ACADEMIC AFFAIRS OFFICE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

No. Acd./ 4235 /IAPC-88 Dated: August 08, 2020

Head, Department of Biotechnology

The Chairman, Senate has considered and approved the syllabi of DBT supported new M.Sc. Biotechnology program on the recommendation of the IAPC (88th meeting, under item No. 88.2.2).

The approved syllabi are attached as **Appendix-A**.

Reeti

Assistant Registrar (Curriculum)

Encl: as above

Copy to (through e mail):-

1. Chairman, Senate & Director
2. All faculty
3. All Heads of Departments/Centres
4. Dean, Academic Affairs
5. Associate Dean of Academic Affairs (Admission)/ (Curriculum) /(Evaluation)
6. Asstt. Registrar (Meeting)
7. Academic webpage/ channel i/ acad portal

Department of Biotechnology
Indian Institute of Technology Roorkee

Course Structure of DBT supported New M.Sc. Biotechnology Program
Duration: 2 years (4 semester) Credit: 94

Semester-1 (Autumn)

SN	Course No.	Course Name	Course Type	Credits	Credit Distribution	Contact hours
1	BT 501	Biochemistry	PCC	03	3L	42
2	BT 502	Cell and Molecular Biology	PCC	03	3L	42
3	BT 503	Plant and Animal Biotechnology	PCC	03	3L	42
4	BT 504	Microbiology	PCC	02	2L	28
5	BT 505	Genetics	PCC	02	2L	28
6	BT 506	Basics of Mathematics and Statistics	PCC	02	2L	28
7	BT 507	Basics of Chemistry and Physics	PCC	02	1.5L – 0.5T	28
8	BT-508	Biochemistry & Analytical Techniques(Lab I)	PCC	03	6P	
9	BT 509	Microbiology(Lab II)	PCC	02	4P	
10	BT 510	Plant and Animal Biotechnology(Lab III)	PCC	02	4P	
Total Credit				**24**		

Semester-2 (Spring)

SN	Course No.	Course Name	Course Type	Credits	Credit Distribution	Contact hours
1	BT 511	Genetic Engineering	PCC	03	3L	42
2	BT 512	Immunology	PCC	03	3L	42
3	BT 513	Bioinformatics	PCC	03	2L – 1T	42
4	BT 514	Genomics and Proteomics	PCC	02	2L	28
5	BT 515	Molecular Diagnostics	PCC	02	2L	28
6	BT 516	Research methodology and Scientific	PCC	02	2L	28
7	BT 517	Molecular Biology and Genetic Eng. (Lab IV)	PCC	03	6P	
8	BT 518	Immunology(Lab V)	PCC	03	6P	
9	BT 519	Seminar	PCC	01	1T	
10	**Elective-I**		PEC	02	2L	28
	BT 520	Biological Imaging				
	BT 521	Microbial Technology				
	BT 522	Environmental Biotechnology				
	BT 523	Drug Discovery and Development				
	BT 524	Structural Biology				
	BT 525	Biophysical Techniques				
Total Credit				24		

Semester-3 (Autumn)

SN	Course No.	Course Name	Course Type	Credits	Credit Distribution	Contact hours
1	BT 601	Bioprocess Engineering & Technology	PCC	03	3L	42
2	BT 602	Emerging Technologies	PEC	02	2L	28
3	BT 603	Critical Analysis of Classical Papers	PCC	02	2L	28
4	BT 604	Bio-entrepreneurship	PCC	02	2L	28
5	BT 605	Intellectual Property Rights, Biosafety and	PCC	02	2L	28
6	BT 606	Project Proposal Preparation & Presentation	PCC	02	1L 1T	28
7	BT 607	Bioprocess Engineering & Technology (Lab VI)	PCC	04	8P	
8	BT-608	Bio-informatics (Lab VII)	PCC	02	4P	
9	BT-609	Dissertation minor	PCC	04		
9	BT 610	Seminar	PCC	01	1T	
Total Credit				**24**		

Semester-4 (Spring)

SN	Course No.	Course Name	Course Type	Credits	Credit Distribution	Contact hours
1	BT 611	Dissertation-major	PCC	20	--	
2	**Elective II**		PEC	02	2L	28
3	BT 612	Computational Biology				
4	BT 613	Nano-Biotechnology				
5	BT 614	Protein Engineering				
	BT 615	Advance cell culture technologies				
6	BT 616	Vaccines				
Total Credit				**22**		

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-501 Course Title: **Biochemistry**
2.Contact Hours: **L**: 3 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 03 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 3 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To give an over view of fundamental and advance knowledge in biochemistry
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies.	7
2.	Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin *etc.*; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.	5
3.	Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.	5
4.	Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylase and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.	3
5.	Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.	3
6.	Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways;glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation;	7
7.	Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation, target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.	12
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/Publisher	Year of Publication/ Reprint
1.	Stryer, L. (2015). *Biochemistry*. (8th ed.) New York: Freeman.	2015
2.	Lehninger, A. L. (2012). *Principles of Biochemistry* (6th ed.). New York, NY: Worth.	2012
3.	Voet, D., &Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons.	2016
4.	Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968), 884-890. doi:10.1038/nature02261.	2003
5.	Richards, F. M. (1991). *The Protein Folding Problem*. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.	1991

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-502 Course Title: **Cell and Molecular Biology**
2.Contact Hours: **L**: 3 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 03 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 3 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To give an over view of fundamental and advance knowledge cell and molecular biology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.	6
2.	Chromatin organization - histone and DNA, structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; gene transcription and silencing by chromatin-Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, trancriptional initiation, elongation and termination; post-transcriptional control: splicing, miRNAs and siRNAs, protein translation machinery and mechanism,universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; post-translational modifications, mitochondrial genetic code, modification and activation.	12
3.	Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.	4
4.	Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and trans-membrane signaling; cell motility and migration; cell death: different modes of cell death and their regulation.	8
5.	Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.	4
6.	Cancer: mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.	8
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science.	2008
2.	Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman.	2016
3.	Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning.	2014
4.	Cooper, G. M., &Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th Ed.).Washington: ASM ; Sunderland.	2013
5.	Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). *Becker's World of the Cell*. Boston (8th Ed.). Benjamin Cummings.	2012
6.	Watson, J. D. (2008). *Molecular Biology of the Gene* (5th ed.). Menlo Park, CA: Benjamin/Cummings.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-503 Course Title: **Plant and Animal Biotechnology**
2. Contact Hours: **L**: 3 **T**:0 **P**: 0
3. Examination Duration (Hrs.): **Theory:** 03 **Practical:** 0
4. Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5. Credits: 3 6. Semester: **Autumn**
7. Pre-requisites: Nil. 8. Subject Area: **PCC**
9. Objective: To give an over view of fundamental and advance knowledge of principles and application of Plant and animal biotechnology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Plant tissue culture: history; totipotency; organogenesis; somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production, transgenic cell culture, elicitor. Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.	10
2.	Genetic engineering: *Agrobacterium*-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - *Agrobacterium*-mediated gene delivery; co-integrate and binary vectors and their utility; gene transfer methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; genome editing; molecular pharming - concept of plants as biofactories for making industrial enzymes and pharmaceutically important compounds.	10
3.	Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and *in vitro* fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, , recombinant approaches to vaccine production, modern vaccines.	8
4.	Overview of genomics – definition, complexity and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning functionfor genes.	6
5.	Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker-assisted selection - strategies for Introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.	8
	Total	**42**

