CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY, KANPUR

STRUCTURE OF SYLLABUS FOR THE

PROGRAM: B.Sc.-M.Sc. INTEGRATED, SUBJECT: BIOTECHNOLOGY

Syllabus Developed by			
Name of BoS Convenor / BoS Member	**Designation**	**Department**	**College/University**
Prof S K Awasthi	Dean, Faculty of Life Sciences	Life Sciences & Biotechnology	CSJM University Kanpur
Prof. Nand Lal	Professor, Head & Convenor	Life Sciences & Biotechnology	CSJM University Kanpur
Prof. Neelam Pathak	External Expert	Biochemistry	RMLAU, Ayodhaya
Prof. Ram Narain	External Expert	Biotechnology	VBS Purvanchal University, Jaunpur
Prof. B N Mishra	External Expert	Biotechnology	Instt. Of Engineering &Technology, Lucknow
Prof. Varsha Gupta	Professor	Life Sciences & Biotechnology	CSJM University Kanpur
Prof. Rolee Sharma	Professor	Life Sciences & Biotechnology	CSJM University Kanpur
Dr. Shilpa Deshpande Kaistha	Associate Professor	Life Sciences & Biotechnology	CSJM University Kanpur
Dr. Swasti Srivastava	Assistant Professor	Life Sciences & Biotechnology	CSJM University Kanpur

Semester wise titles of Papers in B.Sc.-M.Sc. Integrated Biotechnology IST YEAR / IST SEM						
UG PAPERS						
COURSE CODE	**TYPE**	**COURSE TITLE**	**MIN CREDITS**	**CIA**	**ESE**	**MAX. MARKS**
IST YEAR / IST SEM						
L070101T	CORE	Fundamentals Of Chemistry	4	25	75	100
L070102P	PRACTICAL	Practical in Chemistry	2	25	75	100
L070103T	CORE	Cell Biology	4	25	75	100
L070104P	PRACTICAL	Practical in Cell Biology	2	25	75	100
L070105T	CORE	Molecular Biology	4	25	75	100
L070106P	PRACTICAL	Practical in Molecular Biology	2	25	75	100
L070107V	VOCATIONAL	English Communication and Soft Skills	3	25	75	100
Z010101T	CO-CURRICULAR	Food, Nutrition and Hygiene	2	25	75	100 (Q)
		TOTAL	23			700
IST YEAR / IIND SEM						
L070201T	CORE	Biochemistry and Metabolism	4	25	75	100
L070202P	PRACTICAL	Practical in Biochemistry and Metabolism	2	25	75	100
L070203T	CORE	Genetics	4	25	75	100
L070204P	PRACTICAL	Practical in Genetics	2	25	75	100
L070205T	CORE	Environmental Sciences	4	25	75	100
L070206P	PRACTICAL	Practical in Environmental Sciences	2	25	75	100
L070207V	VOCATIONAL	Basics of Computer Application	3	25	75	100
Z020201	CO-CURRICULAR	First Aid and Health	2	25	75	100 (Q)
	MINOR ELECTIVE FROM OTHER FACULTY (IN 1ST YR- Ist/IInd SEM)*		4	25	75	100
		TOTAL	27			800
IIND YEAR / IIIRD SEM						
L070301T	CORE	Immunology	4	25	75	100
L070302P	PRACTICAL	Practical in Immunology	2	25	75	100
L070303T	CORE	General Microbiology	4	25	75	100

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L070304P	PRACTICAL	Practical in General Microbiology	2	25	75	100
L070305T	CORE	Animal Physiology	4	25	75	100
L070306P	PRACTICAL	Practical in Animal Physiology	2	25	75	100
L070307V	VOCATIONAL	Bioinformatics	3	25	75	100
Z030301	CO-CURRICULAR	Human Values and Environment studies	2	25	75	100 (Q)
		TOTAL	23			700
		IIND YEAR / IVTH SEM				
L070401T	CORE	Recombinant DNA Technology	4	25	75	100
L070402P	PRACTICAL	Practical in Recombinant DNA Technology	2	25	75	100
L070403T	CORE	Bioinstrumentation and Analytical Techniques	4	25	75	100
L070404P	PRACTICAL	Practical in Bioinstrumentation and Analytical Techniques	2	25	75	100
L070405T	CORE	Plant Physiology	4	25	75	100
L070406P	PRACTICAL	Practical in Plant Physiology	2	25	75	100
L070407V	VOCATIONAL	Innovation and Entrepreneurship	3	25	75	100
Z040401	CO-CURRICULAR	Physical Education and Yoga	2	25	75	100 (Q)
		MINOR ELECTIVE FROM OTHER FACULTY (IN 2nd YR- IIIrd/IVth SEM)*	4	25	75	100
		TOTAL	27			800
		IIIRD YEAR / VTH SEM				
L070501T	CORE	Animal Biotechnology	4	25	75	100
L070502T	CORE	Genomics, Proteomics	4	25	75	100
L070503T	CORE	Biostatistics	4	25	75	100
L070504T	CORE	Basics of Virology and Oncology	4	25	75	100
L070505P	PRACTICAL	Practical	4	25	75	100
Z050501	CO-CURRICULAR	Analytic Ability and Digital Awareness	2	25	75	100 (Q)
L070506R	PROJECT	Research Project (Synopsis/ Presentation/Review)	4	25	75	100 (Q)
		TOTAL	26			500
		IIIRD YEAR / VITH SEM				
L070601T	CORE	Industrial and Environmental Biotechnology	4	25	75	100
L070602T	CORE	IPR, Biosafety, Bioethics and Entrepreneurship	4	25	75	100
L070603T	CORE	Stem cell and Tissue Engineering	4	25	75	100
L070604T	CORE	Drug Discovery and Targeting	4	25	75	100
L070605P	PRACTICAL	Practical	4	25	75	100
Z060601	CO-CURRICULAR	Communication Skills and Personality Development	2	25	75	100 (Q)
L070606R	PROJECT	Research Project (Report and Viva-Voce)	4	25	75	100 (Q)
		TOTAL	26			500
		GRAND TOTAL (UG)	**152**			**4000**
		PG Papers				
		IVTH YEAR / 7TH SEM				
COURSE CODE	**TYPE**	**COURSE TITLE**	**MIN CREDITS**	**CIA**	**ESE**	**MAX. MARKS**
L070701T	CORE	Molecular Cell Biology	4	25	75	100
L070702T	CORE	Biophysical Techniques	4	25	75	100
L070703T	CORE	Plant Biotechnology	4	25	75	100
L070704T	CORE	Fermentation for Plant and animal products	4	25	75	100
L070705P	PRACTICAL	Practical	4	25	75	100
	PROJECT	Project (Synopsis/ Presentation/Review)#		-	-	-
		MINOR ELECTIVE FROM OTHER FACULTY (IN IVth YR- VIIth/VIIIth SEM)*	4	25	75	100
		TOTAL	20			600

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STRUCTURE OF SYLLABUS FOR THE

PROGRAM: B.Sc.-M.Sc. INTEGRATED, SUBJECT: BIOTECHNOLOGY

IVTH YEAR / 8TH SEM						
L070801T	CORE	Enzymology	4	25	75	100
L070802T	CORE	Advanced Agricultural Biotechnology	4	25	75	100
L070803T	CORE	Vaccines	4	25	75	100
L070804T	CORE	Biomaterials	4	25	75	100
L070805P	PRACTICAL	Practical	4	25	75	100
L070806R	PROJECT	Project (Report and Viva-Voce)#	8	25	75	100
	TOTAL		32			600
VTH YEAR / 9TH SEM						
L070901T	CORE	*In vitro* Culture Technique	4	25	75	100
L070902T	CORE	Research Methodology and Academic Writing	4	25	75	100
L070903T	ELECTIVE	(A)Enzyme Kinetics & Regulation	4	25	75	100
L070904T		(B) Biofuels and alcohol technology				
L070905T	ELECTIVE	(A)Principles of Toxicology	4	25	75	100
L070906T		(B) Bioethics and Biosafety				
L070907P	PRACTICAL	Practical	4	25	75	100
	PROJECT	Project (Synopsis/ Presentation)#		-	-	-
	TOTAL		20			500
VTH YEAR / 10TH SEM						
L071001T	CORE	Drug Metabolism	4	25	75	100
L071002T	CORE	Nanobiotechnology	4	25	75	100
L071003T	ELECTIVE	(A) Metabolic Processes	4	25	75	100
L071004T		(B)Genetic Testing and Sequencing Technologies				
L071005P	ELECTIVE	(A)Intellectual Property Rights	4	25	75	100
L071006T		(B) Onco-Immunology				
L071007P	PRACTICAL	Practical	4	25	75	100
L071008R	PROJECT	Project (Report and Viva-Voce)#	8	25	75	100
	TOTAL		28			600
GRAND TOTAL (PG)			**100**			**2300**

NOTE:

1. *A MINOR ELECTIVE FROM OTHER FACULTY SHALL BE CHOSEN IN Ist, IInd year and IVth YEAR (EITHER Ist / IInd SEMESTER; IIIrd/IVth SEMESTER and VIIth/VIIIth Semester respectively) AS PER AVAILABILITY.
2. The co-curricular papers at UG level shall be qualifying (Q) papers of 100 marks.
3. The yearwise exit and lateral entry in the program shall be as per NEP-2020 guidelines.
4. #In both years of PG program, there will be a Research Project or equivalently a research-oriented Dissertation as per guidelines issued earlier and will be of 4 credit (4 hr/week), in each semester. The student shall submit a report/dissertation for evaluation at the end of the year, which will be therefore of 8 credits and 100 marks
5. Research project can be done in form of Internship/Survey/Field work/Research project/ Industrial training, and a report/dissertation shall be submitted that shall be evaluated via seminar/presentation and viva voce.
6. The student straight away will be awarded 25 marks if he publishes a research paper on the topic of Research Project or Dissertation.

