected in the first year (first two semesters) of an undergraduate programme.
- **NHEQF Level 8** corresponds to the outcomes appropriate for a doctoral-level programme.

Post graduate programmes fall between **Level 6.5 and Level 7**, as outlined in the NHEQF. The framework ensures that PG students acquire both depth in their subject knowledge and the ability to apply their learning to complex, real-world challenges.

For a comprehensive understanding of the detailed learning outcomes for PG programmes, refer to the **National Higher Education Qualifications Framework (NHEQF).**

Graduate Attributes & Learning outcomes descriptors for a higher education qualification at level 6.5 on the NHEQF

Qualifications that signify completion of the postgraduate degree are awarded to students who: **GA1:** have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within research context.

GA2: can apply their knowledge and understanding, and problem-solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.

GA3: have the ability to integrate knowledge and handle complexity, and formulate judgments with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments.

GA4: can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously.

GA5: have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous.

The PG degree (e.g. M.A., M.Com., M.Sc., etc.) will be awarded to students who have demonstrated the achievement of the outcomes located at level 6.5 on the NHEQF. Refer Table 5.1.1

Table5.1.1

Element of the descriptor	**NHEQF level descriptors** *The graduates should be able to demonstrate the acquisition of:*
Knowledge and understanding	• advanced knowledge about a specialized field of enquiry with a critical understanding of the emerging developments and issues relating to one or more fields of learning, • advanced knowledge and understanding of the research principles, methods, and techniques applicable to the chosen field(s) of learning or professional practice, • procedural knowledge required for performing and accomplishing complex and specialized and professional tasks relating to teaching, and research and development.
General, technical and professional skills required to perform and accomplish tasks	• advanced cognitive and technical skills required for performing and accomplishing complex tasks related to the chosen fields of learning.

Element of the descriptor	NHEQF level descriptors *The graduates should be able to demonstrate the acquisition of:*
	• advanced cognitive and technical skills required for evaluating research findings and designing and conducting relevant research that contributes to the generation of new knowledge. • Specialized cognitive and technical skills relating to a body of knowledge and practice to analyse and synthesize complex information and problems.
Application of knowledge and skills	• apply the acquired advanced theoretical and/or technical knowledge about a specialized field of enquiry or professional practice and arrange of cognitive and practical skills to identify and analyse problems and issues, including real-life problems, associated with the chosen fields of learning. • apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems.
Generic learning outcomes	**Effective Communication and Presentation** • Listen attentively, analyze texts and research papers, and present complex information clearly to diverse audiences. • Communicate technical information, research findings, and explanations in a structured manner. • Concisely discuss the relevance and applications of research findings in the context of emerging developments and issues. **Critical Thinking and Analytical Skills** • Evaluate evidence reliability, identify logical flaws, and synthesize data from multiple sources to draw valid conclusions. • Support arguments with evidence, address opposing viewpoints, and critique the reasoning of others. **Self-Directed Learning and Professional Development** • Address personal learning needs in chosen fields of study, work, or professional practice. • Pursue self-paced learning to enhance knowledge and skills, particularly for advanced education and research. **Research Design and Methodology**

Element of the descriptor	NHEQF level descriptors *The graduate should be able to demonstrate the acquisition of:*
	• Define and articulate research problems, formulate hypotheses, and design relevant research questions. • Develop appropriate tools and techniques for data collection and analysis. • Use statistical and analytical methods to interpret data and establish cause-and-effect relationships. **Research Execution and Ethics** • Plan, conduct, and report investigations while adhering to ethical standards in research and practice. • Apply research ethics rigorously in field work and personal research activities. **Problem-Solving and Decision-Making** • Make informed judgments and decisions based on empirical evidence and analysis to solve real-world problems. • Take responsibility for individual and group actions in generating solutions within specific fields of study or professional practice.
Constitutional, humanistic, ethical, and moral values	• Embrace and practice constitutional, humanistic, ethical, and moral values in one's life, • Adopt objective and unbiased actions in all aspects of work related to the chosen fields/subfields of study and professional practice, • participate in actions to address environmental protection and sustainable development issues, • support relevant ethical and moral issues by formulating and presenting coherent arguments, • follow ethical principles and practices in all aspects of research and development, including inducements for enrolling participants, avoiding unethical practices such as fabrication, falsification or misrepresentation of data or committing plagiarism.
Employability & job-ready skills, entrepreneurship skills and capabilities/qualities and mindset	• adapting to the future of work and responding to the demands of the fast pace of technological developments and innovations that drive the shift in employers' demands for skills, particularly with respect to the transition towards more technology-assisted work

Element of the descriptor	NHEQF level descriptors *The graduates should be able to demonstrate the acquisition of:*
	involving the creation of new forms of work and rapidly changing work and production processes. • exercising full personal responsibility for the output of own work as well as for group/team outputs and for managing work that is complex and unpredictable requiring new strategic approaches.

Note: Schools/Departments are instructed to form their Programme Outcomes based on the Graduate attributes. Table 5.1.1 is given as reference outline to frame the Programme Level Outcomes.

Learning outcomes descriptors for a higher education qualification at level 7 on the NHEQF

The PG degree (e.g. M.E./M.Tech. etc.) is awarded to students who have demonstrated the achievement of the outcomes located at level 7 on the NHEQF. Table 5.1.2 are the descriptors for qualifications at levels 7 on the NHEQF.

Table5.1.2

Element of the descriptor	NHEQF level descriptors *The graduates should be able to demonstrate the acquisition of:*
Knowledgeand understanding	• advanced knowledge about a specialized field of enquiry with a critical understanding of the emerging developments and issues relating to one or more fields of learning, • advanced knowledge and understanding of the research principles, methods, and techniques applicable to the chosen field(s) of learning or professional practice, • procedural knowledge required for performing and accomplishing complex and specialized and professional tasks relating to teaching, and research and development.
General, technical and professional skills required to perform and accomplish tasks	• advanced cognitive and technical skills required for performing and accomplishing complex tasks related to the chosen fields of learning. • advanced cognitive and technical skills required for evaluating research findings and designing and conducting relevant research that contributes to the generation of new knowledge. • specialized cognitive and technical skills relating to a body of knowledge and practice to analyse and synthesize complex information and problems.

Element of the descriptor	NHEQF level descriptors *The graduates should be able to demonstrate the acquisition of:*
Application of knowledge and skills	• apply the acquired advanced theoretical and/or technical knowledge about a specialized field of enquiry or professional practice and arrange of cognitive and practical skills to identify and analyse problems and issues, including real-life problems, associated with the chosen fields of learning. • Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems.
Generic learning outcomes	**Effective Communication and Presentation** • Analyse texts and research papers critically and present complex information clearly and concisely to diverse audiences. • Communicate technical information, research findings, and their applications in a structured and concise manner, considering emerging developments and issues. **Critical Thinking and Analytical Skills** • Evaluate there liability and relevance of evidence, identify flaws in arguments, and synthesize data from multiple sources. • Draw valid conclusions supported by evidence while addressing opposing viewpoints. **Research Design and Execution** • Define problems, formulate research questions and hypotheses, and use quantitative and qualitative data to test and establish hypotheses. • Develop appropriate tools for data collection and apply statistical and analytical techniques for data interpretation. • Plan, execute, and report research findings while adhering to ethical standards. **Self-Directed Learning and Professional Growth** • Meet personal learning needs in chosen fields of study or practice through self-paced and self-directed learning. • Upgrade knowledge and research-related skills to pursue advanced education and contribute to professional practice. **Problem-Solving and Decision-Making**

Element of the descriptor	NHEQF level descriptors *The graduates should be able to demonstrate the acquisition of:*
	• Generate solutions to real-world problems through informed judgments and decision-making based on analysis and empirical evidence. • Take responsibility and accountability for individual and group actions in addressing challenges within the chosen field or profession. **Application and Synthesis** • Synthesize and articulate issues, design research proposals, and explore the relevance and implications of findings in professional and academic contexts. • Predict cause-and-effect relationships and make strategic decisions to address challenges in a multidisciplinary environment.
Constitutional, humanistic, ethical, and moral values	• Embrace and practice constitutional, humanistic, ethical, and moral values in one's life, • adopt objective and unbiased actions in all aspects of work related to the chosen fields/subfields of study and professional practice, • participate in actions to address environmental protection and sustainable development issues, • support relevant ethical and moral issues by formulating and presenting coherent arguments, • follow ethical principles and practices in all aspects of research and development, including inducements for enrolling participants, avoiding unethical practices such as fabrication, falsification or misrepresentation of data or committing plagiarism.
Employability & job-ready skills, entrepreneurship skills and capabilities/qualities and mindset	• adapting to the future of work and responding to the demands of the fast pace of technological developments and innovations that drive shift in employers' demands for skills, particularly with respect to the transition towards more technology-assisted work involving the creation of new forms of work and rapidly changing work and production processes. • Exercising full personal responsibility for the output of own work as well as for group/team outputs and form an aging work that are complex and unpredictable requiring new strategic approaches.

Element of the descriptor	NHEQF level descriptors *The graduates should be able to demonstrate the acquisition of:*

Note: Schools/Departments are instructed to form their Programme Outcomes based on the Graduate attributes. Table 5.1.2 is given as reference outline to frame the Programme Level Outcomes.

The levels of PG programmes as per the NHEQF are summarized in Table 5.1.3

Level	Credits	Qualification	Credit Requirement Per year	Credit Points	Total Notional Learning hours
6	160	1– yr P.G. Diploma	40	240	1200
6.5	160	1-Year PG after a 4-yearUG	40	260	1200
6.5	120	2-Year PG after a 3-yearUG	40	260	1200
7	160	2-Year PG after a 4-yearUG such as B.E., B.Tech. etc	40	280	1200

6. Curricular Components

2-year PG: Students entering 2-year PG after a 3-year UG programme can choose to do:

- Only coursework in the third and fourth semester or
- Coursework in the third semester and research in the fourth semester or
- Only research in the third and fourth semester.