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. Enfield, NH: Science.	2000
2.	Razdan, M. K. (2003). *Introduction to Plant Tissue Culture*. Enfield, NH: Science.	2003
3.	Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.	2008
4.	Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.	2015
5.	Umesha, S. (2013). *Plant Biotechnology.* The Energy And Resources.	2013
6.	Glick, B. R., & Pasternak, J. J. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, D.C.: ASM Press.	2010
7.	Brown, T. A. (2006). *Gene Cloning and DNA Analysis: an Introduction*. Oxford: Blackwell Pub.	2006
8.	Primrose, S. B., &Twyman, R. M. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.	2006
9.	Slater, A., Scott, N. W., & Fowler, M. R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.	2003
10.	Gordon, I. (2005). *Reproductive Techniques in Farm Animals*. Oxford: CAB International.	2005
11.	Levine, M. M. (2004). *New Generation Vaccines.* New York: M. Dekker.	2004
12.	Pörtner, R. (2007). *Animal Cell Biotechnology: Methods and Protocols*. Totowa, NJ: Humana Press.	2007

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NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-504 Course Title: **Microbiology**
2. Contact Hours: **L**: 2 **T**:0 **P**: 0
3. Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4. Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5. Credits: 2 6. Semester: **Autumn**
7. Pre-requisites: Nil. 8. Subject Area: **PCC**
9. Objective: To give an over view of fundamental and advance knowledge in Microbiology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.	6
2.	Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria,Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilicarchae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.	9
3.	Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.	3
4.	Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.	5
5.	Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.	5
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th ed.). New York: McGraw-Hill.	2001
2.	Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology*. New York: McGraw-Hill.	2011
3.	Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations.* Boston, MA: John Wiley & Sons.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-505 Course Title: **Genetics**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To give an over view of fundamental and advance knowledge in genetics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.	10
2.	Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.	6
3.	Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.	4
4.	Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.	4
5.	Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.	2
6.	Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.	2
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Hartl, D. L., & Jones, E. W. (1998). *Genetics: Principles and Analysis*. Sudbury, MA: Jones and Bartlett.	1998
2.	Pierce, B. A. (2005). *Genetics: a Conceptual Approach*. New York: W.H. Freeman.	2005
3.	Tamarin, R. H., & Leavitt, R. W. (1991). *Principles of Genetics*. Dubuque, IA: Wm. C. Brown.	1991
4.	Smith, J. M. (1998). *Evolutionary Genetics*. Oxford: Oxford University Press.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-506 Course Title: **Basics of Mathematics and Statistics**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To give an over view of basic knowledge in Basics of Mathematics and Statistics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models *etc*.), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, basics of vectors, introduction to matrices.	10
2.	Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series *etc*.).	6
3.	Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.	6
4.	Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.	6
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Stroud, K. A., & Booth, D. J. (2009). *Foundation Mathematics*. New York, NY: Palgrave Macmillan.	2009
2.	Aitken, M., Broadhursts, B., &Haldky, S. (2009) *Mathematics for Biological Scientists*. Garland Science.	2009
3.	Billingsley, P. (1986). *Probability and Measure.* New York: Wiley.	1986
4.	Rosner, B. (2000). *Fundamentals of Biostatistics*. Boston, MA: Duxbury Press.	2000
5.	Daniel, W. W. (1987). *Biostatistics, a Foundation for Analysis in the Health Sciences*. New York: Wiley.	1987

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-507 Course Title: **Basics of Chemistry and Physics**
2.Contact Hours: **L**: 1.5 **T**:0.5 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To give an over view of fundamental knowledge in chemistry and physics

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Physical quantities and their dynamics: definitions and dimensions; vectors & scalars, displacement, velocity, acceleration, kinematic formulas, angular momentum, torque *etc.* force, power, work, energy (kinetic & potential/electric charge separation, electromagnetic spectrum, photons *etc.*); springs &Hookes laws; elastic and inelastic collisions; Newton's law of motions (centripetal and centrifugal forces *etc.*); simple harmonic motions, mechanical waves, Doppler effect, wave interference, amplitude, period, frequency & wavelength; diffusion, dissipation, random walks, and directed motions in biological systems; low Reynolds number - world of Biology, buoyant forces, Bernoulli's equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics: Maxwell Boltzmann distribution, Maxwell's demon (entropic forces at work in biology, chemical assemblies, self-assembled systems, role of ATP); Coulomb's law, conductors and insulators, electric potential energy of charges, nerve impulses, voltage gated channels, ionic conductance; Ohms law, electrolyte conductivity, capacitors and capacitance, dielectrics; various machines in biology *i.e.* enzymes, allostery and molecular motors	14
2.	Basic constituents of matter - elements, atoms, isotopes, atomic weights, atomic numbers, basics of mass spectrometry, molecules, Avogadro number, molarity, gas constant, molecular weights, structural and molecular formulae, ions and polyatomicions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate-determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; states of matter - vapor pressure, phase diagrams, surface tension, boiling and melting points, solubility, capillary action, suspensions, colloids and solutions; acids, bases and pH - Arrhenious theory, pH, ionic product of water, weak acids and bases, conjugate acid-base pairs, buffers and buffering action *etc*; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation-reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes; bond rotations and molecular conformations - Newman projections, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).	14
	Total	**28**

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Baaquie, B. E. *Laws of Physics: a Primer*. Singapore: National University of Singapore.	2000
2.	Matthews, C. P., & Shearer, J. S. *Problems and Questions in Physics*.New York: Macmillan Company.	1897
3.	Halliday, D., Resnick, R., & Walker, J. *Fundamentals of Physics*.New York: Wiley.	1993
4.	Ebbing, D. D., & Wrighton, M. S.,*General Chemistry*. Boston: HoughtonMifflin.	1990
5.	Averill, B., & Eldredge, P. (2007). *Chemistry: Principles, Patterns, and Applications*.San Francisco: Benjamin Cummings.	2007
6.	Mahan, B. H. (1965). *University Chemistry*. Reading, MA: Addison-Wesley Pub.	1965
7.	Cantor, C. R., & Schimmel, P. R. (2004). *Biophysical Chemistry*. San Francisco: W.H. Freeman.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-508 Course Title: **Laboratory I: Biochemistry & Analytical Techniques**
2. Contact Hours: **L**: 0 **T**:0 **P**: 6
3. Examination Duration (Hrs.): **Theory:** 0 **Practical:** --
4. Relative Weightage: CWS: 0 PRS: 100 MTE: 0 ETE: 0 PRE: 0
5. Credits: 3 6. Semester: **Autumn**
7. Pre-requisites: Nil. 8. Subject Area: **PCC**
9. Objective: The student is expected to develop skills and experience essential for understanding the integrated complexity of the structure and function of living cells and molecules
10. Details of Course:

S. No.	List of Experiments
1.	Preparing various stock solutions and working solutions that will be neededfor the course.
2.	To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3.	To determine an unknown protein concentration by plotting a standard graph ofBSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
4.	Titration of Amino Acids and separation of aliphatic, aromatic and polar aminoacids by thin layer chromatography.
5.	Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice). a) Preparation of cell-free lysates b) Ammonium Sulfate precipitation c) Ion-exchange Chromatography d) Gel Filtration e) Affinity Chromatography f) Dialysis of the purified protein solution against 60% glycerol as ademonstration of storage method g) Generating a Purification Table (protein concentration, amount of totalprotein; Computing specific activity of the enzyme preparation at eachstage of purification) h) Assessing purity of samples from each step of purification by SDS-PAGEGel Electrophoresis i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
6.	Experimental verification that absorption at OD_{260} is more for denatured DNAas compared tonative double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.
7.	Identification of an unknown sample as DNA, RNA or protein using availablelaboratory tools. (Optional Experiments)
8.	Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
9.	Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-509 Course Title: **Laboratory II: Microbiology**
2. Contact Hours: **L**: 0 **T**:0 **P**: 4
3. Examination Duration (Hrs.): **Theory:** 0 **Practical:** --
4. Relative Weightage: CWS: 0 PRS: 100 MTE: 0 ETE: 0 PRE: 0
5. Credits: 2 6. Semester: **Autumn**
7. Pre-requisites: Nil. 8. Subject Area: **PCC**
9. Objective: To develop practical skills related to microbiology
10. Details of Course:

S. No.	List of Experiments
1.	Sterilization, disinfection and safety in microbiological laboratory.
2.	Preparation of media for cultivation of bacteria.
3.	Isolation of bacteria in pure culture by streak plate method.
4.	Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.*
5.	Preparation of bacterial smear and Gram's staining.
6.	Enumeration of bacteria: standard plate count.
7.	Antimicrobial sensitivity test and demonstration of drug resistance.
8.	Maintenance of stock cultures: slants, stabs and glycerol stock cultures
9.	Determination of phenol co-efficient of antimicrobial agents.
10.	Determination of Minimum Inhibitory Concentration (MIC)
11.	Isolation and identification of bacteria from soil/water samples.

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: a Laboratory Manual*. Benjamin-Cummings Publishing Company.	2016
2.	Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). *Collins and Lyne's Microbiological Methods* (8th ed.). Arnolds.	2004
3.	Tille, P. M., & Forbes, B. A. *Bailey & Scott's Diagnostic Microbiology.*	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-510 Course Title: **Laboratory III: Plant and Animal Biotechnology**
2. Contact Hours: **L**: 0 **T**:0 **P**: 4
3. Examination Duration (Hrs.): **Theory:** 0 **Practical:** --
4. Relative Weightage: CWS: 0 PRS: 100 MTE: 0 ETE: 0 PRE: 0
5. Credits: 2 6. Semester: **Autumn**
7. Pre-requisites: Nil. 8. Subject Area: **PCC**
9. Objective: To impart practical knowledge of plant and animal Biotechnology.
10. Details of Course:

S. No.	Contents
Plant Biotechnology	
1.	Prepare culture media with various supplements for plant tissue culture.
2.	Prepare plant explants for inoculation under aseptic conditions.
3.	Attempt *in vitro* andro- and gynogenesis in model plants
4.	Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
5.	Culture *Agrobacterium* and attempt of transformation of any dicot species and hairy root induction.
6.	Generate an RAPD and ISSR profile of experimental plant
7.	Prepare karyotypes and study the morphology of somatic chromosomes of *Allium cepa, A. sativum, A. tuberosum*and compare them on the basis of karyotypes.
8.	Pollen mother cell meiosis and recombination index of select species
9.	Separation of major plant secondary metabolites by TLC/HPLC/GC-MS
10.	Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometeric methods.
11.	Perform PCR amplification of genotypes of a species for studying the genetic variation among the individuals of a species using random primers.
12	Study genetic fingerprinting profiles of plants and calculate polymorphic information content.
Animal Biotechnology	
1.	Count cells of an animal tissue and check their viability.
2.	Prepare culture media with various supplements for plant and animal tissue culture.
3.	Prepare single cell suspension from spleen and thymus.
4.	Monitor and measure doubling time of animal cells.
5.	Chromosome preparations from cultured animal cells.
6.	Isolate DNA from animal tissue by SDS method.
7.	Attempt animal cell fusion using PEG.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-511 Course Title: **Genetic Engineering**
2.Contact Hours: **L**: 3 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 03 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 3 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge of various genetic engineering techniques and their applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.	7
2.	Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc.*; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and *Pichia* vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.	7
3.	Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.	7
4.	Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.	7
5.	Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.	14
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Old, R. W., Primrose, S. B., &Twyman, R. M. (2001). *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications.	2001
2.	Green, M. R., &Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.	2012
3.	*Brown, T. A. (2006).* Genomes *(3*rd *ed.). New York: Garland Science Pub.*	2006
4.	*Selected papers from scientific journals, particularly Nature & Science.*	
5	*Technical Literature from Stratagene, Promega, Novagen, New England Biolab*etc.	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-512 Course Title: **Immunology**
2.Contact Hours: **L**: 3**T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 03 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 3 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge of Immunology and its applications
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.	6
2.	Immunoglobulins - basic structure, classes lasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.	8
3.	Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.	6
4.	Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.	8
5.	Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.	8
6.	Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.	6
Total		42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2006). *Kuby Immunology*.New York: W.H. Freeman.	2006
2.	Brostoff, J., Seaddin, J. K., Male, D., &Roitt, I. M. (2002). *Clinical Immunology*.London: Gower Medical Pub.	2002
3.	Murphy, K., Travers, P., Walport, M., &Janeway, C. (2012). *Janeway's Immunobiology*. New York: Garland Science.	2012
4.	Paul, W. E. (2012). *Fundamental Immunology*. New York: Raven Press.	2012
5.	Goding, J. W. (1996). *Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology*. London: Academic Press.	1996
6.	Parham, P. (2005). *The Immune System*. New York: Garland Science.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-513 Course Title: **Bioinformatics**
2.Contact Hours: **L**:2 **T**:1 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 03 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 3 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge of bioinformatics and its applications.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.	8
2.	DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.	6
3.	Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.	8
4.	Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment-methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.	10
5.	Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of in silico drug design;Virtual library: Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information.	10
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Lesk, A. M. (2002). *Introduction to Bioinformatics*. Oxford: Oxford University Press.	2002
2.	Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis.* Cold SpringHarbor, NY: Cold Spring Harbor Laboratory Press.	2001
3.	Baxevanis, A. D., & Ouellette, B. F. (2001). *Bioinformatics: a Practical Guide to theAnalysis of Genes and Proteins*. New York: Wiley-Interscience.	2001
4.	Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Hoboken, NJ.: Wiley-Blackwell.	2015
5.	Bourne, P. E., &Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.	2009
6.	Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics.* Oxford: Oxford University Press.	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-514 Course Title: **Genomics and Proteomics**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge of genomics and proteomics and its applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.	3
2.	Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.	4
3.	Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.	3
4.	Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.	5
5.	Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.	5
6.	Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.	8
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.	2006
2.	Liebler, D. C. (2002). *Introduction to Proteomics: Tools for the New Biology*. Totowa, NJ: Humana Press.	2002
3.	Campbell, A. M., &Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-515 Course Title: **Molecular Diagnostics**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To emphasizing methodologies used in molecular diagnostic and its major application