Course Proposal

B.Sc.-M.Sc. Integrated Biotechnology

(A Five Year Course)

under

Faculty of Advanced Studies in Life Sciences

Department of Life Sciences and Biotechnology

Proposed By

Dr. Swasti Srivastava

Dr. Ajay Kumar Pandey

(Approved by Board of Studies on 13/5/2022)

Preamble

B.Sc.-M.Sc. Integrated Biotechnology is a five years course that a student can pursue after the completion of Class 12th science. B.Sc.-M.Sc. Integrated Biotechnology is divided into ten semesters. After completion of five years B.Sc.-M.Sc. Integrated Biotechnology degree is awarded, however on student demand after completion of three years B.Sc. Biotechnology degree can be awarded.

Program Educational Objectives

1) Learners will be practitioners and leaders in their chosen field.

2) Learners will function in their profession with social awareness and responsibility

3) Learners will interact with their peers in other disciplines in their workplace and society and contribute to the economic growth of the country.
4) Learners will be successful in pursuing higher studies in their chosen field.
5) Learners will pursue career paths in teaching or research.

Program Outcomes:

1. The overall aim of the integrated biotechnology program is to provide basic understanding of the core principles and working knowledge of modern day biotechnology which will be necessary for future scientific endeavors and make our students pursue higher education and research in the field of allied areas of biotechnology.

2. To make our students capable in the field of biotechnology and its allied areas by means of lecture series and a research project.

3. To provide strong fundamentals of biotechnology and its industrial application.

4. To empower students with a comprehensive understanding of the principles and practices in the field of biotechnology to produce responsible biotechnologists that can work in the area of social welfare and as an entrepreneur with strong ethics and communication skills.

5. To maximize the benefits of biotechnology to the nation and globe to solve problems which will improve the quality of life for those suffering from health related diseases and disorders.

Program Specific Outcomes

1.After successfully completing this course, the Learner should be able to understand the core principles and topics of modern day biotechnology and other allied areas.
2. Learners can implement the knowledge in the domain of advanced biotechnology empowering their applications in research and industry to deliver a sustainable edge to present society.
3. Learners will exhibit contemporary knowledge in biotechnology and will develop problem solving skills and critical thinking to the allied fields of biotechnology.
4. The rapidly developing field of biotechnology offers opportunities for Learners with biotechnology background at national and international level in the field of academics, research, pharmaceutical companies, fertilizer industry, and food processing industries, entrepreneurship ventures, chemical industry, textile industry, aquaculture industries and environment sector.

Course Duration: Minimum one year and maximum five years.
Target Student Group: 10+2 qualified as per Indian education system
Eligibility: Admission to B.Sc.-M.Sc. Integrated program in Biotechnology course shall be open to a person who holds an intermediate (10+2), with any of the combination of subjects amongst biology and mathematics with at least 50% marks in aggregate (5% relaxation for SC/ST).Admission through University Entrance Test.
Student Intake: 30/60; followed by lateral intake as per availability of seats vacated due to exit option after first, second and third year.

Minimum Credits Required for Lateral entry: 20, 40, 60 for entry in second, third and fourth year respectively.

New Course Proposal

Five Year B.Sc.- M.Sc. Integrated Biotechnology

under

Faculty of Advanced Studies in Life Sciences

Department of Biosciences and Biotechnology

Syllabus

Induction Program (Two Weeks) (Mandatory)

Will include activities like Orientation Program, Literary activities, Visit in local area, program on creative arts and culture, teachings in moral conduct, extra-curricular activities.

SEMESTER ONE

Fundamentals of Chemistry

Course Objectives:

1. To educate the students to develop the knowledge of the fundamental principles of chemistry
2. To enable understanding of the nomenclature, structural, isomerism, stereochemistry of organic compounds.

Expected Course Outcome:

1. Understand the fundamental principles of organic chemistry that include chemical bonding,
2. Learn nomenclature, structural of various classes of compounds,
3. Develop concepts of isomerism, stereochemistry, Chirality.
4. Acquire concept of Acidity, Alkalinity, applications of indicator.

Unit 1 (8 lectures)

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 polyatomic ions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenius equation, Maxwell Boltzmann distributions, rate- determining steps, catalysis.

Unit 2 (12 lectures)

Free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); 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, light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds(ionic, covalent, Vander Waals forces); electronegativity, polarity

UNIT 3 (10 lectures)

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 -Arrhenius theory, pH, ionic product of water, weak acids and bases, conjugate

acid base pairs, buffers and buffering action , Indicator, Sparingly Soluble Salts, Common ion effect, Selective Precipitation, acid- base titration and use of indicators

UNIT 4 (10 lectures)

Bond rotations and molecular conformations – Newman projections, conformational analysis of alkanes, alkenes and alkynes, functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).

Suggested Practicals

1. Preparation of acetate-acetic acid buffer solution and measurement of their pH.
2. Potentiometric titration of a strong acid and strong base.
3. Potentiometric titration of a weak acid and strong base.
4. Determination of dissociation constant of a weak acid.

REFERENCE BOOKS:

1. Morrison R.T. & Boyd R.N., *Organic chemistry* (6th edition).
2. IUPAC nomenclature by Robert M. Silverstein.
3. Stereochemistry by P.S. Kalsi.
4. A text book of organic chemistry by Arun Bahl & B.S. Bahl, 16th Edition
5. Principles of Physical chemistry by B.R. Puri, L.R. Sharma and M.S. Pathania, 41th Ed.
6. Biophysical chemistry, Principles and Techniques by Upadhyay, Upadhyay and Nath.
7. Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry.* Wiley
8. Elements of Physical Chemistry by S. Glasstone and D. Lewis
9. Ebbing, D.D., & Wrighton, M.S. (1990). General Chemistry. Boston: Houghton Mifflin. 10.Averill, B., & Eldredge, P. (2007). Chemistry: Principles, Patterns, and Applications.San Francisco: Benjamin Cummings.
11. Mahan, B.H. (1965). University Chemistry. Reading, MA: Addison-Wesley Pub.
12. Cantor, C.R., & Schimmel, P.R. (2004). Biophysical Chemistry. San Francisco: W.H. Freeman

Cell Biology

Course Objectives:

1. The students will learn different areas of cellular biology including the structure and functions of the cell, its organelles, synthesis and function of proteins, membrane structure and function; bioenergetics; cellular communication, division of cell and chromosomal separation in different stages of cell cycle. Explain the organization and functions of DNA, RNA, and proteins

Expected Course Outcome:

1. Understand the structures and purposes of basic components of plant cell, Animal cells, prokaryotic and eukaryotic cells, especially macromolecules, membranes, and different cell organelles.
2. Learn how these cellular components are used to generate and utilize energy in cells.
3. Understand the cytoskeleton structure, protein sorting, Cell cycle, programmed cell death and the cellular components underlying mitotic cell division.

UNIT 1 (10 lectures)

Introduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation. Organization and functions of cell membrane, cytoskeleton and cell motility.

UNIT 2 (8 lectures)

Membrane Vacuolar system Endoplasmic reticulum: Structure, function including role in protein segregation. Golgi complex: Structure, biogenesis and functions including role in protein secretion.

UNIT 3 (12 lectures)

Structure and function: Lysosomes, Vacuoles and micro bodies, Ribosomes, Mitochondria, Genomes, biogenesis. Chloroplasts, genomes, biogenesis, Nucleus: Structure and function, chromosomes and their structure. Extracellular Matrix,

UNIT 4 (10 lectures)

Cell Cycle: Mitosis and Meiosis: Control points in cell-cycle progression. Role of meiosis in life cycles of organisms Programmed Cell Death, basics of signal transduction, regulation of receptor expression and function.

SUGGESTED PRACTICALS

1. Study the effect of temperature and organic solvents on semi permeable membranes.
2. Demonstration of dialysis.
3. Study of plasmolysis and deplasmolysis.
4. Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source.
5. Study of structure of any Prokaryotic and Eukaryotic cell.
6. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, esophagus, stomach, pancreas, intestine, kidney, ovary, testes.
7. Cell division in onion root tip/ insect gonads.
8. Preparation of Nuclear, Mitochondrial & cytoplasmic fractions.

SUGGESTED READING

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J.D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbor Lab. Press, Pearson Pub.

Molecular Biology

Course Objectives:

1.To teach the dynamic properties of chromatin and its folding.
2To teach topological properties of DNA, reassociation kinetic, transposable elements and genetic code
3To provide students with a deep insight and mechanism of the various cellular processes such as DNA Replication, Transcription and Translation.

Expected Course Outcomes: At the end of the course, a student should be able to

1.To learn the dynamic properties of chromatin and its folding.
2.To learn topological properties of DNA, reassociation kinetic, transposable elements and genetic code
3.To understand the mechanism of the various cellular processes such as DNA Replication, Transcription and Translation.

UNIT I: (10 Periods)

DNA as genetic material, Structure of DNA, Types of DNA, Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-direc tional replication, DNA polymerases, The replication complex: Prepriming proteins, primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication, Fidelity of replication.

