

**Department of Biotechnology**  
**Master of Science in Biotechnology (Semester - wise Scheme 2019-2021)**

**Semester-I (Total credits - 24)**

Course code	Course title	L	T	P	Type of course	Credit
SIAL BT 1 1 01 C 3003	Cell and Molecular Biology	3	0	0	Core	3
SIAL BC 1 1 01 C 3003	Principles of Biochemistry	3	0	0	Core	3
SIAL MB 1 1 01 C 3003	General Microbiology	3	0	0	Core	3
SIAL BT 1 1 02 C 3003	Genetics	3	0	0	Core	3
<b>SIAL SC 1 1 01 C 3003</b>	<b>Analytical Techniques</b>	3	0	0	Core	3
<b>SIAL SC 1 1 02 C 00105</b>	<b>Practical-I</b>	0	0	10	Core	5
	<b>Generic Elective Course</b> (to be opted from other Department)	4	0	0	GEC	4

**Semester-II (Total credits - 30)**

Course code	Course title	L	T	P	Type of course	Credit
SIAL BC 1 2 02 C 4004	Immunology	4	0	0	Core	4
SIAL MB 1 2 02 C 3003	Biosafety, Bioethics and IPR	3	0	0	Core	3
SIAL BT 1 2 03 C 4004	Genomics and Genetic Engineering	4	0	0	Core	4
SIAL BT 1 2 04 C 4004	Bioprocess Engineering and Technology	4	0	0	Core	4
SIAL BT 1 2 05 C 4004	Cell and Tissue Engineering	4	0	0	Core	4
SIAL BT 1 2 06 C 00105	Practical-II	0	0	10	Core	5
<b>SIAL SC 1 2 03 DCEC 2002</b>	<b>Research Methodology and Scientific Communication Skills*</b>	2	0	0	DCEC	2
<b>SIAL SC 1 2 04 DCEC 2002</b>	<b>Bio-entrepreneurship*</b>	2	0	0	DCEC	2
SIAL BT 1 2 01 DCEC 4004	Pharmaceutical Biotechnology <sup>#</sup>	4	0	0	DCEC	4
SIAL BT 1 2 02 DCEC 4004	Microbial Biotechnology <sup>#</sup>	4	0	0	DCEC	4
SIAL BT 1 2 03 DCEC 4004	Environment Biotechnology <sup>#</sup>	4	0	0	DCEC	4

\*One of the courses will be opted by the student.      # One of the courses will be opted by the student.

**Semester-III (Total credits - 30)**

Course code	Course title	L	T	P	Type of course	Credit
<b>SIAL SC 1 3 05 C 4004</b>	<b>Biostatistics and Bioinformatics</b>	4	0	0	Core	4
SIAL BC 1 3 07 C 4004	Biophysics and Nano sciences	4	0	0	Core	4
SIAL BT 1 3 07 C 4004	Metabolic Engineering	3	0	0	Core	4
SIAL BT 1 3 08 C 4004	Medical Biotechnology and Diagnostics	4	0	0	Core	4
SIAL BT 1 3 09 C 0084	Practical-III	0	0	8	Core	4
SIAL BT 1 3 10 C 0202	Seminar	0	2	0	Core	2
SIAL BT 1 3 04 DCEC 4004	Animal Biotechnology <sup>#</sup>	4	0	0	DCEC	4
SIAL BT 1 3 05 DCEC 4004	Agriculture Biotechnology <sup>#</sup>	4	0	0	DCEC	4
SIAL BT 1 3 06 DCEC 4004	Food Biotechnology <sup>#</sup>	4	0	0	DCEC	4
	<b>Generic Elective Course</b> (to be opted from other Department)	4	0	0	GEC	4

# One of the courses will be opted by the student.

**Semester-IV (Total credits - 20)**

**Skill Enhancement Course**

Course code	Course title	Type of course	Credit
SIAL BT 1 4 01 SEEC 0020	Dissertation	Core	20
<b>Total credits of the Program</b>			<b>104</b>

L- Lecture , T- Tutorial P-Practical; C- Core; DCEC - Discipline Centric Elective Course - to be opted by the student; SEEC- Skill Enhancement Course; GEC- Generic Elective Course.

**Credit Summary of Courses Offered by Department of Biotechnology**  
**(Academic Session 2019-21)**

**Total Credits: 104**

Semester	Credits				Total credits
	Core courses	Skill enhancement course	Elective courses		
			DCEC (For Department of Biotechnology students)	GEC (For other Department students)	
I	20	-	-	4	<b>24</b>
II	24	-	6	-	<b>30</b>
III	22	-	4	4	<b>30</b>
IV	-	20	-	-	<b>20</b>
<b>Total</b>	<b>66</b>	<b>20</b>	<b>10</b>	<b>8</b>	<b>104</b>

**Generic Elective Course:** Offered by Department of Biotechnology to students from other Departments of University.

Semester	Type of course	Course code	Course title	Credit
I	GEC	SIAL BT 1 1 01 GE 4004	Principles of Biotechnology	4
III	GEC	SIAL BT 1 3 02 GE 4004	Protein Engineering	4

## SEMESTER-I

**Course title: Cell and Molecular Biology**

**Credit: 3**

**Course code: SIAL BT 1 1 01 C 3003**

**Lectures: 45**

**Course objectives:** To understand cellular organization and function at molecular level.

### **Learning Outcomes:**

- Understanding of fundamental concepts of cellular and sub-cellular organization
- Molecular basis of genetic information and function

### **Unit-I**

Archea, prokaryotic and eukaryotic cell (animal and plant cells); Theory of origin of eukaryotic cells; Structure and function of nucleus - nuclear envelope, nuclear pore complex; Nuclear protein-import and export, regulation of nuclear protein import and export; Organization of golgi, lysosome, structure and functions of ER, lysosome, mitochondria, chloroplasts and peroxisomes; Fluid mosaic model, membrane proteins, membrane lipids and membrane fluidity; Transport across cell membrane, passive transport, active transport-primary (P-type, F-type, V-type ATPases, ABC transporters), co-transport-symport and antiport; Ion channels, aquaporins, pinocytosis and phagocytosis; Cells as experimental models.

### **Unit-II**

Introduction to cytoskeletal proteins; Organization of cytoskeletal protein and smooth muscle and skeletal muscles, movement of vesicles-role of actin and myosin; Structure of cilia and flagella; Prokaryotic and eukaryotic cell wall, cell matrix proteins; Cell-matrix interactions and cell-cell interactions; Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata; Signalling molecules, receptors and their functions – G protein coupled receptors- Cyclic-AMP, Cyclic-GMP, IP3, Calcium, Receptor tyrosine kinases - EGF, insulin.

### **Unit-III**

DNA as genetic material, forms of DNA; structure of various type of DNA; chromatin structure; super coiling; polytene and lamp brush chromosomes; properties of DNA in solution; denaturation and renaturation; reassociation reactions; COT curves; types of RNAs and their structures; role of RNA; Unusual bases in RNA; central dogma of molecular biology; DNA polymerases and other enzymes involved in replication; mutagenesis.

### **Unit-IV**

Prokaryotic and eukaryotic gene structure: transcription-RNA polymerase, inhibitors of transcription; proof reading function and fidelity of DNA replication; possible modes of DNA replication; theta model and rolling circle model of DNA replication; replication of DNA in eukaryotes; role of methylation; replication of viral RNA; reverse transcriptase, regulatory region and transcriptional unit of gene; post transcriptional processing of RNA: splicing, cap addition and polyadenylation, polynucleotide phosphorylase.

### **Suggested readings:**

1. The Cell: A Molecular Approach (2018) 8<sup>th</sup> ed., Cooper, GM, Sinauer Associates is an imprint of Oxford University Press, ISBN: 1605357073.

2. Molecular Cell Biology (2016) 8<sup>th</sup> ed., Lodish H, Berk A, Zipursky SL, Matsudaira P, Baltimore D and Darnell J, W.H. Freeman & Company (New York), ISBN: 978-1-4641-0981-2 / ISBN:10: 1464183392.
3. Molecular Biology of the Cell (2008) 6<sup>th</sup> ed., Alberts B, Johnson A, Lewis J and Enlarge M, Garland Science (Princeton), ISBN: 0-8153-1619-4 / ISBN:0-8153-1620-8.
4. Lehninger Principles of Biochemistry (2017) 7<sup>th</sup> ed., Nelson DL, Cox MM, W.H. Freeman and Company, New York, USA. ISBN-10: 1-4641-2611-9.
5. Biochemistry (2019) 9<sup>th</sup> ed., Stryer L, Berg JM, Tymoczko JL, Gatto, Jr. GJ, W.H. Freeman and Company, New York, USA. ISBN-10: 1-319-11467-9
6. Genes XII, (2017) 12th Revised edition ed., Lewin B, Krebs J, Kilpatrick ST, Goldstein ES, Jones and Bartlett Publishers, Inc. Sudbury, Massachusetts, USA. ISBN No. 9781284104493.
7. Molecular Biology of the Gene (2013) 7<sup>th</sup> ed., Watson JD, Baker TA, Bell SP, Gann A, M, Levin RL and Cumming B, San Francisco, ISBN: 0321905377.

## SEMESTER-I

**Course title: Principles of Biochemistry**

**Course code: SIAL BC 1 1 01 C 3003**

**Credit: 3**

**Lectures: 45**

**Course objectives:** To understand structures and functions of bio-molecules, metabolic pathways in the living systems.

### **Learning outcomes:**

- Comprehensive knowledge of biochemical pathways-synthesis and catabolism of major biomolecules

### **Unit-I**

Monosaccharides-structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers. Disaccharides: maltose, lactose and sucrose. Polysaccharides: homo and hetero-polysaccharides, structural and storage polysaccharides. Glycolysis - a universal pathway, reactions of glycolysis, production of acetyl CoA, reactions of citric acid cycle. Gluconeogenesis, glycogenesis and glycogenolysis.

### **Unit-II**

Building blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes. Structural lipids in membranes-phospholipids, glycerophospholipids, galactolipids, sulpholipids, sphingolipids and sterols.  $\beta$ -oxidation of fatty acids. Fatty acid synthase complex. Synthesis of fatty acids.

### **Unit-III**

Amino acids and peptides- classification (essential and non-essential amino acids), chemical reactions and physical properties. Introduction to protein structure and function. Enzymes: classification, kinetics (significance of  $k_m$ ,  $k_{cat}$  and  $V_{max}$ ), inhibition; amino acid metabolism-amino acid deamination and transamination, urea cycle. Synthesis and utilization of ketone bodies. Biosynthesis and breakdown of nutritionally non-essential amino acids. Synthesis of other amino acid derivatives such as neurotransmitters.

### **Unit-IV**

Nucleotides - structure and properties. Nucleic acid structure-Watson - Crick Model of DNA. Structure of major species of RNA - mRNA, tRNA and rRNA. De novo synthesis of purine and pyrimidine nucleotides. Catabolism of purine and pyrimidine. Disorders of purine and pyrimidine metabolism.