10. Details of Course:

S. No.	Contents	Contact Hours
1.	DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs.	4
2.	PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis.	6
3.	Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.	2
4.	Direct detection and identification of pathogenic-organisms that are slow growing or currently lacking a system of *in vitro* cultivation as well as genotypic markers of microbial resistance to specific antibiotics.	5
5.	Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.	5
6.	Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies. Quality oversight; regulations and approved testing.	6
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Campbell, A. M., &Heyer, L. J. (2006). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.	2006
2.	Brooker, R. J. (2009). *Genetics: Analysis & Principles*. New York, NY: McGraw-Hill.	2009
3.	Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, DC: ASM Press.	2010
4.	Coleman, W. B., &Tsongalis, G. J. (2010). *Molecular Diagnostics: for the Clinical Laboratorian*. Totowa, NJ: Humana Press.	2010
1.	Campbell, A. M., &Heyer, L. J. (2006). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-516 Course Title: **Research methodology and Scientific communication skill**

2.Contact Hours: **L**: 2 **T**:0 **P**: 0

3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0

4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0

5.Credits: 2 6. Semester: **Spring**

7.Pre-requisites: Nil. 8. Subject Area: **PCC**

9.Objective: To emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and develop communication skill

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology	8
2.	Choosing a mentor, lab and research question; maintaining a lab notebook.	4
3.	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; 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.	6
4.	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.	10
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.	2001
2.	Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: MacmillanIndia.	2010
3.	On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.	2009
4.	Movie: Naturally Obsessed, The Making of a Scientist.	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-517 Course Title: **Laboratory IV: Molecular Biology and Genetic Engineering**

2.Contact Hours: **L**: 0 **T**:0 **P**: 6

3.Examination Duration (Hrs.): **Theory:** 00 **Practical:** --

4.Relative Weightage: CWS: 0 PRS: 100 MTE: 0 ETE: 0 PRE: 0

5.Credits: 3 6. Semester: **Spring**

7.Pre-requisites: Nil. 8. Subject Area: **PCC**

9.Objective: To impart knowledge of various genetic engineering techniques and their applications

10. Details of Course:

S. No.	Contents
1.	1. Concept of lac-operon: a) Lactose induction of B-galactosidase. b) Glucose Repression. c) Diauxic growth curve of *E.coli*
2.	UV mutagenesis to isolate amino acid auxotroph
3.	Phage titre with epsilon phage/M13
4.	Genetic Transfer-Conjugation, gene mapping
5.	Plasmid DNA isolation and DNA quantitation
6.	Restriction Enzyme digestion of plasmid DNA
7.	Agarose gel electrophoresis
8.	Polymerase Chain Reaction and analysis by agarose gel electrophoresis
9.	Vector and Insert Ligation
10.	Preparation of competent cells
11.	Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency
12.	Confirmation of the insert by Colony PCR and Restriction mapping
13.	Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli,* SDS-PAGE analysis
14.	Purification of His-Tagged protein on Ni-NTA columns a) Random Primer labeling b) Southern hybridization.

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Green, M. R., &Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-518 Course Title: **Laboratory V: Immunology**

2.Contact Hours: **L**: 0 **T**:0 **P**: 6

3.Examination Duration (Hrs.): **Theory:** 00 **Practical:** --

4.Relative Weightage: CWS: 0 PRS: 100 MTE: 0 ETE: 0 PRE: 0

5.Credits: 3 6. Semester: **Spring**

7.Pre-requisites: Nil. 8. Subject Area: **PCC**

9.Objective: To impart practical knowledge immunology techniques and their applications

