INTEGRAL UNIVERSITY, LUCKNOW

SYLLABUS

&

EVALUATION SCHEME

for

M.TECH. BIOTECHNOLOGY

(with effect from 2020-2021)

(Students admitted 2020 onwards)

Integral University
M. Tech. Biotechnology
(with effect from Session 2020-2021)
(Students admitted 2020 onwards)

1st Year **1st Semester**

S. No.	Course Category	Subject Code	Subject	Periods and Credits				Evaluation Scheme				Subject Total
								Sessional (CA)			(ESE)	
				L	T	P	C	CT	TA	Total		
1	DC	BE-501	Biochemistry	2	1	0	3	40	20	60	40	100
2	DC	BE-502	Bioanalytical Techniques	3	1	0	4	40	20	60	40	100
3	DC	BE-503	Microbial Genetics and Technology	2	1	0	3	40	20	60	40	100
4	DC	BE-504	Cell and Molecular Biology	3	1	0	4	40	20	60	40	100
5	DC	BE-505	Bioprocess Engineering	3	1	0	4	40	20	60	40	100
6	DC	BE-506	Biochemistry and Microbiology Lab	0	0	6	3	40	20	60	40	100
Total				**13**	**5**	**6**	**21**	**240**	**120**	**360**	**240**	**600**

BIOCHEMISTRY
BE-501

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: This course is designed to introduce the organic structure of living systems mainly dealing with biomolecules like carbohydrates, proteins, lipids, enzymes and their metabolism. This course will lay the foundation for other advanced courses like physiology, cell biology, molecular biology and metabolic engineering.

UNIT I	**Carbohydrates** Structure and properties of mono, di, oligo and polysaccharides; complex carbohydrates, TCA cycle, glycolysis, gluconeogenesis, pentose phosphate shunt. Respiratory chain, ATP cycle, energy rich compounds.	**8**
UNIT II	**Lipids** Structure and properties of fatty acids, Glycerolipids, phospholipids, sphingolipids, Glycolipids, steroids. Biosynthesis and degradation of fatty acids and cholesterol.	**8**
UNIT III	**Proteins** Structure and properties of amino acids, peptides, proteins and conjugated proteins. Urea cycle. Biosynthesis and degradation of amino acids and proteins.	**8**
UNIT IV	**Nucleic Acids** Structure and properties of purines, pyrimidines, nucleosides, nucleotides, polynucleotides. Ribonuclic acid and deoxyribonucleic acids, nucleoprotrein complexes. Biosynthesis and degradation of purines, pyrimidines and nucleic acids.	**8**

Text Books:

1. Nelson & Cox, Lehninger's Principles of Biochemistry, 5th Edition
2. Harpers Biochemistry, McGraw Hill
3. Stryer, Biochemisrty, Freeman.
4. Donald Voet, J.G.Voet, Biochemistry, John Willey. Voet & Voet, "Biochemistry".

BIOANALYTICAL TECHNIQUES
BE-502

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Course Objective: The paper will help students to acquaint with basic instrumentation, principle and procedure of various sophisticated instruments like HPLC, FACS, GLC and NMR etc. This will enable the students to implement the use of these techniques in biological research and in discovering new products/compounds.

UNITI	**Centrifugation**	**8**
	Centrifugation: types of rotors; principles and application of differential, zonal, density gradient and ultra-centrifugation.	
UNITII	**Electrophoresis and Chromatography**	**8**
	Electrophoresis: principles and applications of moving boundary and zone electrophoresis including gel electrophoresis (PAGE, starch, agarose and Pulse Field gel Electrophoresis),isoelectric focusing, isotachophoresis; Chromatography: Adsorption, partition, ion-exchange, reverse phase, covalent, gel filtration, affinity, gas chromatography, HPLC and FPLC.	
UNITIII	**Spectroscopy and Microscopy**	**8**
	Basic Principles of Spectroscopy: UV-visible, atomic absorption, ESR, NMR, IR, mass and plasma emission spectroscopy. Microscopy: Simple, compound, phase contrast, electron (transmission, scanning) and confocal microscopy.	
UNITIV	**Radiotracer Technology**	**8**
	Radiotracer technology, use of radioactive isotopes in biological system; autoradiography, Geiger-Muller counter, Liquid scintillation counter; CD;ORD;X-ray crystallography; Biosensors; Flow cytometer; Freeze drying; Amino acid analyzer.	
UNITV	**Environmental Analytical Techniques**	**8**
	Analysis of Biomass; measurement of dry weight and biomass composition; Measurement of BOD and COD in Waste-Waters; Gas Analysis for O_2 and CO_2; Flow injection analysis.	

Books Suggested:

1. Wilson K, Walker J, Walker JM,"Principles and Techniques of Practical Biochemistry".
2. Sambrook J, Russell DW, Sambrook J, "Molecular Cloning: A Laboratory Manual".
3. William M, O'Leary Robert, Dony Wu,"Practical Handbook of Microbiology".
4. Brown, TA, "Gene cloning: An introduction".
5. Cantor CR, Schimme IPR, "*Biophysical Chemistry"*.
6. Lehninger A, *"Principles of Biochemistry".*
7. Voet & Voet, "Biochemistry".

MICROBIAL GENETICS & TECHNOLOGY

BE-503

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The course is designed to understand the basics of microbial growth, reproduction, methods of genetic exchange. It will also focus on the media design, modes of operation of fermenter for large scale biomass and product formation and industrial applications of microbes

UNIT I	**Microbial nutrition and growth**	**8**
	Principle of microbial nutrition, formulation of culture media, selective media, factors influencing the choice of various carbon and nitrogen sources, vitamins, minerals, precursors & antifoam agents; Importance of pH; Starter culture; Principles of media and air sterilization; kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilizer, sterilization of air, design of filter; Radiation, chemical and steam sterilization	
UNIT II	**Microbial growth kinetics under different culture systems**	**8**
	Kinetics of microbial growth, substrate utilization and product formation: growth phases of a batch culture, synchronous culture, determination of kinetic parameters by batch, fed batch and continuous culture; Analysis of chemostat performance. Kinetics of growth & product formation by filamentous organisms; Role of maintenance and endogenous metabolism in substrate utilization & growth; structured models: Compartmental models; Gaden's and Deindoerfer's classifications	
UNIT III	**Applied Microbial Genetics**	**8**
	Horizontal gene transfer (Conjugation, transduction and transformation), Complementation, Molecular recombination, Mapping of bacterial genes; Genetic and physical maps; Replication of RNA tumor viruses	
UNIT IV	**Microbial Technology**	**8**
	Isolation, maintenance and preservation of industrial strains. Strain improvement, screening and selection of industrially important microbes**.** Large scale production and commercial applications of enzymes: proteases and amylases ; solvents and antibiotics: acetic acid, ethanol, acetobutanol, penicillin and streptomycin	

Books Suggested:

1. Bailey J E and Ollis DF, "Biochemical Engineering fundamentals".
2. Stanbury PF, Whitaker A, "Principles of Fermentation Technology".

3. "Principles of Cell Energetics": BIOTOL series, Butterworth - Heinemann.
4. Moser A, "Bioprocess Technology - Kinetics & Reactors".
5. Schugerl K, "Biotechnology" Vol.4 Meaning Modeling and Control.
6. Atkinson B, Mavituna F, "Biochemical Engineering and Biotechnology Handbook".
7. Goodenough U, "Genetics".
8. Swanson G P, Mertz & Young, "Cytogenetics".
9. Luria & Darnell, "General Virology".
10. Strickberger MW,*"Introduction to Genetics".*
11. Pirt SJ, "Principles of Microbe and Cell Cultivatio

CELL & MOLECULAR BIOLOGY
BE-504

w.e.f. Session 2020-21

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Objective: The objective of the course is learning and understanding the fundamentals of molecular biology and cellular signalling. The application of the course focuses on fundamental concepts and their implications on disease processes.