### **Suggested readings:**

1. Lehninger: Principles of Biochemistry (2017) 7<sup>th</sup> ed., Nelson, DL and Cox, MM, WH Freeman and Company (New York), ISBN: 978-1319108243.
2. Biochemistry (2017) 6<sup>th</sup> ed., Garrett RH and Grisham CM, Brooks/Cole, ISBN: 9781305577206.
3. Harper's Illustrated Biochemistry (2018) 7<sup>th</sup> ed., Rodwell VW, Bender DA, Botham KM, Kennelly, PJ and Weil PA, McGraw-Hill, ISBN: 9781259837937.
4. Lippincott's Illustrated Reviews Biochemistry (2017) 7<sup>th</sup> ed., Ferrier, Wolters Kluwer India Pvt. Ltd., ISBN: 978-9351297949.
5. Biochemistry (2019) 9<sup>th</sup> ed., Stryer L, Berg JM, Tymoczko JL, Gatto Jr. GJ, W.H. Freeman and Company, New York, USA. ISBN-10: 1-319-11467-9.

## SEMESTER-I

**Course title: General Microbiology**  
**Course code: SIAL MB 1 1 01 C 3003**

**Credit: 3**  
**Lecture: 45**

**Course objective:** To provide an understanding of basic concepts and techniques in Microbiology.

### **Learning outcomes:**

- Demonstrate the practical skills in basic microbiological techniques
- Designate the role of microorganisms in different ecosystems
- Retrieve and use contemporary information on different microbial groups

### **Unit-I**

History of development of Microbiology in 20<sup>th</sup> century; The spontaneous generation controversy; Germ theory of disease; Methods in microbiology: Physical and chemical methods of sterilization; Pure culture techniques, maintenance and preservation of microbial cultures.

### **Unit-II**

Binomial nomenclature; Haeckel's three kingdom classification; Organization of archae, bacteria and eukaryotic cell; Use of DNA and r-RNA sequencing in classification of microorganisms; Woese's three kingdom classification system and its utility - archaea, eubacteria, eukarya; Different groups of acellular microorganisms - viruses, viroids and prions.

### **Unit-III**

General features of microorganisms - bacteria, algae, fungi and protozoa; Bacterial growth and metabolism; Microbes in different environment: extreme environment, deep ocean, space and air. Special features of the thermophilic, methanogenic and halophilic bacteria; Photosynthetic bacteria, Cyanobacteria.

### **Unit-IV**

Scope of Microbiology - Cycle of matter in nature; Microbial interactions – Symbiosis and parasitism; Biodegradation and Bioremediation; Biofilms; Microbes in composting; Biofertilizers and Biopesticides; Microbes and Industry - SCP, microbial enzymes and fermented foods, Vaccines and antibiotics.

### **Suggested readings:**

1. An Introduction to Microbiology (2019), 3<sup>rd</sup>ed., Tauro P, Kapoor KK, Yadav KS, and Sequeira MG. New Age International Publishers. ISBN: 0852268785.
2. Brock Biology of Microorganisms (2018), 15<sup>th</sup>ed., Madigan MT, Martinko JM, Bender KS, Buckley DH, Stahl DA Pearson Education, ISBN 9781292235103.
3. Prescott's Microbiology (2017). 10<sup>th</sup> ed. Sherwood LM, Woolverton C.J McGraw-Hill Education. ISBN 9781259281594.
4. A text book of Microbiology (2013), 3<sup>rd</sup> ed. Dubey, R.C. and Maheswari, D.K. Revised S. Chand and Company Ltd, New Delhi. ISBN: 9788121926201.
5. Microbiology (2001) 5<sup>th</sup> ed., Pelczar Jr. M, McGraw Hill Education ISBN: 9780074623206.

## SEMESTER-I

**Course title: Genetics**

**Course code: SIAL BT 1 1 02 C 3003**

**Credit: 3**

**Lecture: 45**

**Course objective:** To study the fundamental concepts of genetics and its role in unification of different disciplines of biology.

### **Learning outcomes:**

- Understanding of basic concepts of classical genetics and genetic analysis of eukaryotes

### **Unit-I**

Historical background, Principles of Mendelian inheritance, codominance, incomplete dominance, Gene interactions, pleiotropy, Extra chromosomal inheritance: Maternal inheritance (mitochondria and chloroplast), Sex linked inheritance, Sex influenced and Sex limited traits, Gene interactions: Incomplete dominance, codominance, duplicate genes, complementary genes, supplementary genes, lethal genes, pleiotropic genes and multiple alleles.

### **Unit-II**

Linkage: complete and incomplete linkage, linkage analysis and genetic maps, Linkage and recombination of gene, Mechanism of crossing over, Population Genetics and Hardy-Weinberg equilibrium. Genetic analysis: Linkage maps, mapping with molecular markers, Gene mapping by three point test cross, Tetrad analysis, Sex determination and Dosage compensation in Mammals and Drosophila, Quantitative Genetics: Multilocus control; QTL analysis; Quantitative inheritance in plants and human.

### **Unit-III**

Mutations: concept and types, Mechanism of spontaneous mutations, Physical and chemical mutagenesis, Selection and enrichment of mutants, Molecular mechanism of induced mutations, importance of mutation; detection of mutation and directed mutagenesis, Germinal and somatic mutation, insertion, deletion, duplication, translocation, transposition, Numerical alterations of chromosomes: Ploidy and their genetic implications. Types of DNA repair, Molecular mechanism of suppression.

### **Unit-IV**

Nucleosome and chromatin structure, Structure of centromere and telomere, Euchromatin and heterochromatin, Polytene and lamp brush chromosomes, Gene transfer in prokaryotes: Transformation, Conjugation and Transduction, Transposons: types, structures and role in gene regulation, Natural and artificial competence, Operon concept in bacteria and gene regulation, Bacterial plasmids, Lytic and lysogenic cell cycles in Phages.

### **Suggested readings:**

1. Principles of Genetics (2006) 8<sup>th</sup> ed. Gardner EJ, Simmons, MJ and Snustad DP, John Wiley & Sons Inc, ISBN: 8126510439.
2. Essentials of Genetics (2015) 9<sup>th</sup> ed. William S, Michael K, Cummings R, Spencer, CA and Palladino MA, Prentice Hall Internationals, ISBN-10: 0134047796
3. Genetics (2017) 9<sup>th</sup> ed. Daniel L. Hartal & B. Cochrane, ISBN: 128412293X
4. Introduction to Quantitative Genetics (1995) Falconer DS, and Mackay TFC, ISBN: 0582243025.

5. An Introduction to Population Genetics Theory and applications (2013) Nielsen R and Slatkin M, Oxford University Press, ISBN: 1605351539.
6. Evolution 4<sup>th</sup> ed. (2017) D. Futuma and M. Kirkpatrick, ISBN: 9781605356051
7. An Introduction to Genetic Analysis (2015) Griffith AJFJ, Wessler SR, Carroll SV and Doebley J, ISBN: 0-7167-3520-2.



## SEMESTER-I

**Course title: Analytical Techniques**  
**Course code: SIAL SC 1 1 01 C 3003**

**Credit: 3**  
**Lecture: 45**

**Course objective:** To provide an advanced understanding of the core principles of various techniques used in biological experiments.

### **Learning outcomes:**

- Demonstrate principles of various basic and advanced techniques used in biological experiments
- Critically analyze and interpret the results obtained from biological experiments

### **Unit-I**

Principle of microscopy: resolving powers of different microscopes, magnification; different types of microscopes, principle and applications of compound microscopy, dark microscopy, fluorescence microscopy, phase contrast microscopy, confocal microscopy, atomic force microscopy and electron microscopy (SEM, TEM, STEM); fixation and staining, freeze fracture/etch techniques.

### **Unit-II**

Agarose gel electrophoresis, polyacrylamide gel electrophoresis (native PAGE and SDS-PAGE); Western transfer, iso-electric focusing (IEF), 2-Dimensional gel electrophoresis, pulse field electrophoresis; principle and applications of centrifugation, differential centrifugation, density gradient centrifugation and ultracentrifugation; cell separation by flow cytometry.

### **Unit-III**

Paper chromatography (ascending and descending, 2-Dimensional); principle and applications of thin layer chromatography (TLC), column chromatography (gel filtration, ion exchange and affinity chromatography); methods of ligand immobilization, immuno-adsorption-hydrophobic interaction chromatography, metal chelate chromatography, covalent chromatography, high performance liquid chromatography (HPLC) and gas liquid chromatography (GLC).

### **Unit-IV**

Principle and instrumentation of UV-visible, infrared spectroscopy, atomic absorption spectrophotometry, NMR spectroscopy, X-ray diffraction spectroscopy, N-terminal sequencing and peptide synthesis, introduction to proteomics, Yeast 2- hybrid and 3-hybrid systems, EMSA, foot printing, phage display, principle of mass spectrometry, electrospray ionization MS, MALDI, tandem MS for protein identification, ICAT-MS.

### **Suggested readings:**

1. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8<sup>th</sup> ed. Wilson K and Walker J, Cambridge University Press, ISBN No. 131661476X.
2. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1.
3. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder D, W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.

## SEMESTER – I

**Course Title: Practical-I**  
**Course Code: SIAL SC 1 1 02 C 00105**

**Credit: 5**  
**Lecture: 150**

1. Laboratory orientation, calibration, and demonstration of equipment.
2. Solutions, pH and buffers
3. Determination of pKa of acetic acid and glycine
4. Qualitative tests for carbohydrates, lipids, amino acids, and proteins in food samples
5. Metaphase chromosome preparation with G banding and C banding from blood sample
6. RNA *in-situ* hybridization to study gene expression in tissue section
7. Inheritance patterns in man – numerical on pedigree analysis- autosomal patterns, X–linked patterns, Y–linked patterns, mitochondrial inheritance patterns
8. Numerical on Hardy-Weinberg equilibrium
9. Numerical on linkage mapping
10. Different staining methods and microscopic examination of bacteria, actinomycetes, algae, fungi and protozoa
11. Preparation of specific media for isolation of bacteria, and fungi from natural sources
12. Cell counting and cell viability assay
13. Production of microbial enzymes (amylase, phosphatase) and their separation using chromatographic techniques
14. Biochemical characterization of microbial enzymes.
15. Separation of carbohydrates, amino acids and plant pigments using paper/thin layer chromatography
16. Detection of food adulterants
17. Evaluation of microbiological risks in food processing unit through microbiological risk assessment (MRA) tools
18. Assessment of nutritional status of different age group using anthropometric tools

### **Suggested readings:**

1. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D, Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1.
2. An Introduction to Practical Biochemistry (2017) 3<sup>rd</sup> ed., Plummer, D.T., McGraw Hill Education, ISBN: 978-0070994874.
3. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8<sup>th</sup> ed. Wilson K, and Walker J, Cambridge University Press. ISBN: 131661476X.
4. Microbes in Action: A Laboratory Manual of Microbiology (1990) 4<sup>th</sup> Addition, Harry W, Seeley, Paul JV, John J, W. H. Freeman ISBN: 978-0716721000.
5. Genetics: A Laboratory Manual, (2009) 2<sup>nd</sup> ed., American Society of Agronomy; Lab Manual edition, ISBN: 978-0891185611.

6. Infant, Child and Adolescent Nutrition: A Practical Handbook (2013) 1<sup>st</sup> ed., More J, CRC Press, ISBN: 9781444111859.
7. Laboratory Manual of Microbiology and Biotechnology (2014) 1<sup>st</sup>ed.Aneja KR, Scientific International Pvt., Ltd. ISBN: 9789381714553.
8. Microbiology: A Laboratory Manual (2017), 11th ed., Cappuccino, JH, Sherman, N., Pearson Education Inc, ISBN: 9780134298597.
9. An introduction to Practical Biochemistry (2017) 3<sup>rd</sup> ed., Plummer, DT, McGraw Hill Education, ISBN: 978-0070994874.