UNIT II: (10 Periods)
DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair:
Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, translesion synthesis, recombinational repair, nonhomologous end joining. Homologous recombination: models and mechanism.

UNIT III: (10 Periods)
RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5' cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

UNIT IV: (10 Periods)
Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics, Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptide, Fidelity of translation, Inhibitors of translation., Posttranslational modifications of proteins.

SUGGESTED PRACTICALS

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of Plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples
6. Demonstration of AMES test or reverse mutation for carcinogenicity

SUGGESTED READING

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J.D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbor Lab. Press, Pearson Pub.

English Communication and Soft Skills

Course Objectives:

Students will learn about various scientific terms and will be able to enhance skills. Verbal and Non-verbal communication, writing skills.

Expected Course Outcome:

1. Understand the preparation of Well-organized presentation slides
2. Improve presentation skill
3. Learn biological, and Chemical vocabulary and Terminology
4. Understand verbal and Non-Verbal communication

Unit 1 (5 lectures)

Theory of communication, Types and Mode of communication, Language of communication- Verbal and Non verbal (Spoken and written), Personal, Social and Business Communication, Barriers and Strategies, Intrapersonal communication, Interpersonal and Group communication.

Unit 2(5 lectures)

Definitions and Types of Mindset, Learning Mindsets; Secrets of Developing Growth Mindsets. Importance of Time and Understanding Perceptions of Time, Using Time Efficiently, Understanding Procrastination, Overcoming Procrastination, Don't Say "Yes" to Make Others Happy!, Types of People, How to Say "No" , Controlling Anger, Gaining Power from Positive Thinking, What Makes Others Dislike You?, What Makes Others Like You?, Being Attractive.

Unit 3(5 lectures)

Common Errors, Humor in Communication, Humor in the Workplace, Function of Humor in the Workplace, Money and Personality, Managing Money, Health and Personality, Managing Health, Importance of Exercise, Diet and Sleep, Love and Personality ; Managing Love, Ethics and Etiquette, Business Etiquette, Managing Mind and Memory, Improving Memory, Care for Environment

Practical Activities(60 Hr training)

Speaking Skills, Monologue, Dialogue, Group Discussion , Effective Communication, Mis- communication, Interview- Public Speech Reading and understanding, Close reading, comprehension, Summary, Paraphrasing, Analysis and Interpretation, Translation from Indian language to English and vice-versa, Literary and Knowledge Text.

Books and References

1. Raymond Murphy, English Grammar in Use, Cambridge University Press, 1986
2. J C Nesfield, Modern English Grammar
3. Andrew Northedge, The Good Study Guide, Open University, 2001H W Fowler, A Dictionary of Modern English Usage
4. C T Onions, Modern English Syntax, prepared from the author's material by B. D. H. Miller, RKP, London & Henley, 1985
5. Vipin Kumar Tyagi, Technical Communication Skills, Osbert Publishing House, New Delhi, 2017
6. Norman Lewis, Speak Better Write Better English, W. R. Goyal Publishers & Distributors, Delhi, 2004
7. Dorch, Patricia. What Are Soft Skills? New York: Execu Dress Publisher, 2013.
8. Kamin, Maxine. Soft Skills Revolution: A Guide for Connecting with Compassion for Trainers, Teams, and Leaders. Washington, DC: Pfeiffer & Company, 2013.
9. Klaus, Peggy, Jane Rohman & Molly Hamaker. The Hard Truth about Soft Skills. London: HarperCollins E-books, 2007.
10. Pete's S.J., Francis. Soft Skills and Professional Communication. New Delhi: Tata McGraw-Hill Education, 2011.
11. Stein, Steven J. & Howard E. Book. The EQ Edge: Emotional Intelligence and Your Success. Canada: Wiley & Sons, 2006.

***The compulsory co-curricular courses will be offered as per university guidelines.**

Semester Two

Biochemistry and Metabolism

Course Objectives:

1. Demonstrate the structure and function of biomolecules.
2. Outline different pathways involved in cellular metabolism.
3. Relate inhibitors and activators of key metabolic reactions.

Expected Course Outcome:

1. Compare and contrast the structural basis of biological macromolecules.
2. Analyze the chemical bonds of importance in carbohydrates, lipids, proteins, and nucleic acids.

3. Illustrate the catabolism and anabolism of carbohydrates
4. Summarize the energetics and regulation of metabolic pathways
5. Interpret experiments and techniques based on the significance of biomolecules.

UNIT 1 (12 lectures)

A historical perspective. Amino acids & Proteins: Structure & Function. Structure and properties of Amino acids. Types of proteins and their classification, Forces stabilizing protein structure and shape. Different Level of structural organization of proteins, Protein Purification. Denaturation and renaturation of proteins. Fibrous and globular proteins. Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero Polysaccharides, Mucopolysaccharides, Bacterial cell wall polysaccharides, Glycoprotein's and their biological functions.

UNIT 2 (10 lectures)

Lipids: Structure and functions –Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Prostaglandins, Cholesterol. Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines & pyrimidines,. Biologically important nucleotides, Double helical model of DNA structure and forces responsible for A, B & Z – DNA, denaturation and renaturation of DNA.

UNIT 3 (10 lectures)

Enzymes: Nomenclature and classification of Enzymes, Holoenzyme, apoenzyme, Cofactors, coenzyme, prosthetic groups, metalloenzymes, monomeric & oligomeric enzymes, activation energy and transition state, enzyme activity, specific activity, common features of active sites, enzyme specificity: types & theories, Biocatalysts from extreme thermophilic and hyperthermophilic archaea and bacteria. Role of: NAD +, NADP +, FMN/FAD, coenzymes A, Thiamine pyrophosphate, Pyridoxal phosphate, lipoic-acid, Biotin vitamin B12, Tetrahydrofolate and metallic ions.

UNIT 4 (8 lectures)

Carbohydrates Metabolism: Reactions, energetics and regulation. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis. TCA cycle, Electron Transport Chain, Oxidative phosphorylation. ß-oxidation of fatty acids.

SUGGESTED PRACTICALS

1. To study activity of any enzyme under optimum conditions.
2. To study the effect of pH, temperature on the activity of salivary amylase enzymes.
3. Determination of - pH optima, temperature optima, Km value, Vmax value, Effect of inhibitor (Inorganic phosphate) on the enzyme activity.
4. Estimation of blood glucose by glucose oxidase method.
5. Principles of Colorimetry: (i) Verification of Beer's law, estimation of protein. (ii) To study the relation between absorbance and % transmission.
6. Preparation of buffers.
7. Separation of Amino acids by paper chromatography.
8. Qualitative tests for Carbohydrates, lipids and proteins

SUGGESTED READING

1.Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.

2.Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants.American

Society of Plant Biologists.

3 Nelson, D L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.

4.Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.

5.Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co. Ltd.

Genetics

Course Objectives:

1. Recall basic concepts in molecular genetics
2. Dissect classical experiments to understand gene transfer
3. Choose the correct experimental model organism

Expected Course Outcome:

1. Explain genetic inheritance through historical experiments
2. Discuss chromosome organization and sex determination
3. Relate genetic makeup of different organisms
4. Distinguish factors that alter allele frequencies under exemptions
5. Relationship between mutation and evolution

UNIT 1 (10 lectures)

Introduction: Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their genetic significance. Mendelian genetics: Mendel's experimental design, monohybrid, di- hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Verification of segregates by test and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, codominance, semi-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity.

UNIT 2 (10 lectures)

Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant & recessive), duplicate genes and inhibitory genes. Eukaryotic nuclear genome nucleotide sequence composition –unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, middle repetitive sequences- VNTRs & dinucleotide repeats, repetitive transposed sequences- SINEs & LINEs, middle repetitive multiple copy genes, noncoding DNA. Genetic organization of prokaryotic and viral genomes. Packaging of DNA molecules into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene, one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.

UNIT 3 (10 lectures)

Definition and types of mutations , causes of mutations, Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, variations in chromosomes structure - deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression, chromosomal aberrations in human beings, abnormalities– Aneuploidy and Euploidy. Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors and sex determination, Barr bodies, dosage compensation, genetic balance theory, Fragile-X-syndrome and chromosome, sex influenced dominance, sex limited gene expression, sex linked inheritance.

UNIT 4 (10 lectures)

Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four

strand stage. Multiple crossing over, Genetic mapping. Extra chromosomal inheritance: Rules of extranuclear inheritance, maternal effects, maternal inheritance, cytoplasmic inheritance, organelle heredity, genomic imprinting. Evolution and population genetics: Inbreeding and outbreeding, Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systems of mating.

SUGGESTED PRACTICALS

1. Permanent and temporary mount of mitosis.
2. Permanent and temporary mount of meiosis.
3. Mendelian deviations in dihybrid crosses
4. Demonstration of Barr body -Rheo translocation.
5. Karyotyping with the help of photographs
6. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
7. Study of polyploidy in onion root tip by colchicine treatment.

SUGGESTED READING

- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
- Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co

Environmental Sciences

Course Objectives:

1. To make students understand and appreciate the unity of life in all its forms and the implications of lifestyle on the environment.
2. To broaden the understanding of global climate changes and the importance of renewable sources of energy.
3. To give students a basic understanding of the major causes of environmental degradation on the planet, with specific reference to the Indian situation.
4. To inspire students to find ways in which they can contribute personally and professionally to prevent and rectify environmental problems.