1-Year PG: Students entering1-year PG after a 4-year UG programme can choose to do

- only coursework or
- research or
- coursework and research.

5-year Integrated Programme (UG+PG): At the PG level, the curricular component of 5-year integrated programme will be similar to that of 2-year PG mentioned above.

Programmes designed to enhance students' analytical abilities for optimal problem-solving typically focus on advanced skills and real-world experience, with a reduced emphasis on research components. These programmes should feature a curriculum distinct from other academic offerings, tailored to meet their specific objectives.

7. Credit Distribution

For1-yearPG

Table: 7.1.1

Curricular Components	PG Programme (one year) for 4-yr UG (Hons./Hons. With Research) Minimum Credits			
	Course Level	Coursework	Research thesis/project/Patent	Total Credits
Coursework+ Research	500	20	20	40
Coursework	500	40	-	40
Research			40	40

For 2-year PG

Table: 7.1.2

Curricular Components		PG Programme (one year) for 4-yrUG (Hons./Hons. with Research) Minimum Credits			
		Course Level	Coursework	Research thesis/project /Patent	Total Credits
PG Diploma		400	40	--	40
1st Year (1st & 2nd Semester)		400 500	24 16	--	40
Students who exit at the end of 1st year shall be awarded a Post graduate Diploma					
2nd Year (3rd & 4th Semester)	Coursework & Research	500	20	20	40
	Coursework (or)	500	40	--	40
	Research			40	40

Exit Point:

For those who join 2-year PG programmes, there shall only be one exit point. Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma.

8. Course Levels

400-499: Advanced courses which would include lecture courses with practicum, seminar-based course, term papers, research methodology, advanced laboratory experiments/software training, research projects, hands-on-training, internship/apprenticeship projects at the undergraduate level or First year Postgraduate theoretical and practical courses

500-599: For students who have graduated with a 4-yearbachelor's degree. It provides an opportunity for original study or investigation in the major or field of specialization, on an individual and more autonomous basis at the postgraduate level.

9. Switching Subjects in Postgraduate Programme

The first degree often inspires students to explore alternative career paths that may require a shift in their field of study. While transitioning to a different discipline through a postgraduate degree can be challenging, the **National Education Policy (NEP)** provides the necessary flexibility to make it achievable. Postgraduate programmes offer students the opportunity to change their field and pursue their aspirations through the following pathways:

- Students are eligible for admission to a PG programme in either the **major or minor discipline** studied during their undergraduate programme.
- Irrespective of the major or minor disciplines pursued in the undergraduate programme, students may seek admission to **any discipline** of PG programmes by qualifying the relevant National or University-level entrance examination.

Furthermore, candidates who have completed:

- A **4-year UG programme**,
- A **3-year UG+2-year PG programme**, or
- A **5-year integrated UG+PG programme** in STEM subjects is eligible for admission to **M.E. or M.Tech. programmes** in related fields.

This framework enables students to redefine their academic trajectory and achieve their professional goals in a new discipline.

References:

1. **Curriculum and Credit Framework for Postgraduate Programmes,** https://www.ugc.gov.in/pdfnews/4682468_Curriculum-and-Credit-Framework-for-Postgraduate-Programmes.pdf
2. **The National Education Policy 2020** (https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf)
3. **National Credit Framework (NCrF)** (https://www.ugc.gov.in/pdfnews/9028476_Report-of-National-Credit-Framework.pdf)
4. **The National Higher Education Qualifications Framework (NHEQF)** (https://www.ugc.gov.in/pdfnews/2990035_Final-NHEQF.pdf)
5. **Curriculum and Credit Framework for Undergraduate Programmes.** (https://www.ugc.gov.in/pdfnews/7193743_FYUGP.pdf)

DEPARMENT OF BIOTECHNOLOGY

VISION

To produce biologists with strong ethics, integrity, acumen, and preparedness to tackle any emerging problem of global concern by fostering curated opportunities in the course area to push themselves at the global platform.

MISSION

• To impart quality education to students through scientifically designed up-to-date course structure and make them globally competitive.

• To instill confidence in the students for developing analytical skills to find out solutions for current and emerging problems of global concern.

• To provide state of the art academic and laboratory facilities with skilled training and integration of interdisciplinary approach to foster entrepreneurial thinking.

Outline of the syllabus for M.Sc. in Biotechnology (Royal School of Bio-Sciences)

1ST SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
BTC154C101	Biochemistry	400	3	3-0-0
BTC154C102	Microbiology	400	3	3-0-0
BTC154C103	Cell Biology	400	3	3-0-0
BTC154C104	Genetics	400	3	3-0-0
BTC154C115	Practical – I (A)	400	4	0-0-8
BTC154C116	Practical – I (B)	400	4	0-0-8
SWAYAM			3/ 4	
	TOTAL CREDIT FOR 1ST SEMESTER		**20+3/4**	
2ND SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
BTC154C201	Molecular Biology	500	3	3-0-0
BTC154C202	Immunology	500	3	3-0-0
BTC154C203	Bioinformatics and Biostatistics	500	3	3-0-0
BTC154C204	Environmental Biotechnology	500	3	3-0-0
BTC154C215	Practical – II (A)	500	4	0-0-8
BTC154C216	Practical – II (B)	500	4	0-0-8
SWAYAM			3/4	
	TOTAL CREDIT FOR 2ND SEMESTER		**20+3/4**	
TOTAL CREDIT FOR 1ST YEAR = 40 + 6/ 8				
3RD SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
BTC154C301	Bioprocess Technology	500	4	4-0-0
BTC154C302	Analytical techniques	500	4	4-0-0
BTC154C303	IPR, Biosafety, Bioethics and Research Methodology	500	4	4-0-0
BTC154C304	Genetic Engineering	500	4	4-0-0
BTC154C315	Practical – III	500	4	0-0-8
	TOTAL CREDIT 3RD SEMESTER		**20**	
OR 3RD SEMESTER **(For students with 3rd and 4th Semester Research)**				
BTC154R321	**RESEARCH PROJECT – PHASE 1**	**500**	**20**	**0-0-40**
4TH SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
BTC154C421	**Dissertation (Students with research in 4th Sem)**	**500**	**20**	**0-0-40**
(for 'Coursework only' students, in lieu of dissertation)				
BTC154C401	Plant and Animal Biotechnology	500	4	4-0-0
BTC154C402	Biophysical Chemistry	500	4	4-0-0
BTC154C403	Genomics and Proteomics	500	4	4-0-0
BTC154C404	Food Biotechnology	500	4	4-0-0
BTC154C415	Practical – IV	500	4	0-0-8
	TOTAL CREDIT 4TH SEMESTER		**20**	
OR 4TH SEMESTER **(For students with 3rd and 4th Semester Research)**				
BTC154R421	**RESEARCH PROJECT – PHASE 2**	**500**	**20**	
TOTAL CREDIT FOR 2ND YEAR = 40				

Programme wise courses for each semester				
Programme	**Semester**	**Mandatory Course codes**	**Level**	**Credits**
Coursework only	1st	All courses	400	20 + 3/ 4
	2nd	All courses	500	20 + 3/ 4
	3rd	BTC154C301, C302, C303, C304, C315	500	20
	4th	BTC154C401, C402, C403, C404, C415	500	20
Coursework till 3rd Semester and Research in the 4th Semester	1st	All courses	400	20 + 3/ 4
	2nd	All courses	500	20 + 3/ 4
	3rd	BTC154C301, C302, C303, C304, C315	500	20
	4th	BTC154C421	500	20
Coursework (1st and 2nd semester) + Research only (3rd and 4th semester)	1st	All courses	400	20 + 3/ 4
	2nd	All courses	500	20 + 3/ 4
	3rd	BTC154R321	500	20
	4th	BTC154R421	500	20
			Total Credits	**80 + 6/ 8**

SYLLABUS (1st SEMESTER)

Course Title: Biochemistry	**Course Component: Major**
Course code: BTC154C101	**Credit: 3**
Level of course: 400	**L-T-P-C: 3-0-0-3**

Course Objectives: The course is designed to understand the basic characteristics of various biological macromolecules, their formation along with their association in various metabolic pathways.

Course Outcome:

On successful completion of the course the students will be able to:		
Sl. No.	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Remember the core concept of basic biochemistry, structure of various biological macromolecules	BT 1
CO 2	Understand the basic biochemical processes occurring in the living system and involvement of various biological macromolecules in those processes.	BT 2
CO 3	Apply the knowledge gained during the course in the field of research and development.	BT 3
CO 4	Analyse theoretical knowledge in developing practical solutions in solving real life problems associated with biochemistry.	BT 4
CO 5	Evaluate their understanding in chemistry behind reactions occurring in living systems.	BT 5

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	Chemical foundations of Biology: Composition of living matter, Water-properties, pH, pKa, acids, bases, buffers; weak bonds, covalent bonds. Protein: physical and chemical properties of amino acids; Primary, secondary, tertiary and quaternary structure; Globular and fibrous proteins; Amino acid composition and primary structure analysis, Structure-function relationship in model proteins like ribonuclease A, myoglobin and haemoglobin, structure of collagen, Ramachandran Plot	15
II	Carbohydrates: mono, di and polysaccharides; Structural and functional role; Glycoprotein and Glycolipid. Lipids: Structure and properties of storage and membrane lipids; Lipoproteins; Structural organization of biological membrane.	15
III	Nucleic acids: Structure and properties of purines, pyrimidines, nucleosides, nucleotides, helical structure of DNA. Different forms of DNA. Denaturation and renaturation of DNA. Enzyme catalysis: General principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single and bi-substrate enzyme reactions.	15
IV	Metabolic pathways: Energy concepts and energy rich compounds; Glycolysis, glycogenolysis, gluconeogenesis, pentose phosphate pathway, citric acid cycle and oxidative phosphorylation; Fatty acid biosynthesis and oxidation (α and β) Vitamins: Types and biological properties	15
	Total	**60**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

3 credits: 3 × 30 = 90 Notional Credit Hours (60 class hours + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Textbooks

1. Nelson, D. L., Cox, M. M., *Lehninger Principles of Biochemistry*, 4th Edition, 2004, W.H. Freeman and Company, New York, USA
2. Satyanarayana, U. and Chakrapani, U, Biochemistry, 6th Edition, 2021, Elsevier.