## SEMESTER-I

**Course title - Principles of Biotechnology**  
**Course Code - SIAL BT 1 1 01 GEC 4004**

**Credits: 4**  
**Lecture: 60**

**Course objective:** Provide basic understanding of biotechnology; it's scope and applications in the agriculture, medicine, industrial, environment and advancement of biology.

**Learning outcomes:**

- Opportunity for entrepreneurship in the area of bioeconomy and creation of wealth

**Unit-I**

An overview-definition, Scope and importance of biotechnology, Concepts of recombinant DNA technology and Gene Cloning. A brief account of microbes in industry and agriculture, Metabolic engineering for over production of metabolites.

**Unit-II**

Introduction to plant tissue culture and its applications, Gene transfer methods in plants, Transgenic plants (A brief introduction). *In-vitro* fertilization and embryo transfer in humans and livestock. Transfection techniques and transgenic and genome edited animals, Animal Cloning.

**Unit-III**

(A brief account) Biotechnology in medicine, Vaccines, Molecular diagnostics, Forensic, Gene therapy, Nano Medicine & Drug Delivery Cell & Tissue Engineering, Stem Cell therapy. (A brief account) Role of biotechnology in pollution control, Sewage treatment, Energy management, Bioremediation, Restoration of degraded lands and Conservation of biodiversity.

**Unit-IV**

An Overview, Insights and intervention into the Nano world, Important Developments, Societal implications & Ethical issues in Nanotechnology, applications of Nano-biotechnology in different areas. Biotechnology for developing countries and IPR

**Suggested Readings:**

1. Lehninger Principles of Biochemistry (2017) 7<sup>th</sup> ed., D.L. Nelson, M.M. Cox.. W.H. Freeman and Company, New York, USA, ISBN: 1-4641-2611-9.
2. Microbiology- Concepts and Applications, (1993) 6<sup>th</sup> ed., Pelczar MJ et. al., McGraw-Hill Inc, US, ISBN: 0070492581.
3. Plant Biotechnology – The genetic manipulation of plants (2017) 3<sup>rd</sup> ed., Slater A, Scott N and Fowler M, Oxford University Press, ISBN: 1138407674.
4. Animal Cell Culture Methods In: Methods in Cell Biology, (1998) Volume 57, 1<sup>st</sup> ed., Jenni P.M. and David B., Academic Press, eBook ISBN: 9780080859552.
5. Genome-4, (2017) Brown TA, Garland science, Taylor & Francis, NewYork, ISBN: 9780815345084.
6. Diagnostic and Therapeutic Antibodies (Methods in Molecular Medicine) George AJT, and Catherine EU, Humana Press, ISBN: 978-0-89603-798-4.

## SEMESTER-II

**Course title: Immunology**  
**Course code: SIAL BC 1 2 02 C 4004**

**Credit: 4**  
**Lecture: 60**

**Course objective:** To understand overall organization of the immune system and to identify the cellular and molecular basis of immune responsiveness.

### **Learning outcomes:**

- Understanding the working mechanism of the immune system
- Understanding of antibody, MHC, complement system, cytokines, cancer, and organ transplant hypersensitivity

### **Unit-I**

Host-defenses, hematopoiesis, cells of the immune system, primary and secondary lymphoid organs and tissues (MALT). Anatomical barriers, cell types of innate immunity, soluble molecules and membrane associated receptors (PRR), connections between innate and adaptive immunity, chemokines. Antigens and haptens, factors that dictate immunogenicity, B and T cell epitopes.

### **Unit-II**

Structure and distribution of classes and subclasses of immunoglobulins (Ig), Ig fold, effector functions of antibody, antigenic determinants on Ig and Ig super family. Multigene organization of Ig locus, mechanism of V region DNA rearrangement, ways of antibody diversification. Antigen independent phase of B cell maturation and selection, humoral response – T-dependent and T-independent response.

### **Unit-III**

Complement activation by classical, alternate and MB lectin pathway, biological consequences of complement activation, regulation and complement deficiencies. General organization and inheritance of MHC, structure, distribution and role of MHC class I and class II proteins, pathways of antigen processing and presentation. Structure and role of T cell receptor, and co-receptor, T cell development, generation of receptor diversity, selection and differentiation. General properties of effector T cells, cytotoxic T cells (Tc), natural killer cells; NKT cells and antibody dependent cellular cytotoxicity (ADCC).

### **Unit-IV**

Mechanism of tolerance, Organ specific and systemic autoimmune diseases, possible mechanisms of induction of autoimmunity, IgE mediated (Type I) hypersensitivity, antibody mediated cytotoxic (Type II) hypersensitivity, immune complex mediated (type III) hypersensitivity and delayed type (Type IV) hypersensitivity. Immunological basis of graft rejection, clinical manifestations, immunosuppressive therapy, Immunohistochemistry, Immunocytochemistry and privileged sites. Vaccines - active and passive immunization, types of vaccines.

### **Suggested readings:**

1. Kuby Immunology (2018) 8<sup>th</sup> ed., Punt J, Stranford S, Jones P and Owen JA, W.H Freeman and Company, ISBN: 978-1319114701.
2. Janeway's Immunobiology (2017) 9<sup>th</sup> ed., Murphy KM and Beaver C, WW Norton and Company, ISBN: 978-0815345510.
3. Roitt's Essential Immunology (2017) 13<sup>th</sup> ed., Delvis PJ, Martin SJ, Burton DR and Roitt, IM, Wiley-Blackwell, ISBN: 978-1118415771.

4. Lehninger: Principles of Biochemistry (2017) 7<sup>th</sup> ed., Nelson, DL and Cox, MM, WH Freeman and Company (New York), ISBN: 978-1319108243.
5. Lippincott's illustrated Reviews Immunology (2012) 2<sup>nd</sup> ed., Doan T, Melvold R, Viselli S and Waltenbaugh, C, Wolters Kluwer India Pvt, Ltd, ISBN: 978-8184737639.

## SEMESTER-II

**Course title: Biosafety, Bioethics and IPR**

**Course code: SIAL MB 1 2 02 C 3003**

**Credit: 3**

**Lecture:45**

**Course objective:** To introduce the concept of intellectual property rights, patenting and emphasis on biosafety and bioethics.

### **Learning outcomes:**

- Understanding the basics of intellectual property rights
- Understand the importance and level of biosafety at laboratory and industrial levels
- Understand ethical practices and concepts appropriate to the discipline

### **Unit-I**

Biosafety: introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools. Regulations: International regulations-Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations-EPA act and rules, guidance documents, regulatory framework-RCGM, GEAC, IBSC and other regulatory bodies.

### **Unit-II**

Bioethics: Introduction, ethical conflicts in biological sciences-interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research - cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology-Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity - biopiracy.

### **Unit-III**

Patenting: Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications, PCT and conventional patent applications.

### **Unit- IV**

International patenting-requirement, procedures and costs; financial assistance for patenting, introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples;

commercialization of patented innovations; licensing-outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research-backward and forward IP; benefit/Credits sharing among parties/community, commercial (financial) and non-commercial incentives.

**Suggested readings:**

1. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. <http://www.ipindia.nic.in/>
2. World Trade Organisation. <http://www.wto.org>
3. World Intellectual Property Organisation. <http://www.wipo.int>
4. International Union for the Protection of New Varieties of Plants. <http://www.upov.int>
5. National Portal of India. <http://www.archive.india.gov.in>
6. IPR, Biosafety and Bioethics (2013) Parashar S, Goel D, Pearson Publishing India, ISBN: 9788131774700.
7. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology (2017) Nambisan P, Academic Press, ISBN: 9780128092316.
8. <http://dbtindia.gov.in/guidelines-biosafety>



## SEMESTER-II

**Course title: Genomics and Genetic Engineering**

**Course code: SIAL BT 1 2 03 C 4004**

**Credit: 4**

**Lecture: 60**

**Course objective:** To provide basic and high throughput techniques in the areas of genomics and genetic engineering.

### **Learning outcomes:**

- Understanding of high throughput techniques used in genomics and transcriptomics
- Understand concept of genetic engineering including the techniques, applications and limitations
- Demonstrate the ability of designing recombinant molecules and conducting experiments involving genetic manipulation

### **Unit-I**

Origin of genomics: The first DNA genomes, Structure and organization of prokaryotic and eukaryotic genomes - nuclear, mitochondrial and chloroplast genomes, Microbial genomes (including yeast), Plant genomes (Arabidopsis and rice), Animal genomes (fruit fly, mouse, human), Genomes and human evolution, The concept of minimal genome. Genetic maps, Physical maps, EST and transcript maps, Functional maps and Functional genomics, Human genome project-landmarks on chromosomes generated by various mapping method, Comparative genomics and colinearity/syteny in maps, Genetic variation polymorphism, deleterious mutation; FISH to identify chromosome landmarks.

### **Unit-II**

BAC libraries and shotgun libraries preparation (shotgun sequencing); Clone-by-clone or 'hierarchical shotgun' Sequencing, Next Generation sequencing, Genomics in medical practice, personalized medicine, use of SNP in pharmacogenomics, DNA Microarray technology: Basic principles and design, Global gene expression analysis, Comparative transcriptomics, Differential gene expression.

### **Unit-III**

Recombinant DNA Technology: Enzymes used in Recombinant DNA technology (Restriction endonucleases, DNA modifying enzymes, other nucleases, Polymerases, Ligase, kinases and phosphatases), Isolation and purification of DNA (genomic and plasmid) and RNA. Various methods of separation, characterization of nucleic acids including Southern and Northern hybridizations, Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors and their purification.

### **Unit-IV**

Western blotting, generation of genomic and cDNA libraries. plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms. Isolation and amplification of specific nucleic acid sequences, PCR, RT-PCR and qRT-PCR, DNA sequencing methods, strategies for genome sequencing. Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques. Site-directed Mutagenesis, protein engineering. Applications of genetic engineering in plants and animal improvements.

**Suggested readings:**

1. Principles of Gene Manipulation and Genomics (2016) 8<sup>th</sup> ed., Primrose, SB and Twyman, R, Wiley Blackwell, ISBN: 978-1405156660.
2. Gene Cloning and DNA Analysis: An Introduction (201978-6) 7<sup>th</sup> ed., Brown, TA, Wiley Blackwell, ISBN: 978-1119072560.
3. Genome 4 (2017) 4<sup>th</sup> Brown, TA, Garland science, ISBN 13: 978-0815345084.
4. Introduction to Genomics (2015) 2<sup>nd</sup> ed., Lesk, AM, Oxford university Press India, ISBN: 978-0198745891.
5. Genomics and Personalized Medicine: What Everyone needs to Know (2016) 1<sup>st</sup> ed., Snyder, M, OUP-USA, ISBN: 978-0190234768.

## SEMESTER-II

**Course title: Bioprocess Engineering and Technology**

**Credit: 4**

**Course code: SIAL BT 1 2 04 C 4004**

**Lecture: 60**

**Course objective:** To provide fundamental concepts of bioprocess technology and to overcome the challenges of the new and emerging areas of biotechnology industry.