UNIT I	**DNA replication** Initiation, elongation and termination; Roles of DNA Polymerase I, II, III, DNA ligase, DNA gyrase, Topoisomerases, Primase, Helicase, HD protein; Okazaki fragments; RNA primers; Repair by DNA polymerase I and DNA ligase; Eukaryotic replication; Regulation of prokaryotic and eukaryotic replication; Fidelity of replication **End Replication and Role of Telomerase.**	**8**
UNIT II	**Transcription** Transcription: Prokaryotic and eukaryotic transcription: Initiation, elongation and termination; DNA - dependent RNA polymerase (RNA Pol in prokaryotes and RNA Pol I, II, III in eukaryotes): Physical properties, subunit structure; Sigma cycle; Promoter; Enhancer and other regulatory elements; Transcription factors; RNA - dependent DNA polymerase; Reverse transcription. Post- transcriptional / Co-transcriptional processing: Maturation of rRNA, mRNA, tRNA; 5` capping; RNA splicing; Alternative splicing; RNA editing; Poly A tail formation; Regulation of transcription in both prokaryotes and eukaryotes. **mRNA stability, Nuclear export of mRNA and its regulation . Inhibitors of transcription and their mechanism of action.**	**8**
UNIT III	**Translation and Gene Regulation** Genetic code: Evidence for a triplet code; Properties of the code sequential; Ubiquitous (almost); Degenerate; Wobble hypothesis, Nonsense codons; Sense codons; Translation: Activation of amino acids; Charging of tRNA; Adapter role of tRNA; Amino acyl tRNA synthetase; Initiation, elongation and termination of translation in prokaryotes and eukaryotes; A, P and E sites of ribosomes; Roles of initiation, elongation and release factors; Ribosome recycling; **Inhibitors of translation**, Post - translational processing; Protein targeting: targeting of secretory proteins - targeting to endoplasmic membrane, golgi complex, lysosomes and plasma membrane; **Protein degradation Ubiquitin-Proteosome Pathway ,Fidelity of translation** Concept of operon: lac and trp operons, **Attenuation,**	**8**

	RNA **Interference, Chromosome remodeling and Histone modification.**	
UNIT IV	**DNA mutation and Repair**	**8**
	Mutation: Spontaneous, induced; Chemical and physical mutagens; Non sense mutation; Missense mutation; Frame shift mutation; Suppressor mutation; Different methods of DNA repair and SOS response; **Methods to assess genotoxicity. Transposition**	
UNIT V	**Cell Signalling**	**8**
	Cell division; Cell cycle and role of cyclin dependent kinases in its regulation; Cell - cell interaction, **Extracellular Matrix, Structure and organization of actin and myosin; Microtubules and Intermediary filaments; Organization and function**.Apoptosis and factors governing apoptosis; Basics of signal transduction: Synthesis and regulation of signalling molecules , G protein and phospholipids signaling, cyclic nucleotides, role of calcium in signaling, protein kinases as primary elements in signaling.	

Books Suggested:

1. Lewin, “Genes”.
2. Freifelder DM, “Molecular Biology”.
3. Brown T A, “Genomes”.
4. Watson J D, “Molecular Biology of the Gene”.
5. Twyman R M, “Advanced Molecular Biology”.
6. Brown T A, “Gene cloning: An introduction”.
7. Old & Primrose, “Principles of Gene Manipulation”.
8. Primrose S B, “Molecular Biotechnology”.
9. Cibelli J B, Robert P, Keith L, Michael C, West D, “Principles of Cloning”.
10. Voet&Voet, “Biochemistry
11. Stryer L, “Biochemistry”.

BIOPROCESS ENGINEERING

BE-505

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Objective: Students are made capable of designing protocols for industrial scale production of medicinally and commercially important metabolites. Students can develop better understanding and perform more efficiently in commercial as well as research areas associated with medical research, food processing, agriculture, pharmaceutical development, waste management, and numerous other fields of science and industry.

UNIT I	**Introduction to Bioprocess and Engineering calculations**	**8**
	Role of process engineering principles in biotechnological industries, Current scenario of biotechnological industries, Dimensional analysis, Dimensionless numbers and their significance in Heat, Mass and Momentum transfer, Method/Process validation.	
UNIT II	**Material and Energy Balances**	**8**
	Steady state and unsteady state Material and Energy Balance calculations.	
UNIT III	**Fluid mechanics**	**8**
	Fluids vs solids, Fluid statics and applications including manometer; Mass and energy balances in fluid flow; Bernoullis equation, its corrections and applications including pump work; Newton's law of viscosity; Measurement of viscosity of fermentation broths; flow curves for Non- Newtonian fluids and examples from bioprocess fluids; Pressure drop due to skin friction; Significance of friction factor and Reynold's number; Boundary layer theory and form friction; Pressure drop due to form friction; Flow past immersed bodies and drag coefficients; Pressure drop in flow through packed beds; Fluidization and Pressure drop across fluidized beds; Flow machinery and control: overview of valves and pumps.	
UNIT IV	**Heat transfer**	**8**
	Heat transfer requirements of microbial cultivations including correlations for the determination of heat transfer coefficients; Models of heat transfer and examples; Fourier's law of heat conduction and analogy with momentum transfer, heat transfer through a cylindrical pipe wall; Convection and concept of heat transfer coefficient,	

	application of dimensional analysis to heat transfer from pipe to a flowing fluid; Thermal boundary layer and Prandtl number; Overall heat transfer coefficient; Correlations for heat transfer coefficients in natural and forced convection; Overview of heat exchangers and concept of LMTD.	
UNIT V	**Mass transfer**	**8**
	Diffusion and mass transfer: Fick's law of diffusion; Analogy with momentum and energy transport; Diffusivities of gases and liquids; Fundamentals of mass transfer: Theories of mass transfer, concept of mass transfer coefficient, correlation for mass transfer coefficients, Oxygen requirements of microbial culture: oxygen mass transfer fundamentals, oxygen transfer and oxygen demand, oxygen transfer by aeration and agitation, determination of oxygen transfer coefficient by various methods including sulfite oxidation, dynamic gassing out and oxygen balance methods, factors affecting oxygen transfer coefficients.	

Books Suggested:

1. McCabe WL, Smith JC, Harriot P, "Unit operations of Chemical Engineering", Mc Graw-Hill.
2. Cussler EL, "Diffusion" Cambridge University Press.
3. Doran PM, "Bioprocess Engineering Principles", Academic Press.
4. Pirt SJ, "Principles of Microbe and Cell Cultivation".

BIOCHEMISTRY & MICROBIOLOGY LAB
BE-506

Pre-requisite	Co-requisite	L	T	P	C
None	None	0	0	6	3

Objective: The lab is designed to train the students in basic and some advanced techniques of Biochemistry like isolation, purification, and estimation of biomolecules. It also deals with microbial techniques of isolation, purification and maintenance of microbial cultures.

Microbiology:

1. Maintenance and identification of microorganisms.
2. Biochemical Characterization of microbes
3. Analysis of various pigments in cyanobacteria
4. Standardization of growth curve of different microbes

Biochemistry:

5. Electrophoresis in Agarose and SDS gels
6. Membrane separation of proteins
7. Extraction of phytochemicals and thin layer chromatography
8. Estimation of carbohydrates-glucose and starch
9. Estimation of proteins and nucleic acid

Reference:

1. J.Jayaraman, Lab Manual in Biochemistry, Wiley Eastern LTd
2. Bergey's Journal of Determinative Biotechnology Edn
3. Collins and Lyne, Microbiological Methods, Butterworths, Singapore,5thEd.
4. Plummer, An Introduction to Practical Chemistry, Tata-McGraw Hill, New Delhi, 3rd Ed.

Integral University
M. Tech. Biotechnology
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1st Year **2nd Semester**

S. No.	Course Category	Subject Code	Subject	Periods and Credits				Evaluation Scheme				Subject Total
								Sessional (CA)			ESE	
				L	T	P	C	CT	TA	Total		
1	DC	BE-507	Fermentation Technology	3	1	0	4	40	20	60	40	100
2	DC	BE-508	Downstream Processing	2	1	0	3	40	20	60	40	100
3	DC	BE-509	Genetic Engineering	2	1	0	3	40	20	60	40	100
4	DC	BE-510	Enzyme Engineering	3	1	0	4	40	20	60	40	100
5	DE	BE-512	Nanobiotechnology	2	1	0	3	40	20	60	40	100
		BE-513	Plant Cell Technology									
		BE-514	Pharmaceutical Biotechnology									
		BE-515	Bioreactor Engineering									
6	DC	BE-511	Fermentation Technology & Genetic Engineering Lab	0	0	6	3	40	20	60	40	100
7	DC	BE-516	Applied Microbiology and Biotechnology	2	1	0	0	40	20	60	40*	100*
Total				**14**	**6**	**6**	**20**	**240**	**120**	**360**	**240**	**600**

* A zero-credit foundation course. Candidate has to pass the course by securing at least 50% marks

FERMENTATION TECHNOLOGY
BE-507

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Objective: The objectives of this course are to develop the understanding of ideal and non-ideal bioreactors, introduce concepts of heterogeneous reaction system, Develop understanding of strategies for scale-up of bioreactor, built concepts of control and monitoring in bioreactors.