Reference Books

1. Voet, D and Voet, J.G., Biochemistry, 4th Edition, 2012, Wiley
2. Berg, J.M., Tymoczko, J.L., Gatto, G.J. and Stryer, L, Biochemistry, 8th Edition, 2015, W.H. Freeman and Company

Course Title: Microbiology	**Course Component: Major**
Course code: BTC154C102	**Credit: 3**
Level of course: 400	**L-T-P-C: 3-0-0-3**

Course Objective: The course aims to give a holistic theoretical and practical knowledge in field of general microbiology, its core concept, scopes, applications and future prospects.

Course outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the core concept of basic microbiology, microbial structure, their taxonomic classification, microbial ecology and their applications.	**BT 1**
CO 2	**Understand** isolation, screening, characterization, and identification of important microbes from various sources.	**BT 2**
CO 3	**Apply** the knowledge gained during the course in the field of research and development.	**BT 3**
CO 4	**Analyse** theoretical knowledge in developing practical solutions in solving real life problems associated with microbiology.	**BT 4**
CO 5	**Evaluate** future prospects by pursuing entrepreneurial ventures in this field.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	**Microbial Diversity and Systematics:** Classical and modern methods and concepts in classification of microorganisms. Bergey's manual of determinative Bacteriology, 16s rDNA sequencing and ribosomal database project. Microbial systematics, Molecular Taxonomy,	**15**

II	**Study of microorganisms**: General characteristics and salient features related to structure, function, physiology and significance of cyanobacteria, actinomycetes, fungi, yeast, viruses, rickettsia & mycoplasma. Ultrastructure of a bacterial cell: spore, cell wall, flagella, cell membrane, capsule, pili. Microbial growth. Virus structure and composition, virus replication and pathogenicity, Basic microbiological techniques: Microscopy, Pure culture, nutrition, enrichment, sterilization, disinfection, safety in the microbiological laboratory. microbial gene transfer: transformation, transduction, conjugation, plasmids, transposons.	**15**
III	Study of eco-physiological, biochemical and nutritional aspects of phylogenetically diverse representative groups of organisms: extremophiles - thermophiles, psychrofiles, halophiles, methanogens, archaebacteria, Nitrogen fixing organisms and nitrogen fixing genes, Mycorrhiza: types and its functions **Microbial Ecology:** interactions among microbial populations, microbial interaction with animals, microbial interaction with plants, quorum sensing **Diseases of humans:** Bacterial meningitis, botulism, poliomyletis, hepatitis and AIDS.	**15**
IV	**Antibiotics:** types & mode of action, resistance to antibiotics. Prebiotics and Probiotics, Bacteriocins, vaccines and adjuvants, Bioprocess technology, bioprocess control and monitoring variables, Media formulations, sterilization, Thermal death kinetics, batch and continuous sterilization systems, extracellular enzymes, biotechnologically important intracellular products, exopolymers.	**15**
	Total	**60**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

3 credits: 3 × 30 = 90 Notional Credit Hours (60 class hours + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Textbooks

1. Willey, J., Sherwood, L., Woolverton, C.J., Prescotts Microbiology, , ISBN-10: 9813151269, ISBN-13: 978-9813151260, McGraw Hill Edition, 10th edition.
2. Ananthanarayan and Paniker's Textbook of Microbiology, ISBN-10: 9789386235251, ISBN-13: 978-9386235251, Universities Press
3. Reed, G., Prescotts and Dunn Industrial Microbiology, ISBN-10: 8123910010, ISBN-13: 978-8123910017, CBS Publishers & Distributors

Reference Books

1. Madigan, M.T.,Martinko, J.M., Bender, K. S., Buckley,D.H., Stahl, D.A.Brocks Biology of Microorganisms, ISBN-10: 9332586861, ISBN-13: 978-9332586864, Pearson's Education,
2. Bauman R.W., Microbiology with Diseases by Taxonomy, Pearson Education, ISBN-10: 9332587272, ISBN-13: 978-9332587274

Course code: BTC154C103	**Credit: 3**
Level of course: 400	**L-T-P-C: 3-0-0-3**

Course Objective: The course aims to give a holistic theoretical and practical knowledge in field of cell biology, its core concept, scopes, applications and future prospects.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	Ability to **remember** how cellular components are used to generate and utilize energy in cells.	**BT 1**
CO 2	**Understand** the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles	**BT 2**
CO 3	**Apply** their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation.	**BT 3**
CO 4	**Analyse** the cell signalling and how it regulates cellular functions. Also, how its dysregulation leads to cancer and other diseases.	**BT 4**
CO 5	**Evaluate** the how cells grow, divide, and die and how these important processes are regulated.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	**Cell Structure and Methods in Cell Biology:** Cell: Difference between prokaryotes and eukaryotes, structural and functional organization of eukaryotes, difference between plant and animal cells, Cell wall and cell membrane, Cell motility, sub cellular organelle like Nucleus, Endoplasmic reticulum, Golgi, Mitochondria, Lysosomes; Fractionation of sub cellular organelles, Principles and applications of the microscopy, Cell counting.	**15**
II	**Bio-membrane structure and Function:** Plasma Membrane: organization and properties, Dynamics transport across membrane, Cell signalling: Types of receptors (Intracellular and cell surface), signal transduction by membrane bound, cytosolic and nuclear receptors via various pathways **Endo-membrane System and Cellular Motility:** General organization of protein transport within and outside the cell, Mechanisms of endocytosis and exocytosis, Protein sorting and secretion, Vesicular transport, Mechanism of intracellular digestion.	**15**
III	**Cell Dynamics:** Cell dynamics, cytoskeleton and cell surface, Microfilaments: Structural organization, cell motility and cell shape; Microtubule: Structural and functional organization, cilia, flagella, centriole; Intermediate filaments, Cell-cell interactions and cell matrix interaction **Cell Cycle & Cell Death:** Mitosis, Meiosis, Eukaryotic Cell cycle and its regulation, Apoptosis, Cancer biology - Mechanism of carcinogenesis, tumor suppressor genes and oncogene.	**15**

IV	**Cell Differentiation:** Cell differentiation, hormones and growth factors; Stem cell differentiation, Blood cell formation, Fibroblast and their differentiation, Mating cell type in yeast, Surface antigen changes in Trypanosomes.	**15**
	Total	**60**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

3 credits: 3 × 30 = 90 Notional Credit Hours (60 class hours + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text Books

1. Gupta P.K., Genetics, ISBN-10 8171339328, ISBN-13 978-8171339328, Rastogi Publications, Meerut.
2. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R. *Molecular Biology of the Gene*, 6th edition, 2008. Cold Spring Harbour Lab. Press, Pearson Pub.
3. De Robertis, E.D.P. and De Robertis, E.M.F. *Cell and Molecular Biology*, 8th edition, 2006, Lippincott Williams and Wilkins, Philadelphia.

Reference Books:

1. Karp, G..*Cell and Molecular Biology: Concepts and Experiments*, 6th edition, 2010. John Wiley & Sons. Inc.
2. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P., *The World of the Cell*, 7th edition, 2009, Pearson Benjamin Cummings Publishing, San Francisco.

Course Title: Genetics	**Course Component: Major**
Course code: BTC154C104	**Credit: 3**
Level of course: 400	**L-T-P-C: 3-0-0-3**

Course Objective: The course is designed to understand the various laws governing inheritance and learn about chromosomal aberrations and structure of chromosomes.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic concept of Mendelian principles of heredity and use those principles to analyse genetic data.	**BT 1**
CO 2	**Understanding** of how genetic concepts affect broad societal issues including health and disease, food and natural resources, environmental sustainability, etc.	**BT 2**
CO 3	**Apply** to real life situations and one's life the principles of human heredity.	**BT 3**
CO 4	**Analyse** the historical and current knowledge regarding human heredity, and understand how such knowledge has influenced law, medicine, and society**.**	**BT 4**

CO 5	**Evaluate** the fundamentals of gene technology to understand how such technology impacts humans.	**BT 5**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Mendelian genetics:** Brief survey of Mendelian Genetics, law of dominance, independent assortment, linkage and crossing over, interaction of genes, Extrachromosomal inheritance: mitochondrial & chloroplast inheritance.	**15**
II	**Microbial genetics:** Bacterial chromosome and plasmids, bacterial mutants, prototroph and auxotroph. Transformation, conjugation and transduction in bacteria. Bacteriophage and their genetic systems, Lytic and Lysogenic cycles in lambda (λ) phage: genetic recombination and heteroduplex DNA.	**15**
III	**Mutation:** types, rates and the agents that cause mutation, Molecular basis of mutation, Genome instability: chromosomal aberration; Cell division and errors in cell division. Assay of mutagenic agents (Ames's test).	**15**
IV	**Concept of Human Genetics:** Human Chromosome and abnormalities, Mendelian pedigree pattern, polygenic and multifactorial inheritance, inborn errors of metabolism, Hardy-Weinberg equilibrium, genotype and allele frequency, sex determination, role of Y-chromosome and mechanism. Introduction to cancer genetics	**15**
	Total	**60**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

3 credits: 3 × 30 = 90 Notional Credit Hours (60 class hours + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Textbooks

1. Gupta P.K., Genetics, ISBN-10 8171339328, ISBN-13 978-8171339328, Rastogi Publications, Meerut.
2. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., Molecular *Biology of the Gene*, 7th edition, 2012. Cold Spring Harbour Lab. Press, Pearson Pub.
3. Fairbanks, D. J., Genetics: The Continuity of Life, Wadsworth Publishing, ISBN-10: 0534252796
4. Russel, P. J., iGenetics, Pearsons Education India, ISBN-10: 9332571627, ISBN-13: 978-9332571624

Reference Books:

1. Karp, G..*Cell and Molecular Biology: Concepts and Experiments*, 6th edition, 2010. John Wiley & Sons. Inc.
2. Klug, W., Cummings, M., Spencer, C.A., Palladino, M.A., Concept of Genetics, ISBN-10: 9789332577466, ISBN-13: 978-9332577466, Pearsons Education India.