### **Learning outcomes:**

- Understanding of design and operations of a process for bio-based products
- Understanding the structure, operation and functions of various fermenters
- Critical analysis and improvement in any bioprocess from market point of view

### **Unit-I**

Microbial growth and death kinetics; Ideal and non-ideal reactors; Residence Time Distribution; Unstructured models of microbial growth; structured models of microbial growth. Elements in bioreactor design- overview of bioreactor, Construction materials, types of bioreactors, its developments using microbial processes, mammalian cell culture, and plant cell culture, components of bioreactors and importance.

### **Unit-II**

Analysis of batch and continuous culture; modifying batch and continuous reactors; fed-batch operations; Multiphase bioreactor system; upstream processing: media formulation and optimization; sterilization (medium and air)-thermal death kinetics of microorganisms; aeration, agitation and heat transfer in bioprocess; Translation of laboratory, pilot and plant scale data-scale up and scale down.

### **Unit-III**

Separation of insoluble products-filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration; final purification: drying; crystallization; storage and packaging.

### **Unit-IV**

Monitoring of Bioprocesses: On line data analysis for measurement and control of important physicochemical and biochemical parameters, parameter estimation techniques for biochemical processes, parameter estimation techniques for biochemical processes, Computer based data acquisition. Techno-economic feasibility of bioprocess; effluent treatment and disposal.

### **Suggested Readings:**

1. Bioprocess Engineering: Basic Concepts (2017) 3rd ed. Shuler, ML, and Kargi, F. Pearson Prentice Hall, ISBN: 0137062702.
2. Principles of Fermentation Technology (2016) 3<sup>rd</sup> ed. Stanbury P, Allan Whitaker, Stephen Hall. Imprint (Butterworth-Heinemann), ISBN: 9780080999531.
3. Biochemical Engineering Fundamentals (2013) 5<sup>th</sup> reprint J. E. Bailey and Ollis, D. F. McGraw-Hill Education (India) Pvt Ltd., ISBN: 0070701237.
4. Bioprocess Engineering Principles (2013) 2<sup>nd</sup> ed. Doran, P.M, Academic Press, ISBN: 978-0-12-220851-5.
5. Bioreactors Analysis and Design (2011) Panda T, Tata McGraw Hill, ISBN: 978-0-07-070424-4.

## SEMESTER-II

**Course title: Cell and Tissue Engineering**

**Course code: SIAL BT 1 2 05 C 4004**

**Credit: 4**

**Lectures: 60**

**Course objective:** To design, optimize and maintain biomedical systems in tune with community needs and environmental concerns.

**Learning outcomes:**

- Designing a system to meet desired needs within realistic constraints
- Understanding professional and ethical responsibilities as well as regulatory issues

**Unit-I**

Definition of biomaterials, requirements of biomaterials, classification of biomaterials, properties of common biomaterials, Physical and mechanical properties of biomaterials, Engineering biomaterials for tissue engineering, Degradable materials (collagen, silk, hydrogels and polylactic acid), 3-D architecture/printing and cell incorporation, Biocompatibility, basic transplant immunology.

**Unit-II**

Fundamental of tissue engineering, Structural and organization of tissues: Epithelial, Endothelial, Mesenchymel, Connective. Basic wound healing, cell migration, in-vitro testing.

**Unit-III**

Types of cells for tissue engineering, progenitor cells and cell differentiations, cell matrix and cell-cell interaction. Aspect of cell culture: cell expansion, cell transfer, genetic engineering of cell, cell storage and cell characterization, growth factor delivery in tissue engineering, cell attachment: differential cell adhesion, receptor-ligand binding, and tissue specific cell surface markers.

**Unit-IV**

Tissue engineering of Bone, Cartilage, Blood vessels, Heart, Cell transplantation, Ethical, social and regulatory issues with tissue engineering.

**Suggested readings:**

1. Principles of Tissue Engineering (2013) 4<sup>th</sup> ed., Lanza, RP, Langer, R and Vacanti, JP, Academic Press, ISBN 13: 978-0123983589.
2. Biomaterials (Bioengineering and Health Science (2014) 1<sup>st</sup> ed., Migonney, V, ISTE Ltd., ISBN-13: 978-1848215856.
3. Nanomedicine and Tissue Engineering: State of the Art and Recent Trends (2016) 1<sup>st</sup> ed., Kalarikkal, N, Augustine, R, Oluwafemi, OS, Joshy, KS and Thomas, S, Apple Academic Press. ISBN 13: 978-1771881180.
4. Tissue Engineering (2018) 2<sup>nd</sup> ed., Blitterswijk, CV and Boer, JD, Academic Press ISBN 13: 978-0128100288.
5. Biomaterials: A Basic Introduction (2018) 1<sup>st</sup> ed., Chen, Q and Thouas, G, CRC Press, ISBN 13: 978-1138749665.

## SEMESTER-II

**Course title: Practical-II**  
**Course code: SIAL BT 1 2 06 C 00105**

**Credit: 5**  
**Lectures: 150**

1. Determination of A, B, O and Rh blood groups in human beings
2. Detection of antigen/antibody in a given sample using Enzyme Linked Immunosorbent Assay (ELISA)
3. Polyclonal antibody production in mice/rabbit and detection using antigen
4. DNA extraction and amplification of desired gene using PCR technique
5. Restriction analysis and DNA finger printing methods, RAPD, SSR etc.
6. RNA extraction and cDNA synthesis using reverse transcription process
7. Hydroponic culturing of plantlets under normal and stressed conditions.
8. Callus culture using various explants, regeneration of shoots and root induction.
9. Protoplast isolation, culture and visualization using Calcofluor staining.
10. Preparation of artificial seeds through gel entrapment and viability testing
11. To determine Volumetric Oxygen Transfer Coefficient (kLa) in fermentation system by dynamic method/sulphite method.
12. Comparative studies on the kinetics of free and immobilized enzymes/cells.
13. To estimate growth kinetic parameters of *Escherichia coli* in a bioreactor and analysis of various parameters.
14. Data Analysis Introduction to Metabolic Flux Analysis (MFA).
15. Comparative study of batch, fed-batch and continuous fermentations in a fermenter
16. To study various techniques for the separation of soluble and insoluble components of a biological mixture
17. To study dye decolorization using microbial/plant biomass or metabolites
18. Analysis of emerging pollutants in municipal/domestic wastewater

## SEMESTER-II

**Course title: Research Methodology and Scientific Communication Skills**      **Credit: 2**  
**Course code: SIAL SC 1 2 03 DCEC 2002**      **Lectures: 30**

**Course objective:** To provide knowledge about tools and techniques related with scientific communication and research methodology.

### **Learning outcomes:**

- Understanding the existence of scientific knowledge in ancient times
- Acquiring the skills of scientific reading, writing and presentations
- Appreciating the scientific ethics through case studies

### **Unit-I**

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

### **Unit-II**

Choosing a mentor, lab and research question; maintaining a lab notebook. Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences.

### **Unit-III**

Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

### **Unit-IV**

Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

### **Suggested readings:**

1. Research Methodology: Methods And Techniques (2019) 4<sup>th</sup> ed., Kothari CR and Garg G, New Age International Publishers, ISBN: 978-9386649225.
2. Communicate Science Papers, Presentations, and Posters Effectively (2015) Patience GS, Boffito DC, Patience P, Academic Press, ISBN: 978-0128015001.

3. **Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences** (2014) 4<sup>th</sup> ed., Matthews JR and Matthews RW, Cambridge University Press ISBN: 978-1107691933.
4. **Doing Science: Design, Analysis, and Communication of Scientific Research.** (2001) Valiela I, Oxford: Oxford University Press, ISBN 10:019538573X.
5. **On Being a Scientist: a Guide to Responsible Conduct in Research.** (2009) 3<sup>rd</sup> ed., Washington DC, National Academies Press.

## SEMESTER-II

**Course title: Bio-entrepreneurship**  
**Course code: SIAL SC 1 2 04 DCEC 2002**

**Credit: 2**  
**Lectures: 30**

**Course objectives:** To teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

### **Learning Outcomes:**

- Gain entrepreneurial skills and understand the various operations involved in venture creation
- Identifying scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies

### **Unit-I**

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

### **Unit-II**

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

### **Unit-III**

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

### **Unit-IV**

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

### **Suggested readings:**

1. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge, Routledge Studies in Innovation, Organizations and Technology (2018) 1<sup>st</sup> ed. Onetti, A, & Zucchella, A, CRC press, Taylor and Francis group. ISBN: 9781138616905.
2. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Shimasaki, CD (2014) Amsterdam: Elsevier. Academic Press is an imprint of Elsevier, ISBN: 0124047300.



3. Innovation, Commercialization, and Start-Ups in Life Sciences. (2014) 1<sup>st</sup> ed. Jordan, JF, CRC Press. Taylor and Francis group, ISBN: 9781482210125.
4. The Dynamics of Entrepreneurial Development and Management. (2011) 6<sup>th</sup> ed., Desai V, New Delhi: Himalaya Pub. House, ISBN: 9350244543.
5. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences (2008) Adams, DJ, Sparrow JC, Bloxham, Scion, ISBN:1904842364.

## SEMESTER-II

**Course title: Pharmaceutical Biotechnology**

**Course code: SIAL BT 1 2 01 DCEC 4004**

**Credit: 4**

**Lectures: 60**

**Course objective:** To provide basic and applied knowledge of biotechnological processes in the field of drugs and vaccines.

### **Learning outcomes:**

- Understanding the roles of biomolecules in the treatment of diseases
- Knowledge of developing new drug and vaccine products
- Understanding role of genomic information in development and treatment of diseases

### **Unit-I**

Biotechnology in pharmaceutical perspective: Biology in drug discovery; Traditional drug discovery vs. rational drug discovery, rational drug discovery pipeline, concept of target based drug design and target discovery, role of plant biotechnology in edible vaccine development. Definition: Generics and its advantages; Biogenerics and Biosimilars; Why biosimilars are not (bio) generics; The advent of Biosimilars; Protein-based biopharmaceuticals; Manufacturing processes; Global market; International Non-proprietary Names (INN) nomenclature system biosimilars regulation (EU position, US pathways, Government initiatives).

### **Unit-II**

Biotechnology in pharmaceutical industry: Major areas for biotechnology in the pharmaceutical industry such as antibiotics, vaccines, diagnostics, antibodies, biopharmaceuticals (insulin, interferon, GSF, CSF & therapeutic proteins etc.); Commercial aspects, priorities for future biotechnological research.

### **Unit-III**

Industrial enzymes in drug development: Penicillin amidase, lipase, oxidoreductase, nitrilase, protease etc. Use of all these enzymes for enantioselective synthesis of pharmaceutically important drugs / drug intermediates, future directions.

Approved follow-on proteins/Biosimilars; Characteristics of high-selling peptides and proteins; Products with expired patents; Challenging originator's patents; Target products for FOB (follow-on biologicals)/ Biosimilars development peptides; Recombinant nonglycosylated proteins; Recombinant glycosylated proteins; Industries dealing with biogenerics and its market value; World scenario; Indian scenario.

### **Unit-IV**

Genomics in target discovery: Concept of genome, genes and gene expression, genome sequencing and sequence comparison methods (e.g. BLAST), gene expression comparison methods (microarray). Comparative genomics and expression genomics for target discovery of communicable diseases and lifestyle disease.

