Integral University, Lucknow

Effective from Session: 2020-2021							
Course Code	BS501	**Title of the Course**	rDNA Technology	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	3	1	0	4
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	The objective of this course is to give students a basic understanding of various components required for gene cloning						

Course Outcomes	
CO1	Know the role of the several molecular tools applied in gene cloning for construction of recombinant molecules (DNA and Vectors).
CO2	Several techniques involved in production of CDNA and Genomic library and primer synthesis
CO3	Classification and properties of an ideal plasmid, plasmid as cloning vector
CO4	Different types of cloning vectors used in genetic engineering
CO5	Different types of screening and selection procedure of identifying recombinants.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Cloning Procedure	Outline of cloning procedure, Host controlled restriction and modification: Restriction endonucleases and cognate methylases, Class I, II & III restriction enzymes, Nomenclature, Recognition sites, Variants of Type II Restriction enzyme, Unit of restriction enzymes, Restriction digestion: Partial and Complete Digestion, Star activity, Restriction mapping, Formation of chimeric DNA, Homopolymer tailing, Synthetic Linkers, Adaptors and DNA ligase; Filling in and Trimming back; Significance of T4 DNA polymerase & Klenow Fragment, Alkaline phosphatase, Reverse transcriptase in cloning.	8	CO-1
2	RNA/DNA synthesis and labelling	Purification of mRNAs; mRNA abundance; Synthesis of cDNA:, Various methods for first and second strand DNA synthesis; cDNA and Genomic library construction; Chemical synthesis of oligonucleotides by Phosphoramidite and Photolithographic methods; Preparation of probe DNA by radioactive and nonradioactive labeling methods: Nick translation, End filling, Random primer methods	8	CO-2
3	Plasmids	Plasmids: Plasmid classification on basis of phenotypic traits: Cryptic, Fertility, Resistance, Bacteriocinogenic, Degradative, Virulence; Conjugative / non conjugative plasmids; Relaxed and stringent control of copy number; Plasmid incompatibility; Plasmid host range, Mobilizable plasmids and Triparental mating; Plasmid as cloning vector (recombinant plasmids): Properties of ideal plasmid cloning vectors, pBR322, pUC & pGEM3Z series, , Binary and Cointegrate vectors derived from Ti plasmid of Agrobacterium; Transcriptional and translational fusion vectors; Fusion proteins; Selectable markers; Reporter genes.	8	CO-3
4	Phage as cloning vector	Phage as a cloning vector: Advantage of using phage lambda vector, Genome map of phage lambda, In vitro packaging, Insertional and replacement vectors: λgt10, λgt11, λEMBL3, λEMBL4, λEMBL3A, λEMBL4A; Cosmid vectors; M13 phage and its role in single stranded DNA production, M13 series of vectors; Phagemids; Yeast as cloning vector: Basic principles of development of yeast vectors, 2μ plasmid, YEP, YRP YCP, YIP; Artificial chromosomes: YACs, BACs and PACs	8	CO-4
5	Screening and selection of recombinants	Basic techniques in mammalian cell culture; Cell culture media; Serum free media; maintenance of the culture and cell lines; Cloning in mammalian cells; transgenics, viral v Screening and selection of recombinants: Functional (genetic) complementation (Blue-white screening, Red-white screening), Nutritional complementation, Gain of function, Colony hybridization, Plaque hybridization, Southern blotting and hybridization, Dot blot, Zoo blot, Plus-Minus screening, Northern blotting, Immunological screening, Western blotting, South-Western blotting, North-Western blotting, HART, HAT.	8	CO-5

Reference Books:

1. Genetic Engineering Rastogi & Pathak Brown, T.A.
2. Freifelder, DM “Molecular Biology”.
3. Brown, TA “Genomes”.
4. Watson, JD “Molecular Biology of the cell”
5. Gene cloning: An introduction” Old & Primrose “Principles of Gene Manipulation

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	P08	PSO1	PSO2	PSO3	PS04
CO1	3	1				3		1	1		3	
CO2	3	1				3		1	2			
CO3	3	1				3		1	2		3	
CO4	3	1				3		1	1		3	
CO5	3	1				3		1	1		3	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	BS502	**Title of the Course**	Bioprocess Engineering & Industrial Biotechnology	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	This course is designed to acquire knowledge on basics of thermodynamics of reactor systems with special emphasis on bioreactor design, operation, flow patterns, and analysis of enzyme kinetics in biochemical engineering reactions along with downstream processing.						