Course Title: Practical – I (A)	**Course Component: Major**
Course code: BTC154C115	**Credit: 4**
Level of course: 400	**L-T-P-C: 0-0-8-4**

Course Objective: The course is designed with an objective to give the students a wholesome practical knowledge on Microbiology, and Biochemistry.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the practical skills associated with Microbiology, Genetics and Biochemistry.	**BT 1**
CO 2	**Understand** isolation, screening, characterization, and identification of important microbes from various sources.	**BT 2**
CO 3	**Apply** the knowledge gained during the course in the field of research and development.	**BT 3**
CO 4	**Analyse** theoretical knowledge in developing practical solutions in solving real life problems associated with microbiology.	**BT 4**
CO 5	**Create** an understanding in expanding the future prospects by pursuing entrepreneurial ventures in this field.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	• Safety measures in Biochemistry laboratory. • Effect of α-amylase on starch • Determination of Km and Vmax of α-amylase activity • Preparation of phosphate buffer. • Preparation citrate buffer	**24**
II	• Principles of Colorimetry and Verification of Beer's law • Separation of Amino acids by paper chromatography. • Separation of various biomolecules by using TLC.	**24**
III	• Estimation of carbohydrates (glucose, maltose, lactose) present in a sample solution by DNS method • Estimation of protein by Lowry's method • Extraction and estimation of cellular protein from animal tissue by ammonium salt precipitation method.	**24**
IV	• Preparation of common bacteriological media and sterilization • Isolation and enumeration of microorganisms from various sources. • Staining of microorganisms (Bacteria and Fungi) • Biochemical characterization of microorganisms (IMViC test, catalase test, gelatine liquefaction, antibiotic sensitivity assay). • Growth curve, measure of bacterial population by standard plate count. • Antibiotic sensitivity assay	**24**
	Total	**96**
Pedagogy: Lectures, Experiments, Laboratory sessions		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (96 lab hours + 24 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Texts and Reference: As suggested under theory papers.

Course Title: Practical – I (B)	**Course Component: Major**
Course code: BTC154C116	**Credit: 4**
Level of course: 400	**L-T-P-C: 0-0-8-4**

Course Objective: The course is designed with an objective to give the students a wholesome practical knowledge on Genetics and Cell Biology.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the practical skills associated with Cell Biology and Genetics.	**BT 1**
CO 2	**Understand** the mechanism of cell division and differentiation**.**	**BT 2**
CO 3	**Apply** the knowledge identifying various mechanisms involved in cell growth and development	**BT 3**
CO 4	**Analyze** the equipment used and the underlying safety measures in a laboratory pertaining to cell biology.	**BT 4**
CO 5	**Combine** the concepts of cell biology and genetics to explain cellular anomalies related to genetic errors.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	• Study the effect of temperature and organic solvents on semi permeable membrane. • Demonstration of dialysis. • Study of plasmolysis and de-plasmolysis. • Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source.	**24**
II	• Study of structure of any Prokaryotic and Eukaryotic cell. • Study of cell counting and their viability • Cell division in onion root tip/ insect gonads. • Identification of blood cells in human blood smear	**24**

III	• Calibration of Microscope • To prepare the media for culturing Drosophila melanogaster • To clean and sterilize the Drosophila culture bottle • Preparation of metaphase plate from mouse bone marrow. • Preparation of human karyotypes from well spread metaphase photographs	**24**
IV	• Temporary slide preparation of buccal smear to study Barr-body. • Introduction of chromosome abnormalities in mammalian chromosomes. • Temporary slide preparation of Grasshopper testis study the meiotic phases. • Temporary slide preparation of onion root tip to study the mitotic phases.	**24**
	Total	**96**
Pedagogy: Lectures, Experiments, Laboratory sessions		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (96 lab hours + 24 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Texts and Reference: As suggested under theory papers.

SYLLABUS (2nd SEMESTER)

Course Title: Molecular Biology	**Course Component: Major**
Course code: BTC154C201	**Credit: 3**
Level of course: 500	**L-T-P-C: 3-0-0-3**

Course Objective: The course is designed to understand the organization of the prokaryotic/eukaryotic genome and the various molecular processes taking place in the living system

Course Outcome:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the various molecular events associated with the growth and development of the cell.	**BT 1**
CO 2	**Understand** how replication, transcription and translation processes occur within the living cell.	**BT 2**
CO 3	**Apply** the knowledge gained during the course in the field of research and development.	**BT 3**
CO 4	**Analyse** the effects of various factors on molecular events including replication, transcription and translation.	**BT 4**
CO 5	**Evaluate** the knowledge to design experiments to manipulate cellular and molecular processes.	**BT 5**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Genes and Chromosomes:** Organization of bacterial genome; DNA structure, Structure of eukaryotic chromosomes; Complexity of genome and its reassociation kinetics (Cot curve analysis); Clusters and repeats; Chromatin: Heterochromatin and Euchromatin; Nucleosome structure and its phasing: DNase sensitivity, DNA methylation and imprinting, Human genome project and its importance, Structural genomics, Sequence components, Satellite, microsatellite and minisatellite chromosome.	**15**
II	**Replication in prokaryotes & eukaryotes:** Initiation and its regulation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA. **Repair:** Gene stability and Replication error repair, DNA repair enzymes: Photoreactivation, Nucleotide and base excision repair, Mismatch repair and SOS repair.	**15**
III	**Prokaryotic & Eukaryotic Transcription:** Promoters, Initiation, Elongation and Termination steps of prokaryotic transcription and its comparison with eukaryotic transcription. Enhancers, Transcription factors: TATA binding proteins (TBP) and TBP associated factors (TAF), Activators and repressors; Processing of primary transcripts; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; **Translation & Transport:** Translation machinery; Ribosomes; Steps of translation and its mechanism in prokaryotes and eukaryotes: Initiation, elongation and termination; Genetic codon and its properties; Co- and post translational modifications; Protein trafficking.	**15**
IV	**Regulation of gene expression:** Prokaryotic gene expression with reference to inducible and repressible operons, Concept of eukaryotic gene regulation, Chromatin remodelling, Epigenetics: Chromatin marking system; Regulatory RNA: Basic concepts of miRNA, siRNA and RNAi.	**15**
	Total	**60**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

3 credits: 3 × 30 = 90 Notional Credit Hours (60 class hours + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text Books

1. Watson, J. D., Baker, T. A., Bell, S. T., Gann, A. *Molecular Biology of the Gene*, Pearsons Education, 7th edition, ISBN 978-81-7758-181-2
2. Berk, A., Zipursky, S. L., Matsudaira, P.T., Baltimore, D., Darnell, J., Lodhish, H. F. *Molecular Cell Biology*, W.H. Freeman & Co Ltd (Latest Edition), ISBN-10: 0716731363, ISBN-13: 978-0716731368

Reference Books

1. Karp, G. *Cell and Molecular Biology: Concepts and Experiments*, 6th edition, 2010. John Wiley & Sons. Inc.

2. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. *The World of the Cell*, 7th edition, 2009, Pearson Benjamin Cummings Publishing, San Francisco.

Course Title: Immunology	**Course Component: Major**
Course code: BTC154C202	**Credit: 3**
Level of course: 500	**L-T-P-C: 3-0-0-3**

Course Objective: The course aims to give detailed concept in the core areas of immunology and understand the various forms of immunity and also the diseases associated with immune disorders.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the basic forms of immune system present in the body.	**BT 1**
CO 2	**Understand** the mechanism of the immune system.	**BT 2**
CO 3	**Apply** the knowledge learnt in relating the same to the defence of the body during diseases.	**BT 3**
CO 4	**Analyse** the importance of the various molecules that play an important role in immune function.	**BT 4**
CO 5	**Evaluate** the various diseases that occurs in the system to the forms of immune disorders.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	**Immunology- fundamental concepts and anatomy of the immune system:** Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs and cells of the immune system-primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue (MALT&CALT); Mucosal Immunity; Antigens - immunogens, haptens.	**15**
II	**Immune responses generated by B and T lymphocytes:** Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Antibody diversity, somatic hypermutation and class switching; Basis of self– and non-self-discrimination; MHC antigens and their role in immune responses, Kinetics of immune response, memory; B cell maturation, activation and differentiation; 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.	**15**
III	**Antigen – Antibody Interactions:** Precipitation, Agglutination; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay and Immunofluorescence. Complement system and complement fixation test. **Clinical Immunology:** Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases.	**15**

IV	**Transplantation and tumor immunology:** Transplantation– Immunological basis of graft rejection; Tumor immunology – Tumor antigens; Immune response to tumors and immune evasion by the tumor, Immunodeficiency-Primary and acquired immunodeficiency Vaccines: History, development, types and process of preparation and delivery	**15**
	Total	**60**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

3 credits: 3 × 30 = 90 Notional Credit Hours (60 class hours + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text books

1. Kuby, J., Thomas, J.K., Barbara, A.O. Immunology, 6th Edition, W. H. Freeman, 2002.
2. Janeway et al., Immunobiology, 4th Edition, Current Biology publications.,1999.

Reference books:

1. Brostoff, J., Seaddin, J.K., Male,D., Roitt, I.M., Clinical Immunology, 6thEdition, Gower Medical Publishing,2002.
2. Paul, R., Fundamental of Immunology, 4thedition, Lippencott,1999.
3. Goding, Monoclonal antibodies, Academic Press.1985.