Course Outcomes:

At the end of the course, the student should be able to

1. Know the importance of the environment and awareness of natural resources to find the causes, effects, and consequences if not protected.
2. Acquire knowledge of renewable and non-renewable energy resources to solve future problems on energy demand.
3. Enriching the understanding of the need for eco-balance and the importance of biodiversity conservation.
4. Identify the numerous causes for environmental pollution, hazards, their management, and control methods.
5. Find ways to protect the environment from global climatic changes and their mitigation.
6. Recognize some of the social issues and gain knowledge on the protection of the environment.

7.Develop adequate knowledge of the population, which enables them to make better life decisions as well as enter a career in an environmental profession or higher education.

Unit 1 (12 lectures)

Definition, scope, importance, the need for public awareness on natural resources Forest resources– use, exploitation, causes, and consequences of deforestation. Water resources – use of surface and subsurface water; dams - effect of drought, water conflicts. Land resources – Land degradation, soil erosion, and desertification. Indian Case studies. Food resources – Definition, world food problems, Traditional and modern agriculture, and its impacts and remedies. Definition of renewable and non-renewable energy resources. Non-renewable energy resources - oil, Natural gas, Coal, Nuclear energy. Renewable energy - Solar energy, Hydroelectric power, Ocean thermal energy, wind, and geothermal energy. Biomass energy and BioGas.

Unit 2 (10 lectures)

Concept of ecosystem, Structure, and functions of an ecosystem, Food chains, food webs. Energy flow in an ecosystem, ecological pyramids, and ecological succession. Case studies: Biomagnification of DDT. Biodiversity-Bio-geographical classification of India, hotspots, values of biodiversity. Threats to biodiversity - a Case study. Conservation of biodiversity. GM Crops

Unit 3 (8 lectures)

Air, water, soil, Thermal Pollution: Causes, effects and control measures; Nuclear hazard. Solid waste Management-Causes, Effects and control measures. Floods, earthquakes, cyclones, tsunami and landslides, Case studies. Global climate change and the greenhouse effect – Kyoto Protocol, Carbon sequestration, Acid rain, Ozone depletion problem – Montreal Protocol.

Unit 4 (10 lectures)

Urban problems related to energy and sustainable development, Water conservation, Rainwater harvesting, Wasteland Reclamation. Environment Protection Act - Prevention and control of Pollution of Air and Water. Wildlife protection and Forest Conservation Acts. Population growth, variation among nations, population explosion, Family Welfare Programme, Environment, Women and Child Welfare, Human rights, HIV/AIDS, Role of information technology on the environment and human health.

Suggested Practicals

1. Calculation of Total Dissolved Solids (TDS) of water sample.
2. Calculation of BOD of water sample.
3. Calculation of COD of water sample.
4. Bacterial Examination of Water by MPN Method.

Suggested Reading

- Anubha Kaushik and C.P. Kaushik, Environmental Science and Engineering, 2016, 5thEdition, ISBN: 978-81-224-4013-3, New Age International.
- G. Tyler Miller Jr and Scott E. Spoolman, Living in the Environment, 2012. 17th Edition,ISBN-13: 978-0-538-73534-6, Brooks / Cole.
- Basic Environmental Sciences For Undergraduates by Dr. Tanu Allen, Dr. Richa K. Tyagi. Dr Sohini Singh, 2014, 1st Edition, ISBN-10: 938375827, Vayu Education of India.

Basics of Computer Application

Course Objectives:

1.Gaining foundation in the fundamentals of computers concerning computer components and their usage
2.Making students understand different web technologies and computer networks
3.Exploring the application suite of software for the betterment of presentation and management of data

Expected Course Outcome:

1.The students will have the knowledge and skills to describe the software and hardware components

2.Explain some of the web technologies and illustrate how these can be used to manage scientific data.

3.Obtain and analyse information and data relating to specific word applications for fine document preparation and report writing.

4.Data computation using spreadsheet application and presentation application for scientific findings.

5.Perform practical data management techniques, including DDL and DML and database querying.

Unit 1 (5 lectures)

History of Computers, Basic Components of Computer Systems, CPU, Memory, I/O Devices, Operating system, DOS and Unix system commands Web Technologies Introduction to Internet - URL, WWW, HTML, Internet Protocols- HTTP, TCP/IP, E-Mail & FTP,Computer networks:

Unit 2 (10 lectures)

Networks and Data Communications: LAN, MAN & WAN – Network Topologies. Basics of Network, Uses of the network, types of networks, Network topologies. Python environment, printing and manipulating text- comments to annotate your code, error message and debugging, storing strings in variables, and manipulating strings. Patterns in Biology, modules, patterns in a string, searching and extracting patterns and Positions, creating, and iterating dictionaries.

Suggested Practical (60 hrs training classes)

Word Processing: Word basics, Editing and formatting a document, layout and inserting and managing graphics, formatting tables. Spreadsheet basics, Editing worksheets, Form cells – formatting worksheets, formulas and function, data filtering and sorting, chart, and graphs. Presentation basics, Creation of Presentation, editing presentation, formatting presentation, working with multimedia. Database basics, advantages of Database, create a database, updating and manipulating data, DDL and DML command, database querying. Bash and Bash Scripts – Common Shell programs, Executing commands, Developing Good Scripts, Creating and running a script, Scripts basics, and Debugging bash scripts. Shell initialization file, Variables, Quoting characters, Shell expansion, and Aliases, variables, condition statements, and loop statements.Reading text from files, file content and file name, dealing with newlines, writing text to files, closing files.

Reference Books:

1. A. Goel, Computer Fundamentals, Pearson Education, 2010.
2. Peter Norton, 2017, Introduction to Computers, 7th Edition, Tata McGraw Hill Publications.
3. Joan Lambert, and Curtis Frye, 2017 Microsoft Office 2016 Step by Step, Microsoft Press
4. Rajaraman V, and Adabala N, 2014, Fundamentals of Computers, PHI Publication Jason 5.Cannon, 2014, Command Line
5. Kung Fu: Bash Scripting Tricks, Linux Shell Programming, First edition, Create Space Independent Publishing Platform.
6. Richard Blum & Christine Bresnahan, 2015, Linux Command Line and Shell Scripting Bible, 3ed Wiley publisher.

***The compulsory co-curricular courses will be offered as per university guidelines.**

 # Minor Elective (From other Faculty) –will be offered as per electives offered by university

Semester Three

Immunology

1. Recall the basics of immunology and facilitate the understanding of core immunology
2. Develop skills necessary for the critical analysis of contemporary literature on topics related to health and diseases.
3. Outline the molecular and cellular basis of the development and function of the immune system in states of health and disease.

Expected Course Outcome:

1. Describe the role of the immune cells in both maintaining health and contributing to disease.

2. Identifying the cellular and molecular basis of antigen processing and immune responses.
3. Distinguish and define the molecular basis of complex cellular processes involved in immune disorders.
4. Translate theoretical immunology into clinical decision-making and cancer diagnosis.
5. Effectively interpret underlying mechanisms of disease and therapeutic implications of vaccines.
6. Build a strong foundation for more advanced courses in immunology.

UNIT I (10 lectures)

Immune Response - An overview, components of mammalian immune system, molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, T- lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination.

UNIT II (10 lectures)

Regulation of immunoglobulin gene expression – clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity.

UNIT III (10 lectures)

Major Histocompatibility complexes – class I & class II MHC antigens, antigen processing. Immunity to infection – immunity to different organisms, pathogen defense strategies, avoidance of recognition. Autoimmune diseases, Immunodeficiency-AIDS.

UNIT IV (10 lectures)

Vaccines & Vaccination – adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics – RIA, ELISA.

SUGGESTED PRACTICALS

1. Differential leucocytes count
2. Total leucocytes count
3. Total RBC count
4. Haemagglutination assay
5. Haemagglutination inhibition assay
6. Separation of serum from blood
7. Double immunodiffusion test using specific antibody and antigen.
8. ELISA.

SUGGESTED READING

1. Abbas AK, Lichtman AH, Pillai S. (2007) . Cellular and Molecular Immunology. 6 th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11thedition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.

4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinburg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

General Microbiology

Course Objectives:

1. Recall necessary information related to all microorganisms in general
2. Elaborate on laboratory safety and specialized microbiological laboratory skills
3. Apply the knowledge gained towards research, diagnostic, and therapeutic purposes

Expected Course Outcome:

1. Demonstrates the structure, diversity, classification, and application of microorganisms
2. Compare the ubiquitous nature of microorganisms and their ecological niches
3. Outline the theoretical basis of the tools, technologies, and methods common to microbiology
4. Illustrate problem-solving skills and other concepts in microbiology
5. Relate the role of microbes in the fields of medicine and biotechnology

UNIT 1 (12 lectures)

Fundamentals, History and Evolution of Microbiology. Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria. Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms erg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

UNIT 2(8 lectures)

Cultivation and Maintenance of microorganisms: Nutritional categories of microorganisms, methods of isolation, Purification and preservation.

UNIT 3 (10 lectures)

Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria. Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.

UNIT 4 (10 lectures)

Control of Microorganisms: By physical, chemical and chemotherapeutic Agents Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal. Food Microbiology: Important microorganisms in food Microbiology: Molds, Yeasts, bacteria. Major foodborne infections and in oxidations, Preservation of various types of foods. Fermented Foods.

SUGGESTED PRACTICALS

1. Isolation of bacteria & their biochemical characterization.
2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources.
4. Determination of bacterial cell size by micrometry.