Course Outcomes	
CO1	Learn about engineering calculations. Know different principles and concepts governing Fluid flow in a reactor system.
CO2	Students will be able to apply mass and energy balances to calculate the concentration of different gases in the fermenter off-gas, amount of reactant used, amount of oxygen etc.
CO3	Understand the techniques used for isolation and purification of desired products.
CO4	Operate and optimize the factors affecting fermentation for producing industrial products.
CO5	Treat the solid waste and effluent treatment.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**SI Units**	SI units; Dimension analysis; Fluid flow; Fluid statics; Bernoulli's equations.	8	CO-1
2	**Mass and energy balance in biological processes, Heat transfer**	Mass and energy balance in biological processes, Heat transfer: Different modes of heat transfer coefficient; Boiling & evaporation; Heat exchanger design.	8	CO-2
3	**Screening and strain improvement**	Isolation, maintenance and preservation of industrial strains. Strain improvement, screening and selection of industrially important microbes. Media for Industrial Fermentation, sterilization.	8	CO-3
4	**Design and analysis of fermenter; Downstream Processing**	Design and analysis of fermenter; Types of fermenters, evaluation of fermentation parameters, Downstream Processing: Filtration, centrifugation, cell disruption, extraction, drying, crystallization and characterization. Large scale production and commercial applications of enzymes: proteases and amylases; solvents: acetic acid, ethanol, aceto-butanol.	8	CO-4
5	**Applied microbial technology**	Solid waste treatment and management, Effluent Treatment: Aerobic and anaerobic water treatment processes: activated sludge, trickling filter, fluidized expanded bed reactor, Upflow anaerobic sludge blanket reactor. Bioleaching, Bioremediation, Biodegradable plastics, Biofuels / Biodiesel, Biopesticides, Biofertilizers and Vermitechnology.	8	CO-5

Reference Books:

1. Doran, PM "Bioprocess Engineering Principles".
2. Pirt, SJ "Principles of Microbe and Cell Cultivation" Whitaker "principles of Fermentation
3. Technology".
4. Bailey & Ollis "Biochemical Engineering Fundamentals".
5. Moo –Young "Comprehensive Biotechnology" Cruger & Cruger "Biotechnology: A text book of
6. Industrial Microbiology".
7. Prescott & Dunn "Industrial Microbiology".
8. Bruce Rittman Perry L. McCarty "Environmental Biotechnology: Principles and Applications".

e-Learning Source:

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1				2		1	3			
CO2	3	1				2		1	3	2	2	
CO3	3	1				2		1		3	3	
CO4	3	1				2	3	1		3	3	
CO5	3	1				2	1	2		2	3	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2021-2022							
Course Code	BS503	**Title of the Course**	Immunology	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	UG in Biological Science	**Co-requisite**	Biotechnology				
Course Objectives	The objective of this course is to provide students with detailed understanding of historical aspects of immunology, different cells of the immune system and their role in immune protection and application of immunological techniques. The course will provide knowledge about autoimmunity, hyper sensitivity, complement system, and vaccination etc. One of the major goals of this course is to provide basic understanding of immunology and immune responses in response to various infectious and non- infectious diseases i.e. cancer, diabetes, neurological disorders etc.						