Course Title: Bioinformatics and Biostatistics	**Course Component: Major**
Course code: BTC154C203	**Credit: 3**
Level of course: 500	**L-T-P-C: 3-0-0-3**

Course Objectives: The course aims to give a holistic theoretical and practical knowledge in field of bioinformatics and biostatistics to understand the various cellular activities.

Course outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the various software and biological databases and their application in the analysis of various biological experiments.	**BT 1**
CO 2	**Understand** the various software and their use in the analysis of various biological results.	**BT 2**
CO 3	**Apply** the knowledge to analyse the results of biological experiments statistically using various computational tools	**BT 3**
CO 4	**Analyze** the various biological events and their probable outcome using computational tools.	**BT 4**

CO 5	**Evaluate** various databases and software for the experiments/ analysis of the results of biological experiments.	**BT 5**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Basics of bioinformatics:** Definition, Scope and Goal, Application in Computational Biology, Limitations; **Biological Database:** Types of databases, biological database: GenBank, EMBL, DDBJ, Uniprot-KB: SWISS-PROT, PDB, Ace DBs, literature databases PubMed; Webtools: ExPASy server **Sequence Analysis and Sequence Alignment:** Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues, Basic concepts of sequence alignment, Uses of Sequence Alignment, Pairwise, multiple, Database Similarity search, **Scoring matrices:** Basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles **Sequence similarity search:** BLAST and FASTA	**15**
II	**Molecular Phylogenetics:** Basic concepts, Methods in evaluation of phylogeny and steps in constructing alignments and phylogenetic Trees, Types of phylogenetic tree. **Structural bioinformatics:** proteins and its structure, Determination of protein 3Dstructure, Protein structure visualization, comparison, Secondary and tertiary structure prediction, **Chemi-informatics and Computer Aided Drug Designing (CADD):** Introduction to cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Basics of medicinal chemistry. Prodrugs and soft drugs, Drug targets, Drug solubility, Natural resources of lead compounds, Pharmacokinetics & drug metabolism.	**15**
III	**Statistical tools:** Measures of central tendencies and dispersion, concept of probability and theoretical distributions (Binomial, Poisson and normal distribution), Correlation and Regression; Univariate and multivariate multiple regression. Random numbers, sampling methods, random plot design. Basics of testing of hypothesis. Analysis of variance (one way and two way), Students t test, Chi-square test, F-test and Z-test.	**15**
IV	**Statistical Science and biological assays:** Importance, nature and planning of bioassays; Direct and indirect bioassays; Design of experiments by Analysis of variance and Dose-response analysis. **Analysis of biochemical data:** Application of multiple regressions in epidemiologic and clinical data; Study of association between disease and risk factors. Application of odds ratio, Logistic regression with dichotomous response variable.	**15**
	Total	**60**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

3 credits: 3 × 30 = 90 Notional Credit Hours (60 class hours + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text Books

1. Zar, J. H. 2000. Biostatistical Analysis. Pearson Education, India.
2. Kothari, C. R. Research Methodology: methods and techniques. New Age International Publishers, India.

Reference Books

1. Quinn, G. P. & Keough, M. J. 2002. Experimental design and data analysis for biologists. Cambridge University Press, UK.
2. Gould. 2002. BioStats Basics. W H Freeman & Co, USA.

Course Title: Environmental Biotechnology	**Course Component: Major**
Course code: BTC154C204	**Credit: 3**
Level of course: 500	**L-T-P-C: 3-0-0-3**

Course Objective: This course is offered with the objective of familiarizing students with the current and pertinent environmental issues and possible approaches to mitigate them.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** and identify area and time-specific environmental issues.	**BT 1**
CO 2	**Understand** the significance of environmental problems persisting in a place.	**BT 2**
CO 3	**Apply** the knowledge to relate cause and effect of major issues pertaining to the environment.	**BT 3**
CO 4	**Analyze** the scientific basis of the negative effects of pollutants on the environment.	**BT 4**
CO 5	**Evaluate** a detailed information system, starting from cause, effect, and solution to better prepare oneself to mitigate environmental concerns.	**BT 5**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Environmental Pollution:** Concept of Environmental Pollution; Origin of pollution; Classification and nature of Environmental Pollutants; Major sources; Impacts of Environmental Pollution at local regional and global level.	**15**
II	**Air pollution:** Concept of air Pollution; Major air pollutants and their sources; Meteorological aspects of air pollution; Oxides of nitrogen and sulphur; Particulate matter; Air pollution standards; Indoor and outdoor air pollution; Air pollution episodes and disasters; Effects of air pollution on human health, animals, plants, material and climate; Formation of fog and photochemical smog and acid rain; Monitoring of air pollution; Control on release of smoke.	**15**

III	**Soil Pollution:** Concept of soil pollution; Causes of soil salinity; Different causes of soil degradation; Chemical and metallic pollution of agricultural soil; Mining and soil pollution; Control of soil pollution. **Solid Waste:** Concept of solid waste; Industrial solid waste; Domestic solid waste; Agricultural solid waste; Municipal solid waste; Major sources of solid wastes; Effects of solid waste generation on quality of air, water and public health; Technical approach for solid waste management; Disposal of organic and medical waste; Recovery and recycling of metallic waste; Disposal of plastic waste and hazardous wastes.	**15**
IV	**Environmental Quality Assessment and Monitoring:** What is environmental quality? Quality of environment for life on earth and man; Deterioration of environmental quality with reference to anthropogenic impact; Methods of assessment of environmental quality; Short term studies/surveys; Rapid assessment; Continuous short- and long-term monitoring **Environmental Impact Assessment (EIA):** Need of EIA; Scope and objectives; Types of environmental impacts; Steps involved in conducting the EIA Studies; Environmental Impact Assessment techniques; Merits and Demerits of EIA studies.	**15**
	Total	**60**
Pedagogy: Lectures, Experiments, Laboratory sessions		

Credit distribution:

3 credits: 3 × 30 = 90 Notional Credit Hours (60 class hours + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text Books

1. Wang, L. et al. (2010). Environmental Biotechnology, Humana Press. (available at UTS Library, either in hard copy or electronic version)
2. Wang, L. et al. (2010). Environmental Engineering, Humana Press. (available at UTS Library, either in hard copy or electronic version)

Reference Books

1. Vallero, D. A. (2010). Environmental Biotechnology: A Biosystems Approach, Elsevier. (available at UTS Library)
2. Evans, G. M. and Furlong, J. C. (2011). Environmental Biotechnology: Theory and Application, Wiley-Blackwell. (available at UTS Library)
3. Jördening, H. J. and Winter, J. (2005). Environmental Biotechnology: Concepts and Applications, Wiley-VCH. (available at UTS Library E-book)

Course Title: Practical – II (A)	**Course Component: Major**
Course code: BTC154C215	**Credit: 4**
Level of course: 500	**L-T-P-C: 0-0-8-4**

Course Objective: The course is designed with an objective to give the students a holistic practical knowledge on Molecular Biology and Immunology.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the practical skills associated with molecular biology and immunology.	**BT 1**
CO 2	**Understand** the techniques of isolation of genetic material from different sources.	**BT 2**
CO 3	**Apply** the knowledge gained during the course in the field of research and development.	**BT 3**
CO 4	**Analyse** different DNA samples to establish identity of individuals.	**BT 4**
CO 5	**Create** an understanding in expanding the future prospects by pursuing entrepreneurial ventures in this field.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	• Isolation of genomic DNA from plants/bacteria/animal cell. • Quantification and purity determination of isolated genomic DNA by UV-spectrophotometry and agarose gel electrophoresis.	**24**
II	• Extraction of RNA • Isolation of plasmid DNA by alkaline lysis and phenol method. • Restriction digestion of DNA • Polymerase chain reaction of genetic DNA • Agarose gel electrophoresis	**24**
III	• Blood film preparation, staining and identification of blood cells. • Preparation of antigen. • Immunization of mice, serum collection and preservation. • Purification of IgG from serum.	**24**
IV	• SGOT – PT test; agglutination. • Immuno-electrophoresis, Immuno-peroxidase test; Immuno-fluorescence test, ELISA. • Isolation of lymphoid cells (mouse) from spleen. • Separation of mononuclear cells.	**24**
	Total	**96**
Pedagogy: Experiments and Laboratory sessions		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (96 lab hours + 24 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Texts and Reference: As suggested under theory papers.

Course Title: Practical – II (B)	**Course Component: Major**
Course code: BTC154C216	**Credit: 4**
Level of course: 500	**L-T-P-C: 0-0-8-4**

Course Objective: The course is designed with an objective to give the students a holistic practical knowledge on Bioinformatics and Environmental Biotechnology.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the different bioinformatics databases.	**BT 1**
CO 2	**Understand** the process of molecular identification of organisms using bioinformatics tools.	**BT 2**
CO 3	**Apply** the knowledge in the field of environmental safety	**BT 3**
CO 4	**Analyse** different soil samples for their suitability for sustainable agriculture.	**BT 4**
CO 5	**Develop** frugal tests for and methods for industrial use.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	• Introduction to bioinformatics software • Database search and sequence download • Sequence retrieval and analysis • BLAST, FASTA: Search and analysis of data	**24**
II	• Sequence alignment: algorithms for global and local alignments, pairwise alignment and multiple sequence alignment • Phylogenetic analysis and tree building • Protein structure download and structural analysis • ADMET – drug properties analysis and toxicology study	**24**
III	• Determination of BOD in contaminated water • Determination of COD in contaminated water • Screening of faecal coliform in water samples.	**24**
IV	• Screening of hydrocarbon degrading microbes from different environmental sources. • Production of secondary metabolites from environmental isolates. • Determination of soil and water pH from different locations.	**24**
	Total	**96**
Pedagogy: Experiments and Laboratory sessions		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (96 lab hours + 24 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship

- student teaching
- classroom presentation *etc.*

Texts and Reference: As suggested under theory papers.