10. Details of Course:

S. No.	Contents
1.	Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2.	Antibody titre by ELISA method.
3.	Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4.	Complement fixation test.
5.	Isolation and purification of IgG from serum or IgY from chicken egg.
6.	SDS-PAGE, Immunoblotting, Dot blot assays.
7.	Blood smear identification of leucocytes by Giemsa stain.
8.	Separation of leucocytes by dextran method.
9.	Demonstration of Phagocytosis of latex beads and their cryopreservation.
10.	Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11.	Demonstration of ELISPOT.
12.	Demonstration of FACS.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-520 Course Title: **Biological Imaging**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PEC**
9.Objective: To impart knowledge of Biological Imaging.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Wide-field fluorescent microscopy. Widefield fluorescence microscopy can be used in combination with other common contrast techniques such as phase contrast and differential interference contract (DIC) microscopy. This combination is useful when performing live-cell imaging to examine general cell morphology or viability while also imaging regions of interest within cells.	5
2.	CLSM Imaging. A conjugate pinhole in optical path of confocal microscope prevents fluorescence from outside of focal plane from being collected by photomultiplier detector or imaged by camera. In CLSM, a single pinhole (and single focused laser spot) is scanned across specimen by scanning system. This spot forms a reflected epi-fluorescence image back on original pinhole. When specimen is in focus, fluorescent light from it passes through pinhole to detector.	5
3.	Imaging by 'Nipkow Disc' method which is a mechanical opaque disc which has a series of thousands of drilled or etched pinholes arranged in a spiral pattern. Each illuminated pinhole on disc is imaged by microscope objective to a diffraction-limited spot on region of interest on specimen.	4
4.	Live-cell imaging of whole embryos, tissues and cell spheroids *in vivo* in a gentle manner with high temporal resolution and in three dimensions. One is able to track cell movement over extended periods of time and follow development of organs and tissues on a cellular level. The next evolution of light-sheet fluorescence microscopy, termed lattice light-sheet microscopy as developed by Eric Betzig (Nobel Prize Laureate 2014 for PALM super-resolution microscopy) will even allow live-cell imaging with super-resolved *in vivo* cellular localization capabilities.	2
5.	Super-Resolution in a Standard Microscope: From Fast Fluorescence Imaging to Molecular Diffusion Laws in Live Cells; Photoswitching Fluorophores in Super-Resolution Fluorescence Microscopy; Image Analysis for Single-Molecule Localization Microscopy Deconvolution of Nanoscopic Images; Super-Resolution Fluorescence Microscopy of the Nanoscale Organization in cells; Correlative Live-Cell and Super-Resolution Microscopy and Its Biological Applications; SAX Microscopy and Its Application to Imaging of 3D-Cultured Cells; Quantitative Super-Resolution Microscopy for Cancer Biology and Medicine.	8
6.	Structured Illumination Microscopy; Correlative Nanoscopy: AFM Super-Resolution (STED/STORM) ; Stochastic Optical Fluctuation Imaging.	4
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Rajagopal Vadivambal, Digvir S. Jayas. (2015). *Bio-Imaging: Principles, Techniques, and Applications*. ISBN 9781466593671 - CAT# K20618.	2015
2.	Alberto Diaspro, Marc A. M. J. van Zandvoort. (2016). *Super-Resolution Imaging in Biomedicine*. ISBN 9781482244342 - CAT# K23483.	2016
3.	Taatjes, Douglas, Roth, Jürgen (Eds.). (2012). *Cell Imaging Techniques Methods and Protocols*. ISBN 978-1-62703-056-4.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-521 Course Title: **Microbial Technology**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PEC**
9.Objective: To impart knowledge of Microbial Technology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (*e.g.*, engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 system as nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/strains and their applications; Strain improvement to increase yield of selected molecules, *e.g.*, antibiotics, enzymes, biofuels.	5
2.	Environmental application of microbes; Ore leaching; Biodegradation - biomass recycle and removal; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.	5
3.	Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical/operational, commercial and ethical); Attributes required in industrial microbes (*Streptomyces* sp., Yeast) to be used as efficient cloning and expression hosts (biologicals production); Generating diversity and introduction of desirable properties in industrially important microbes (*Streptomyces*/Yeast); Microbial cell factories; Downstream processing approaches used in industrial production process (*Streptomyces* sp., Yeast).	6
4.	Application of microbes and microbial processes in food and healthcare industries - food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Non-recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (*e.g.*, Yeast) - exploiting the existing natural diversity or the artificially introduced diversity through conventional acceptable techniques (mutagenesis, protoplast fusion, breeding, genome shuffling, directed evolution *etc.*).	6
5.	Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and meta-transcriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, meta-genomic library construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (*e.g.*, protease, antibiotic) *etc.*	6
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Lee, Y. K. (2013). *Microbial Biotechnology: Principles and Applications*. Hackensack, NJ: World Scientific.	2013
2.	Moo-Young, M. (2011). *Comprehensive Biotechnology*. Amsterdam: Elsevier.	2011
3.	Nelson, K. E. (2015). Encyclopedia of Metagenomics. *Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools*. Boston, MA: Springer US.	2015
4.	*The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet*. (2007). Washington, D.C.: National Academies Press.	2007
5.	Journals: (a) Nature, (b) Nature Biotechnology, (c) Applied microbiology and biotechnology, (d) Trends in Biotechnology, (e) Trends in Microbiology, (f) Current opinion in Microbiology, (g) Biotechnology Advances, (h) Genome Research)	
6.	Websites: http://jgi.doe.gov/our-science/	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-522 Course Title: **Environmental Biotechnology**
2. Contact Hours: **L**: 2 **T**:0 **P**: 0
3. Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4. Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5. Credits: 2 6. Semester: **Spring**
7. Pre-requisites: Nil. 8. Subject Area: **PEC**
9. Objective: To impart knowledge of Environmental Biotechnology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology.	4
2.	Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT *etc.*), technological aspects of bioremediation (*in situ, ex situ*).	4
3.	Application of bacteria and fungi in bioremediation: White rot fungi *vs* specialized degrading bacteria: examples, uses and advantages *vs* disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization).	4
4.	Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (*e.g. Trichoderma, Pseudomonas fluorescens*); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.	8
5.	Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.	8
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	G. M. Evans and J. C. Furlong (2003), *Environmental Biotechnology: Theory and Applications*, Wiley Publishers.	2003
2.	B. Ritmann and P. L. McCarty, (2000), *Environmental Biotechnology: Principle & Applications*, 2nd Ed., McGraw Hill Science.	2000
3.	Scragg A., (2005) *Environmental Biotechnology*. Pearson Education Limited.	2005
4.	J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), *Biofiltration for Air Pollution Control*, CRC Press.	1998
5.	H. J. Rehm and G. Reed, (2001), *Biotechnology – A Multi-volume Comprehensive Treatise*, Vol. 11, 2nd Ed., VCH Publishers Inc.	2001
6.	H. S. Peavy, D. R. Rowe and G. Tchobanoglous, (2013), *Environmental Engineering*, McGraw-Hill Inc.	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-523 Course Title: **Drug Discovery and Development**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PEC**
9.Objective: To impart knowledge of Drug Discovery and Development
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three-dimensional structures and physicochemical properties of drugs and receptors; Modelling drug/receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.	6
2.	Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, *etc.*; Bioanalytical assay development in support of *in vitro* and *in vivo* studies (LC/MS/MS, GC/MS and ELISA).	5
3.	Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/PD/TK studies; Scope of GLP, SOP for conduct of clinical & non clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design of clinical studies.	5
4.	Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies.	4
5.	Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation.	4
6.	Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label *vs.* off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance to current ethical guidelines, Ethical Committees and their set up, Animal Ethical issues and compliance.	4
Total		28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Krogsgaard-Larsen *et al. Textbook of Drug Design and Discovery*. 4th Edition. CRC Press.	
2.	Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.	2010
3.	Nally, J. D. (2006) *GMP for Pharmaceuticals*. 6th edition. CRC Press	2006
4.	Brody, T. (2016) *Clinical Trials: Study Design, Endpoints and Biomarkers,* Drug Safety, and FDA and ICH Guidelines. Academic Press.	2016

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-524 Course Title: **Structural Biology**
2. Contact Hours: **L**: 2 **T**:0 **P**: 0
3. Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4. Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5. Credits: 2 6. Semester: **Spring**
7. Pre-requisites: Nil. 8. Subject Area: **PEC**
9. Objective: To impart knowledge of Structural Biology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of structural biology; Primary, secondary, tertiary and quaternary structure of protein; Motifs and domains of protein structures; Structure of RNA and DNA; Conformational analysis	4
2.	Enzymes structure-function relationship and the basis of structure-based drug design	2
3.	Folding and flexibility; helix-coil transition, equilibrium & kinetics studies, duplex to single strand transition, A to B to Z transition, stacking and unstacking equilibrium	4
5.	Symmetry, space group crystal lattices, The Laue equations. Braggs Law. Fourier syntheses, electron density as a Fourier series. structure determination of macromolecules by crystallography technique	8
6.	Nuclear Magnetic Resonance, chemical shift, relaxation dynamics, protein structure determination using multidimensional NMR, molecular mechanisms, thermodynamic concepts and conformational exchange of biomolecules	8
7.	Structures of large molecular machines and virus assembly	2
	Total	**28**

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Cantor, C. R. and Schimmel, W.H., "Biophysical Chemistry Part-I and Part-III", Freeman & Co.	1981
2.	McPherson, A. **"** Introduction to Macromolecular Crystallography", 2nd edition, Wiley-Blackwell.	2009
3.	Drenth, J., "Principles of Protein X-Ray Crystallography", 3rd edition, Springer.	2007
4.	Rhodes, G., "Crystallography Made Crystal Clear", 3rd edition, Academic Pres	2006
5.	Voet, D. and Voet, J. G., "Biochemistry" 3rd edition, John Wiley and Sons.	2004
6	Keeler J. "Understanding NMR Spectroscopy" 2nd edition, Academic Press	2010
7	Wüthrich K "NMR of Proteins and Nucleic Acids" 2nd edition, (Baker Lecture Series)/ John-Wiley.	1986
8	Cavanagh, J., Fairbrother, W.J., Palmer III, A.J., Skelton, N.J., and Rance M. "Protein NMR Spectroscopy: Principles and Practice" 2nd edition, Academic Press	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-525 Course Title: **Biophysical Techniques**
2. Contact Hours: **L**: 2 **T**:0 **P**: 0
3. Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4. Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5. Credits: 2 6. Semester: **Spring**
7. Pre-requisites: Nil. 8. Subject Area: **PEC**
9. Objective: To impart knowledge of various biophysical techniques
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Physico-chemical properties of Biomolecules, Folding and flexibility; Techniques for studying macromolecular structure, stability, energetics and interactions.	2
2.	Principles and applications of UV Visible Spectroscopy; Fluorescence Spectroscopy; Circular Dichroism Spectroscopy	6
3.	Principles and Applications of Nuclear Magnetic Resonance (NMR) Spectroscopy – Chemical Shifts, Coupling constants, Nuclear Overhauser effect, Relaxation parameters, Two dimensional NMR, Structural and dynamics information of macromolecules using NMR	6
4.	Principles and Applications of Differential Scanning calorimetry, Isothermal calorimetry and Surface Plasmon Resonance	6
5.	Symmetry, Space group crystal lattices, Brag's law, Structure determination of macromolecules by Crystallography technique,	6
6.	Principles of Cryo-electron microscopy, tomography, small angle X-ray scattering (SAXS)	2
	Total	**28**