Course Outcomes	
CO1	Understand the fundamentals of immune system
CO2	Understand antigen-antibody interactions and various immunological techniques based on these interactions.
CO3	Understand the mechanism of generation of diversity in immune response
CO4	Understand the Differentiation and activation of B and T lymphocytes, antigen presentation, and significance of MHC.
CO5	Students will gain knowledge about the importance of complement, tolerance and hyperactivation of immune response.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Fundamentals of Immunology**	Fundamentals of Immunology: Cells and organs of immunity: Memory, specificity, diversity, self vs. non-self-discrimination, Structure of primary and secondary lymphoid organs, Cell mediated vs. humoral immunity, T and B-lymphocytes; Nature of antigen and antibody: Antigen vs. Immunogen, Structure of antibody: constant and variable regions, Fab and Fc; isotype, allotype and idiotype; Abzymes.	8	CO-1
2	**Antigen-antibody interactions**	Antigen-antibody interactions and its measurement: Direct binding assays, Agglutination and precipitation, radioimmunoassay and ELISA, fluorescence analysis, Hybridoma technology, applications of monoclonal antibodies in biomedical research, clinical diagnosis and treatment	8	CO-2
3	**Generation of diversity in the immune response**	Generation of diversity in the immune response: Clonal selection theory-concept of antigen specific receptors, genes encoding antigen specific receptors on T and B-lymphocytes, genetic rearrangement, class switch, Comparison of receptors and B and T lymphocytes	8	CO-3
4	**Differentiation of B and T lymphocyte**	Differentiation of B and T lymphocyte. Activation of T cells and B cells by antigen: Antigen processing, Antigen presentation to T cells, Products and factors released by T cell activation-interleukins, interferons, B cell activating factors, T cell and B cell interactions leading to antibody synthesis. Central role of major histocompatibility complex (MHC), genes and products in immune response: T cell recognition of antigen and MHC products, Structure of MHC gene complex and its products polymorphism of MHC gene products, Associated MHC functions-allograft, graft vs. host and mixed leucocyte responses.	8	CO-4
5	**Tolerance vs. activation of immune response metabolism**	Tolerance vs. activation of immune response. Complement- components of classical and alternative pathways. Hypersensitivity: Types I, II, III and IV responses. Autoimmunity.	8	CO-5

Reference Books:

1. Coleman, R.M, "Fundamental Immunology"
2. Richard A. Goldsby Thomas J. Kindt Janis Kuby Barbara A. Osborne "Immunology".
3. Peter Parkham Peter Parham "The Immune System".
4. Abul K Abbas, Andrew H. Lichtman, Abdul K. Abbas, Jordan S. Pober "Cellular & Molecular Immunology"

e-Learning Source:

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1				3		2	3	2		
CO2	3	1				3		2	3	2	3	
CO3	3	1				3		1	3	2		
CO4	3	1				3		1	3	2		
CO5	3	1				3		1	3	2		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2023-24							
Course Code	BS504	**Title of the Course**	Advanced Molecular Techniques	**L**	**T**	**P**	**C**
Year	2	**Semester**	III	3	1	0	4
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	To develop in students the understanding about advanced techniques used in molecular biology and biotechnology and their applications.						

Course Outcomes	
CO1	The students will be able to explain Polymerase chain reaction (PCR), its modifications and application in different areas.
CO2	The students will be able to Compare various methods of gene silencing in plants and animals.
CO3	The students will be able to Describe the principle and application of first generation and next generation sequencing technologies.
CO4	The students will be able to Compare various types of molecular markers and their pros and cons. Interpret the mechanism of protein-protein and protein-DNA interaction.
CO5	The students will be able to Explain the principle, instrumentation, and application of various methods gene transfer in plants and animals.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	Principle & applications of PCR	Principle and variants of PCR; RACE, DD-RTPCR, Degenerate PCR, TA cloning, Realtime PCR, Scorpion PCR, Site Directed Mutagenesis: oligonucleotide directed, PCR based Mutagenesis, Error prone PCR.	8	CO-1
2	Gene silencing	Antisense RNA technique, Sense co-suppression in plants and animals, RNAi, in gene silencing, ribozymes. Zinc Finger Nuclease (ZFN) Technology, Transcription activator-like effector nuclease (TALEN) Technology, Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas9 technology	8	CO-2
3	DNA and RNA sequencing techniques	Sanger method, Maxam and Gilbert procedure, automated DNA sequencing, Pyrosequencing; High throughput Sequencing (Illumina/Solexa, Ion Torrent, Pacific Bioscience and Nanopore), shot gun cloning, clone contig cloning, Microarray.	8	CO-3
4	Molecular Markers	RFLP, RAPD, AFLP, SCAR, STS, microsatellites, SSCP, QTL, SNP, Yeast two-hybrid system, DNase I foot printing, Electrophoretic Mobility Shift Assay (EMSA), Protein Microarray.	8	CO-4
5	Introduction of DNA into living cells	Overview of the methods for introduction of DNA into living cells: Chemical transformation, microprojectile bombardment, electroporation, and microinjection.	8	CO-5