SYLLABUS (3rd SEMESTER)

Course Title: Bioprocess Technology	**Course Component: Major**
Course code: BTC154C301	**Credit: 4**
Level of course: 500	**L-T-P-C: 4-0-0-4**

Course Objectives: The course aims to give a holistic theoretical and practical knowledge in field of bioprocess technology involving microbial cultures, its core concept, scopes, applications and future prospects.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the core concept of modern biotechnology and its application in food, pharma- and petroleum industries.	**BT 1**
CO 2	**Understand** the production procedure of alcoholic beverages, antibiotics and drugs.	**BT 2**
CO 3	**Apply** the knowledge gained during the course in the field of research and development.	**BT 3**
CO 4	**Analyze** theoretical knowledge in developing practical solutions in solving real life problems associated with microbiology.	**BT 4**
CO 5	**Evaluate** their understanding in expanding their future prospects by pursuing entrepreneurial ventures in this field.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	Basic principle of Biochemical engineering: Isolation screening and maintenance of industrially important microbes, microbial growth and death kinetics (particularly with reference to industrially useful microorganisms), strain improvement for increased yield and other desirable characteristics	**16**
II	Detailed study of the design and operation of different types of fermenters, Mode of fermentation processes: Bioreactor designs, types of fermentations and fermenters: Upstream processing: scale up and scale down process. Fermentation process kinetics: Reaction kinetics: effect of temperature on reaction rate, activated complexes, catalyzed reactions, thermal death of micro-organisms, enzyme inhibition, Fermentation kinetics: advantages and limitations, Downstream processing: Bio separation: drying, crystallization, storage and packaging, treatment of effluent and its disposal	**16**

III	Applications of enzymes in food processing: enzymatic bioconversions e.g. starch and sugar conversion processes, High-Fructose Corn Syrup, and their downstream processing, backing by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing, cheese making by proteases. Application of microbes in food process operations and production: Fermented foods microbes and their use in pickling, producing colours and flavours, and process of wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins: production and applications.	**16**
IV	Biodegradation of xenobiotic compounds and toxic wastes, removal of spilled oil & grease deposits, Biosurfactants, Bioremediation of soil & water, solid waste & waste water treatment, use of microorganism for the production of energy: Biogas (production of methane and hydrogen), fuel alcohol production & hydrocarbon production	**16**
	TOTAL	**64**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (64 class hours + 16 Seminar + 10 Assignments + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text Books

1. Fermentation and Biochemical Engineering Handbook, Principles, Process Design, and Equipment; Edited by Henry C. Vogel; Noyes Publications, New Jersey, U.S.A. ISBN: 0-8 155-1407-7.
2. Biotechnology- Volume 3- Bioprocessing; VCH Verlagsgesellschaft mbH. Weinheim, ISBN 3-527-28313-7 (Weinheim); ISBN 1-56081-153-6 (New York).

Reference Books

1. Principles of Fermentation Technology, P. E. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heinemann, ISBN: 07506 45016.
2. Practical Fermentation Technology, B. Mcneil and L. M. Harvey, John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, ISBN 978-0470-014349

Course Title: Analytical Techniques	**Course Component: Major**
Course code: BTC154C302	**Credit: 4**
Level of course: 500	**L-T-P-C: 4-0-0-4**

Course Objective: The course is designed with an objective to give students the technical know-how of the working of analytical equipment used in Biotechnology.

Course Outcomes:

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

SI No	Course Outcome	Blooms Taxonomy Level
CO 1	**Remember** the specific technique to be used for different analytical characterizations.	**BT 1**
CO 2	**Understand** the working principles of various equipment used in analysis.	**BT 2**
CO 3	Ability to **apply** the acquired knowledge to address research problems.	**BT 3**
CO 4	Ability to **analyse** the data generated by using sophisticated equipment.	**BT 4**
CO 5	Ability to **evaluate** alternative and better methods of sample analysis to reduce time and increase throughput.	**BT 5**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Basic techniques**: Buffer preparations; pH measurement; Cell disintegration; Dialysis and Ultra filtration. **Spectroscopy:** Principles and applications of UV-Visible, Fluorescence and Infrared spectroscopy. **Chromatography:** Principles and applications of Paper and Thin layer chromatography; Size exclusion, Ion exchange, Hydrophobic, Reverse phase and Affinity chromatography; HPLC and FPLC.	**16**
II	**Electrophoresis:** Theory and application of Polyacrylamide and Agarose gel electrophoresis; Different variants of polyacrylamide gel electrophoresis (PAGE) like native, SDS-PAGE, 2D-PAGE, Blotting Techniques: Southern, Western and Northern blotting, Immunoblotting, Immunoelectrophoresis, Immunofluorescence, ELISA.	**16**
III	**Centrifugation:** Sedimentation, Analytical ultra-centrifugation, Preparative ultra-centrifugation: zonal and equilibrium density gradient ultracentrifugation. **Radioactivity:** Concept of radioactivity; Radioactivity counting methods with principles of different types of counters; Autoradiography; Applications of radioactive tracers in biology.	**16**
IV	**Microscopy:** Principles and applications of Simple, Compound and Phase contrast microscope, Fluorescence microscope, confocal microscope, Electron microscopy: SEM & TEM, Cryo-Electron microscopy	**16**
	Total	**64**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (64 class hours + 16 Seminar + 10 Assignments + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text Books

1. Wilson, K., and Walker, J. *Principles and Techniques of Practical Biochemistry*, 5th edition, 2000.

2. Freifelder, D., *Physical Biochemistry, application to Biochemistry and Molecular Biology*, 2nd edition, 1982.

Reference Books:

1. Holme, D., and Peck, H. *Analytical Biochemistry*, 3rd edition, 1998,
2. Scope, R. K. *Protein Purification: Principles and Practice*, 3rd edition, 1993.

Course Title: IPR, Biosafety, Bioethics and Research Methodology	**Course Component: Major**
Course code: BTC154C303	**Credit: 4**
Level of course: 500	**L-T-P-C: 4-0-0-4**

Course Objective: The course aims to introduce students to Intellectual Property Rights and apprise them of ethical issues in the biological sciences and the laws pertaining to these in both the global and national context and also to aware the students with ethical practices appropriate for various scientific disciplines at all times and to adopt safe working practices relevant to the different biotech industries & fields of research.

Course outcome:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** intellectual property laws/principles (including copyright, patents, designs and trademarks) to real problems and to analyse the social impacts of intellectual property law and policy.	**BT 1**
CO 2	**Understand**, recognize and distinguish an ethical issue from other issues	**BT 2**
CO 3	**Apply** the knowledge gained during the course in spreading IPR related awareness.	**BT 3**
CO 4	**Analyse** experimental results for their potential to file suitable IPR.	**BT 4**
CO 5	**Evaluate** their understanding in expanding their future prospects by pursuing entrepreneurial ventures in this field.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	Concept of Property: Tangible and Intangible Property, Intellectual Property-Origin Development and Objectives, Classification of Intellectual Property-Patents, Copyright, Trademark, Industrial Design, Geographical Indications, Protection of Plant Varieties and Traditional Knowledge, Relevance of Intellectual Property Rights for Science and Technology; Patentability Criterion-Discovery and Invention, Patentable Subject Matters; Novelty, Utility (Industrial Applicability), Non-Obviousness (Inventive Step) and Written Description, Product Patents vis-à-vis Process Patents; Patentability of Biotechnology Inventions; Patent Laws in Indian and International Perspective; Indian Patent Act 1970 (Patent Amendment Acts-1999, 2002 and 2005); International Conventions relating to Intellectual Property; General Agreement on Trade and Tariff (GATT); Trade Related Aspects of Intellectual Property Rights (TRIPS)	**12**

II	Biosafety: Definition and requirement; Important symbols and their meaning, Biosafety in relation to human health, environment, transgenic research and applications; International Legal Instruments on Biosafety Cartagena Protocol on Biosafety, Nagoya Protocol Laws relating to Biosafety in India: The Biological Diversity Act, 2002, Biosafety procedures, rules and guidelines under Environment (Protection) Act 1986 and Rules 1989; Biosafety Regulation: Principles and Practices in Microbial and Biomedical Labs; Guidelines for research involving genes; Regulatory bodies at National and International level	**17**
III	Nature, Concept and Relevance of Bioethics; Basic Principles of Bioethics; Legal, Social and Economic Impacts of the Products and Techniques in Biotechnology; Bioethics in Plants, Animals and Microbial Genetic Engineering; Ethical issues in Healthcare; Biopiracy and Bioethics: Application of IPR regime to Biological Resources and Biopiracy, Access to Biological Resources, Benefit Sharing and Informed Consent	**17**
IV	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature study approaches, analysis Plagiarism, Research ethics. Effective technical writing, how to write report, Developing a Research Proposal, Format of research proposal, presentation and assessment by a review committee.	**18**
	Total	**64**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (64 class hours + 16 Seminar + 10 Assignments + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text books

1. Cornish, W. R., Intellectual Property (Latest Edition)
2. Intellectual Property Rights by Paul Goldstein
3. Intellectual Property Rights by K. R. G. Nair, Ashok Kumar, K. R. G. Nair
4. Kilner, John, et.al, eds., Cutting-Edge Bioethics. Eerdmans 2002.

Reference Books:

1. B.L. Wadera, Patents, Trademarks, Copyright, Designs and Geographical Indications
2. S. Ignacimuthu, Bioethics, Alpha Science International, Limited (2009)
3. Matthew Rimmer, Intellectual Property and Biotechnology: Biological Inventions (2008)
4. Arthur L. Caplan, Robert Arp, Contemporary Issues in Bioethics (2014)

Course Title: Genetic Engineering	**Course Component: Major**
Course code: BTC154C304	**Credit: 4**

Level of course: 500	L-T-P-C: 4-0-0-4

Course Objective: The course aims to give in depth knowledge in field of genes and genetic engineering, the mechanism of creation of recombinant products and the role of instrumentation and sequencing process in genetic engineering.