5. Enumeration of microorganisms - total & viable count.

SUGGESTED READING

- Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4 th edition. John and Sons, Inc.
- Jay JM, Loessner MJ and Golden Da. (2005).Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
- Pelczar MJ, Chan ECS and Krieg NR. (1993) Microbiology. 5 th Edition McGraw Hill Book Company.
- Willy JM, Sherwood LM and Woolverton CJ (2008). Prescott, Harley and Klein's Microbiology, 7th edition. McGraw Hill Higher Education.

Animal Physiology

Course Objectives

1.To familiarize students with the principles and basic facts of Animal Physiology and with some of the laboratory techniques and equipment used in the acquisition of physiological data. The course will focus on organ-system physiology; however, cellular and molecular mechanisms will be discussed in order to present a current view of physiological principles. Where appropriate, basic chemical and physical laws will be reviewed in order to enhance and to promote student understanding.

2.The laboratory component of the course is designed to reinforce the topics discussed in lecture, as well as to familiarize students with some of the laboratory techniques and equipment used in the acquisition of physiological data.

Expected Course Outcome:

The students will be able to describe, identify, and/or explain:

1.The various physiological organ-systems and their importance to the integrative functions of the human body. Study digestive system organs and their functions.

2.Structure and functions of the cardiovascular system, including the mechanical and electrical properties of cardiac muscle function. Regulation of blood pressure.

3.Organization structural and functional organization of the nervous system. The resting membrane potential, the action potential, action potential propagation along the axon. Structure and functions of the kidney nephrons, including glomerular filtration, tubular reabsorption, tubular secretion, and excretion. The renin-angiotensin-system.

4.Principles of hormone action, including structure, mechanism of release from endocrine cell, mode of transport in blood, mechanism of action in target cells, and systemic effects of important hormones. Focus on classic endocrine glands, including the hypothalamus and the pituitary glands, thyroid and parathyroid glands, adrenal glands, endocrine pancreas.

UNIT 1 (10 lectures)

Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins , Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice Respiration: Exchange of gasses, Transport of O 2 and CO2, Oxygen dissociation curve, Chloride shift

UNIT 2(6 lectures)

Composition of blood, Plasma proteins & their role, blood cells, Haemopoiesis, Mechanism of coagulation of blood. Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.

UNIT 3(12 lectures)

Muscle physiology and osmoregulation: Structure of cardiac, smooth & skeletal muscle, threshold stimulus, All or None rule, single muscle twitch, muscle tone, isotonic and isometric contraction, Physical, chemical & electrical events of mechanism of muscle contraction. Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation.

UNIT 4 (12 lectures)

Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, saltatory conduction, Neurotransmitters Mechanism of action of hormones (insulin and steroids) Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions.

SUGGESTED PRACTICALS

1. Finding the coagulation time of blood
2. Determination of blood groups
3. Counting of mammalian RBCs
4. Determination of TLC and DLC
5. Demonstration of action of an enzyme
6. Determination of Hemoglobin

SUGGESTED READING

1.Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.

2.Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition. John Wiley & Sons,Inc.

Bioinformatics

Course Objectives:

1. Learn the basic practical techniques of bioinformatics.
2. Extend the knowledge of bioinformatics and biological databases to solving real research problems.
3. Formulate the use of a wide variety of tools, servers, biological databases and apply them in appropriate fields.

Expected Course Outcome:

1. Choose knowledge of the basic principles of biology, computer science, and mathematics
2. Evaluate biological databases using bioinformatics algorithms
3. Build existing software effectively to extract information from large databases and apply the information in computer modeling
4. Assess problem-solving skills, including the ability to develop new algorithms and analysis methods
5. Perceive knowledge about analyzing big datasets statistically and bioinformatically
6. Improve skills in a professional environment via an industrial or academic internship in bioinformatics

UNIT I

History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web. (5 Periods)

UNIT II

Protein Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure of each source and using it on the web. Introduction of Data Generating Techniques and Bioinformatics problem posed by them- Restriction Digestion, Chromatograms, Blots, PCR, Microarrays, Mass Spectrometry. (10 Periods)

Practicals (60hrs training)

Sequence and Phylogeny analysis, Detecting Open Reading Frames, Outline of sequence Assembly, Mutation/Substitution Matrices, Pairwise Alignments, Introduction to BLAST, using it on the web, Interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis. Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission.Genome Annotation: Pattern and repeat finding, Gene identification tools.

Sequence information resource, Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR),. Understanding and using: PDB, Swissprot, TREMBL,. Using various BLAST and interpretation of results. Retrieval of information from nucleotide databases. Sequence alignment using BLAST, Multiple sequence alignment using Clustal W.

SUGGESTED READING

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.

2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.

3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

***The compulsory co-curricular courses will be offered as per university guidelines.**

Semester Four

Recombinant DNA Technology

Course Objectives:

1. Recall different DNA modifying enzymes used in recombinant DNA technology
2. Compare different vectors and their applications in recombinant DNA technology
3. .Illustrate different techniques used in genetic engineering

Expected Course Outcome:

1. Choose from different DNA modifying enzymes to modify given DNA as per requirement
2. Design different vectors for cloning and expression of genes in various expression systems
3. Apply appropriate techniques to research in various fields of biotechnology
4. Evaluate different strategies for cloning of gene from various cDNA libraries
5. List the risks associated with genetic engineering experiments.
6. Modify genes for higher yield of biotechnology-derived products

Unit 1 (10 lectures)

Molecular tools and applications -restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, Electroporation, Ultrasonication, Principle and a applications of Polymerase chain reaction (PCR), primer-design, and RT- (Reverse transcription) PCR.

Unit 2 (12 lectures)

Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription, Genome mapping, DNA fingerprinting, Applications of Genetic Engineering Genetic engineering in animals: Production and

applications of transgenic mice, role of ES cells in gene targeting in mice, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each)

Unit 3 (8 lectures)

Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two).

Unit 4 (10 lectures)

Genetic engineering in plants: Use of *Agrobacterium tumefaciens* and *Arhizogenes*, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.

Suggested Practicals

1. Isolation of chromosomal DNA from plant cells.
2. Isolation of chromosomal DNA from E. coli
3. Qualitative and quantitative analysis of DNA using spectrophotometer
4. Plasmid DNA isolation
5. Restriction digestion of DNA
6. Making competent cells
7. Transformation of competent cells.
8. Demonstration of PCR

Suggested Readings

1. Old RW and Primrose SB (2014) Principles of gene manipulation, 7th edn Wiley Blackwell Scientific Publications.
2. Jogdand SN (2016) GENE biotechnology 4th Edition Himalaya publishing group.
3. Somnath De (2016) Basic Concept of Recombinant DNA Technology Createspace Independent Publications India
4. Sambrook and Russel. Molecular cloning Vol. 1-3, CSH Press (from 2001 till date updated protocols)

Bioinstrumentation and Analytical Techniques

Course Objectives:

1. Demonstrate the principle and applications of various techniques in biotechnology
2. Analyze various samples using appropriate techniques
3. Utilize analytical instruments for biomolecular estimation

Expected Course Outcome:

1. List the various Good Laboratory Practices (GLPS)
2. Recall concepts related to solution preparation
3. Outline the principles of various analytical instruments
4. Summarize the role of instrumentation
5. Infer the applications of various analytical instruments
6. Demonstrate advanced analytical instruments to carry out an estimation of various biomolecules

UNIT 1(10 lectures)

Microscopy, Resolving powers of different microscopes, different fixation and staining techniques, Simple microscopy, phase contrast microscopy, fluorescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy.

UNIT II (10 lectures)

Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infra- red), centrifugation, cell fractionation techniques, isolation of subcellular organelles and particles. Incorporation of radioisotopes in biological samples, Detection and measurement of different types of radioisotopes, safety guidelines.

UNIT III (10 lectures)

Introduction to the principle of chromatography. Paper chromatography, thin layer chromatography, column chromatography silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

UNIT IV (10 lectures)

Introduction to electrophoresis. Starch-gel, polyacrylamide gel (native and SDS-PAGE), agarose-gel electrophoresis, pulse field gel electrophoresis, immuno- electrophoresis, isoelectric focusing, Western blotting. Introduction to Biosensors and Nanotechnology and their applications.

SUGGESTED PRACTICAL

1. Native gel electrophoresis of proteins
2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
3. Preparation of the subcellular fractions of rat liver cells.
4. Preparation of protoplasts from leaves.
5. Separation of amino acids by paper chromatography.
6. To identify lipids in a given sample by TLC.
7. To verify the validity of Beer's law and determine the molar extinction coefficient of NADH.

SUGGESTED READING

- Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley& Sons. Inc.
- De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
- Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
- Becker, W.M., Kleinsmith, L.J., Hardin, J. and Bertoni, G.P. 2009 The World of the Cell.7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, and F. J. Holler, S.R. Crouch,9th Edition, Thomson Asia (P) Ltd., Singapore, 2014.

Plant Physiology

Course Objectives:

1. Recall the concepts central to the study of plant science
2. Apply a comprehensive exposure to the subject of plant physiology
3. Summarize cutting edge technologies employed in contemporary plant biology

Expected Course Outcome:

1. Demonstrate the basics of plant biology and the organization of plants
2. Relate physiological mechanisms of plant growth, function, and development
3. Translate the fundamental concepts of plant physiology

4. Outline the plant metabolism
5. Illustrate mineral nutrition in plants
6. Extend a broad overview of the geographical distribution of plants

UNIT 1 (10 lectures)

The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf) Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing, Photorespiration.

UNIT 2 (10 lectures)

Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport Structure, function and mechanism of action of phytochromes, cryptochromes and phototropins.