Reference Books:

1. Brown, TA (2020) Gene Cloning and DNA Analysis: An Introduction, 8th edition. John Wiley & Sons
2. Old & Primrose (1980). Principles of Gene Manipulation: An introduction to Genetic Engineering, University of California Press
3. Jose B. Cibelli Robert P. Lanza Keith Cambell Michasel D. West “Principles of Cloning”
4. Adrian Slater, Nigel W. Scott, Mark R. Fowler “Plant Biotechnology: The Genetic Manipulation of Plants”
5. Richard A. Dixon Robert A. Gonzales “Plant Cell Culture: A Practical Approach”
6. S.H. Mantell, J.A. Matthews, R.A. McKee “Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants”
7. Angela Stafford Graham Warren “Plant Cell and Tissue Culture (Biotechnology Series)”
8. Rastogi & Pathak (2009). Genetic Engineering, Oxford University Press.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1			2	3		1	1		3	
CO2	3	1			2	3		1	1		3	
CO3	3	1			2	3		1		3	3	
CO4	3	1			2	3		1	1		3	
CO5	3	1			2	3		1			3	

1. Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	BS505	**Title of the Course**	CELL BIOLOGY	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	This course imparts in depth knowledge of cell structure, functions and cellular processes including the signaling pathways involved in growth and development. Also the course connects the cellular functioning with the application of technology and molecular genetics, enabling the students to explore and identify novel research leads for the greatest benefit of mankind.						

Course Outcomes	
CO1	Students will understand the structures and purposes of basic components (membranes and organelles) of prokaryotic and eukaryotic cells, as well as transport of molecules and ions across cells.
CO2	Students will understand cellular components underlying cell division and cell cycle.
CO3	Students will learn about cell communication and signaling through distinct signaling pathways that will help them to discover novel therapeutic targets/agents.
CO4	Students will understand pathways and mechanisms of intracellular protein targeting
CO5	They will be able to understand the procedure of RDT based technologies cell culture and their various applications for humankind.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Ultrastructure and Organization of eukaryotic cell**	Structural organization of Cytoskeleton (Microtubules, Microfilaments, actins etc.); Structure and functions of cell membrane, Transport across cell membrane: Diffusion, Facilitated diffusion, Active transport.	8	CO-1
2	**Cell division and cell cycle**	Mitosis and Meiosis; Cell cycle: Check points, role of cyclin and cyclin dependent kinases in its regulation, programmed cell death, aging and senescence.	8	CO-2
3	**Cell communication and signaling**	Cell - cell and cell – extracellular matrix interactions: Plasmodesmata, Gap junction, Tight junction, Adherens, Cohesin, Elastin, Collagen, Fibronectins, Laminins, Integrins; Basics of signal transduction: Role of calcium, cAMP, G-protein, inositol phosphates, phospholipases and protein kinases in signal transduction.	8	CO-3
4	**Protein traffic in cells**	Protein sorting and signal sequences; protein translocation in ER and vesicular transport to Golgi, lysosomes and plasma membrane; protein import into nuclei, mitochondria, chloroplasts and peroxisomes.	8	CO-4
5	**Applied Cell Biology**	Basic techniques in mammalian cell culture; Cell culture media; Serum free media; maintenance of the culture and cell lines; Cloning in mammalian cells; transgenics, viral vectors, Stem cell and their applications, gene knockout technology.	8	CO-5