Course Outcome:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the core concept of Genetic Engineering, DNA modifying enzymes and cloning vectors *etc*.	**BT 1**
CO 2	**Understand** the production procedure of recombinant products by molecular cloning.	**BT 2**
CO 3	**Apply** the knowledge gained during the course in the field of research and development.	**BT 3**
CO 4	**Analyze** theoretical knowledge in developing biotechnological solutions in solving various problems.	**BT 4**
CO 5	**Evaluate** their understanding in expanding their future prospects by pursuing entrepreneurial ventures in this field.	**BT 5**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Basics Concepts:** DNA modifying enzymes; Cohesive and blunt end ligation; Linkers; Adaptors Homo-polymeric tailing; Labelling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNase I foot printing	**16**
II	**Cloning Vectors:** Plasmids; Bacteriophages; M13 mp vectors; pUC19 and Bluescript vectors, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/ bacculo & retroviral vectors; Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Baculovirus and Pichia vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors.	**16**
III	**Cloning Methodologies:** Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Jumping and hopping libraries; Southwestern and Far-western cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression	**16**
IV	**Application and study of gene regulation:** DNA transfection, reporter assay, expression strategies for heterologous genes in bacteria, mammalian cells and plants. Targeted gene replacement. **Sequencing methods:** Enzymatic DNA sequencing; Chemical sequencing of DNA; high throughput DNA sequencing.	**16**
	Total	**64**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (64 class hours + 16 Seminar + 10 Assignments + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text books

1. Primrose, S.B., Twyman, R.M., and Old, R.W. *Principles of Gene Manipulation*. 6th Edition, S.B. University Press, 2001.
2. Brown, T.A., Genomes 3, 3rd ed. Garland Science, 2006.

Reference books

1. Sambrook, J., and Russel, D.W., Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
2. Selected papers from scientific journals.
3. Technical Literature from Stratagene, Promega, Novagen, New England Biolab, etc.

Course Title: Practical – III	**Course Component: Major**
Course code: BTC154C315	**Credit: 4**
Level of course: 500	**L-T-P-C: 0-0-8-4**

Course Objective: The course is designed with an objective to train the students in the practical aspect of bioprocess technology, analytical techniques used in biotechnological research, and genetic engineering.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the practical skills associated with Cell Biology and Genetics.	**BT 1**
CO 2	**Understand** the process of isolation of production of fruit-based beverages.	**BT 2**
CO 3	**Apply** the knowledge gained during the course in the development of synthetic seeds.	**BT 3**
CO 4	**Analyse** different DNA samples employing different genetic engineering tools.	**BT 4**
CO 5	**Create** an entrepreneurial venture in field of analytics.	**BT 5**

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	• Designing of stirred tank bioreactor • Production of wine from fruit juice • Isolation of protoplast from plant • Fusion of protoplast	**24**

	• Preparation of synthetic seeds • MBRT Test	
II	• Isolation of genomic DNA from plant • Isolation of genomic DNA from animal • Isolation of genomic DNA from bacteria • Isolation of plasmid DNA from bacteria	**24**
III	• Determination of purity of DNA by spectrometric analysis • Restriction digestion of genomic DNA • PCR amplification of genomic DNA • Agarose gel electrophoresis	**24**
IV	• Paper chromatography • Thin layer chromatography • Silica gel column chromatography • Agarose gel electrophoresis • SDS-PAGE	**24**
	Total	**96**
Pedagogy: Lectures, Experiments, Laboratory sessions		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (96 lab hours + 14 Assignments + 10 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Texts and Reference: As suggested under theory papers.

OR

3rd SEMESTER (*For students with 3rd and 4th Semester Research*)

Course Title: Research Project – Phase 1	**Course Component: Research**
Course code: BTC154R321	**Credit: 20**
Level of course: 500	**L-T-P-C: 0-0-40-20**

SYLLABUS (4th SEMESTER)

Course Title: Dissertation – 1 **	**Course Component: Research**
Course code: BTC154C421	**Credit: 20**
Level of course: 500	**L-T-P-C: 0-0-40-20**

*** Only for Students with research in the 4th Semester*

For 'Coursework only' students, in lieu of dissertation

Course Title: Plant and Animal Physiology	**Course Component: Major**
Course code: BTC154C401	**Credit: 4**
Level of course: 500	**L-T-P-C: 4-0-0-4**

Course Objectives: The objective is to teach the students the structure and function of plants and animals so that they learn about the structure of organs, organ systems, and cells, and how they function.

Course Outcome:

On successful completion of the course the students will be able to:		
SI No	**Course outcome**	**Blooms Taxonomy Level**
CO1	**Remember** about the various organs, organ structures and cell types in plants and animals.	**BT1**
CO2	**Understand** the functions of the organs and organ systems in growth and development.	**BT2**
CO3	Utilize fundamental understanding to analyse the diverse life processes, including the operations of the nervous system, respiratory system, cardiovascular system, excretory system, and digestive system.	**BT3**
CO4	Compare and contrast between different biological systems.	**BT4**

Detailed syllabus:

Modules	Topics & Course Contents	Period
I	Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing, factors affecting stomatal movement. Role of micro and macro nutrients in plants and their mechanism of transport.	**16**
II	Photosynthesis and its importance: Photosynthetic pigments and photosystems, C3, C4 and CAM photosynthesis. Plant growth regulators and its role, Movement in plants, Physiology of flowering, seed dormancy and germination, photoperiodism and vernalization.	**16**
III	Digestive system: Comparative account of physiology of digestive system in herbivores and carnivores. Digestion and absorption of various nutrients; Hormonal control of secretion of enzymes in Gastrointestinal tract in humans. Disorders of the digestive system. Excretory system: Comparative account of physiology of excretory system; Structure of kidney and its functional unit; Micturition; Urine formation; Disorders of the excretory system. Cardiovascular System: Comparative account of circulation; Lymphatic system; Components of blood and their functions; Haemopoiesis; Structure of mammalian heart; Origin and conduction of cardiac impulses; ECG – its principle and significance. Disorders of the cardiovascular system.	**16**
IV	Nervous System: Comparative account of nervous system; Structure of neuron; Types of neurons, Resting membrane potential, Origin of action potential and its propagation; Synaptic transmission; Reflex action and its types. Disorders of nervous system. Respiratory system: Structural components of respiratory system; Mechanism of respiration, Gaseous exchange: CO_2 and O_2 transport, Disassociation curve, respiratory volumes; Comparative account of respiratory systems in animals; Disorders of nervous system. High altitude respiratory adaptations.	**16**
	Total	**64**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

4 credits: 4 × 30= 120 Notional Credit Hours (64 class hours + 16 Seminar + 10 Assignments + 30

Experiential learning)

Experiential learning activities may include:

- Undergraduate research
- Participation in a student design team
- Completion of an internship
- Student teaching
- Classroom presentation *etc*.

Text Books

1. Guyton, A.C. & Hall, J.E. (2015). Textbook of Medical Physiology. XIII Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company. 51 | Page
2. Tortora, G.J. & Grabowski, S. (2017). Principles of Anatomy & Physiology. XI Edition John Wiley & Sons
3. Marieb E.N & Hoehn K.N (2022). Human Anatomy & Physiology. 12th Ed, Pearson Education.
4. Salisbury, F.B. and Ross, C.W. Plant Physiology, Wadsworth Publishing Co. Ltd. 1991, Latest edition.
5. Taiz, L. and Zeiger, E. Plant Physiology, 4th edition, Sinauer Associates Inc .MA, USA, 2006, Latest edition.

Reference Books

1. Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills
2. Dr Ian Kay (1998). Introduction to Animal Physiology. 1st Ed, Garland Science.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.

Course Title: Biophysical Chemistry	**Course Component: Major**
Course code: BTC154C402	**Credit: 4**
Level of course: 500	**L-T-P-C: 4-0-0-4**

Course Objective: The course aims to give a holistic theoretical and practical knowledge in field of basics of Biophysical Chemistry, its role in the life form, and techniques to understand various Biophysical phenomena in living system.

Course Outcome:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the practical skills associated with Biophysical Chemistry.	**BT 1**
CO 2	**Understand** molecular events associated with protein chemistry and basic principles associated with various instruments and techniques.	**BT 2**
CO 3	**Apply** the knowledge gained during the course in the field of research and development.	**BT 3**
CO 4	**Analyse** theoretical knowledge in developing practical solutions in solving real life problems associated with biophysical chemistry.	**BT 4**
CO 5	**Evaluate** their understanding in expanding their future prospects by pursuing entrepreneurial ventures in this field.	**BT 5**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Interaction in biological systems:** Intra and inter molecular forces, electrostatic interactions, hydrogen bonding, van der Waal interactions, hydrophobic interactions, disulfide bond. **Biophysics of Water:** Physicochemical properties of water, Molecular structure, Nature of hydrophobic interactions, Water Structure. **Bioenergetics:** Concept of energy coupling in biological processors, Energy requirements in cell metabolism, structure and role of mitochondria, high energy phosphate bond, energy currency of cell, biological oxidation, Electron-transport chain, Oxidative Phosphorylation including chemiosmotic hypothesis.	**16**
II	**Protein Structure:** Conformational properties of polypeptide, Ramachandran plot. Primary and secondary structure of proteins; alpha helix, beta sheet and random coil Tertiary structure; concept of domain and fold, Quaternary structure; Oligomeric proteins and cooperativity, Metalloproteins, Structural features of membrane proteins, intrinsically disordered proteins. **Protein purification techniques:** Gel filtration assay. SDS-PAGE Vs Native PAGE, 2D Gel electrophoresis	**16**
III	**Multiple equilibrium:** Titration of proteins to evaluate total and net charge; Scatchard and hill plots; Protein stability, denaturation, unfolding equilibrium; Kinetics and thermodynamics of protein folding; Protein refolding and aggregation; Effect of solvent and temperatures on the protein stability and folding, Heat Shock Proteins (Hsp) and their role in protein folding, scrapie proteins, Differential scanning calorimetry.	**16**
IV	**Methods for the structure analysis:** Far-UV and near UV-Circular Dichroism (CD); Fluorescence, single molecule fluorescence spectroscopy, fluorescent probes; Hydrogen-Deuterium (H-D) exchange; Fourier-transform Infrared (FT-IR) spectroscopy; Mass spectrometry (ESI and MALDI-TOF); Nuclear magnetic resonance (NMR) spectroscopy; X-ray crystallography.	**16**
	Total	**64**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

4 credits: 4 × 30= 120 Notional Credit Hours (64 class hours + 16 Seminar + 10 Assignments + 30 Experiential learning)

Experiential learning activities may include:

- Undergraduate research
- Participation in a student design team
- Completion of an internship
- Student teaching
- Classroom presentation *etc*.