UNIT 3 (10 lectures)

Photosynthesis pigments, concept of two photo systems, photophosphorylation, calvin cycle, CAM plants, photorespiration, compensation point, Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

UNIT 4 (10 lectures)

Growth and development: Definitions, phases of Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberellins, cytokinins, abscisic acid, ethylene), Physiological role and mode of action, seed dormancy and seed germination, concept of photo-periodism and vernalization

SUGGESTED PRACTICALS

1. Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf.
2. Demonstration of plasmolysis by *Tradescantia* leaf peel.
3. Demonstration of opening & closing of stomata
4. Demonstration of guttation on leaf tips of grass and garden nasturtium.
5. Separation of photosynthetic pigments by paper chromatography.
6. Demonstration of aerobic respiration.
7. Preparation of root nodules from a leguminous plant.

SUGGESTED READING

- Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
- Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
- Fahn, A. 1974 Plant Anatomy. Pergamon Press, USA and UK.
- Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
- Mauseth, J.D. 1988 Plant Anatomy. The Benjamin/Cummings Publisher, USA.
- Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4 th edition, W.H. Freeman and Company, New York, USA.
- Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd.
- Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4th edition, Sinauer Associates Inc .MA, USA

Innovation and Entrepreneurship

Course Objectives

1. To introduce entrepreneurship opportunities in biotechnology

2. To learn concepts of entrepreneurs, business development strategies, market
3. To understand role of government schemes in development of Bio-entrepreneurship
4. To discuss emerging biotechnology based industries related to drug development, transgenics, environmental biotechnology
5. To understand ethics and IPR in biotech industries

Expected Course Outcome:

On completion of this course, the students will be able to:

1. Understand the importance of Bio-entrepreneurship and its scope
2. Understand the important aspects of establishing bio-industries
3. learn fundamental aspects of Intellectual property Rights to students who are going to play a major role in development and management of innovative projects in industries
4. Pave the way for the students to catch up Bio-entrepreneurship as an career option

Unit 1:

What is innovation and entrepreneurship? Where does innovation come from? How to drive innovation, Can entrepreneurship be taught? Toolset and skillset, Entrepreneurial mindset. The importance of failure: Putting failure to work, Pivoting, The failure value cycle;Analyzing markets: What's a startup? Common mistakes, Market segmentation, TAM SAM SOM, Beachhead market; Engage with customers: Minimum viable product,

Unit 2:

Ideate: Business Bootcamp, Business Insights from Data, Collaboration & Communication, Design Thinking & Customer Discovery, Future & Emerging Tech; Plan: Disruptive Business Models, Collaboration & Communication, Entrepreneurial Sales & Marketing,, Financial Literacy for Entrepreneurs; Launch: Collaboration & Communication, Influence & Change Management, Digital Marketing, Technology for Entrepreneurs, Entrepreneurial Finance,Business development in biotechnology - Factors affecting biotech business: (finance,infrastructure, equipment, manpower , resources , project location, end product, quality issues, etc) Basic principles and practices of management - Definition, concepts and application

Practicals (60 hrs training)

Case studies: Closed vs. open innovation: Closed innovation system, Case Xerox, Open innovation, Case transistor and iPod, IP and source of innovation; The changing landscape: The need for open innovation, The triple helix framework, The business model and open innovation frameworks; Open innovation at work: Breaking down the fortress, the story of IBM, Open innovation culture, Open innovation companies,Organization types, coordination, control and decision making in management.et replicate and innovate the processes of creating and starting a company established by applying qualitative research methodology (SWOT, participant observation, ethnography, etc.). Labs of Innovation and Entrepreneurship, Engage with customers

REFERENCES

1.Biotechnology Entrepreneurship 1st Edition.Starting, Managing, and Leading Biotech Companies.CraigShimasaki. Academic Press.2014.
2.Introduction to Biotech Entrepreneurship: From Idea to Business.A
European Perspective. Matei, Florentina, Zirra, Daniela (Eds.).Springer nature publication.2019
3.Biotechnology Entrepreneurship from Science to Solutions -- Start-Up, Company Formation and Organization, Team, Intellectual Property, Financing, Part 1st Edition. Michael L. Salgaller. Logos Press.2010
4.How to Start a Biotech Company. Sourish Saha et.al., Independently published. 2019
5.Baron, R. A., & Shane, S. A. (2008). Entrepreneurship: A process perspective (1st ed.). Toronto, ON: Nelson. ISBN-13: 97801761033472. Osterwalder, A., & Pigneur, Y. (2010). Business model generation: A handbook for visionaries, game changers, and challengers. Hoboken, NJ: Wiley. ISBN-13: 9780470876411
6. Wise, S. E. (2011). Hot or not: How to know if your business idea will fly or fail? Toronto, ON: Ryerson Entrepreneur Institute. ISBN-13: 9781468024494
7..Kawasaki, G. (2015). The art of the start 2.0: The time-tested, battle-hardened guide for anyone starting anything. New York, NY: Penguin. ISBN-13: 9781591847847

***The compulsory co-curricular courses will be offered as per university guidelines.**

 # Minor Elective (From other Faculty) –will be offered as per electives offered by university

Semester Five

Animal Biotechnology

Course Objectives:

1. Explain the methods of gene manipulations in animal cells and embryonic stem cells
2. Develop breeding and conservation approaches in animals
3. Appraise the legal and ethical issues related to animal maintenance.

Expected Course Outcome:

1. Extend the best practices followed during maintenance of cell lines
2. Apply different techniques to manipulate the genome of animal cells.
3. Formulate ideas for the production of genetically modified organisms.
4. Organize different approaches in reproduction technology
5. Utilize the concept of molecular techniques involved in animal conservation

Unit 1 (10 lectures)

Introduction to Animal Biotechnology- Concept and Scope of Biotechnology, Cloning vectors-I - Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC, Cloning vectors-II, Expression vectors, Restriction enzymes I, Restriction enzymes types and detailed study of Type II, Gene cloning, Gene transfer techniques, Construction of genomic and cDNA libraries screening of DNA Libraries

Unit2 (10 lectures)

Blotting techniques I (Southern and Northern), Blotting techniques II- Western blotting, DNA sequencing, Polymerase Chain Reaction, DNA Fingerprinting, DNA Microarray principle and technique. Genetically modified organisms-I (Nuclear Transplantation), Genetically modified organisms-II (Retroviral Method), Genetically modified organisms-III (DNA microinjection)

Unit 3 (10 lectures)

Transgenic Animals, Applications of transgenic animals I- Production of Pharmaceuticals, Applications of transgenic animals: production of donor organs, Applications of transgenic animals: knockout mice, Production of transgenic plants- Agrobacterium mediated transformation, Applications of transgenic plants: Insect and herbicide resistant plants, Animal cell culture, Expressing cloned genes in mammalian cells, Diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia)

Unit 4 (10 lectures)

Recombinant DNA in medicine I- Recombinant insulin & Human growth hormone, Gene Therapy, Animal propagation— Artificial insemination, Conservation Biology I- In vitro fertilization and embryo transfer in humans, In vitro fertilization and embryo transfer in farm animals, Animal diseases need help of Biotechnology- Foot-and-mouth disease

Suggested Practicals

1. Sterilization techniques: Theory and Practical: Glassware sterilization, Media sterilization, Laboratory sterilization
2. Sources of contamination and decontamination measures.
3. Preparation of Hanks Balanced salt solution
4. Preparation of Minimal Essential Growth medium
5. Isolation of lymphocytes for culturing
6. DNA isolation from animal tissue
7. Quantification of isolated DNA.
8. Resolving DNA on Agarose Gel.
9. Plasmid DNA isolation

10. Restriction digestion

Suggested Reading

1 Primrose S B and R M Twyman. Principles of Gene manipulation and Genomics. 7th Ed.2006 Blackwell Publishing 667p

2 Sandy B Primrose, Richard Twyman, Bob Old. Principles of Gene Manipulation: An Introduction to Genetic Engineering. 6th Ed.2001 Wiley Blackwell Publishing 667p

3 T A Brown. Gene Cloning and DNA Analysis: An Introduction. 8th Ed.2020.Wiley- Blackwell publishing 395p.

4 Monika Jain. Recombinant DNA Techniques: A Textbook.2012. Alpha Science International Ltd; 1st edition,288pp.

5 James D Watson, Michael Gilman, Jan Witkowski and Mark Zoller. Recombinant DNA .2nd ed. Scientific American Books, New York 1992. 626pp.

6 Julia Lodge, Peter Lund, Steve Minchin. Gene Cloning 7.1st Edition. Taylor & Francis 474pp.

7 Richard J Reece. Analysis of Genes and Genomes, 2004. John Wiley & Sons Inc, 490pp.

8 M M Ranga Animal Biotechnology 3rd Ed.2007. Agrobios India, 210pp.

9 A K Srivastava Animal Biotechnology.2018. Oxford & IBH Publishing Co Pvt.Ltd,458pp.

10 B Singh , S K. Gautam .Textbook of Animal Biotechnology.2013.Oxford & IBH Publishing Co Pvt.Ltd,620pp.

11 John Masters. Animal Cell Culture:2000. A Practical Approach. OUP Oxford,334pp.

12 T Satyanarayana, Bhavdish Narain Johri, Anil Prakash. 2012.Microorganisms in Sustainable Agriculture and Biotechnology. Springer publishing, 850 pp.

13 Jogdand, S N. Gene Biotechnology,2019. Himalaya Publishing House.4thEd.447pp. 15.Joshi, P. Genetic Engineering and Its Applications. 2006.Agrobios India.328pp.