### **Suggested readings:**

1. Pharmaceutical Biotechnology (2016) Helmer E, Syrawood Publishing House, ISBN: 978-1682861066.
2. Pharmaceutical Biotechnology (2014) Sreenivasulu V, Jayaveera KN and Adinarayana K, S Chand & Company, ISBN: 978-8121942478.

3. Pharmaceutical Biotechnology Fundamentals and Application (2013) Kokare C, Nirali Prakashan, Educational Publishers, ISBN: 978-8185790688.
4. Pharmaceutical Biotechnology: Concepts and Applications (2011) Walsh G, Wiley India Pvt Ltd, ISBN: 978-8126530250.
5. Pharmaceutical Biotechnology (2002) 2<sup>nd</sup> ed. Cromelin DJA and Sindelar RD, Taylor and Francis Group, ISBN: 978-3-527-65125-2.

## SEMESTER-II

**Course title: Microbial Biotechnology**  
**Course code: SIAL BT 1 2 02 DCEC 4004**

**Credit: 4**  
**Lectures: 60**

**Course objective:** To introduce students to basic and advanced knowledge in the field of microbial technology and fermentation for use in human welfare.

### **Learning outcomes:**

- Understanding microbial fermentation for the production of useful products
- Understanding basic techniques related to downstream processing of alcohols, enzymes and organic acids
- Understanding the fermentation process of genetic engineered microorganisms

### **Unit-I**

Fermentative production of industrial alcohol, uses, raw materials, microorganisms, inoculums preparation, preparation of wort, fermentation and recovery. Fermentative production of beer – Medium components, malt, malt adjuncts, hops, water. Preparation of wort, mashing, wort boiling, microorganism, inoculum preparation, fermentation, cold storage maturation, carbonation, packing and preservation. Principles of wine making – Fruit selection, picking, crushing, sulphite addition, processing, fermentation, aging and bottling.

### **Unit-II**

Fermentative production of citric acid, uses, microorganism, inoculum preparation, medium preparation, fermentation, recovery and mechanism of citric acid production. Fermentative production of vitamin B12 – Uses, structure of vit-B12, microorganisms, inoculums preparation, medium preparation, fermentation and recovery. Fermentative production of glutamic acid – Uses, microorganism, inoculum preparation, production medium, fermentation and downstream processing

### **Unit-III**

Antibiotics – Commercial production of benzyl penicillin, uses, microorganism, inoculums preparation, production medium, fermentation, recovery and semi-synthetic penicillins. Fermentative production of tetracyclines-uses, chlortetracycline, oxy-tetracycline, tetracycline and semisynthetic tetracyclines, structures, microorganisms, inoculum preparation, production medium, fermentation and recovery methods.

### **Unit-IV**

Production and application of microbial enzymes. – Amylases and proteases, uses, microorganisms, inoculum preparation, production medium, fermentation and recovery, steroid transformations-substrates, typical structures, microorganisms, inoculum preparation, 11-hydroxylation, process and recovery. Principles of vaccine production and types of vaccines, Microbial biopesticides, microbial products from genetically modified organisms eg. insulin.

### **Suggested readings:**

1. Microbial Biotechnology: Progress and Trends (2017) 1<sup>st</sup> ed., Harzevili FD and Chen H, CRC Press; ISBN: 978-1138748699.
2. Microbial Biotechnology (2016) Cooper E, Syrawood Publishing House, ISBN: 978-1682860977.

3. Encyclopedia of Metagenomics. Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools (2015). Nelson, KE Boston, MA, Springer US, ISBN: 978-1-4899-7479-2.
4. Microbial Biotechnology: Principles and Applications. Hackensack, (2013). 2<sup>nd</sup> ed. Lee, YK, World Scientific. ISBN: 978-981-256-676-8.
5. Comprehensive Biotechnology (2011) 3<sup>rd</sup> ed., Moo-Young, M, Elsevier, ISBN: 9780444640468.

## SEMESTER-II

**Course title: Environmental Biotechnology**

**Course code: SIAL BT 1 2 02 DCEC 4004**

**Credit: 4**

**Lecture: 60**

**Course objective:** To provide information about various factors responsible for environmental pollution and its mitigation using biotechnology.

**Learning outcomes:**

- Understanding the source and mechanism of environmental pollution
- Understanding the role of microbes and plants in remediation and management of environmental pollution
- Understanding the replacement/options available for non-degradable pollutants

### **Unit-I**

Water, Soil and Air: their sources and effects. Major pollutants and their effects on flora and fauna, Removal of Specific Pollutants, concepts of bioaugmentation, biostimulation, biodegradation, biosorption and biofilms in the bioremediation of pollutants, Sources of Heavy metal pollution, microbial systems for heavy metal accumulation, biosorption & detoxification mechanisms. In-situ and ex-situ bioremediation strategies.

### **Unit-II**

Primary, secondary and tertiary treatment of waste water, biological treatment of anaerobic and aerobic; biochemistry and microbiology of aerobic and anaerobic treatment, use of genetically engineered organisms. Emerging biotechnological processes in waste - water treatment, Bioremediation of contaminated ground water; Membrane technology in waste water treatment, Bioreactors for waste water treatment, treatment of typical industrial effluents: dairy, distillery, dye, and pharmaceutical industries.

### **Unit-III**

Solid waste treatment, characteristics of municipal, industrial and biomedical wastes; Aerobic and anaerobic methods, Physical and chemical treatment of solid waste, Composting and vermin-composting. Use of bacteria, fungi, plants, enzymes, and GE organisms; Bioremediation of contaminated soils and waste land. Phytoremediation of soil metals; Treatment for waste water from dairy, distillery, tannery, sugar and antibiotic industries.

### **Unit-IV**

Xenobiotic compounds: aliphatic, aromatics, polyaromatic hydrocarbons, polycyclic aromatic compounds, pesticides, surfactants and microbial treatment of oil pollution. Basic organic reaction mechanism - common prejudices against enzymes - advantages & disadvantages of biocatalysts - isolated enzymes versus whole cell systems.- mechanistic aspects and enzyme sources.- biocatalytic application, kinetics, and thermodynamics of microbial processes for the transformation of environmental contaminants. Use of solar radiation in industrial effluent treatment; solar detoxification process; environment friendly technologies: biosurfactants, biofertilizers, biopesticides, microbial enhanced oil recovery, resource management, integrated waste management; production of biogas and biofuel from waste.

**Suggested readings:**

1. Environmental Science and Technology, (2019) 9<sup>th</sup> ed., Stankey EM, Lewis Publishers, New York. ISBN: 1420059203.

2. Environmental Biotechnology: Principles and Applications (2017) 1<sup>st</sup> ed., Rittmann B and Mccarty P, McGraw Hill Education; ISBN: 978-1259002885.
3. Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development (2016) 1<sup>st</sup> ed., Sangeetha J, Thangadurai D, David M and Abdullah MA, Apple Academic Press; ISBN: 978-1771883627.
4. Environmental Biotechnology: Basic Concepts and Applications (2011) 2<sup>nd</sup> ed., Thakur IS, I K International Publishing House Pvt. Ltd; ISBN: 978-9380578477.
5. Biodegradation and Bioremediation: (2004), Singh A. and Ward O.P., Soil Biology, Springer, ISBN: 978-3-540-21101-3.

## SEMESTER-III

**Course title: Biostatistics and Bioinformatics**

**Credit: 4**

**Course code: SIAL SC 1 3 05 C 4004**

**Lectures: 60**

**Course objective:** To introduce the students in the field of bioinformatics and enables them to understand the concepts of statistics in biology.

### **Learning outcomes:**

- Understanding statistical analysis of biological data
- Understanding the role of computer science in predicting structure and function of biomolecules
- Understanding similarities and differences among living organisms on the basis of genetic information

### **Unit-I**

Definition of selected terms scale of measurements related to statistics; Methods of collecting data, Presentation of data statistical Tables, Need for reduction of data measures of averages and location, Measures of dispersion: Range, quartile deviation, mean deviation and relative deviation. Probability: basic concepts; basic theorems of probability addition and multiplication theorems; conditional probability of Bayes Theorems. Probability mass function, probability density function, cumulative distribution function.

### **Unit-II**

Probability distribution definition and applications; Binominal distribution, Poisson distribution, Normal distribution, logic of statistical standard error estimation testing of hypothesis. Tests of significance: Null hypothesis, alternative hypothesis, type I error, type II error, level of significance, and power of test. Tests for mean based on normal distribution, one sample t-test, two-sample t-test, paired-sample t-test, Chi-Squared test, and Tests for variance based on normal distribution – one sample and two-sample problem. One-way and Two-way analysis of variance (ANOVA) techniques. Correlation concept and applications, Spearman's rank correlation coefficient, regression concept and applications.

### **Unit-III**

Historical background. Scope of bioinformatics - genomics, proteomics, computer aided drug design (structure based and ligand based approaches), Applications of bioinformatics. Introduction to biological databases - primary, secondary and composite databases, Different formats of molecular biology data. NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB)

### **Unit-IV**

Similarity, identity and homology. Alignment-local and global alignment, pairwise and multiple sequence alignments, alignment algorithms, amino acid substitution matrices (PAM and BLOSUM), BLAST and CLUSTAL omega. Identification of open reading frames (ORF), Concept of orthology, paralogy and homology in gene and protein sequences. Methods and tools for phylogenetic analysis, maximum parsimony, maximum likelihood and distance methods; creation, evaluation and interpretation of evolutionary trees phylogenetic tree.

### **Suggested Readings:**

1. Fundamentals of Statistics (2016) Goon, AM, Gupta, MK and Dasgupta, B. Vol. I & II. World Press, ASIN: B01LB7MH74.



2. Statistical Methods (2012) 1<sup>st</sup> ed., Das, NG. Vol I & II. Tata McGraw Hill, ISBN: 9780070263512.
3. Probability and Statistics for Engineers and Scientists (2013) 9<sup>th</sup> ed., Walpole, RE, Myers, RH, Myers, SL and Ye, Pearson Education India KE ISBN: 978-9332519084
4. Biostatistics: A Foundation. for Analysis in the Health Sciences (2012) 10<sup>th</sup> ed., Daniel, WW and Cross, CL. John Wiley & Sons, ISBN: 978-1118302798
5. Essential Bioinformatics (2006) 1<sup>st</sup> ed., Xiong J, Cambridge University Press, ISBN 13: 978-0521600828.
6. Fundamental concepts of Bioinformatics (2003) Krane DE and Raymer ML Pearson, ISBN: 978-8177587579.
7. An Introduction to Bioinformatics (2017) 1st ed., Knight R, Larsen and Keller Education, ISBN: 978-1635490459.
8. Concepts of Bioinformatics and Genomics ( 2016) 1<sup>st</sup> ed., Momand J, McCardy A, Heubah, S and Warter-Perez N, Oxford University Press, ISBN: 978-0199936991

## SEMESTER-III

**Course title: Biophysics and Nanosciences**

**Course code: SIAL BC 1 3 07 C 4004**

**Credit: 4**

**Lectures: 60**

**Course objectives:** To explore the complexity of living systems with a quantitative physical approach, fundamentals of nanoscale structured materials and also discuss various biomedical & agricultural applications of different nanomaterials.