Reference Books:

1. Roberts, Peter Walter “Essential Cell Biology”
2. Baltimore “Molecular Cell Biology”
3. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter
4. “Molecular Biology of the Cell”
5. Lodish H, Baltimore D, Berk A, Zipursky SL, Matsudaira P, Darnell J. (1995). Molecular cell

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	**3**	**1**				**1**			**3**	**2**		
CO2	**3**	**1**				**2**			**3**	**2**		
CO3	**3**	**1**				**2**			**3**	**2**		
CO4	**3**	**1**				**2**			**3**	**2**		
CO5	**3**	**1**		**3**	**2**	**3**	**1**			**2**	**3**	

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session:							
Course Code	BS506	**Title of the Course**	rDNA/Immunology Lab.	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**0**	**0**	**12**	**6**
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	The course is designed to train the students in basic and some advanced techniques of Immunology like qualitative and quantitative analyses of antigen-antibody interaction. It also deals with Molecular biology techniques of isolation and purification of bacterial plasmid and chromosomal DNA and their application in cloning.						

Course Outcomes	
CO1	The student will practically learn to isolate plasmid DNA and genomic DNA and will learn to perform Agarose gel electrophoresis of DNA.
CO2	The student will practically learn quantitation and Restriction digestion of DNA
CO3	The course will aid to learn cloning of DNA.
CO4	The student will learn to study the production and characterization of products (as antibiotics) from microbes
CO5	The student will practically learn and understand the antigen-antibody interaction by Double Immunodiffusion method, Ouchterlony's Method, Immunoelectrophoresis, Western Blotting and ELISA.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1.	**Exp. 2**	Isolation and characterization of DNA from Bacteria/ Phage/Plants / Animals	12	**CO-1**
2.	**Exp. 3**	Quantitative Estimation of genomic DNA: Determination of Absorption Spectra of genomic DNA	3	**CO-2**
3.	**Exp. 1**	Restriction digestion of DNA and assigning restriction sites	6	**CO-2**
4.	**Exp. 4**	Preparation of competent cells	3	**CO-3**
5.	**Exp. 5**	Cloning of foreign DNA into plasmid vector	6	**CO-3**
6.	**Exp. 6**	Transformation with recombinant plasmid DNA	6	**CO-3**
7.	**Exp. 7**	Isolation of plasmid DNA by alkaline lysis as well as by Quick Method followed by Agarose Gel Electrophoresis	6	**CO-1**
8.	**Exp. 8**	Identification of recombinants	6	**CO-3**
9.	**Exp. 9**	Microbial Production, Separation & Purification of Organic Acids, Enzymes, Proteins, Antibiotics and Characterization of Primary & Secondary Metabolites	6	**CO-4**
10.	**Exp. 10**	To identify sensitivity of antigen & antibody by double Immunodiffusion: Ouchterlony's Method, Immunoelectrophoresis, Blood Group determination.	6	**CO-5**

Reference Books:

1. Keith Wilson John Walker John M. Walker "Principles and Techniques of PracticalBiochemistry" Chirikjian "Biotechnology Theory & Techniques"
2. Joseph Sambrook David W. Russell Joe Sambrook "Molecular Cloning: A Laboratory Manual" William M., Ph.D. O'Leary Robert Dony Wu "Practical Handbook of Microbiology"
3. Brown, TA "Gene cloning: An introduction"
4. Plummer David T., (1988), An introduction to practical biochemistry, 3rd Ed., Tata McGraw-Hill Publishing Co. Ltd. New Delhi, 109-121

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1			3		3	1		3	2
CO2	3	3	1			3		3	1		3	2
CO3	3	3	1			3		3	1		3	2
CO4	3	3	1			3		3	1		3	2
CO5	3	3	1		2	3	1	3	1		3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session:							
Course Code	BS511	**Title of the Course**	Applied Biotechnology	**L**	**T**	**P**	**C**
Year	II	**Semester**	IV	**3**	**1**	**0**	**4**
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	This course has been designed to recollect some basic but very important concepts in biotechnology as well as plant and animal cell culture with advanced knowledge of various recent developments taking it to the industrial level. This course also aimed to teach the students about the application of transgenic plants, cloning mechanisms, IVF, and commercial production of vaccines.						