Genomics, Proteomics

Course Objectives:

Gaining a better understanding of the interactions between genes and the environment by means of genomics is helping researchers find better ways to improve health and prevent disease, Proteomics research permits the discovery of new protein markers for diagnostic purposes and the study of novel molecular targets for drug discovery. The protein markers identified have a broad range of potential applications. They may be used for clinical diagnostic or prognostic purposes.

Expected Course Outcome:

Students will be able to understand the DNA sequencing methods.

Students will be able to employ knowledge of computers in filing, retrieving and interpreting biological data.

Students will be able to identify interactions between different proteins and the spectroscopic determination of their sequence.

UNIT I (10 lectures)

Introduction to Genomics, DNA sequencing methods – manual & automated: Maxam & Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods, Computer tools for sequencing projects: Genome sequence assembly software.

UNIT II (8 lectures)

Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organisms' Genomes and Databases.

UNIT III (12 lectures)

Introduction to protein structure, Chemical properties of proteins. Physical interactions that determine the property of proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bonds, Hydrophobic interactions. Determination of sizes (Sedimentation analysis, gel filtration, SDS-PAGE); Native PAGE, Determination of covalent structures – Adman degradation.

UNIT IV (10 lectures)

Introduction to Proteomics, Analysis of proteomes. 2D-PAGE. Sample preparation, solubilization, reduction, resolution. Reproducibility of 2D-PAGE. Mass spectrometry based methods for protein identification. *De novo* sequencing using mass spectrometric data.

SUGGESTED PRACTICALS

1. Use of SNP databases at NCBI and other sites
2. Use of OMIM database
3. Detection of Open Reading Frames using ORF Finder
4. Proteomics 2D PAGE database
5. Softwares for Protein localization.
6. Hydropathy plots
7. Native PAGE
8. SDS-PAGE

Suggested Readings

1. Genetics – Principle and Analysis – Hart and Jones.
2. Genetics – Peter J. Russell.
3. Principles of Genetics – Snustad and Simmons.
4. Genetics – A Continuity of Life– Daniel J. Fairbanks, W. Ralph Anderson
5. Concepts of Genetics– Klug and Cummings.
6. Modern Genetic Analysis – Griffith Genetics –
7. A Continuity of Life – Daniel Fairbanks, Ralph Anderson.
8. Concepts of Genetics – Klug and Cummings.
9. Principles of Genetics – Hartt and Jones, Genetics Fairbanks, Ralph. Anderson.

Biostatistics

Course Objectives:

To provide training to students because there are more and more career fields that need workers who are statistically literate, especially in our growing data-driven economies, such as medicine and healthcare, data science, communications and public relations, government and public policy, journalism, marketing, business, and finance.

Expected Course Outcome:

Student will develop a sound understanding of data representation and interpretation

Students will be able to collect samples and determine their significance in relation to standards.

UNIT I (10 lectures)

Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis.

UNIT II (10 lectures)

Probability classical & axiomatic definition of probability, Theorems on total and compound probability), Elementary ideas of Binomial, Poisson and Normal distributions.

UNIT III (10 lectures)

Methods of sampling, confidence level, critical region, testing of hypothesis and standard error, large sample test

and small sample test. Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA).

UNIT IV (10 lectures)

Correlation and Regression. Emphasis on examples from Biological Sciences.

SUGGESTED PRACTICALS

1. Based on graphical Representation
2. Based on measures of Central Tendency & Dispersion
3. Based on Distributions Binomial Poisson Normal
4. Based on t, f, z and Chi-square

Suggested Reading

1. Motulsky, H. (2014). Intuitive biostatistics: a nonmathematical guide to statistical thinking. Oxford University Press, USA.

2. Van Belle, G., Fisher, L.D., Heagerty, P.J., & Lumley, T. (2004). Biostatistics: a methodology for the health sciences(Vol. 519). John Wiley & Sons.

3. Le, C.T., & Eberly, L.E. (2016). Introductory biostatistics. John Wiley & Sons.

Basics of Virology and Oncology

Course Objectives:

The course introduces the basics of viral taxonomy, and their importance. The course introduces the molecular biology of cancer (oncogenes and tumor suppressor genes) as well as the biologic hallmarks of cancer. The course also describes the risk factors for the major cancers worldwide.

Expected Course Outcome:

1. Identify the major types of cancer worldwide.
2. Describe how genes contribute to the risk and growth of cancer.
3. List and describe the ten cellular hallmarks of cancer.
4. Define metastasis, and identify the major steps in the metastatic process.
5. Describe the role of imaging in the screening, diagnosis, staging, and treatments of cancer
6. Explain how cancer is treated
7. Understand vector-virus and host-virus relationship.

Unit 1 (8 lectures)

History and principles of virology, virus taxonomy, introduction to replication strategies. Virus structure and morphology. Viruses of veterinary importance and zoonotic viruses. Principles of biosafety, containment facilities, maintenance and handling of laboratory animals and requirements of virological laboratory. Plant viruses, plant virus propagation. Bacteriophages, bacteriophage propagation and viroids. Oncolytic viruses.

Unit 2 (10 lectures)

Vector virus relationship interactions: Virus dissemination & mechanism of virus transmission in vectors, natural cycle, maintenance of viruses in nature, basis of vector competence, mechanical transmission, virus

dissemination, susceptibility- intrinsic and extrinsic factors. Xenodiagnosis- methods and application. In vivo, in vitro and in vivo systems for virus growth, estimation of yields, methods for purification of viruses with special emphasis on ultracentrifugation methods. Host cell 'shut off', apoptosis, necrosis, stress response, alteration of signaling pathways, cellular basis of transformation, types of cenotaph effects, ultrastructural cytopathology. Cellular injury associated markers, mechanism of viral persistence and latency—in vivo and in vitro models (JE, measles, LCM and HIV)

Unit 3 (12 lectures)

What is Cancer? Understanding Cancer, Risk Factors of Cancers? Sign & Symptoms of common Cancers, Contributing Factors of Cancer, Characteristics of cancer and cancer cells, , Genetics of Cancer, Basic Introduction to Genetics Genetic Variation and Mutation Two-Hit Hypothesis and Genomic Instability, Ten Cellular Hallmarks of Cancer, The Human Cell and Hallmarks of Cancer Preparing the Cancer Cell to Move and Metastasize, Metastasis Overview Introduction to Metastasis, Imaging in Oncology, Imaging Overview, Introduction to Imaging , Types of Imaging, Imaging in Clinical Oncology, Theory of Oligometastases and How Treatment is Supported by Imaging, Treatment Overview, Types of Treatment, Types of Treatments for Individual Cancers, Chemotherapy, Radiation, Surgery, Hormonal Therapy, Targeted Therapy & Immunotherapy

UNIT 4 (10 lectures)

Incidence and Etiology of Cancer, Cancer Incidence, The Common Cancers Introduction, Gender Based Cancers :Introduction- Male & Female, Gender Based Cancers Breast Cancer + Case Study, Gender Based Cancers Cervical, Endometrial, Ovarian Cancers + Case Study, Other Common Cancers, Childhood Cancers, Liver Cancer Overview, Incidence, Risk Factors, Screening, Staging For Liver Cancer, Treatment of Liver Cancer, TNM Staging, The Metastatic Process, An Ecological Paradigm: Why Do Cancer Cells Metastasize from the Primary Tumor?, Principles of Cancer Screening & Awareness, Government Cancer Screening Guidelinesin India, Screening Process in Community Setting.

Suggested Practicals

Isolation of Structural Proteins of the Virus.

Size Fractionation of Viral Structural Proteins.

Characterizing viral genomes.

Sequence Analysis of Viral Genomes.

Measuring the Size of Viral Genomes.

The Polymerase Chain Reaction – Detection and Characterization of Extremely Small Quantities of Viral Genomes or Transcripts.

Use of Immune Reagents for Study of Viral Proteins.

Suggested Reading

1. Fields Virology Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick, T.P. Monath, B. Roizman, and S.E. Straus, eds.), 3rd Edition. Lippincott-Raven, Philadelphia, PA.

2. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S.J. Flint, V.R. Racaniello, L.W. Enquist, V.R. Rancaniello, A.M. Skalka. Latest edition / Pub. Date: December 2003 Publisher: American Society Microbiology--- Chapters 3-13.

3. Laboratory Animal Medicine: Principles and Procedures. Margi Sirois. Latest edition / Pub. Date: November 2004. Publisher: Elsevier Health Sciences.