UNIT I	**Analysis of Ideal Bioreactors**	**8**
	Analysis of ideal bioreactors: The ideal batch reactor, Continuous Stirred Tank Reactor (CSTR), series of CSTRs, turbidostat, chemostat, fed batch, plug flow reactors	
UNIT II	**Heterogeneous Reaction Systems**	**8**
	Heterogeneous reaction systems: Zero order and First order kinetics of concentration profile with reference to spherical geometry and other shapes, Effectiveness factor, External and internal mass transfer, General comments on heterogeneous reactions in bioprocessing.	
UNIT III	**Monitoring, Control and Modelling of Bioreactors**	**8**
	Modeling, analysis and design of bioreactor; Control of bioreactors, case studies; Solid state fermentation. Overview of methods for online and offline monitoring of bioreactors: bioprocess control methodologies; Analysis of alternate bioreactor configurations including cell-recycle, air-lift, and immobilized-cell bioreactors.	
UNIT IV	**Fermentative Production of Metabolites**	**8**
	Media for industrial fermentation; Large scale production of amylase, acetic acid, ethanol, penicillin and L-Lysine.	
UNIT V	**Scale-up of Bioreactor**	**8**
	Scale-up of microbial bioreactors: Various approaches to scale-up including regime analysis and scale-down; Scale-up methods by currently used rules-of-thumb viz. constant P/V, K_La etc.	

Books Suggested:

1. Fogler, H. S. (1999). Elements of chemical reaction engineering.
2. Doran, P. M. (1995). *Bioprocess engineering principles*. Academic press.
3. Bailey, J. E., & Ollis, D. F. (1976). Biochemical engineering fundamentals. *Chemical Engineering Education*.
4. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier

DOWNSTREAM PROCESSING
BE-508

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: To impart to the students the knowledge of various separation and purification techniques and enable them to design these processes.

UNIT I	**Introduction to Bioprocess and Primary isolation methods**	**8**
	Overview of a bioprocess including upstream and downstream processing; Intracellular and extracellular product recovery: cell disruption and extraction. Primary isolation methods including separation of particulate by filtration, centrifugation, settling, sedimentation, decanting, microfiltration and membrane based method; Solvent extraction, sorption, precipitation, ultrafiltration and Reverse osmosis.	
UNIT II	**Purification methods**	**8**
	Fractional precipitation, electrophoresis, chromatography, adsorption, product polishing, crystallization, drying.	
UNIT III	**New and Emerging techniques**	**8**
	Pervaporation, Super liquid extraction, Foam based separation, Lyophilization, High Throughput Screening.	
UNIT IV	**Effluent Treatment**	**8**
	Aerobic and anaerobic water treatment processes: activated sludge, trickling filter, fluidized expanded bed reactor, Upflow anaerobic sludge blanket reactor.	

Books Suggested

1. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, Oxford University Press
2. B.Shivshankar, Bioseparations: Priniples and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012
3. Bioseparation & bioprocessing (2nd Ed.) 2-Volume set, Ed SUBRAMANIAN Ganapathy, Wiley-VCH, (09-2007)
4. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, WileyInterscience Publication, 1988.
5. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989

GENETIC ENGINEERING
BE-509

Pre-requisite	Co-requisite	L	T	P	C
Molecular Biology	**None**	**2**	**1**	**0**	**3**

Objective: The course is designed to make the students understand the concept and basic steps in gene cloning, to acquaint them with various vectors and enzymes used in recombinant DNA technology, transformation and screening techniques. They will also be acquainted with modern techniques such as PCR technology, Real-Time PCR, Site-directed mutagenesis, Antisense RNA technology and RNA interference.

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UNIT I	**Enzymes used in Genetic Engineering**	**8**
	Types of restriction enzymes, Nomenclature, Isoschizomers, Neoschizomers, Heterohypekomers, DNA digestion, Restriction mapping; Other enzymes used in Genetic Engineering: Alkaline phosphatase, DNA ligase, Reverse transcriptase, DNA Polymerase, Polynucleotide kinase, DNase, RNase, Terminal deoxynucleotidyl transferase, Taq polymerase, Topoisomerase.	
UNIT II	**Cloning vectors**	**8**
	Cloning vectors viz. Plasmids, λ phage, M13 phages, Yeast cloning vectors, Plant and animal viruses, Cosmids, Phagemids, Phasmids, Ti plasmid based vectors; Stringent and relaxed plasmids; Cloning strategies used with different vectors; Expression vectors; Linkers, Adaptors, Homopolymer tailing.	
UNIT III	**Transformation**	**8**
	Transformation of host cells, chemical induction,in vitro packaging, Agrobacterium mediated transformation, microprojectile bombardment, electroporation, and microinjection; Genomic and cDNA library construction; Subtractive hybridization.	
UNIT IV	**Techniques in r-DNA Technology**	**8**
	Techniques in r-DNA Technology: DNA sequencing; PCR, Variants of PCR, Cloning of PCR product, RACE, Real-Time PCR; Site-directed mutagenesis; Antisense RNA technology; RNA interference; Cosuppression, Molecular markers: RFLP, RAPD, AFLP, EST.	

	Selectable markers, Reporter genes, Preparation of probes, Colony hybridization, Southern hybridization, Northern hybridization, Dot blots, Western blotting, Public concerns related to recombinant DNA technology; Safety guidelines of rDNA research.	

Books Suggested:

1. Old RW, and Primrose SB, Principles of Gene Manipulation, Blackwell Scientific Pub.
2. Lewin B, "Genes VIII".
3. Winnecker EL, "From Genes to Clones".
4. Freifelder DM, “Molecular Biology”.
5. Brown TA, “Genomes”.
6. Watson JD, “Molecular Biology of the Gene”.
7. Twyman RM, “Advanced Molecular Biology”.
8. Brown TA, “Gene cloning: An introduction”.
9. Old & Primrose, “Principles of Gene Manipulation”.
10. Primrose SB, “Molecular Biotechnology”.
11. Cibelli JB, Robert P, Keith L, Michael C, West D, “Principles of Cloning”.
12. Voet & Voet, “Biochemistry”.
13. Voet & Voet, “Biochemistry”.

ENZYME ENGINEERING
BE-510

Pre-requisite	Co-requisite	L	T	P	C
None	None	3	1	0	4

Objective: To enable the students with the know-how of designing enzymatic processes and reactors, understanding enzyme kinetics, understanding and designing immobilization process and the basics of enzymatic reactions in organic media.

UNIT I	**An introduction to Enzymes and applications**	**8**
	Introduction, Allosteric enzymes, Ribozymes, Abzymes; Applications in industrial, medical, analytical, chemical, pharmaceutical and food sectors; Enzyme isolation and purification methods.	
UNIT II	**Enzyme kinetics**	**8**
	Michaelis-Menten kinetics, kinetics for reversible reactions; Effect of various types of inhibition, evaluation of kinetic parameters; Multi-substrate reactions and their kinetics.	
UNIT III	**Enzyme immobilization**	**8**
	Immobilized enzymes: Methods of enzyme immobilization, factors affecting immobilized enzymes, kinetics of immobilized enzymes, internal and external mass transfer effects in immobilized-enzyme reactors, intra-particle diffusion, micro-environmental effects on enzyme kinetics, enzyme deactivation, operational stability and optimization, general design considerations for the immobilization process.	
UNIT IV	**Design and Analysis of enzyme reactors**	**8**
	Types of Reactors (Modes of operation), Basic design of enzyme reactors under Ideal conditions (Batch and continuous mixed reactors, continuous packed bed reactor under plug flow regime), Effect of Diffusional restrictions on Enzyme reactor design and performance in heterogeneous systems. Parameters affecting the performance of enzyme reactors.	
UNIT V	**Case study of Enzymatic Processes**	**8**
	Enzyme reactions in organic media; Study cases of Enzymatic Processes: (any one enzyme/biocatalyst like Proteases, Acylases, Lipases, Oxidoreductases, Aldolases, Amylases etc. to mention a few (Recommended topics to be covered-Applications of the biocatalyst,	

	sources and production of biocatalyst, structure and mechanism, improvement of the biocatalysis reaction).	

Books Suggested:

1. Lee JM, "Biochemical Engineering", Prentice Hall.
2. Lehninger A, "Principles of Biochemistry".
3. Vieth WR, "Design and Analysis of immobilized Enzyme Flow Reactors".
4. Stryer L, “Biochemistry”.
5. Voet, Voet, “Biochemistry”.
6. Shuler, “Bioprocess Engineering”.
7. Fersht A, “Enzyme Structure and Mechanism”.
8. Sigman DS, Sigman PS, “The Enzymes: Mechanisms of Catalysis”.
9. Palmer T, “Enzymes”.
10. Dixon, Webb, “Enzymes”.
11. Andres Illanes, “Enzyme Biocatalysis: Principles and applications”
12. Vladimir Leskovac, “Comprehensive Enzyme Kinetics”

FERMENTATION TECHNOLOGY & GENETIC ENGINEERING LAB
BE-511

L	T	P	C
0	0	6	3

Objective: The lab is designed to train the students in basic and some advanced techniques of fermentation and Genetic Engineering.