Course Outcomes	
CO1	Understand the techniques of microbial, plant and animal cell culture.
CO2	Understand the basic mechanisms of protoplast biology, in-vitro selection of mutants, the process of plant organ development and their application in agriculture and horticulture.
CO3	Understand the development of transgenic plants with special acquired protective mechanisms against drought, salt stress, pathogens, herbs and development of edible vaccines.
CO4	Understand the cloning strategies, antigen recognition and presentation by B and T lymphocytes and their application in vaccine development.
CO5	Understand the techniques of in-vitro fertilization and embryo transfer technique, test tube babies.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to Tissue and organ culture**	Introduction to Tissue and organ culture, Establishment and maintenance of callus and suspension cultures, cellular differentiation and regulation of morphogenesis; somatic embryogenesis.	8	CO-1
2	**Isolation and culture of protoplast**	Isolation and culture of protoplast, DNA uptake by protoplast, protoplast fusion and somatic hybridization; in vitro selection of mutants- mutants for salts, disease, cold, drought, herbicide and other stress conditions; systems for somatic hybrids / cybrids; Haploid production: Androgenesis; anther and microspore culture, Gynogenesis: Embryo culture and rescue in agricultural and horticultural crops, Virus free plants through meristem culture; shoot tip culture, Plant micropropagation, Somaclonal variation.	8	CO-2
3	**Applications of transgenic plants**	Applications of transgenic plants: Developing insect resistance, disease-resistance, herbicide resistance, salt and submergence stress, fruit ripening, Edible vaccines. Cloning in plant and cells.	8	CO-3
4	**T cell cloning and IVF**	T cell cloning mechanisms of antigen recognition by T arid B lymphocytes, Application of T cell cloning in vaccine development; In vitro Fertilization and Embryo transfer technique, test tube babies.	8	CO-4
5	**Therapeutic and prophylactic biotechnology**	Principles and strategy for developing vaccines; newer methods of vaccine preparation, sub-unit vaccines, transplants, drug designing, drug targeting, microencapsulation in medicine.	8	CO-5

Reference Books:

1. H. S. Chawla “Plant Biotechnology: A Practical Approach”
2. Adrian Slater, Nigel W. Scott, Mark R. Fowler “Plant Biotechnology: The Genetic Manipulation of Plants”
3. Richard A. Dixon Robert A. Gonzales “Plant Cell Culture: A Practical Approach”
4. S.H. Mantell, J.A. Matthews, R.A. McKee “Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants”
5. Angela Stafford Graham Warren “Plant Cell and Tissue Culture (Biotechnology Series)”
6. Brown TA “Gene cloning: An Introduction”
7. Old & Primrose “Principles of Gene Manipulation”
8. Bhojwani and Razdan “Plant Tissue Culture”
9. Brown TA “Gene cloning: An introduction”
10. Old & Primrose “Principles of Gene Manipulation”

e-Learning Source:

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1		3		3		1	1		3	
CO2	3	1		3		3		1			3	
CO3	3	1		3		3		1			3	
CO4	3	1		3	3	3		1	1		3	
CO5	3	1		3		3		1			3	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2021-2022							
Course Code	BS512	**Title of the Course**	Free Radical Biology	**L**	**T**	**P**	**C**
Year	II	**Semester**	IV	**3**	**1**	**0**	**4**
Pre-Requisite	UG in Biological Science	**Co-requisite**	Biotechnology				
Course Objectives	The main objective of this course is to impart students an understanding of free radicals, their properties, cause of generation of free radicals, damage caused by free radicals and free radical associated diseases. Moreover, role of antioxidants and antioxidant enzymes in neutralizing the free radicals have also been included for the development of better therapeutic intervention against free radical associated diseases.						