Text Books:

1. Nelson, D.L., Cox, M.M. *Lehninger Principles of Biochemistry*, 4th Edition, 2004, W. H. Freeman and Co., New York, USA

Reference Books:

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. *Biochemistry*, 6th Edition, 2006, W.H. Freeman and Co.
2. Buchanan, B., Gruissem, W. and Jones, R. *Biochemistry and Molecular Biology of Plants*, 2nd Edition,

2015, American Society of Plant Biologists, USA.

Course Title: Genomics and Proteomics	**Course Component: Major**
Course code: BTC154C403	**Credit: 4**
Level of course: 500	**L-T-P-C: 4-0-0-4**

Course objectives: The course is designed to appraise the students to the vital concepts of technologies pertinent to Genomics and Proteomics, their applications and demonstrate skills to apply the knowledge in scientific queries.

Course outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the various techniques involved in the study of genomics and proteomics.	**BT 1**
CO 2	**Understand** the basic principle of all the techniques associated with genomics and proteomics study.	**BT 2**
CO 3	**Apply** the knowledge in the study of genomics and proteomics of a cell under specific conditions.	**BT 3**
CO 4	**Analyze** the effect of various intrinsic and extrinsic factors in the genome and proteome of a cell under certain conditions	**BT 4**
CO 5	**Evaluate** better and alternative methods to analyse the sample in cost effective manner.	**BT 5**

Detailed syllabus:

Modules	**Topics / Course content**	**Periods**
I	**Genomics:** DNA markers - SNP; STR; QTLs, RFLP; RAPD, cDNA and genomic libraries, Physical mapping of DNA by building genomic libraries, Clone contigs, YAC, BAC and PAC, Functional Genomics, DNA microarray, Functional analysis by gene knockouts	**16**
II	**PCR and Its Applications:** Primer design; Fidelity of thermostable enzymes; DNA polymerases, Types of PCR - multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; Basic concepts of genome sequencing, Next generation sequencing strategies, brief study about 3rd and 4th generation of sequencing	**16**
III	**Basics of proteomics:** Protein folding and modification, Types of proteomics, Protein sequencing, Protein structure determinations and Structural proteomics, Proteomic interactions (Y2H approaches, Co-IP); Concepts of protein engineering.	**16**
IV	**Proteomic technologies:** Microarray technology; Analytical proteomics tools (1-D & 2-D gel electrophoresis); Chromatography, in gel digestion, Mass spectrometry and analysis (ESI, MALDI), LC/MS-MS; Peptide mass fingerprinting.	**16**
	Total	**64**
Pedagogy: Lectures, Assignments, Seminars		

Credit distribution:

4 credits: 4 × 30= 120 Notional Credit Hours (64 class hours + 16 Seminar + 10 Assignments + 30 Experiential learning)

Experiential learning activities may include:

- Undergraduate research
- Participation in a student design team
- Completion of an internship
- Student teaching
- Classroom presentation *etc*.

Text Books:

1. Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Campbell AM & Heyer LJ, Benjamin Cummings 2007; CSH Press, NY. ISBN-10: 8131715590
2. Principles of Proteomics. R.M Twyman (2004) (BIOS Scientific publishers). ISBN-10: 1859962734
3. Genome III – T.A. Brown Garland Science Publ. June 08, 2006. ISBN-10: 0815341385

Reference Books:

1. Principles of Gene Manipulation and Genomics- Primrose S & Twyman R, 7th Edition, Blackwell, 2006. ISBN-10: 1405135441
2. Principles of Genome Analysis and Genomics. Primrose SB & Twyman RM. 2007. Blackwell. ISBN-10: 1405101202
3. Introduction to Genomics. A.M Lesk, Oxford University press, 2007. ISBN-10: 0199557489
4. A Primer of Genome Science. Greg Gibson and Spencer V. Muse. 2nd ed. 2004. SINAUER Associates Inc. ISBN-10: 0878932364

Course Title: Food Biotechnology	**Course Component: Major**
Course code: BTC154C404	**Credit: 4**
Level of course: 500	**L-T-P-C: 4-0-0-4**

Course Objective: The main objective of the course is to provide the graduates with the knowledge of biofertilizers and their applications in agriculture.

Course Outcome:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the various sources for production of food	**BT 1**
CO 2	**Understand** the principles and applications of enzymes and molecules	**BT 2**
CO 3	**Apply** the knowledge in practical applications for preparation of food	**BT 3**
CO 4	**Analyze** the role of biotechnology in food production.	**BT 4**
CO 5	**Develop** sophisticated methods for efficient production of traditional food items integrating biotechnology.	**BT 5**

Detailed Syllabus:

Modules	**Topics & Course Contents**	**Periods**
I.	Role of microorganisms in food production, History of the use of microorganisms in food, microorganisms in dairy products, meat industry and wine industry. Factors affecting microbial growth, Cancer causing foods, Contaminants in food, enzymes in food industry.	**16**

II	Colouring agents in food industry, Flavouring agents in food industry, Role of anti-oxidants, emulsifying and stabilising agents and food preservatives in flavour, Role of Flavour Enhancers, Stabilizers and Sweeteners in food industry	**16**
III	Food spoilage-causes and prevention, Food poisoning- causes and prevention, Foodborne diseases, refrigerated foods, canned foods, Dry Foods, Fermented and Pickled Foods, Food Labels and Allergens. Methods of Food preservation and processing, Methods in Food packaging.	**16**
IV	Fermented foods and their role in human health, Macro and Micronutrients from foods, Regulators of food industry, FSSAI, FDA, MOFPI, Regulations in production of GM foods. Benefits and risks of GM foods	**16**
	Total	**64**
Pedagogy: Lectures, Experiments, Laboratory sessions		

Credit distribution:

4 credits: 4 × 30= 120 Notional Credit Hours (64 class hours + 16 Seminar + 10 Assignments + 30 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Text Books:

1. Ratledge, C. and Kristiansen, B. (Eds.) (2006) Basic Biotechnology. 3rd Edition. Cambridge University
2. Johnson-Green, P. (2002). Introduction to Food Biotechnology

Reference Books:

1. Adams, M.R., and Moss, M.O. (2000). Food Microbiology. Second Edition. The Royal Society of Chemistry, UK.
2. Wood, B.J.B. (Editor) (1998). Microbiology of Fermented Foods, 2-Volumes, Second Edition. Blackie Academic & Professional, London.

Course Title: Practical – IV	**Course Component: Major**
Course code: BTC154C415	**Credit: 4**
Level of course: 500	**L-T-P-C: 0-0-8-4**

Course Objective: The course is designed with an objective to train the students in the practical aspect of plant and animal physiology, genomics and proteomics, and food biotechnology.

Course Outcomes:

On successful completion of the course the students will be able to:		
SI No	**Course Outcome**	**Blooms Taxonomy Level**
CO 1	**Remember** the practical skills associated with Cell Biology and Genetics.	**BT 1**
CO 2	**Understand** isolation, screening, characterization, and identification of important microbes from various food sources.	**BT 2**

CO 3	**Apply** the knowledge gained during the course in the field of research and development.	**BT 3**
CO 4	**Analyse** the genetic basis of health issues and provide solutions based on genomics and proteomics.	**BT 4**
CO 5	**Develop** scientifically sound and optimized methods for food analyses.	**BT 5**

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	• Study of frog/human blood film. • Finding the coagulation time, blood groups, RBC count, TLC, DLC • Haemolysis: effect of isotonic, hypotonic, & hypertonic solution on Erythrocyte. • Determination of Haemoglobin • Preparation of haemin crystals.	**24**
II	• Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf. • Demonstration of plasmolysis by Tradescantia leaf peel. • Demonstration of opening & closing of stomata • Demonstration of guttation on leaf tips of grass • Separation of photosynthetic pigments by paper chromatography. • Demonstration of aerobic respiration. • Preparation of root nodules from a leguminous plant.	**24**
III	• Primer designing for PCR amplification of DNA. • Protein isolation plant and animal samples. • Separation of proteins by SDS-PAGE • Detection of proteins using western blotting	**24**
IV	• Isolation of pathogens from food samples. • Estimation of proteins and carbohydrate from given food sample. • Estimation of antioxidant properties of green leafy vegetables • Estimation of fatty acids from a lipid sample • Adulteration test of dairy products	**24**
	Total	**96**
Pedagogy: Lectures, Experiments, Laboratory sessions		

Credit distribution:

4 credits: 4 × 30 = 120 Notional Credit Hours (96 lab hours + 14 Assignments + 10 Experiential learning)

Experiential learning activities may include:

- undergraduate research
- participation in a student design team
- completion of an internship
- student teaching
- classroom presentation *etc.*

Texts and Reference: As suggested under theory papers.

OR

4th SEMESTER (For students with 3rd and 4th Semester Research)

Course Name: Research Project – Phase 2	**Course Component: Research**
Course code: BTC154R421	**Credit: 20**
Level of course: 500	**L-T-P-C: 0-0-40-20**