1. Immobilization (calcium alginate/ polyacrylamide/glutaraldehyde) of whole cells and enzymes.
2. Organic acid/ alcohol/ enzyme production through fermentation, estimation of product, its separation and its purification
3. Design and scale-up of fermentation parameters
4. Isolation of plasmid/ phage and plant/ animal (genomic) DNA.
5. Agarose gel electrophoresis, visualization of DNA on gels and analysis of isolated DNA.
6. Amplification of DNA (using PCR) and restriction digestion.
7. RAPD to study biodiversity.
8. Competent cell preparation, transformation, ligation and screening of transformants.
9. Quantitative estimation, absorption spectra and Tm determination of DNA.
10. Blotting Techniques: Southern/ Northern/ Western Blot Techniques.

NANOBIOTECHNOLOGY

BE-512

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: Use knowledge of nano science and mathematics to follow protocols, conduct science or engineering procedures, fabricate products, make conclusions about results, troubleshoot, discover and independently seek out innovations in the rapidly changing field of nanotechnology. Compile and analyze data and draw conclusions at the nano level.

UNIT I	**Nanoscales**	**8**
	What is meant by Nanoscale – Nanoscale Processes – Physical and Chemical Properties of Materials in the Nanoscales - Nanoscale Measurements.	
UNIT II	**Properties and measurements of nanomaterials**	**8**
	Optical Properties – Absorption and Fluroscence – Microscopy measurements – SEM –TEM - AFM and STM. Confocal and TIRF Imaging	
UNIT III	**Nanobiology**	**8**
	Properties of DNA and motor proteins – Measurements of Conductivity of DNA nanowires and angular properties of motor -- Lessons from Nature on making nanodevices	
UNIT IV	**Bioconjugation of nanomaterials to biological molecules**	**8**
	Reactive Groups on biomolecules (DNA & Proteins) - Conjugation to nanoparticles (ZnS- Fe3O4) - Uses of Bioconjugated Nanoparticles. NANO DRUG DELIVERY: Various Drug Delivery Systems – aerosol - Inhalants - Injectibles – Properties of Nanocarriers – Efficiency of the Systems.	

Books Suggested:

1. Nanobiotechnology: Concepts, Applications and Perspectives, Christof M. Niemeyer (Editor), Chad A. Mirkin (Editor) , Wiley-VCH; 1 edition , 2004.
2. Nanobiotechnology: BioInspired Devices and Materials of the Future by Oded Shoseyov and Ilan Levy, Humana Press; 1 edition 2007.
3. Nanobiotechnology Protocols (Methods in Molecular Biology) by Sandra J Rosenthal and David W. Wright , Humana Press; 1 edition , 2005.

PLANT CELL TECHNOLOGY
BE-513

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The objective of the course is to make students aware of the basic concepts of plant tissue culture. It deals with the initiation and maintenance of different types of cultures and genetic engineering techniques. The concepts of molecular markers and their applications are also being taught.

UNIT I	**Introduction to Plant tissue culture**	**8**
	Totipotency; Regeneration of plants; Different types of culture media; Nutritional components of culture media; Regulation of cell differentiation; Types of culture: callus, suspension, organogenesis, somatic embryogenesis, micropropagation.	
UNIT II	**Types of plant cell cultures**	**8**
	Isolation, purification and culture of protoplasts; Protoplast fusion and somatic hybridization; Selection systems for somatic hybrids / cybrids; Production of haploid plants: anther, pollen culture and ovule culture; Induction of mutation; Somaclonal variation; Production of disease free plants (meristem culture).	
UNIT III	**In vitro Production of secondary metabolites**	**8**
	Production of secondary metabolites by plant cell cultures; batch and continuous cultures. Biotransformation using plant cell cultures; Bioreactor system and models for mass cultivation of plant cells, hairy root culture.	
UNIT IV	**Genetic transformation in plants and molecular markers**	**8**
	Genetic transformation methods for production of transgenic plants: Microprojectile bombardment, microinjection and electroporation. Detailed mechanism of *Agrobacterium* mediated genetic transformation; Applications of transgenic plants; Reporter genes; Selectable markers. Genetic engineering-Safety, social, moral and ethical considerations. Molecular Markers: RFLP, RAPD, AFLP, microsatellites, SCAR (sequence characterized amplified regions) and SSCP (single strand conformational polymorphism).Molecular Markers: RFLP maps, RAPD maps, STS, microsatellites, SCAR (sequence characterized amplified regions), SSCP (single strand conformational polymorphism), AFLP, ESTs, QTL, map based cloning, molecular marker assisted selection.	

Books Suggested:

1. Chawla HS, “Plant Biotechnology: A Practical Approach”.
2. Slater A, Scott NW, Fowler MR “Plant Biotechnology: The Genetic Manipulation of Plants”.
3. Dixon RA, Gonzales RA, “Plant Cell Culture: A Practical Approach”.
4. Mantell SH, Matthews JA, McKee RA, “Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants”.
5. Stafford A, Warren G, “Plant Cell and Tissue Culture (Biotechnology Series)”.
6. Brown TA, “Gene cloning: An Introduction”.
7. Old, Primrose, “Principles of Gene Manipulation”.
8. Bhojwani SS, Razdan, “Plant Tissue Culture”.

PHARMACEUTICAL BIOTECHNOLOGY
BE-514

Pre-requisite	Co-requisite	L	T	P	C
-	-	2	1	0	3

Objective: To equip students with the know-how of various pharmaceutical products and processes, and also with the applications of biotechnology in the pharmaceutical sector.

UNIT I	**Introduction** Pharmaceutical industry & development of drugs; types of therapeutic agents and their uses; economics and regulatory aspects.	**8**
UNIT II	**Drug Action, Metabolism and Pharmacokinetics** Mechanism of drug action; physico-chemical principles of drug metabolism; radioactivity; pharmacokinetics.	**8**
UNIT III	**Chemotherapeutics** Chemotherapy for bacterial, fungal, viral infections, drugs acting on protozoal infection, malarial infection and helminth parasites. Cancer chemotherapy, Drug interactions.	**8**
UNIT IV	**Principles of Drug Manufacture; Biopharmaceuticals** Compressed tablets; dry and wet granulation; slugging or direct compression; tablet presses; coating of tablets; capsule preparation; oral liquids – vegetable drugs – topical applications; preservation of drugs; analytical methods and other tests used in drug manufacture; packaging techniques; quality management; GMP. Biopharmaceuticals: Various categories of therapeutics like vitamins, laxatives, analgesics, contraceptives, hormones	**8**

References Books :

1. Gareth Thomas. Medicinal Chemistry. An introduction. John Wiley. 2000.
2. Katzung B.G. Basic and Clinical Pharmacology, Prentice Hall of Intl. 1995

BIOREACTOR ENGINEERING
BE-515

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The objective of the course is to develop the concepts of ideal and non-ideal bioreactor design, residence time distribution in ideal and non-ideal bioreactors.

UNIT I	**Introduction to reactor design**	**8**
	Introduction; General design information; Design considerations for maintaining sterility of process streams and process equipments; piping and instrumentation; materials of construction for bioprocess plants. Flow injection analysis for measurement of substrates, product and other metabolites.	
UNIT II	**Analysis of Reactors**	**8**
	Bioreactors for submerged liquid fermentation of microbial cells in: batch reactors - Calculation of batch time, Non-ideality; in semi-continuous reactors; in continuous reactors – PFTR, CSTR; and Combination of reactors.	
UNIT III	**Design of unconventional Bioreactors**	**8**
	Design and analysis of Packed Bed Bioreactor, Airlift Bioreactor, Hollow Fiber Bioreactor, Plant Cell Bioreactor, Mammalian Cell Bioreactor and bioreactors for solid state fermentation.	
UNIT IV	**Introduction to Residence Time Distribution**	**8**
	Residence Time Theory; Residence Time Models: Ideal Reactors and Reactor Combinations, Hydrodynamic Models; Drawbacks of Classical RTD measurements; Transient behavior in bioreactor. Capital Cost Estimating: Components Of Capital Cost, Working Capital; Estimating Purchased Equipment Costs; Estimating Installed Costs.	