Course Outcomes	
CO1	Understand free radicals, their classification, physical and chemical properties, sources, biological significance.
CO2	Understand the mineral biochemistry and their association with free radicals.
CO3	Students will learn about enzymatic and non-enzymatic antioxidants, their sources, and their role in targeting various diseases.
CO4	Students will learn the free radical-mediated oxidation of various macromolecules and their role in tissue injury.
CO5	Reconstitution of damaged molecules and membranes and the role of de-novo enzymes in the third line of defense.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to free radicals**	Introduction to free radicals, classification, physical and chemical properties, generation of free radicals- environmental factors and biological factors, biological significance.	8	CO-1
2	**Mineral biochemistry and Free radicals**	Mineral biochemistry and Free radicals: Calcium, phosphorus, agnesium. Trace elements: Iron, Iodine, Zinc, Copper.	8	CO-2
3	**Prooxidants, antioxidants, nutritional antioxidants**	Prooxidants, antioxidants, nutritional antioxidants, sources of antioxidants: microbial, plant, marine. Role of free radicals in the development of diseases: Alzheimer's, Parkinson's, Cancer.	8	CO-3
4	**Role of free radicals in development of diseases**	Role of free radicals in development of diseases: Mechanisms of Protein oxdidation, Lipid peroxidation, DNA oxidation. Types of oxidized lesions and their biological importance	8	CO-4
5	**Defense mechanisms against free radicals**	Role of antioxidants in the prevention of diseases. First line of defense: superoxide dismutase (SOD), catalase, glutathione peroxidase, glutathione reductase and xanthine oxidase, Second line of defense: glutathione (GSH), vitamin C, uric acid, albumin, bilirubin, vitamin E, carotenoids, flavonoids and ubiquinol	8	CO-5

Reference Books:

1. Free Radicals in Chemistry and Biology,
2. Milan Lazár Free Radicals in Biology and Medicine (Paperback),
3. Barry Halliwell, John Gutteridge DNA & Free Radicals (Textbook Binding)by Barry Halliwell (Author),
4. Okezie I. Aruoma (Editor) An Introduction to Free Radical Chemistry, A.F.Parsons

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1				1		1	3			
CO2	3	1				1		1	3	2		
CO3	3	1				1		1	3	2		
CO4	3	1				1		1	3	2		
CO5	3	1				1		1	3	2		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2021-2022							
Course Code	BS513	**Title of the Course**	Food Biotechnology	**L**	**T**	**P**	**C**
Year	II	**Semester**	IV	**3**	**1**	**0**	**4**
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	This course was designed to enable the students to understand various aspects of food biotechnology including food spoilage, food preservation techniques, food borne diseases, dairy products, their contamination, and associated milk-borne diseases, the importance of different flavors in food industry, food laws and standards, and BIS Certification of food products.						