### **Learning outcomes:**

- Understanding the core concepts of biology, chemistry and physics and how they interconnect in biophysical systems
- Expansion of knowledge of standard molecular and biophysical techniques to design experiments in a specific research area
- Understanding fundamental principles of nanotechnology also discuss state-of-the-art synthesis of different nanomaterials
- Elucidating the emerging need of nanotechnology in environment, health; and safety, and incorporate them into basic education that can be immediately employed in industry

### **Unit-I**

Introduction to Biophysics and history of Biophysics, main features of quantum theory, Elementary particles and their interactions, mechanism of molecular energy transfer, Distribution of molecular energy and velocity at equilibrium, Energy of activation, Different types of forces and stereo-chemical factors responsible for molecular conformation, Defining conformation of a macromolecular chain, complex array of biomolecular structures found in DNA and proteins due to interactions. Main methods of studying the structure of proteins and DNA, protein folding pathways, Levinthal's paradox, Molten globule, Anfinsen's experiment, Methods for investigating folding: Fluorescence spectroscopy, Circular dichroism. Macromolecular interactions, Biophysical methods of interactions: Microcalorimetry (Isothermal Titration Calorimetry (ITC), Surface Plasmon Resonance (SPR).

### **Unit-II**

Basic concepts and laws of thermodynamics, Gibbs free energy, Enthalpy and Entropy, Energetic processes in living organism, Information and Entropy, Coupling of fluxes, Coupling of Chemical Reactions, Redox potential in biological system, ATP production. Introduction to membrane Biophysics, fundamental role of biomembranes, interfacial phenomena and membranes, surface and interfacial tensions, self-assembly of membranes, molecular structure of membranes, Structure & function of membranes, Nernst equation (based on membrane permeable for a single kind of ions), Resting membrane potential, Action potential, Biophysics of synapse, patch clamping/voltage clamp and their applications to the study of biomacromolecules.

### **Unit-III**

Overview of Nanotechnology - Historical perspective of integration of biology, chemistry, and material science. Opportunities and promises of Nanobiotechnology. Top down and bottom up approaches of synthesis of nanoparticles, synthesis of nanoparticles by physical, chemical and biological methods; nucleation and growth of nanosystems, factors affecting synthesis of nanoparticles, Debye-Scherrer method, particle size determination using UV absorption spectra peaks and photoluminescence peaks, dynamic light scattering (DLS), SEM. Nanomaterials used in biotechnology-nanoparticles, carbon nanotubes, quantum dots and nanofibres.

## **Unit-IV**

Miniaturized Devices-nanotechnology and biomedical devices: Overview of smart devices for medical field, lab on chip concept, epipen, intelligent pill, wobbling gels.

Nanotechnology and diagnostics and therapy-Nano-Biosensing-biosensors and nanobiosensors -basics, DNA aptamers for nano-biosensing. Use of nanotechnology in diagnosis of chronic diseases like diabetes and coronary heart diseases; parasitic disease like malaria.

Nanotechnology in agriculture, food technology & environment: Insecticides development using nanotechnology and Nanofertilizers, nanotechnology in food processing, safety & smart packaging, applications of nanotechnology in water purification and oil spill removal.

### **Suggested readings:**

1. An introduction to Biophysics (2018), 1<sup>st</sup> ed., Burns, D, Forgotten Books, ISBN: 978-1330860212.
2. Biophysics - An Introduction (2014) 1<sup>st</sup> ed., Cotterill, R, Wiley, ISBN: 978-8126551606.
3. Biophysics: An Introduction (2012) 2<sup>nd</sup> ed., Glazer, Springer, ISBN: 978-3642252112.
4. Nanobiotechnology: Concepts, Applications and Perspectives (2012) 1<sup>st</sup> ed., Niemeyer, CM and Mirkin, CA, Wiley India Pvt Ltd., ISBN 13: 978-8126538409.
5. A Textbook of Nanoscience and Nanotechnology (2017) 1<sup>st</sup> ed., Pradeep T, McGraw Hill Education, ISBN: 978-1259007323.

## SEMESTER-III

**Course title: Metabolic Engineering**  
**Course code: SIAL BT 1 3 07 C 4004**

**Credit: 4**  
**Lectures: 60**

**Course objective:** To cover basic as well as applied aspects of metabolic engineering.

### **Learning outcomes:**

- Understanding of applicability of metabolic engineering in changing the flux
- Understanding the engineering of metabolic pathway for directed product/metabolite synthesis

### **Unit-I**

Historical perspective and introduction; Importance of metabolic engineering; Paradigm shift; Information resources; Scope and future of metabolic engineering; Building blocks of cellular components; Polymeric biomolecules; Protein structure and function; Biological information storage – DNA and RNA.

### **Unit-II**

Transport mechanisms and their models; Enzyme kinetics; Mechanisms and their dynamic representation; Regulation of enzyme activity versus regulation of enzyme concentration; Regulation of metabolic networks; Regulation of at the whole cell level; Examples of important pathways; Case studies and analytical-type problems.

### **Unit-III**

The theory of flux balances; Derivation of the fundamental principle; Degree of freedom and solution methods; Moore-Penrose inverse and Tsai-lee matrix construction; Examples of applications of flux analysis introduction Metabolic Control Theory; Control coefficients; Elasticity coefficients; Summation and connectivity theorems; Case Studies and examples.

### **Unit-IV**

The concept of metabolic pathway synthesis; Need for pathway synthesis, Examples for illustration; Overall perspective of MFA, MCA and MPA and their applications; Three success case studies.

### **Suggested readings:**

1. Metabolic Engineering (2016) Becker R, Syrawood Publishing House, ISBN: 978-1682861530.
2. Systems Metabolic Engineering (2014) Wittmann C, and Lee SY, Springer, ISBN: 978-940178319.
3. Metabolic Engineering for Bioprocess Commercialization (2016) 1<sup>st</sup> ed., Stephen VD, Springer, ISBN-13: 978-3319419640.
4. Systems Metabolic Engineering (2012) C. Wittmann, Sang Yup Lee (Editors), Spinger, ISBN: 9400745338.
5. The Metabolic Pathway Engineering Handbook (2009) Christina D. Smolke (Ed.),CRC Press (Taylor & Francis Group) ISBN: 9781439802960.

## SEMESTER-III

**Course title: Medical Biotechnology and Diagnostics**

**Credit: 4**

**Course code: SIAL BT 1 3 08 C 4004**

**Lectures: 60**

**Course objective:** To give an overview about the disease and its diagnostic techniques used in the medical field.

### **Learning outcomes:**

- Understanding the basics of genetical information responsible for disease development
- Understanding the classical and advanced methods used for the diagnosis of various diseases
- Understanding the treatment of diseases using gene therapy and related therapies

### **Unit-I**

Chromosomal disorders- Numerical disorders e.g. trisomies & monosomies, structural disorders e.g. deletions, duplications, translocations & inversions, Chromosomal instability syndromes. Gene controlled diseases – autosomal and X- linked disorders, mitochondrial disorders.

Pathogenic mutations. Gain of function mutations: oncogenes, Huntingtons disease, Pittsburg variant of alpha 1 antitrypsin. Loss of function -tumour suppressor, genomic, dynamic mutations - Fragile- X syndrome, myotonic dystrophy, mitochondrial diseases.

### **Unit- II**

Invasive techniques - amniocentesis, fetoscopy, chorionic villi sampling (cvs), noninvasive techniques- ultrasonography, X-ray, TIFA, maternal serum and fetal cells in maternal blood, diagnosis using protein and enzyme markers, monoclonal antibodies, DNA/RNA based diagnosis Hepatitis, CML – bcr/abl, HIV - CD 4 receptor, microarray technology- genomic and cDNA arrays, application to diseases.

### **Unit-III**

Overview of molecular diagnostics, molecular diagnostics: past, present, and future, History & scope, definition, principle of biosensors: classification of biosensors based on transducer & recognition element. Components & basic designing of Biosensors, different types of biosensors, nanotechnology and biosensors: carbon nanotubes, Gold nanoparticles. Latex agglutination test, enzyme linked immunosorbant assay, dot and slot blot assay.

### **Unit-IV**

PCR in molecular diagnostics; multiplex-PCR, quantitative real time PCR (qRT-PCR) and their applications for diagnosis of disease applications, DNA diagnostic system: molecular beacons and its variants for their applications in detection, molecular diagnostics in bacterial detection, rolling circle amplification, application of padlock and selector probes in molecular medicine, DNA aptamers for nano-biosensing, diagnostics for point-of-care and resource limited settings, smartphones in medical diagnostics, rapid diagnostic tests (lateral flow assays), concepts of microfluidics, BioMEMs in diagnostics.

### **Suggested readings:**

1. Human Molecular Genetics (2018) Strachan T and Read A, Garland Science publisher, ISBN: 9780815345893.
2. Medical Biotechnology (2013) Glick BR, Patton CL and Delovitch TL, ASM Press, ISBN: 155581705X.
3. Biotechnology in Medical Sciences (2017) Khan FA, CRC Press; ISBN: 978-1138076792

4. Biomedical Nanotechnology (2005) 1st ed., Malsch, N, CRC Press, ISBN: 978-0824725792.
5. Biosensors and Nanotechnology: Applications in Health Care Diagnostics (2018) 1st ed., Altintas Z, Wiley-Blackwell, ISBN: 978-1119065012.
6. Biosensors: Essentials (2016) 1st ed., Evtugyn, G, Springer, ISBN: 978-3662509388
7. Nucleic Acids as Molecular Diagnostics (2014) 1st ed., Keller, A, Wiley VCH, ISBN: 978-3527335565.
8. Lateral Flow Immunoassay (2009) Raphael C. Wong, Harley YT, Humana Press, ISBN: 978-1-58829-908-6.
9. Medical Biotechnology (2013) Glick BR, Patton CL and Delovitch TL, ASM Press. ISBN10 155581705X.
10. Molecular Diagnosis of Infectious Diseases (Methods in Molecular Medicine) (2004) Decker J, Reischl U, Humana Press, ISBN: 978-1-59259-679-9.
11. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, (2006) Kayser O and Warzecha H, Wiley-Blackwell, ISBN: 978-3-527-60552.
12. Human Molecular Genetics (2018) Strachan T and Read A, Garland Science publisher, ISBN: 9780815345893.