Books Suggested:

1. Panda, Tapobrata. Bioreactors: Analysis and Design. Tata McGraw Hill, 2011.
2. Moser, Anton, Bioprocess Technology: Kinetics and Reactors. Springer Verlag, 1988.
3. Bailey J.E. & Ollis, D.F. Biochemical Engineering Fundamentals, 2nd ed., McGraw Hill, 1986

4. Lee, James M. Biochemical Engineering, PHI, USA.
5. Atkinson, Handbook of Bioreactors, Blanch, H.W. Clark, D.S. Biochemical Engineering, Marcel Decker, 1999.
6. Max S. Peters and Klaus, D. Timmerhaus, Plant Design and Economics for Chemical Engineers, 4th Edition, McGraw Hill Book Co., 1991.
7. M. V. Joshi and V.V. Mahajani, Process Equipment Design, 3rd Edition, Macmillan India Ltd., 2000.
8. Michael R. Ladisch, Bioseparations Engineering: Principles, Practice and Economics.

APPLIED MICROBIOLOGY AND BIOTECHNOLOGY
BE-516

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	0

Objective: The course helps in recollecting some basic but very important concepts in microbiology and biotechnology with advanced knowledge of various recent developments at industrial level in microbiology and biotechnology.

UNIT I	**Types of microorganisms** Structure and genetic system of viruses and bacteria, Actinomycetes, fungi, Cyanobacteria and algae, Criteria used in the classification of microorganisms: morphology, cytology, genetics, host specialization, serology.	**8**
UNIT II	**Modern trends in microbial production** Modern trends in microbial production of bioplastics (PHB, PHA), bioinsectices (thuricide), biopolymer (dextran, alginate, Xanthan, pullulan), Biofertilizers (Nitrogen fixer/Phosphate Solubilizers/siderophore producers), Single Cell Protein, micro algae as – food – feed and colourant. Potential Application of *Spirulina arthrospira* as a nutritional and therapeutic supplement in health management.	**8**
UNIT III	**Pharmaceutical Microbiology** Antibiotics and synthetic antimicrobial agents, Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis). Bacterial resistance to antibiotics. Microbial contamination and spoilage of pharmaceutical products, Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry.	**8**
UNIT IV	**Industrial microbes and their products** A brief idea about the products obtained from microbes, biology of industrial microorganisms such as Streptomyces, yeasts, *Spirulina*and*Penicillium*, Basic principle of fermentation technology, Overview of fermenter design, factors governing the chemical and biological aspects in a bioreactor, commercial production of penicillin, ethanol, vinegar, vitamin B12, Protease, citric acid and glutamic acid from microbial sources–production of commercially useful non-microbial products produced through recombinant microbes.	**8**

Books recommended

1. *Prescott, Harley and Klevin; Microbiology; 2 nded.*
2. Microbiology,Peleczar, TMH Publication
3. Pirt SJ, "Principles of Microbe and Cell Cultivation
4. Murray Moo-Young, Comprehensive Biotechnology, Vol. 1& III.
5. Microbes & Fermentation, A. Lel and Kotlers Richard J. Mickey, Oriffin publication
6. Industrial Fermentations, Leland, N.Y. Chemical publishers.
7. Prescott and Dunn's- Industrial Microbiology, 4th, ed. Biotechnology series, Rrhym, Reed & Weinheim, Verlag-chemie.

INTEGRAL UNIVERSITY, LUCKNOW

SYLLABUS

&

EVALUATION SCHEME

for

M.TECH. BIOTECHNOLOGY

2nd Year

(with effect from 2021-2022)

Integral University
M. Tech. Biotechnology
(with effect from Session 2020-2021)
(Students admitted 2020 onwards)

2nd Year **3rd Semester**

S. No.	Course Category	Subject Code	Subject	Periods and Credits				Evaluation Scheme				Subject Total
								Sessional (CA)			ESE	
				L	T	P	C	CT	TA	Total		
1	DC	BE-601	Bioinformatics, Genomics and Proteomics	2	1	0	3	40	20	60	40	100
2	DC	BE-602	Immunotechnology	2	1	0	3	40	20	60	40	100
3	DE		Departmental Elective	2	1	0	3	40	20	60	40	100
4	DC	BE-699	M.Tech. Dissertation	0	0	8	4	40	20	60	40	100
5	DC	BE-603	Colloquium	0	0	4	2	40	20	60	40	100
6	DC	*BE-604	Advances in Molecular Techniques	2	1	0	0	40*	20*	60*	40*	100*
Total				**8**	**4**	**12**	**15**	**200**	**100**	**300**	**200**	**500**

* A zero-credit foundation course. Candidate has to pass the course by securing at least 50% marks.

Departmental Electives

1. Animal Cell Engineering (BE-605)
2. Biochemical Reaction Engineering (BE-606)
3. Environmental Biotechnology (BE-607)
4. Secondary Metabolism in Plants (BE-608)
5. Plant Developmental Biology (BE-609)
6. Biosensors: Design and Applications (BE-610)
7. IPR, Biosafety and Bioethics (BE-611)
8. Medical Biotechnology (BE-612)

BIOINFORMATICS, GENOMICS AND PROTEOMICS
BE-601

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The objective of the course is learning and understanding the detailed developments and applications of the field of Bioinformatics in varied area of biological research. The course generally focuses on genomics, proteomics and computational biology studies and their relevance on research platform.

UNIT I	**Bioinformatics & Sequence Analysis**	**8**
	Nucleic acid sequence data banks, GenBank; EMBL; Brief overview of Human Genome Project (HGP): goals and applications. Pair wise sequence alignment: Needleman and Wunsch; Smith Waterman algorithms; Database Similarity Searches: Basic Local Alignment Search Tool (BLAST) & FASTA methods.	
UNIT II	**Applied Bioinformatics**	**8**
	Drug Designing, Stages of Drug Designing, DNA microarrays and its applications, Determination of Secondary & Tertiary structure of proteins: Chou Fasman method, Homology Modeling and its applications; Gene prediction studies: Promoter and regulatory regions scanning.	
UNIT III	**Structural & Functional Genomics**	**8**
	Multiple sequence alignments: Strategies and applications in Phylogenetics. Structural genomics (SG): Basic principles and applications, approaches for target selection. Functional genomics: application of sequence based and structure-based approaches to assignment of gene functions e.g. sequence comparison, structure analysis (especially active sites, binding sites) and comparison, pattern identification.	
UNIT IV	**Proteomics: Tools and Databases**	**8**
	Proteomics: an introduction; Study of transcriptome and proteome; Protein-protein interactions: databases such as DIP, PPI server and tools for analysis of protein protein interactions. Protein arrays: basic principles; bioinformatics-based tools for analysis of proteomics data, Tools available at ExPASy Proteomics server; Introduction to Protein Sequence Data Banks: UniProt, SwissProt.	

References Books:

1. Baxevanis AD, Ouelettte BFF; Bioinformatics: A practical Guide to the analysis of genes and proteins., Wiley 2004, ISBN: 978-0-471-47878-2
2. Stephen A., David K, Womble D; Introduction to Bioinformatics: A Theoretical and Practical Approach., 2003, Humana Press, ISBN-13: 978-1588292414
3. Harren Jhoti, Andrew R. Leach; Structure- based Drug Discovery, Springer, 2007, ISBN 1402044070
4. Andrew Leach; Molecular Modelling: Principles and Applications (2nd Edition), Prentice Hall, 2001, ISBN 13: 9780582382107
5. Cynthia Gibas, Per Jambeck; Developing Bioinformatics Computer Skills: An Introduction to Software Tools for Biological Applications, 2001, O'Reilly Media publishers.
6. Barry A. Bunin, Brian Siesel, Guillermo Morales, Jurgen Bajorath; Chemoinformatics: Theory, Practice, & Products, Springer Science & Business Media, 2006.

Research Publications:

1. Zhang W, Pei J, Lai L. Computational Multitarget Drug Design, J ChemInf Model, 2017. doi: 10.1021/acs.jcim.6b00491
2. Leelananda SP, Lindert S. Beilstein. Computational methods in drug discovery, J Org Chem,. 2016 Volume 12. Pg- 2694-2718.

Websites:

1. **Error! Hyperlink reference not valid.**simulation software: www.schrodinger.com
2. National Center for Biotechnology Information, www.ncbi.nlm.nih.gov/.
3. Auto Dock, autodock.scripps.edu

Online document/video/audio:

1. Computational chemistry in drug discovery. European Bioinformatics Institute - EMBL-EBIhttps://www.youtube.com/watch?v=9DESulCWbRQ.
2. Webinar recording: a sequel for beginners: ligand-based drug design — the basics https://www.youtube.com/watch?v=ef5EaooBYUU.

IMMUNOTECHNOLOGY
BE 602

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The objective of the course is to apprise the students about components associated with immune system and molecular mechanism of their working. The course also deals with implications of deregulation of basic regulatory networks that lead to immune system related disorders.