11. Suggested Books:

S. No.	Authors/ Name of Books/Publisher	Year of Publication/Reprint
1.	Cantor, C. R. and Schimmel, P. "Biophysical Chemistry" Vol. I, II and III, W.H. Freeman and Company, New York, USA.	2010
2.	Wilson, K. and Walker, J., "Principles and Techniques of Practical Biochemistry" 5th edition, Cambridge University Press.	2000
3	Keeler J. "Understanding NMR Spectroscopy" 2nd edition, Academic Press	2010
4	Wüthrich K "NMR of Proteins and Nucleic Acids" 2nd edition, (Baker Lecture Series)/ John-Wiley.	1986
5	Serdyuk, I.N., Zaccai, N.R., Zaccai, J., "Methods in Molecular Biophysics-Structure, Dynamics, Function", Cambridge University Press	2007
6	Edward H.Egelman, "Comprehensive Biophysics- Vol 1: Bophysical techniques for structural characterization of macromolecules", Elsevier.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-601 Course Title: **Bioprocess Engineering & Technology**
2.Contact Hours: **L**: 3 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 03 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 3 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge of Bioprocess Engineering & Technology.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.	4
2.	Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.	4
3.	Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.	8
4.	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, electrophoresis; final purification: drying; crystallization; storage and packaging.	8
5.	Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.	6
6.	Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.	6
7.	Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery	6
	Total	42

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.	2002
2.	Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford: Pergamon Press.	2010
3.	Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.* New York: M. Dekker.	1997
4.	Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*. New York: McGraw-Hill.	1986
5.	El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology.* Boca Raton: CRC/Taylor & Francis.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-602 Course Title: **Emerging Technologies**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge of various emerging technologies in Biology.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic Microscopy:** Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Dark field; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beam-splitters, boosting the signal. **Advanced Microscopy:** Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beam-splitter; beam scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to-noise ratio, multichannel images. nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, three-dimensional reconstruction; advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Beyond the Diffraction Limit: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photo-activated Localization Microscopy (PALM).	8
2.	Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.	4
3.	High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modeling and designing testable predictions.	3
4.	X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small-angle X-ray scattering, Atomic force microscopy.	3
5.	History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for *in vivo* genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.	6
6.	Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies.	4
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication
1.	Campbell, I. D. (2012). *Biophysical Techniques*. Oxford: Oxford University Press.	2012
2.	Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). *Methods in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.	2007
3.	Phillips, R., Kondev, J., & Theriot, J. (2009). P*hysical Biology of the Cell*. New York: Garland Science.	2009
4.	Nelson, P. C., Radosavljević, M., & Bromberg, S. (2004). *Biological Physics: Energy, Information, Life*. New York: W.H. Freeman.	2004
5.	Huang, B., Bates, M., & Zhuang, X. (2009). *Super-Resolution Fluorescence Microscopy.* Annual Review of Biochemistry, 78(1), 993-1016. doi:10.1146/annurev.biochem.77.061906.092014.	2009
6.	Mohanraju, P., Makarova, K. S., Zetsche, B., Zhang, F., Koonin, E. V., & Oost, J. V. (2016). *Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems.* Science, 353(6299). doi:10.1126/science.aad5147.	2016
7.	Lander, E. (2016). *The Heroes of CRISPR.* Cell, 164(1-2), 18-28. doi:10.1016/j.cell.2015.12.041.	2016
8.	Ledford, H. (2016). *The Unsung Heroes of CRISPR*. Nature, 535(7612), 342-344. doi:10.1038/535342a.	2016
9.	Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J. A., & Charpentier, E. (2012). *A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity*. Science, 337(6096), 816-821. doi:10.1126/science.1225829.	2012
10.	Hamers-Casterman, C., Atarhouch, T., Muyldermans, S., Robinson, G., Hammers, C., Songa, E. B., Hammers, R. (1993). *Naturally Occurring Antibodies Devoid of Light Chains*. Nature, 363(6428), 446-448. doi:10.1038/363446a0.	1993
11.	Sidhu, S. S., & Koide, S. (2007). *Phage Display for Engineering and Analyzing Protein Interaction Interfaces.* Current Opinion in Structural Biology, 17(4), 481-487. doi:10.1016/j.sbi.2007.08.007.	2007
12.	Steyaert, J., & Kobilka, B. K. (2011). *Nanobody Stabilization of G Protein-Coupled Receptor Conformational States*. Current Opinion in Structural Biology, 21(4), 567-572. doi:10.1016/j.sbi.2011.06.011.	2011
13.	Vincke, C., & Muyldermans, S. (2012). *Introduction to Heavy Chain Antibodies and Derived Nanobodies*. Single Domain Antibodies, 15-26. doi:10.1007/978-1-61779-968-6_2.	2012
14.	Verheesen, P., & Laeremans, T. (2012). *Selection by Phage Display of Single Domain Antibodies Specific to Antigens in their Native Conformation*. Single Domain Antibodies, 81-104. doi:10.1007/978-1-61779-968-6_6.	2012
15.	Li, J., Xia, L., Su, Y., Liu, H., Xia, X., Lu, Q. Reheman, K. (2012). *Molecular Imprint of Enzyme Active Site by Camel Nanobodies*. Journal of Biological Chemistry J. Biol. Chem., 287(17), 13713-13721. doi:10.1074/jbc.m111.336370.	2012
16.	Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni, M. (2013). *Allosteric Inhibition of VIM Metallo-β-Lactamases by a Camelid Nanobody.*Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305.	2013
17.	Chakravarty, R., Goel, S., & Cai, W. (2014). *Nanobody: The "Magic Bullet" for Molecular Imaging?* Theranostics, 4(4), 386-398. doi:10.7150/thno.8006.	2014

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-603 Course Title: **Critical Analysis of Classical Papers**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart training on critical paper and data analyses
10. Details of Course:

S. No.	Contents	Contact Hours
	Molecular Biology	
1.	Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from *Pneumococcus* type III. Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. **Note:** This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.	1
2.	Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56. **Note:** Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.	1
3.	Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8 **Note:** In this one page paper Watson and Crick first described the structure of DNA double helix Study help - Watson_Crick_Nature_1953_annotated	2
4.	Transposable mating type genes in *Saccharomyces cerevisiae* James Hicks, Jeffrey N. Strathern & Amar J.S. Klar; Nature 282, 478-483,1979 **Note:** This paper provided evidence for 'cassette hypothesis' of yeast mating type switches *i.e.* interconversion of mating types in yeast *(S. cerevisiae)* occurs by DNA rearrangement.	2
5.	Messelson & Stahl experiment demonstrating semi-conservative replication of DNA. Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82 **Note:** The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"	1
6.	*In vivo* alteration of telomere sequences and senescence caused by mutated *Tetrahymena* telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990 **Note:** This paper demonstrates that the telomerase contains the template for telomere synthesis	1
Cell Biology		
1.	A protein-conducting channel in the endoplasmic reticulum Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371-80 **Note:** This paper demonstrates the existence of a protein conducting channel Study help - A brief history of Signal Hypothesis	2
2.	Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15 **Note:** In this groundbreaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion	2
3.	A yeast mutant defective at an early stage in import of secretory protein precursors into the	2

	endoplasmic reticulum Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45 **Note:** Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC) Suggested reference paper - A biochemical assay for dentification of PCC.	
4.	Reconstitution of the Transport of Protein between Successive Compartments of the Golgi Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16 **Note:** This paper describes setting up of an *in vitro* reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP *etc.*	2
5.	A complete immunoglobulin gene is created by somatic recombination Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14 **Note:** This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.	2
6.	A novel multigene family may encode odorant receptors: a molecular basis for odor recognition Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87 **Note:** This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in *Drosophila* olfactory epithelium where a large family of odorat receptors is expressed.	2
7.	Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 **Note:** This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.	2
Developmental Biology/ Genetics		
1.	Mutations affecting segment number and polarity in *Drosophila* Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980 **Note:** This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.	2
2.	Information for the dorsal--ventral pattern of the *Drosophila* embryo is stored as maternal mRNA Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7 **Note:** This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes	2
3.	Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7 **Note:** One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cillia in it. Suggested Reference paper - Design and execution of a embryonic lethal mutation screen in mouse.	2
	Total	28

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-604 Course Title: **Bio-entrepreneurship**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge of Bio-entrepreneurship
10. Details of Course:

S. No.	Contents	Contact Hours
1.	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.	6
2.	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.	6
3.	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.	8
4.	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).	8
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/ Reprint
1.	Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.	2008
2.	Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.	2014
3.	Onetti, A., & Zucchella, A. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge*. Routledge.	
4.	Jordan, J. F. (2014). *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press.	2014
5.	Desai, V. (2009). *The Dynamics of Entrepreneurial Development and Management*. New Delhi: Himalaya Pub. House.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-605 Course Title: **Intellectual Property Rights, Biosafety and Bioethics**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge on Intellectual Property Rights, Biosafety and Bioethics
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.	5
2.	Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.	5
3.	Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops *vs* cisgenic plants or products derived from RNAi, genome editing tools.	6
4.	International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).	6
5.	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.	6
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. New Delhi: Tata McGraw-Hill Pub.	2001
2.	*National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI	
3.	*Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication Oct.	2007
4.	Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.	2010
5.	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/	
6.	Karen F. Greif and Jon F. Merz, *Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies*, MIT Press	
7.	World Trade Organisation. http://www.wto.org	
8.	World Intellectual Property Organisation. http://www.wipo.int	
9.	International Union for the Protection of New Varieties of Plants. http://www.upov.int	
10.	National Portal of India. http://www.archive.india.gov.in	
11.	National Biodiversity Authority. http://www.nbaindia.org	
12.	Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf	1990
13.	Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). *Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants*. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9	2009
14.	Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). *An Overview of General Features of Risk Assessments of Genetically Modified Crops*. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8	2008
15.	Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.	2008
16.	Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp	2008
17.	Alonso, G. M. (2013). *Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments*. Retrieved from http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews.	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-606 Course Title: **Project Proposal Preparation & Presentation**
2.Contact Hours: **L**: 1 **T**:1 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 00 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Autumn**
7.Pre-requisites: Nil. 8. Subject Area: **PCC**
9.Objective: To impart knowledge on how to prepare project proposals and how to make presentation
10. Details of Course:

S. No.	Contents	Contact hours
1.	Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources. Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.* Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.	10
2.	Poster Presentation: Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.	8
3.	Oral presentation: At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.	10
	Total	**28**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-607 Course Title: **Laboratory VI: Bioprocess Engineering & Technology**

2.Contact Hours: **L**: 0 **T**:0 **P**: 8

3.Examination Duration (Hrs.): **Theory:** 00 **Practical:** --

4.Relative Weightage: CWS: 0 PRS: 100 MTE: 0 ETE: 0 PRE: 0

5.Credits: 4 6. Semester: **Autumn**

7.Pre-requisites: Nil. 8. Subject Area: **PCC**

9.Objective: To impart practical knowledge of Bioprocess Engineering & Technology

10. Details of Course:

S. No.	Contents
1.	Basic Microbiology techniques a) Scale up from frozen vial to agar plate to shake flask culture. b) Instrumentation: Microplate reader, spectrophotometer, microscopy. c) Isolation of microorganisms from soil samples.
2.	Experimental set-up a) Assembly of bioreactor and sterilization. b) Growth kinetics. c) Substrate and product inhibitions. d) Measurement of residual substrates.
3.	Data Analysis a) Introduction to Metabolic Flux Analysis (MFA).
4.	Fermentation a) Batch. b) Fed-batch. c) Continuous.
5.	Unit operations a) Microfiltration: Separation of cells from broth. b) Bio-separations: Various chromatographic techniques and extractions.
6.	Bioanalytics a) Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts*. Upper Saddle River, NJ: Prentice Hall.	2002
2.	Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford: Pergamon Press.	2010
3.	Blanch, H. W., & Clark, D. S. (1997). B*iochemical Engineering*. New York: M. Dekker.	1997
4.	Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals.* New York: McGraw-Hill.	1986
5.	El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology*. Boca Raton: CRC/Taylor & Francis.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-508 Course Title: **Laboratory VII: Bioinformatics**

2.Contact Hours: **L**: 0 **T**:0 **P**: 4

3.Examination Duration (Hrs.): **Theory:** 00 **Practical:** --

4.Relative Weightage: CWS: 0 PRS: 100 MTE: 0 ETE: 0 PRE: 0

5.Credits: 2 6. Semester: **Autumn**

7.Pre-requisites: Nil. 8. Subject Area: **PCC**

9.Objective: To impart practical knowledge of Bioinformatics

10. Details of Course:

S. No.	Contents
1.	Using NCBI and Uniprot web resources.
2.	Introduction and use of various genome databases.
3.	Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/TrEMBL, UniProt.
4.	Similarity searches using tools like BLAST and interpretation of results.
5.	Multiple sequence alignment using ClustalW.
6.	Phylogenetic analysis of protein and nucleotide sequences.
7.	Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8.	Using RNA structure prediction tools.
9.	Use of various primer designing and restriction site prediction tools.
10.	Use of different protein structure prediction databases (PDB, SCOP, CATH).
11.	Construction and study of protein structures using Deepview/PyMol.
12.	Homology modelling of proteins.
13.	Use of tools for mutation and analysis of the energy minimization of protein structures.
14.	Use of miRNA prediction, designing and target prediction tools.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT:Department of Biotechnology

1.Subject Code: BT-609Course Title: **Dissertation-minor**

2.Contact Hours: **L**: 0 **T**:0 **P**: 4

3.Examination Duration (Hrs.): **Theory:** 00 **Practical:** --

4.Relative Weightage: CWS: 0 PRS: 100 MTE: 0 ETE: 0 PRE: 0

5.Credits: 4 6. Semester: **Autumn**

7.Pre-requisites: BT-606 8. Subject Area: **PCC**

9.Objective: To impart knowledge of how to adapt to the research environment and understand how projects are executed in a research laboratory.