### SEMESTER – III

**Course title: Practical-III**

**Course code: SIAL BT 1 3 09 C 0084**

**Credit: 4**

**Lectures: 120**

1. To study the laboratory organization and aseptic manipulations in plant and animal cell culture lab.
2. Isolation and culturing of animal cells from primary tissue explant.
3. Sub-culturing of monolayer confluent cells.
4. Counting of animal cells using haemocytometer.
5. Staining of monolayer confluent cells using geimsa and crystal violet.
6. To discriminate between viable and non-viable animal cells using trypan blue.
7. Database search (GenBank, PDB) using BLAST and Sequence submission protocols.
8. Sequence alignments (Pair wise and Multiple), Sequence and structure prediction
9. Construction of phylogenetic tree and prediction
10. Protein structure modelling and docking
11. Genomic DNA isolation from plant/bacteria and qualitative and quantitative analysis of DNA.
12. Bacterial culture: establishing a pure culture; identification of bacteria; staining techniques; antibiotic sensitivity of bacteria
13. Isolation of plasmid DNA, and its digestion by restriction endonucleases and separation of restriction fragments by agarose gel electrophoresis
14. Isolation of RNA and separation on agarose gel and Quantitative estimation of RNA
15. Green fluorescence protein (GFP) and bacterial transformation experiments
16. Western blot analysis of the proteins using antibodies
17. Denaturation kinetics study of biomolecules using UV-VIS spectrophotometry
18. Comparative study for the synthesis, characterization and applications of nanoparticles

#### **Suggested readings:**

1. An Introduction to Practical Biochemistry (2017) 3<sup>rd</sup> ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN: 978-0070994874.
2. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed. Keith Wilson & John Walker, Cambridge University Press. ISBN: 131661476X.
3. Molecular cloning, A Laboratory Manual Vol. I-III. (2012) 4<sup>th</sup> ed., Green MR and Sambrook J, Cold Spring Harbor Laboratory Press.
4. Gene Cloning and DNA Analysis (2010) Brown TA, Wiley-Blackwell publishing .
5. Physical Biochemistry: Principles and Applications (2010) 2<sup>nd</sup> ed., Sheehan D, Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN:978-0-470-85603-1.
6. A laboratory Course in Nanoscience and Nanotechnology (2014) Poinern GEJ, CRC press, ISBN: 978-1482231038.

### **SEMESTER – III**

**Course title: Seminar**

**Course code: SIAL BT 1 3 10 C 0202**

**Credit: 2**

Seminar will be of 45-minute duration during which the presentation will be followed by questions session by the audience comprising of faculty and students. Every student shall be required to submit the topic of his/her seminar in consultation with the Head of the Department/Faculty members/student advisors well in advance so that the same may be displayed on the notice board. The presenter has to write an Abstract to be distributed during Seminar in addition to two copies of write-up giving relevant details of the background of the subject, methods used and references/List of sources from where the material for presentation has been collected.



## SEMESTER – III

**Course title: Animal Biotechnology**  
**Course code: SIAL BT 1 3 04 DCEC 4004**

**Credit: 4**  
**Lectures: 60**

**Course objective:** This course is an introduction to the theory, standard practices, and methodologies of animal biotechnology.

### **Learning Outcomes:**

- Understanding animal tissue culture techniques, gene transfer and gene manipulation methods, and transgenic animal technology.

### **Unit-I**

Biology and characterization of cultured cells- cell adhesion, proliferation, differentiation, morphology of cells and identification. Basic technique of mammalian cell culture *in vitro*, Measuring parameters of growth in cultured cells, cell viability and cytotoxicity. Germplasm conservation and establishment of gene banks. Large-scale culture of cell lines- monolayer, suspension and immobilized cultures.

### **Unit-II**

Organ and histotypic culture- technique, advantages, limitations, applications. Biotransformation - Induction of cell line mutants and mutations. 3D cultures. Whole embryo culture. Somatic cell hybridization. Stem cells: types (embryonic, adult), isolation, identification, expansion, differentiation and uses, stem cell engineering, ethical issues. Commercial applications of animal tissue culture. Hazards and safety aspects of tissue culture.

### **Unit-III**

Manipulation of animal reproduction and characterization of animal genes Manipulation of reproduction in animals. Artificial insemination, embryo transfer, in-vitro fertilization. Embryo transfer in cattle and applications. Somatic cell cloning - cloning of Dolly. Ethical issues. Production of recombinant vaccines. Probiotics for disease control.

### **Unit-IV**

Vectors for gene transfer in animals: retrovirus. Gene constructs- promoter/enhancer sequences for transgene expression in animals. Selectable markers for animal cells- thymidine kinase, dihydrofolatereductase, CAT. Transfection of animal cells- calcium phosphate coprecipitation, electroporation, lipofection, peptides, direct DNA transfer, viral vectors, microinjection. Methods for producing transgenic animals- retroviral, microinjection, engineered stem cell. Targeted gene transfer. Transgene integration and identification methods. Transgenic and genome edited animals. Ethical issues in transgenesis.

### **Suggested readings:**

1. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8th ed. Keith Wilson & John Walker, Cambridge University Press, ISBN No: 131661476X.
2. Principles of gene manipulation (2016), 8<sup>th</sup> ed. Primrose Twyman and Old. Blackwell Science, ISBN: 1405135441.
3. Animal Biotechnology (2013) Verma A and Singh A, Elsevier, ISBN: 9780124160026.
4. Molecular Biotechnology (2009), 4<sup>th</sup> ed. Glick and Pasternak, ASM Press, ISBN10: 1555814980.
5. Recombinant DNA (2006) 3<sup>rd</sup> ed., Watson JD, Richard M. Meyers, Amy AC, Jan AW, Cold Spring Harbor Laboratory Press, ISBN: 0716728664.

## SEMESTER – III

**Course title: Agriculture Biotechnology**  
**Course code: SIAL BT 1 3 05 DCEC 4004**

**Credit: 4**  
**Lecture: 60**

**Course objective:** To provide knowledge of standard practices, methodologies and applications of biotechnology in agriculture.

### **Learning Outcomes:**

- Understanding the classical and modern approaches of plant/crop breeding
- Understanding the manipulation of plants for improved traits responsible for stress tolerance and nutrition fortification
- Understanding of preservation and protection of plants/crops

### **Unit-I**

Conventional methods for crop improvement (pedigree, heterosis and mutation breeding), limitations of conventional breeding, plant Genome – nuclear and cytoplasmic, significance of organelle genomes, genome size and sequence components, molecular markers: definition, properties, types of molecular markers: restriction based and PCR based, RFLP, AFLP, development of SCAR and SSR markers, other markers: CAPS, SNP, Marker Assisted Selection (MAS), screening and validation, trait related markers and characterization of genes involved.

### **Unit-II**

Plant growth regulators; mode of action, effects on *in vitro* culture and regeneration; in-vitro storage organ formation; callus culture, suspension culture- batch and continuous culture, Protoplast culture, somatic hybridization. micropropagation, Meristem culture, Shoot tip culture and production of virus free plants, somaclonal variations, in-vitro production of haploid plants – androgenesis and gynogenesis, doubled haploid production through distant hybridization, *in-vitro* and *in-vivo* pollination and fertilization, embryo culture, embryo rescue, somatic embryogenesis, artificial seeds, germplasm conservation and cryopreservation.

### **Unit-III**

Mapping genes on specific chromosomes, QTL mapping, gene pyramiding, transcript mapping techniques, development of ESTs, the concept of gene synteny, the concept of map-based cloning and their use in transgenics, Antisense RNA technology- FlavrSavr Tomato, biopesticides in agriculture (botanicals and microbials), integrated pest management, Production and applications of biofertilizers (bacterial, fungal and algal); Plant secondary metabolites: Control mechanisms and manipulation of alkaloids and industrial enzymes (Shikimate and PHA pathway), importance of secondary metabolites in agriculture.

### **Unit - IV**

Genetic engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake, Genetic engineering for biotic stress tolerance (Insects, fungi, bacteria, viruses, weeds). genetic engineering for abiotic stress tolerance (drought, flooding, salt and temperature). genetic engineering for quality improvement of protein, lipids, carbohydrates, vitamins (e.g. Golden Rice) & mineral nutrients, production of antibody in plants; Plant genetic resources, GATT & TRIPS, Patenting of biological material, patenting of transgenic organisms and genes, Plant breeders rights (PBRs) and farmers rights, Concerns about GM crops – environmental, biosafety and ethics.

### **Suggested readings:**

1. Introduction to plant Biotechnology (2018) 3<sup>rd</sup> ed., Chawla HS, CRC Press, ASIN: B07LH5S4P3.
2. Applied Biotechnology in Genetic Engineering, Pharmaceuticals and Agriculture (2016) Adam J, Syrawood Publishing House, ISBN: 978-1682862766.
3. Molecular Markers in Plants (2012), Henry RJ, Wiley-Blackwell. ISBN: 978-0-470-95951-0.
4. Genetic Transformation of Plants-Series: Molecular Methods of Plant Analysis (2013) Vol. 23, Jackson JF and Linskens HF, Springer, ASIN: B000PY3TJ0.
5. Plant Biotechnology – The genetic manipulation of plants (2017) 3rd ed., Slater A, Scott N and Fowler M, Oxford University Press. ISBN: 1138407674.
6. Plant Transformation Technologies (2011), 1st ed., Stewart CN and Touraev, A Wiley-Blackwell. ISBN: 9780813821955.

## SEMESTER – III

**Course title: Food Biotechnology**  
**Course code: SIAL BT 1 3 06 DCEC 4004**

**Credit: 4**  
**Lectures: 60**

**Course objective:** To develop the understanding of biotechnological applications in food fortification and food processing

### **Learning outcomes:**

- Understand food fermentation for improved nutrition
- Understand novel food additives and supplements
- Understand mechanism and process of food spoilage and its preservation
- Understand monitoring of food quality and packaging of food

### **Unit-I**

Introduction: microorganisms in food-historical developments, food fermentation Technology: origin, scope and development of fermented products, primary feed stock, raw materials and conversions, fermented food and microbial starters, commercial potential, food fermentation industries, their magnitude, R&D innovations.

### **Unit-II**

Development of novel food and food Ingredients: Single cell protein, polysaccharides, low calorie sweeteners, naturally produced flavor modifiers, amino acids, vitamins, food supplements, food coloring, nutraceuticals, water binding agents. Bioreactors in food fermentations: Cultivation of microorganisms, instrumentation regulation and process control, laboratory scale submerged and solid state fermentation, pilot scale submerged and solid state fermentation.

### **Unit-III**

Food spoilage and preservation: general principle of spoilage, microbial toxins (endotoxins and exotoxins), contamination and preservation, factors affecting spoilage. Methods of food preservation (thermal processing, cold preservation, chemical preservatives & food dehydration); Role of radiations in food preservation, characteristics of radiation of interest in food preservation. Principles underlying the destruction of microorganisms by irradiation. Effect of irradiations on food constituents. Legal status of food irradiation.

### **Unit-IV**

Biological controls and monitoring of food quality, packaging of food: Need for packaging, requirements for packaging, containers for packaging (glass, metal, plastics, molded pulp and aluminium foil), dispensing devices.

### **Suggested readings:**

1. Introduction to Food Biotechnology (2018) Johnson-Green P, CRC Press, ISBN: 0815351100.
2. Fundamentals of Food Biotechnology (2015) Lee BH, Willey, ISBN: 9781118384954.

3. Food Biotechnology Principles and Practices (2013) Joshi VK, Singh RS, Ik International Publishers Pvt. Ltd., ISBN: 9789381141496.
4. Food Microbiology: Fundamentals and Frontier (2012) 4<sup>th</sup> ed. Beuchat, D and Montville. ASM Press, ISBN: 9781555816261.
5. Biotechnology: Food Fermentation (2009) Vol. I & II. Eds. Joshi, VK and Pandey, A (1999) Educational Publishers and Distributers, Kerala. ISBN: 9788187198055
6. Modern Food Microbiology 6<sup>th</sup> ed., Jay, J.M. (2000). Kluwer Academic/Plenum publisher, ISBN: 978-0-387-23413-7.