UNIT I	**Humoral and Cell Mediated Immunity**	**8**
	B-cell and T cell activation, Structure and function of MHC molecules. Exogenous and endogenous pathways of antigen processing and presentation. Antibodies and antibody based therapy: Production of Polyclonal antibodies with different types of antigens : antigen preparation and modification, adjuvant, dose and route of antigen administration, collection of sera, purification of antibodies; Inhibitors of tumor necrosis factor, targeting the IL2 receptor with antibodies or chimeric toxins, monoclonal antibodies to CD3.	
UNIT II	**Hybridoma Techniques and Monoclonal Antibody Production**	**8**
	Myeloma cell lines - fusion of myeloma cells with antibody producing B-cells-fusion methods - selection and screening methods for positive hybrids - cloning methods - production, purification and characterization of monoclonal antibodies. Application of monoclonal antibodies in biomedical research, in clinical diagnosis and treatment; Production of human monoclonal antibodies and their applications.	
UNIT III	**Immunotherapy for Allergic Diseases**	**8**
	Specific and nonspecific immunotherapy for Asthma and allergic diseases, Drug therapy in HIV: AIDS and other Immunodeficiencies; Vaccine and peptide therapy, newer methods of vaccine preparation, sub-unit vaccines, immuno-diagnosis of infectious diseases, serological techniques-ELISA, RIA and Immunoblotting.	
UNIT IV	**Transplantation**	**8**
	Graft rejection, evidence and mechanisms of graft rejection, prevention of graft rejection, immunosuppressive drugs, HLA and disease, Xenotransplantation. Drugs: Antimetabolites, corticosteroids, anti-inflammatory agents; Cytokines: Cytokines regulating immune inflammation: interleukin-4, interleukin-20, interleukin-12; The interferons: Basic biology and therapeutic potential.	

References Books:

1. "Cellular & Molecular Immunology" by Abbas AK, Lichtman AH, Abbas AK, Pober JS, Publisher: Elsevier;
   Year: 2012; Edition: 7th
1. "Immunology" by Kuby; Publisher: WH Freeman and Company, New York; Year: 2007; Edition: 6th.
2. "Elements of Immunology" by Fahim Halim Khan; Publisher: Pearson; Year: 2009; Edition: 1st
3. "Immunology" by Roitt, Publisher: Edinburg Mosby; Year: 2002; Edition: 6th.

ADVANCES IN MOLECULAR TECHNIQUES
BE-604

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	0

Objective: To demonstrate proficiency in advanced molecular biology techniques and to inculcate an understanding of advanced molecular techniques, including advanced background information and theory, applications, limitations, advantages and disadvantages, common problems and troubleshooting.

UNIT I	**PCR-based Techniques** Principle and applications of PCR; RACE; DD-RTPCR; Degenerate PCR, TA cloning, Realtime PCR, Scorpion probes, Site directed mutagenesis, PCR-based mutagenesis, Error-prone PCR	**8**
UNIT II	**Gene Silencing** Antisense RNA technique, Sense co-supression in plants and animals, RNAi, Gene silencing, Ribozymes	**8**
UNIT III	**Sequencing Techniques** Rapid DNA and RNA sequencing techniques, Sanger method, Maxam and Gilbert procedure, Automated DNA sequencing, Pyrosequencing, Genomics: High throughput, Shot gun, Clone contig, Microarray, Protein microarray	**8**
UNIT IV	**Molecular Markers and other Molecular Techniques** Molecular markers, RFLP, RAPD, AFLP, SCAR, STS, Microsatellites, SSCP, Yeast two-hybrid system, DNase foot printing	**8**

References Books:

1. Molecular Cloning; Sambrook and Russel, Cold Spring Harbor Laboratory
2. Gene Cloning and DNA Analysis: An Introduction, T.A. Brown; Blackwell Publications
3. Principles of Gene manipulation and genomics; Primrose and Twyman; Wiley Publishing

ANIMAL CELL ENGINEERING
BE 605

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The course will help students to understand mechanisms of gene manipulation of animal cells, stem cell therapeutics and other frontier areas associated with molecular medicine.

UNIT I	**Animal Cell Culture**	**8**
	Animal Biotechnology and its scope, Principles of sterile techniques and cell propagation, Cell culture media: Physicochemical Properties, Chemically defined and Serum free media. Culture Environment, Cell Adhesion. Types of culture system: monolayer culture, Roller bottle, Suspension culture, static suspension culture, agar culture, agitated micro carrier suspension culture, hollow fiber systems, Scaling up factors. Strategies of medium optimization, Organotypic cultures, Animal Tissue Engineering, Bioartificial Organs, Scaffolds and Biomaterials used in Tissue Engineering.	
UNIT II	**Primary Culture**	**8**
	Isolation of Tissue, isolation of cells from explants by enzymatic disaggregation, mechanical disaggregation, EDTA treatment. Steps involved in primary cell culture, Cell line characterization: Morphology, Chromosome Analysis, Antigenic Markers, Transformation, Immortalization, Cell counting, Rates of Synthesis, Generation Time. Measurement of cell growth and viability, cell synchronization, cell transformation, maintenance of cell culture through sub-culturing and cloning, cryo-preservation, application of cell cultures. Types of microbial contamination and Eradication of Contamination	
UNIT III	**Mammalian Cell Lines**	**8**
	Mammalian cell expression system, gene transfer techniques in Mammalian cells, Stem cell culture: principles for identification, purifications, assessment of proliferation heterogeneity, long-term maintenance and characterization, Embryonic and adult stem cells and their applications. Genetically modified stem cells in gene therapy, Markers for stem cell identification, characterization of differentiated cell types, Applications of stem cells.	
UNIT IV	**Transgenic Animals**	**8**
	Animal virus vectors; Shuttle vectors. Cloning in mammalian cells, Integration of DNA into mammalian genome, Methods of transformation: (Microinjection, Electroporation, Microprojectile bombardment, Liposomal packaging),Animal as bioreactors, problems after developing transgenic animals. Applications of transgenic animals, In vitro-fertilization, Gene	

	Therapy: *Ex-vivo* gene therapy, *In vivo* gene therapy, Prodrug activation therapy, Nucleic acid therapeutic agents. Protein production by genetically engineered mammalian cell lines, Manipulation of Growth hormone: somatotropic hormone, Thyroid horomone; Probiotics as growth promoters, Ideal characteristics probiotics, uses of probiotics.	

References Books:

1. "Gene Cloning and DNA Analysis" by TA Brown, Publisher: Oxford Balckwell Science, Year: 2008, 2011, Edition: 4th, 5th.
2. Old & Primrose "Principles of Gene Manipulation", Publisher: Balckwell; Year: 2014, Edition: 7th
3. "Methods of Tissue Engineering" Anthony Atala, Robert P. Lanza; Publisher: Elsevier; Year: 2005,
4. "Animal Cell Biotechnology: Methods and Protocols" by Nigel Jenkins; Publisher: New Jersey: Humana Press; Year: 2005.

BIOCHEMICAL REACTION ENGINEERING
BE-606

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The course will help students to understand mechanisms of gene manipulation of animal cells, stem cell therapeutics and other frontier areas associated with molecular medicine.

UNIT I	**Reaction Basics**	**8**
	Rate of reaction, reaction order and rate laws, Rate-limiting step. Chain reactions. Pyrolysis reactions. Steady state ideal reactors: completely mixed and plug flow.	
UNIT II	**Reactors**	**8**
	Reactor size comparisons for PFR and CSTR. Reactors in series and in parallel. How choice of reactor affects selectivity vs. conversion. Theory of the continuous and semi-continuous fermentor operation.	
UNIT III	**Reactor Engineering I**	**8**
	Non-ideal reactor mixing patterns, Residence time distribution, Tanks in series model. Combinations of ideal reactors. Non isothermal reactors. Equilibrium limitations, stability. Derivation of energy balances for ideal reactors; equilibrium conversion, adiabatic and nonadiabatic reactor operation.	
UNIT IV	**Reactor Engineering II**	**8**
	Oxygen transfer in fermentors. Applications of gas-liquid transport with reaction. Reaction and diffusion in porous catalysts. Combined internal and external transport resistances.	