Course Outcomes	
CO1	Learn the basic concepts of food spoilage and preservation techniques.
CO2	Learn about the chemical and microbiological examination milk constituents, milk grading, contamination and milk-borne diseases.
CO3	Learn about the microbial flavors in the food industry.
CO4	Understand the food laws and standards, Quality and safety assurance in the food and dairy industry, and BIS product certification and licensing quality systems.
CO5	Determine the microorganisms and their metabolites in different foods using distinct techniques.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Food as substrate for Microorganisms**	Food as substrate for Microorganisms; General principles underlying spoilage of foods and different methods of preservation of foods, Microbial food poisoning and infection; investigation of foodborne outbreaks, prevention and control.	8	**CO-1**
2	**Microbiology and spoilage**	Microbiology and spoilage of meat and meat products, fish and poultry, fruits and vegetables, sugar and sugar products, canned foods, process of canning of foods.	8	**CO-2**
3	**Milk and milk products**	Milk and milk products: Clean milk production, collection, cooling and transportation of milk, Therapeutic value and nutritive value of fermented milk products; Spoilage of milk and milk products; Milkborne diseases; antimicrobial systems in milk; sources of contamination of milk; Chemical and microbiological examination of milk; grading of milk; Starter lactic cultures; management and preparation of starter cultures; starter defects.	8	**CO-3**
4	**Microbial flavors in Dairy and Food industry**	Microbial flavors in Dairy and Food industry; Food adulteration and contamination of food with harmful microorganisms; food laws and standards; Indian and International food safety laws and standards; Quality and safety assurance in food and dairy industry; food and dairy arithmetic; standardization of products and costing; BIS Laboratory Services; BIS product certification and licensing quality systems; Certification by BIS.	8	**CO-4**
5	**Determining Microorganisms and their Products in Foods**	Determining Microorganisms and their Products in Foods: Culture, Microscopic, and Sampling Methods, Conventional; SPC, Membrane Filters, Microscope colony Counts, Agar Droplets, Dry Films, Most probable Numbers (MPN), Dye- reduction, Roll Tubes, Direct, Microscopic Count (DMC), Microbiological Examination of surfaces, Air Sampling, Metabolically Injured Organisms	8	**CO-5**

Reference Books:

1. Food Microbiology – Frazier 5. Food Microbiology – J.De and De
2. Technology of Food preservation. Norman potter, CBS.
3. Milk and Milk Products, Clarence Henry Eckles TMH Publ.
4. Food processing Biotechnological Applications, S.S. Marwaha and Arora, AsitechPubl.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1		1		2		1	3			
CO2	3	1		2		2	2	1	2			
CO3	3	1		1		2		1	3			
CO4	3	1	2	3		2		1	2			
CO5	3	1				2	1	1	1			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	BS514	**Title of the Course**	Seminar	**L**	**T**	**P**	**C**
Year	II	**Semester**	IV	3	1	0	2
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	The students will be able to summarize and present the existing data related to a specific topic in the form of a report. Every student will present a seminar on a topic related to theoretical or experimental, advanced topic.						

Course Outcomes	
CO1	The students will understand and interpret latest advancements through different technical papers, reports, Journals, Data sheets, books etc
CO2	The students will inculcate the skills for literature survey and will learn to manage resources effectively.
CO3	The students will be able to summarize the recent research and technologies in the form of review and will be able to deliver power point presentations on an assigned topic.
CO4	The students will be able to communicate his/her ideas with his peers as audience, which will enhance both oral and written communication skills.
CO5	The students will be able to create interest to pursue lifelong learning.

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2			1	3	1	2	3	2	1	3
CO2	3					3		2		2		3
CO3	3	2	1			3		2		2	1	3
CO4	3	3	3					2	3	1		3
CO5	3					2		3		1		3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**

Integral University, Lucknow

Effective from Session: 2020-21							
Course Code	BS515	**Title of the Course**	Project Work	**L**	**T**	**P**	**C**
Year	II	**Semester**	IV	0	0	12	8
Pre-Requisite	UG in Biological Science	**Co-requisite**					
Course Objectives	The main objective of this course is to develop independence in experimental design and interpretation and to develop research skills. To promote education and research in biotechnology and provide academic and professional excellence for immediate productivity in industrial, governmental, or clinical settings for an ultimate benefit of society and environment.						

Course Outcomes	
CO1	The students will be able to perform literature review, identify state of the art in that field.
CO2	The students will be able to define the problem and develop synopsis of a defined research problem
CO3	The students will be able to establish a methodology using advanced tools / techniques for solving the problem including project management and finances.
CO4	The students will be able to prepare the research report and its oral demonstrations.
CO5	The students will be gain practical experience in project management in biotechnological industry, be able to use various techniques in contemporary research for project, perform numerical analysis and interpret the results

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2			2	3	1	3	2	1	3	3
CO2	3	2				3	1	3	2	1		3
CO3	3					3		3			3	3
CO4	3	2			1	3		3	2	1		3
CO5	3		2	3	2	3		3	2	1	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	**Sign & Seal of HoD**