## SEMESTER-III

**Course title: Protein Engineering**  
**Course code: SIAL BT 1 3 02 C 4004**

**Credit: 4**  
**Lectures: 60**

**Course objectives:** To introduce different methods and strategies commonly used in protein engineering

### **Learning outcomes:**

- Understanding analysis of structure and function of proteins
- Understanding importance of critical amino acids involved in catalysis, stability and regulation of proteins
- Understanding protein evolution using genetic engineering approaches with improved biochemical properties

### **Unit-I**

Protein structures; Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, *etc.* Protein engineering with unnatural amino acids and its applications.

### **Unit-**

Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: UV spectrophotometry; CD spectroscopy; Fluorescence spectroscopy; Hydrodynamic properties–viscosity, Dynamic light scattering; hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy-emphasis on parameters that can be measured/obtained from NMR and their interpretation.

### **Unit-III**

Computational approaches to protein engineering: sequence and 3D structure analysis, Active site residues and modifying agents; Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles, mesophiles and thermophiles.

### **Unit-IV**

Experimental methods of protein engineering: Rational and directed evolution; Module shuffling; Guided protein recombination, Basics of optimization and high throughput screening Application to devices with bacteriorhodopsin as an example; Applications to vaccines.

### **Suggested readings:**

1. Protein-Protein Interactions: Techniques and Applications (2018) O'Neill PB, Larsen and Keller Education, ISBN: 978-1635496536.
2. Protein Engineering and Design (2017) Torres A, Syrawood Publishing House, ISBN: 978-1682864029.
3. Protein Engineering Techniques: Gateways to Synthetic Protein Universe (2016) 1<sup>st</sup> ed., Poluri KM and Gulati K, Springer; ISBN: 978-9811027314.
4. Handbook of Protein Engineering (2015) 2<sup>nd</sup> ed., Callisto TA, ISBN: 978-1632394101
5. Protein Engineering (Nucleic Acids and Molecular Biology) (2010) Koehrer C and RajBhandary UL, Springer, ISBN: 978-3642089923

6. Protein Engineering, Principles and Practice (2006) Cleland JL and Craik CS, Vol 7, Springer Netherlands. ISBN: 978-0471103547.
7. Structure in Protein Chemistry (2006) 2<sup>nd</sup> ed. Kyte J, Garland publishers, ASIN: B013J9NXQG.

## SEMESTER-IV

**Course title: Dissertation**

**Credit: 20**

**Course code: SIAL BT 1 4 01 SEEC 0020**

### **Guidelines for Project File**

Research experience is as close to a professional problem-solving activity as anything in the curriculum. It provides exposure to research methodology and an opportunity to work closely with a faculty guide. It usually requires the use of advanced concepts, a variety of experimental techniques, and state-of-the-art instrumentation.

Research is genuine exploration of the unknown that leads to new knowledge which often warrants publication. But whether or not the results of a research project are publishable, the project should be communicated in the form of a research report written by the student.

Sufficient time should be allowed for satisfactory completion of reports, taking into account that initial drafts should be critiqued by the faculty guide and corrected by the student at each stage.

The file is the principal means by which the work carried out will be assessed and therefore great care should be taken in its preparation.

### **In general, the File should be comprehensive and include**

- A short account of the activities that were undertaken as part of the project;
- A statement about the extent to which the project has achieved its stated goals.
- A statement about the outcomes of the evaluation and dissemination processes engaged in as part of the project;
- Any activities planned but not yet completed as part of the project, or as a future initiative directly resulting from the project;
- Any problems that have arisen that may be useful to document for future reference.
- The guidelines and format for dissertation is given below:

## **Dissertation Guidelines**

### **1. GENERAL :**

The manual is intended to provide broad guidelines to the M.Sc. candidates in the preparation of the dissertation report. In general, the project report shall report, in an organised and scholarly fashion an account of original research work of the candidate leading to the discovery of new facts or techniques or correlation of facts already known.

### **2. NUMBER OF COPIES TO BE SUBMITTED:**

Students should submit three copies to the Head of the Department concerned on or before the specified date.

### **3. ARRANGEMENT OF CONTENTS OF DISSERTATION:**

Dissertation material should be arranged as follows:



1. Cover Page & Title page
2. Declaration
3. Certificate
4. Abstract (Hindi and English)
5. Acknowledgements
6. Table of Contents
7. List of Tables
8. List of Figures
9. List of Symbols, Abbreviations and Nomenclature (Optional)
10. Chapters
11. References
12. Appendices
13. One page CV

The Tables and Figures shall be introduced in the appropriate places.

#### **4. PAGE DIMENSIONS AND MARGIN:**

The dimensions of the dissertations should be standard A4 size paper may be used for preparing the copies, **standard margin** with 1.5 line spacing.

#### **5. MANUSCRIPT PREPARATION:**

The general text of thesis shall be typed in font style Times New Roman and font size 12. Same quality of paper should be used for the preparation of the entire report/thesis; except figure, photos are shown.

**5.1 Cover Page & Title Page** - A specimen copy of the Cover page & Title page for report/thesis are given in Annexure I.

**5.2 Certificate**-The Bonafide Certificate as per the format shown in Annexure II

**5.3 Abstract:** Abstract should be an essay type (HINDI and ENGLISH) of narration not exceeding 500 words outlining the research problem, the methodology used for tackling it and a summary of the findings, typed in 1.5line spacing.

**5.4 Acknowledgements:** The acknowledgements shall be brief and should not exceed onepage. The student's signature shall be made at the right bottom above his / her name typed in capitals.

**5.5 Table of contents** - The table of contents should list all material following it as well as any material which precedes it. The title page, Bonafide Certificate and Acknowledgment will not find a place among the items listed in the Table of Contents but the page numbers in lower case Roman letters are to be accounted for them. One and a half spacing should be adopted for typing the matter under this head. A specimen copy of the Table of Contents for report / thesis is given in Annexure III.

**5.6 List of Table** - The list should use exactly the same captions as they appear above the tables in the text and the caption shall follow 'sentence case'. One and a half spacing should be adopted for typing the matter under this head.

**5.7 List of Figures** - The list should use exactly the same captions as they appear below the figures in the text and the caption shall follow 'sentence case'. One and a half spacing should be adopted for typing the matter under this head

**5.8 List of Symbols, Abbreviations and Nomenclature** - One and a half spacing should be adopted for typing the matter under this head. Standard symbols, abbreviations etc. should be used.

**5.9 Chapters** - The chapters may include

Chapter I – Introduction

Chapter II - Literature Review

Chapter III –Materials and Methods

Chapter IV- Results and Discussion

5.10. Research output/outcome if any published or presented in conference/seminar/symposium may be included.

**5.11. List of References** - Any works of other researchers, if used either directly or indirectly, should be indicated at appropriate places in the report/thesis. The citation may assume any one of the following forms. **APA Style.**

APA in-text citation style uses the author's last name and the year of publication, for example: (Field, 2005).

Example:

Derwing, T. M., Rossiter, M. J., & Munro, M. J. (2002). Teaching native speakers to listen to foreign-accented speech. *Journal of Multilingual and Multicultural Development*, 23(4), 245-259.

Thomas, H. K. (2004). *Training strategies for improving listeners' comprehension of foreign-accented speech* (Doctoral dissertation). University of Colorado, Boulder.

## **6. TYPING INSTRUCTIONS**

### **6.1 General**

This section includes additional information for final typing of the thesis. Some information given earlier under 'Manuscript preparation' shall also be referred. The impressions on the typed/duplicated/printed copies should be black in colour. Corrections, interlineations and crossing out of letters or words will not be permitted in any of the copies of the report/thesis intended for submission. Erasures, if made, should be neatly carried out in all copies. A sub-heading at the bottom of a page must have at least two full lines below it or else it should be carried over to the next page. The last word of any page should not be split using a hyphen. One and a half spacing should be used for typing the general text. The general text shall be typed in Font Style Times New Roman and Font Size 12.

Single spacing should be used for typing:

- (i) Long Tables
- (ii) Long quotations
- (iii) Foot notes
- (iv) Multilane captions
- (v) References

**6.2 Chapters** The format for typing chapter headings, division headings and sub division headings shall be same as given in Table of Contents.

## **7. BINDING SPECIFICATIONS**

Thesis should be spiral or soft cover book bound, the cover of thesis should be of dark greencolor, printed with golden ink and the text for printing should be identical as prescribed for the title page.

**APPENDIX I A:(A typical Specimen of Cover Page & Title Page–DISSERTATION)**

<Font Style Times New Roman - Bold>

**TITLE OF DISSERTATION**

<Font Size 18><1.5 line spacing>

**DISSERTATION**

<Font Size 14>

***Submitted by***

<Font Size 14><Italic>

**NAME OF THE CANDIDATE**

<Font Size 16>

Under the Supervision of

**NAME OF THE SUPERVISOR**

***in partial fulfillment for the award of the degree of***

<Font Size 14><1.5 line spacing>

**MASTER OF SCIENCE IN**

**NAME OF THE PROGRAMME**

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**DEPARTMENT OF**

**SCHOOL OF .....**

**CENTRAL UNIVERSITY OF HARYANA**

**MAHENDERGARH-HARYANA**

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**MONTH AND YEAR**

## DECLARATION

I ....., student of the School of Interdisciplinary and Life Sciences, Central University of Haryana, Mahendergarh hereby declare and certify with my signature that my thesis entitled

..... submitted to the Department of ....., Central University of Haryana, India in partial fulfillment of the requirements for the award of the Degree of Masters of Science is a record of original research work done by me and the dissertation has not been the basis for the award of any degree/diploma/associateship/fellowship or similar title of any candidate of any University. I have faithfully and accurately cited all my sources, including books, journals, handouts and unpublished manuscripts, as well as any other media, such as the Internet, letters or significant personal communications.

I understand the concept of “plagiarism” and declare that while drafting this dissertation I have refrained from plagiarism. I know that plagiarism not only includes direct copying, but also the extensive use of other’s ideas without proper referencing or acknowledgement (which includes the proper use of references and quotation marks).

If my dissertation found to be plagiarized at any point of time, I’ll be solely responsible and will be ready to accept any decision taken by the competent authority including rejection of my dissertation.

(Supervisor)

(Signature of student)

**For example**

(A typical Specimen of Table of Contents)

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**TABLE OF CONTENTS**

<b>CHAPTER NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
	<b>ABSTRACT</b>	iii
	<b>LIST OF TABLES</b>	xvi
	<b>LIST OF FIGURES</b>	xviii
	<b>LIST OF SYMBOLS, ABBREVIATIONS</b>	xxvii
<b>1</b>	<b>INTRODUCTION</b>	1
	1.1 GENERAL	1
	1.2 NEED FOR THE STUDY	2
	1.3 OBJECTIVES OF THE STUDY	3
<b>2</b>	<b>REVIEW OF LITERATURE</b>	4
	2.1 INTRODUCTION	4
	2.2 .....	4
	2.2.1 Product .....	6
	2.2.2 Product....	6

## **ANNEXURE II**

### *Curriculum vitae*

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#### **Personal Details**

Name :

Date of birth : DD Month, YYYY

Place of birth :

Nationality : Indian

Permanent Address :

Email Id :

Mobile No. :

#### **Education**

M.Sc. (Subject) : YYYY Central University of Haryana, India

B.Sc. (Subject). : YYYY (Name of the University) with .... % of marks

Higher Secondary : YYYY (Name of the board) with .... % of marks

Secondary : YYYY, ( Name of the board) with .... % of marks