References Books:

1. Fogler H.S. Elements of chemical reaction Engineering. 4th edition, Prentice- Hall of India Pvt Ltd, 2006.
2. Levenspiel O., Chemical Reaction Engineering. 3rd edition, Wiley New York. 1992.
3. Rao D.G., Introduction to Biochemical Engineering, McGraw-Hill, 2005.
4. Villadsen, J., Nielsen, J., & Lidén, G. Bioreaction engineering principles. 3rd edition Springer. 2011
5. Smith J.M., Chemical Engineering Kinetics. 3rd edition. New York, McGraw-Hill, 1981.
6. Steinfeld, J. I., Francisco J. S., & Hase W. L. Chemical Kinetics and Dynamics. 2nd ed. Upper Saddle River, NJ: Prentice Hall, 1999.
7. Holland, C. D., & Anthony, R. G. Fundamentals of Chemical Reaction Engineering, John Wiley and Sons, 1990.

ENVIRONMENTAL BIOTECHNOLOGY
BE-607

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The main objective of this course is to impart students an understanding of pollution of environment by air, water and soil responsible for degradation of natural resources and degradation of biodiversity. It also familiarizes them with various remediation techniques, non polluting technologies viz. bioenergy and biomining**.**

UNIT I	**Title of the Unit Introduction to Ecosystem & Environmental Pollution** Source of air, water and solid wastes, Ecosystem, Ecosystem Management, Renewable resources, Role of biotechnology in environmental protection,. Air, water and soil pollution: cause and control measures. Treatment technologies, Biofilters and Bioscrubbers for treatment of industrial waste.	**8**
UNIT II	**Bioreactors & Rural Biotechnology** Biocompositing, Biofertilizers; Vermiculture; Organic farming; Biomineralization; Biofuels; Bioethanol and Biohydrogen; Energy management and safety.	**8**
UNIT III	**Water Quality Modeling For Streams** Characterization of effluents, effluent standards, Waste water collection; control and management; waste water treatment, sewage treatment through chemical, microbial and biotech techniques, Treatment of waste water from dairy, tannery, sugar and antibiotic industries. Waste recovery system. Primary methods; setting, pH control, chemical treatment. Secondary methods; Biological treatment, Tertiary treatments; like ozonization,	**8**
UNIT IV	**Environmental Regulations and Technology** Regulatory Concerns, Technology; Laws, regulations and permits, Air, Water, Solid Waste, Environmental Auditing, National Environmental Policy act, Occupational Safety and Health Act (OSHA), Storm Water Regulations; Technology (waste water); Recycling of Industrial wastes: paper, plastics, leather and chemicals.	**8**

References Books:

1. E.P. Odum "Fundamentals of Ecology" V.B. Saunders and Co. 1974.
2. W.J. Weber "Physics-Chemical Process for water quality control, Wiley-international Ed.
3. L.L. Gaccio water and water population Handbook Marcel Dekkar, New York.
4. Pradipta Kumar Mohapatra "Textbook of Evironmental Biotechnology" I.K. International Publishing House Pvt. Ltd., New Delhi.
5. Allan Scagg "Environmental Biotechnology" Oxford University Press, Canada. 2004.
6. Environmental Biotechnology by Prof. Jogdand, Himalayan publishing House, 2010.

SECONDARY METABOLISM IN PLANTS AND MICROBES
BE-608

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The main objective of this course is to impart students an understanding of biologically active compounds accumulated in plants especially as secondary metabolites that have been used as a source of major, essential oils, anti-oxidants and phytopharmaceutical ranging from anti-cancer activity to HIV. There has been an exclusive demand for herbal plants and extracts which can be used to improve human health and well being.

UNIT I	**Types of Secondary Metabolites and their Synthesis** Introduction to primary & secondary metabolism: structure, biosynthesis and metabolism of important secondary products; Glycosides, isoprenoids, cardenolides, alkaloids, phenylpropanoids and antibiotics.	**8**
UNIT II	**Enzymes involved in Secondary Metabolism** Important groups of secondary metabolic enzymes; Significance of secondary metabolism and products for the producer organism.	**8**
UNIT III	**Regulation of Secondary Metabolism** Regulation and expression of secondary metabolism; regulation of enzyme activity; regulation of enzyme amount; integration with differentiation and development; action of inducers; coordinated enzyme expression and sequential gene expression.	**8**
UNIT IV	**Culture Systems and Biotransformation** Metabolic products produced by *in vitro* culturing of plant cells, selection of plant cells/tissues for the production of a specific product, Culture system in secondary plant product biosynthesis-batch continuous cultures and immobilized plant cells, Biotransformation of precursors by cell culturing. Metabolic pathway engineering for production of secondary metabolites.	**8**

Books:

1. Slater A, Scott NW, Fowler MR "Plant Biotechnology: The Genetic Manipulation of Plants".
2. Mantell SH, Matthews JA, McKee RA, "Principles of Plant Biotechnology: An
3. Introduction to Genetic Engineering in Plants".
4. Brown TA, "Gene cloning: An Introduction".
5. Old, Primrose, "Principles of Gene Manipulation".
6. Buchanan, "Plant Biochemistry & Molecular Biology".

PLANT DEVELOPMENTAL BIOLOGY
BE-609

Pre-requisite	Co-requisite	L	T	P	C
BE-513		2	1	0	3

Objective: To make the students aware of the plant differentiation and development. The students will also knowledge about the plant aging and senescence.

UNIT I	**Basics of Differentiation** Concept of totipotency and differentiation, Mechanisms of differentiation: cellular differentiation, induction, asymmetric division, morphogens.	**6**
UNIT II	**Seed and Embryo Development** Seed Germination, Hormonal control of seed germination, Embryo development, Signalling and cell development, Plant cell division, Meristem development and patterning.	**8**
UNIT III	**Organ Development in Plants** Root development, shoot development, Flower development, Stomata development and patterning, Homeotic genes and its role in development, Developmental plasticity.	**8**
UNIT IV	**Aging and Regulation of Development** Aging & Senescence, Environmental regulation and development, the problem with Rubisco and photorespiration: the physiological, ecological and evolutionary aspects of photosynthesis in C4 plants.	**8**

References:

1. Raghavan, V. Developmental Biology of Flowering Plants, Springer publications, 2000.
2. Claudia Köhler and Lars Hennig. Plant Developmental Biology: Methods and Protocols, Springer publications, 2010.
3. **Cutler**, Sean, **Bonetta**, Dario (Eds.). Plant Hormones Methods and Protocols, Springer publications, 2009.
4. L. D. Noodén, Aldo Carl Leopold, Senescence and aging in plants, Academic Press, 1988.

BIOSENSORS: DESIGN AND APPLICATIONS
BE-610

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The course will give an overview of biosensors, their fabrication and other details.

UNIT I	**Biosensors : An overview** Overview of biosensors and bio-electronic devices, History, concepts and applications. Fundamental elements of biosensor devices and design considerations, calibration, dynamic range, signal to noise, sensitivity. Fundamentals of surfaces and interfaces, modifications of sensor surface. Bio-electrochemistry, Electrochemistry for biosensors, Principles of potentiometry and potentiometric biosensors; amperometry and amperometric biosensors; Conductimetric and Impedimetric Biosensors.	**8**
UNIT II	**Molecular Recognition Elements** Molecular recognition elements: Enzymes, Antibodies and DNA. Kinetics and thermodynamics of bio-recognition reactions. Enzyme sensors and affinity sensors: immune sensors, oligo-nucleotides sensors, SPR, FRET, Membrane protein sensors: ion channels, receptors, whole cell sensors – bacteria, yeast, mammalian cells, non-biological and bio-mimicry: molecularly imprinted polymers, non-biological organic molecules.	**8**
UNIT III	**Basic Fabrication of Biosensors** Immobilization: adsorption, encapsulation - (hydro-gel, sol-gel glass, etc.), covalent attachment, diffusion issues. Optical Biosensor, Microlithography for biosensors, FETS and Bio-FETS, MEMS and Bio-MEMS. Lab-on-a-chip: TAS and m-TAS devices, Sensors based on Fiber Optic. Electro-chemiluminescence, pH sensors, artificial receptors.	**8**
UNIT IV	**Application** Physical sensors: piezoelectric, resistive, bridge, displacement measurement, blood pressure measurement, quartz crystal microbalance. Applications of biosensors in Agriculture, food safety, food processing, Biomedical: Point-Of-Care system, Noninvasive Biosensors in Clinical Analysis. Biosensor-based instruments; Blood chemistry sensors, sensors for Genetic testing. Applications of biosensors in Bio-security, environmental.	**8**

References Books:

1. Handbook of Chemical and Biological Sensors", Richard F Taylor; IOP Publishing Ltd; Edition Year: 1996
2. "Handbook of Biosensors and Biosensor Kinetics"; Ajit Sadana & Neeti Sadana, Elsevier; Edition Year: 2011
3. "Biosensors"; Jonathan M. Cooper; Oxford University Press; Edition Year: 2003

Websites:

1. http://www.sciencedirect.com/science/journal/09565663
2. http://www.nature.com/subjects/biosensors
3. http://www1.lsbu.ac.uk/water/enztech/biosensors.html

IPR, BIOSAFETY AND BIOETHICS
BE-611

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The knowledge of IPR, Bio-safety and Bioethics recognizes the need for the possibility to exchange views and ideas of the students in the form of patent in the field of science and technology development. The basic knowledge of this subject paper is very useful and for student in term of how they save and protect their invention or intellectual property in proper ways.