10. Details of Course:

S. No.	Contents
1.	Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.
2.	At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-612 Course Title: **Computational Biology**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PEC**
9.Objective: To impart knowledge of Computational Biology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.	4
2.	Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.	4
3.	Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies.	4
4.	Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.	2
5.	Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions.	4
6.	Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extra-precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings.	4
7.	Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation.	4
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.	2001
2.	Bourne, P. E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.	2009
3.	Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford: Oxford University Press.	2004
4.	Campbell, M & Heyer, L. J. (2006), *Discovering Genomics, Proteomics and Bioinformatics*, Pearson Education.	2006
5.	Oprea, T. (2005). C*hemoinformatics in Drug Discovery*, Volume 23. Wiley Online Library.	2005
6.	Gasteiger, J. & Engel,T. (2003), *Chemoinformatics: a Textbook*, Wiley Online Library.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-613 Course Title: **Nano-Biotechnology**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PEC**
9.Objective: To impart knowledge of Nano-Biotechnology
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.	4
2.	Thin films; Colloidal nanostructures; Self Assembly, Nano-vesicles; Nanospheres; Nanocapsules and their characterisation.	4
3.	Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.	5
4.	Nanoparticles for diagnostics and imaging; concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nano-devices for biosensor development.	5
5.	Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nano scaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.	5
6.	Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different strata of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.	5
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials*, Wiley-VCH Verlag GmbH & Co. KGaA	2003
2.	David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*; Wiley-Liss	2004
3.	Neelina H. Malsch (2005), *Biomedical Nanotechnology*, CRC Press	2005
4.	Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier	2013
5.	Recent review papers in the area of Nanomedicine.	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1.Subject Code: BT-614 Course Title: **Protein Engineering**
2.Contact Hours: **L**: 2 **T**:0 **P**: 0
3.Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4.Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5.Credits: 2 6. Semester: **Spring**
7.Pre-requisites: Nil. 8. Subject Area: **PEC**
9.Objective: To impart knowledge of Protein engineering
10. Details of Course:

S. No.	Contents	Contact Hours
1.	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.	6
2.	Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation.	6
3.	Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, *etc.*, Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens *etc.*, Application to devices with bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery.	6
4.	Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles *vis-à-vis* those from mesophiles; Protein design, Directed evolution for protein engineering and its potential.	6
5.	Case Studies.	4
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Edited by T E Creighton, (1997), *Protein Structure: a Practical Approach*, 2nd Edition, Oxford university press.	1997
2.	Cleland and Craik, (2006), *Protein Engineering, Principles and Practice*, Vol 7, Springer Netherlands.	2006
3.	Mueller and Arndt, *Protein Engineering Protocols*, 1st Edition, Humana Press.	
4.	Ed. Robertson DE, Noel JP, (2004), *Protein Engineering Methods in Enzymology*, 388, Elsevier Academic Press.	2004
5.	J Kyte; (2006), *Structure in Protein Chemistry*, 2nd Edition, Garland publishers.	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-615 Course Title: **Advance cell culture technologies**
2. Contact Hours: **L**: 2 **T**:0 **P**: 0
3. Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4. Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5. Credits: 2 6. Semester: **Spring**
7. Pre-requisites: Nil. 8. Subject Area: **PEC**
9. Objective: To impart knowledge of modern animal cell, stem cell and plant cell culture technologies with industrial applications
10. Details of Course:

S. No.	Contents	Contact Hours
1	Techniques of cell culture: batch, batch fed and continuous cultures, design of media, cytotoxicity and viability assays, other cell based assays in drug discovery programs; cell separation techniques, flow cytometry and fluorescence associated cell sorting	3
2	Origin of stem cells: principles and applications of developmental biology, early embryonic development, types of cleavage and mechanisms, gastrulation; cell fate determination.	3
3	Concepts of stem cells: basic concepts and properties; totipotency; Pluripotency; embryonic stem (ES) cells; germinal stem cells; adult stem cells; tumor/ cancer stem cells; stem cell plasticity; general methods of characterization of stem cells; concept of differentiation of ES cell; maintenance of ES in undifferentiated state.	3
4	Stem cells and cloning: therapeutic and reproductive cloning; nuclear transfer methods; applications of nuclear transfer in ES cells; stem cells and transgenic animal production; nuclear reprogramming; safety of nuclear transfer in ES cells.	3
5	Stem cell therapy and future of stem cell research: potential of stem cell therapy for various diseases like AIDS/HIV; alzhemier's disease; anaemia; multiple sclerosis; Parkinson disease; rheumatoid arthritis; injuries; cancer; tissue engineering	2
6	Plant growth regulators and their rational use in nutrient media formulation, pathways of regeneration, micro-techniques – callus formation, how to develop plant cell culture, maintenance and preservation of plant cell culture.	5
7	Principles for production of value added products and secondary metabolites by plant cell culture, plant stem cells, medicinal plant cell suspension cultures: pharmaceutical applications and high-yielding strategies using cell culture. Hairy root cultures and strategies for mass production of value added plant products. Process strategies for plant cell culture, metabolic engineering of plant cell culture, methods and mechanisms for genetic manipulation plant cell culture, novel strategies for the rational engineering of valuable secondary metabolites using plant cell culture by smart cell approach	9
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1	Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.	2004
2	Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.	
3	Lanza, R.P., Langer, R. and Vacanti, J., "Principles of Tissue Engineering", Academic Press.	2019
4	Lanza R., "Essentials of Stem Cell Biology" 2nd Edition. Academic Press	2020
5	I. A. Freshney, Culture of Animal Cells, Academic Press	2018
6	Atala, A., Lanza R., Thomson J. A., "Principles of Regenerative Medicine" Elsevier Inc.	2018

9	Plant Cell Culture: Essential Methods, Author(s): Michael R. Davey Paul Anthony; First published:5 March 2010; Print ISBN:9780470686485 |Online ISBN:9780470686522 |DOI:10.1002/9780470686522, Wiley	2010
10	Plant Cell and Tissue Culture - A Tool in Biotechnology Basics and Application. Authors: Neumann, Karl-Hermann, Kumar, Ashwani, Imani, Jafargholi. Publishher: Springer International Publishing. ISBN: 978-3-030-49096-6	2020

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Biotechnology

1. Subject Code: BT-616 Course Title: **Vaccines**
2. Contact Hours: **L**: 2 **T**:0 **P**: 0
3. Examination Duration (Hrs.): **Theory:** 02 **Practical:** 0
4. Relative Weightage: CWS: 20-30 PRS: 0 MTE: 20-30 ETE: 40-50 PRE: 0
5. Credits: 2 6. Semester: **Spring**
7. Pre-requisites: Nil. 8. Subject Area: **PEC**
9. Objective: To impart knowledge of vaccine
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.	6
2.	Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.	7
3.	Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.	8
4.	History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.	3
5.	New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).	4
	Total	28

11. Suggested Books:

S. No.	Author(s)/ Title/ Publisher	Year of Publication/Reprint
1.	Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immuno Biology: the Immune System in Health and Disease*. USA: Garland Science Pub.	2005
2.	Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby Immunology*. New York: W.H. Freeman.	2013
3.	Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.	2004
4.	Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.	