UNIT I	**History Of IPR**	**8**
	Jurisprudential definitions and concepts of property, rights, duties and their correlation; History and evolution of IPR like patent, design and copyright. Significance of IPR; Requirement of a patentable novelty; Issues related to IPR protection of software and database; IPR protection of life forms; International convention in IPR; Geographical indication; Distinction among various forms of IPR; Rights / protection, infringement or violation, remedies against infringement: civil and criminal.	
UNIT II	**Patent Process**	**8**
	Obtaining patent; Invention step and prior art and state of art procedure; Detailed information on patenting biological products and biodiversity; Appropriate case studies; Indian Patent Act 1970 (amendment 2000); Major changes in Indian patent system as post TRIPS effects; Budapest treaty	
UNIT III	**Biosafety Levels**	**8**
	Biosafety Levels : Safety guidelines for rDNA research and infectious agents ; Containment facilities and its disposal; Radiation hazards; Safety concerns about transgenics: Environmental, Health, Economic. Safety concerns related to Animal Models.	
UNIT IV	**Bioethics**	**8**
	Bioethics: Introduction, necessity and limitation; Ethical conflicts in Biotechnology; Different paradigms of bioethics: National and International guidelines; Bioethics of genes; Bioethics in health care: Bioethical dilemmas in medical and surgical treatment; Legal implications in bioethics.	

Books:

1. Old and Primrose “Principles of Gene Manipulation”.
2. Keru M “Ethical Biotechnology”, Global Vision Publishing House.
3. Huxley TH “Evolution and ethics”, Princeton University Press.
4. Arya R “Bioethics”.
5. Erbisch FH and Maredia KM “Intellectual Property Rights”, Universities Press.
6. Glick and Pasternak “Molecular Biotechnology”.
7. Knight ‘Patent strategy for researches and research managers’, Wiley Publications

MEDICAL BIOTECHNOLOGY
BE 612

Pre-requisite	Co-requisite	L	T	P	C
None	None	2	1	0	3

Objective: The course will acquaint the students with pathogenesis and management of different diseases.

UNIT I	**Genetic Disorders**	**8**
	General, systemic and specific syndromes. Classification of genetic diseases. Chromosomal abberations–Numerical disorders e.g. trisomies & monosomies, Structural disorders e.g. deletions, duplications, translocations & inversions, Genetic diseases–Autosomal, X-linked and Y-linked disorders and Mitochondrial disorders.	
UNIT II	**Molecular Basis of Human Diseases**	**8**
	Pathogenic mutations and Dynamic Mutations - Fragile- X syndrome, Myotonic dystrophy. Prevention and treatment of human diseases Avoiding exposure to pathogen Antibiotics and chemotherapeutic agents - drug resistance and antibiotic policy Using body's immune responses Alternative systems - Chinese, European and Indian (Siddha, Ayurveda, Naturopathy, etc.) Gene therapy; Chemotherapy and radiotherapy of tumors; Stem cell therapy.	
UNIT III	**Pathogenesis of Different Diseases**	**8**
	Pathogen, pathogenesis, clinical condition, laboratory diagnosis, epidemiology, chemotherapy and prevention of the following diseases. Viral - influenza, measles, hepatitis, Bacterial - pneumonia, tuberculosis, Typhoid, Fungal-histoplasmosis, Protozoan - Amoebic dysentery. AIDS. Nosocomial infections, Factors that influence hospital infection, hospital pathogens, route of transmission, investigation, prevention and control.	
UNIT IV	**Techniques in Laboratory Diagnosis**	**8**
	Haematology, biochemistry, microbiology, serology, radiology and other special methods. Prenatal diagnosis–Amniocentesis, Chorionic Villi Sampling (CVS), Non-invasive techniques-Ultrasonography, X-ray, Diagnosis using protein and enzyme markers, monoclonal antibodies. Microarray technology-genomic and cDNA arrays, application to diseases. Biosignalanalyzer, CT scan and Magnetic Resonance Imaging assisting the heart and kidney.	

Books:

1. Mackie and McCartney; Practical Medical Microbiology; Elsevier; Edition: 14th; Year: 2012.
2. Pratibha Nallari and V. Venugopal Rao; Medical Biotechnology; Oxford University Press; Edition: 2nd; 2012.
   a. Name of the authors: Jochen Decker (Editor), Udo Reischl (Editor)
   b. Molecular Diagnosis of Infectious Diseases (Methods in Molecular Medicin; Humana Press; 2003.

Colloquium

BE-603

Pre-requisite	Co-requisite	L	T	P	C
None	None	0	0	4	2

Objective: To acquaint the student with the various techniques used in contemporary research in food technology that will be useful in successful completion of their project work in the fourth semester**.**

1. Searching for scientific literature (Sciencedirect, SCOPUS, Google Scholar etc.)
2. Exposure to different manuscript forms (Review, Short note, Research article, Communication).
3. Design of experiments in research.
4. Basic statistical analysis (ANOVA, RSM, ANN).
5. Different manuscript formats and referencing styles (Use of Mendeley, Endnotes.).
6. Publishing manuscripts (plagiarism check, cover letters, suggesting reviewers etc).
7. Thesis writing and presentation.
8. Exposure of students to research in laboratory.
9. Ethics in conducting research.

References:

1. Sciencedirect:https://www.sciencedirect.com/
2. Mendeley:https://www.mendeley.com

Books:

1. Gupta, S.P., Statistical Methods; S. Chand & Sons, NewDelhi.
2. Jerold H.Zar (2009): Bio-statistical Analysis, 4th Edition, Pearson EducationInc.

M.TECH. DISSERTATION
BE-699

Pre-requisite	Co-requisite	L	T	P	C
None	None	0	0	8	4

Objective: To acquaint the student with the various techniques used in contemporary research in biotechnology that will be useful in successful completion of their project work in the fourth semester.

1. Biological Databases (e.g.; sequence databases, structure databases and specialized databases) and their retrieval tools and methods.
2. Sequence similarity searching (e.g.; BLAST and FASTA).
3. Protein sequence analysis using ExPASy Bioinformatics resource portal and multiple sequence alignment using Clustal W tool.
4. 3-D structure prediction of protein through homology modeling and their visualization by PyMol/DS Visualizer/RasMol.
5. Media preparation and sterilization for plant and animal tissue culture.
6. Induction of callus and suspension culture.
7. Multiple shooting and organogenesis from buds.
8. Plant regeneration by micropropagation.
9. Preparation of media for the given animal cell culture.
10. Maintenance of established cell lines.
11. Cell counting & viability by vital staining.
12. Staining of animal cells.

Books:

1. Bioinformatics: A Practical Approach by K Mani and N Vijayaraj, Aparna Publications, Coimbatore.
2. Bioinformatics: Sequence, Structure and Databanks- A Practical Approach by Des Heggins and Willie Taylor, Oxford University Press.
3. Debra Davis “Animal Biotechnology: Science-Based Concerns”
4. Nigel Jenkins “Animal Cell Biotechnology: Methods and Protocols
5. Chawla HS, “Plant Biotechnology: A Practical Approach”.
6. Slater A, Scott NW, Fowler MR “Plant Biotechnology: The Genetic Manipulation of Plants”.

Integral University
M. Tech. Biotechnology
(with effect from Session 2020-2021)
(Students admitted 2020 onwards)

2nd Year **4th Semester**

S. No	Course Category	Subject code	Name of the Subject	Periods and Credits				Evaluation Scheme				Subject Total
				L	T	P	C	Sessional (CA)			ESE	
								CT	TA	Total		
1.	DC	BE-699	M.Tech. Dissertation	0	0	0	4	40	20	60	40	100
2.	DC	BE-699	M.Tech. Dissertation	0	0	0	4	40	20	60	40	100
3.	DC	BE-699	M.Tech. Dissertation	0	0	0	4	40	20	60	40	100
4.	DC	BE-699	M.Tech. Dissertation	0	0	0	4	40	20	60	40	100
Total				**0**	**0**	**0**	**16**	**160**	**80**	**240**	**160**	**400**

L: Lecture **T**: Tutorial **P**: Practical **C**: Credit **CA**: Continuous Assessment

CT: Class Test **TA**: Teacher's Assessment **ESE**: End Semester Examination

DC: Departmental Core