4. Guides for the Care and Use of Laboratory Animals. National Research Council. Latest edition / Pub. Date:

January 1996. Publisher: National Academy Press. 5.Laboratory Biosafety Manual,WHO, http://www.who.int/csr/resources/publications/biosafety/who_cds_csr_l yo_20034/en/ 6.Virology: 1994. 3rd ed. Fraenkel Conrat et al, Prentice Hall.
7. Introduction to Modern Virology. 2001. 5th ed. Dim mock et al., Blackwell Scientific Publ.
8. Basic Virology, 1999. By Wagner and M. Hewlett, Blackwell Science Publ.
9. Virology Methods Manual. Brian W.J. Mahy (Editor), Hillar O. Kangro (Editor). Latest edition/Pub. Date: January 1996. Publisher: Elsevier Science & Technology Books.
10. Methods and Techniques in Virology. Pierre Payment, Trudel (Editor). Latest edition / Pub. Date: July 1993. Publisher: Marcel Dekker.Diagnostic Virology Protocols: Methods in Molecular Medicine. John R. Stephenson (Editor), Alan Warnes Latest edition / Pub. Date: August 1998. Publisher: Humana Press.
11. Diagnostic Procedures for Viral, Rickettsial, and Chlamydial Infections. Edwin H. Lennette (Editor), David A. Lennette, Evelyne T. (Eds.) Lennette, Evelyne T. Lennette (Editor). Latest edition / Pub. Date: January 1995. Publisher: American Public Health Association Publications
12. Basic Virology, 3rd Edition, Edward K. Wagner, Martinez J. Hewlett, David C.Bloom, David Camerini,ISBN: 978-1-405-14715-6 October 2007 Wiley-Blackwell

***The compulsory co-curricular courses will be offered as per university guidelines.**

Semester Six

Industrial and Environmental Biotechnology

Course Objectives:

1. Recall knowledge on medium formulation and strain improvement for enhanced production of bioproducts.
2. Develop fundamental knowledge to explore microbes for the production of industrially relevant primary and secondary metabolites
3. Extend knowledge on the industrial method of fermentation processes for the production of bioproducts.
4. It also develops an attitude of concern for the environment and acquiring skills to help the concerned individuals in identifying and solving environmental problems.

Expected Course Outcome:

1. Outline process-flow sheeting for the industrial fermentation processes
2. Demonstrate the methods of cell culture under various conditions, formulate and optimize media and apply strain improvement to enhance the production
3. Apply the knowledge of kinetics for microbial growth and product formation
4. Choose from the production processes for primary and secondary metabolite
5. Explain the production of commercially critical recombinant proteins
6. Understand the importance of environmental issues and problems at local, national and international levels.

Unit 1 (8 lectures)

A historical overview of industrial fermentation processes and products. Outline of the various unit operations involved in integrated bioprocesses. Isolation, preservation, and improvement of industrial microorganisms for overproduction of primary and secondary metabolites: medium requirements for fermentation process-carbon, nitrogen, minerals, vitamins, and other nutrients-examples of complex media.

Unit 2 (11 lectures)

Production of primary metabolites :Commercially essential organic acids (e.g. Citric acid, acetic acid). Amino acids (erg. glutamic acid, lysine, aspartic acid,). Alcohols (ethanol, 2, 3,butanediol);Production of Bacterial pigments – prodigiosin – violacein ,fungal monascin - bacterial and algal carotenoids – astaxanthin ; Production of commercially important enzymes (eg. Proteases, lipases, cellulases and other commercially essential enzymes for the food and pharmaceutical industries). Production of recombinant proteins having therapeutic and diagnostic applications

Unit 3 (9 lectures)

Conventional fuels and their environmental impact – Firewood, Plant, Animal, Water, Coal and Gas. Modern fuels and their environmental impact – Methanogenic bacteria, Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol, Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents.

Degradation of lignin and cellulose using microbes. Phyto-remediation. Degradation of pesticides and other toxic chemicals by microorganisms- degradation of aromatic and chlorinated hydrocarbons and petroleum products.

UNIT 4 (10 lectures)

Treatment of municipal waste and Industrial effluents. Bio-fertilizers Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Algal and fungal biofertilizers (VAM) Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium). Environmental significance of genetically modified microbes, plants and animals.

SUGGESTED PRACTICALS

1. Electrical Conductivity of Wastewater
2. Alkalinity of Wastewater
3. Chloride Content in Water Samples
4. Sulfate Content in Water Samples (Turbidimetric Method)
5. Calculation of Total Dissolved Solids (TDS) of water sample.
6. Calculation of BOD of water sample.
7. Calculation of COD of water sample.
8. Moisture Content in Soil
9. pH of the Soil
10. Bacterial Examination of Water by MPN Method.
11. Organic Matter and Organic Carbon Content in Soil Samples

Suggested Readings

1. Peter F Stanbury, Allan Whitaker, Stephen J Hall, "Principles of Fermentation Technology" Butterworth Heinemann, Third Edition,2016.
2. Wulf Crueger, AnnelieseCrueger, K.R.Aneja, "Biotechnology -A textbook of Industrial Biotechnology" Medtech,2017.
3. Colin Ratledge, Bjorn Kristiansen, "Basic Biotechnology" Cambridge University Press, Third Edition, 2006
4. Thangadurai D and Sangeetha J (2017) Industrial Biotechnology: Sustainable production and Bioresource Utilization. CRC press

IPR, Biosafety, Bioethics and Entrepreneurship

Course Objectives:

This course is designed to impart knowledge and skills necessary to train the students to be on par with the routine of Industrial activities in drug regulatory affairs. This course is designed to impart knowledge and skills necessary to

train the students on entrepreneurship management.

Expected Course Outcome:

On completion of this course it is expected that students will be able to understand,

1. Assist in the Regulatory Audit process.
2. Establish regulatory guidelines for drug and drug products
3. The Regulatory requirements for contract research organization
4. The Role of enterprise in national and global economy
5. Dynamics of motivation and concepts of entrepreneurship
6. Demands and challenges of Growth Strategies And Networking

UNIT 1 (10 lectures)

Introduction to Indian Patent Law. World Trade Organization and its related intellectual property provisions. Intellectual/Industrial property and its legal protection in research, design and development. Patenting in Biotechnology, economic, ethical and depository considerations. Patent costs and values; and the post-grant processes for enforcing, Safeguarding IPR.

UNIT 2 (10 lectures)

Entrepreneurship: Selection of a product, line, design and development processes, economics on material and energy requirement, stock the product and release the same for making etc. The basic regulations of excise: Demand for a given product, feasibility of its production under given constraints of raw material, energy input, financial situations, export potential etc.

UNIT 3 (10 lectures)

Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International. Ethical issues against molecular technologies.

UNIT 4 (10 lectures)

Biosafety– Introduction to biosafety and health hazards concerning biotechnology. Introduction to the concept of containment level and Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).

PRACTICALS

1. Proxy filing of Indian Product patent
2. Proxy filing of Indian Process patent
3. Planning of establishing a hypothetical biotechnology industry in India
4. A case study on clinical trials of drugs in India with emphasis on ethical issues.
5. Case study on women health ethics.
6. Case study on medical errors and negligence.
7. Case study on handling and disposal of radioactive waste

Suggested Readings

1. Hirsch RD & Peters MP, "Entrepreneurship," Tata McGraw Hill Publishers, New Delhi, 2002.
2. Holt DH, "Entrepreneurship – New Venture Creation," Prentice Hall of India, 1999.

Stem cell and Tissue Engineering

Course Objectives:

1. Recall the fundamental concepts of stem cells
2. Dissect mechanistic details about stem cells and regeneration (horizontal and vertical integration)
3. Extend these concepts in the industrial and academic sectors

Expected Course Outcome:

1. Relate the fundamental aspects of stem cell technology
2. Illustrate the principles and methodologies about the mechanistic aspects
3. Determine the commonalities and distinguish between embryonic and adult stem cells
4. Apply the knowledge gained in regenerative aspects and therapeutic potential
5. Formulate solutions in a socially and ethically responsible manner concerning the use of stem cells and state-of-the-art technologies

Unit 1 (8 lectures)

Embryonic stem cells, Blastula, Inner cell mass, Totipotent, pluripotent, multipotent and Induced pluripotent stem cells characterization, potency, self-renewal, cell division, and differentiation

Unit2 (10 lectures)

Signal transduction pathways and signaling molecules involved cellular proliferation, differentiation, and dedifferentiation. Relationship between cellular proliferation and differentiation concerning stem cells, how embryonic stem cells are obtained, in vitro multiplication: embryonic stem cells gene manipulation and nuclear transfer technology.

Unit 3 (12 lectures)

Methods to obtain stem cells from adults (Amniotic fluid, cord blood cells, Mesenchymal stem cells, etc). Induced pluripotent technology (IPS), genes, and their mode of action in inducing stemness in adult cells. Advantages and disadvantages of IPS technology Heart regeneration, angiogenesis, kidney regeneration, a neurodegenerative disorder, spinal cord injury,tissue engineering

Unit 4 (10 lectures)

Overview of embryonic and adult stem cells for therapy in Neurodegenerative diseases; Parkinson's, Alzheimer's, Spinal Cord Injuries and other brain Syndromes; Tissue system Failures; Diabetes; Cardiomyopathy; Kidney failure; Liver failure; Cancer; Hemophilia, etc. Human stem cell research: Ethical consideration; Stem cell religion consideration; Stem cell- based theories: Preclinical regulatory consideration, and Patient advocacy.

Suggested Readings

1. Cherian E (2011) Stem cells JP brothers medical publishers
2. Atala A (2012) Progenitor and Stem Cell Technologies and Therapies Woodhead publishing
3. Phinney DG (2011) Adult stem cells: Biology and methods of analysis Humana press

Drug Discovery and Targeting

Course Objectives:

The subject imparts basic knowledge of the drug discovery process. This information will make the student competent in the drug discovery process. This course is designed to impart knowledge on the area of advances in novel drug delivery systems.

Expected Course Outcome:

Upon completion of the course, the student shall be able to,

1. Explain the various stages of drug discovery
2. Appreciate the importance of the role of genomics, proteomics and bioinformatics in drug discovery
3. Explain various targets for drug discovery
4. Explain various lead seeking method and lead optimization
5. Appreciate the importance of the role of computer aided drug design in drug discovery
6. The various approaches for development of novel drug delivery systems
7. The criteria for selection of drugs and polymers for the development of delivering system
8. The formulation and evaluation of Novel drug delivery systems.

Unit 1(10 lectures)

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. Modeling drug/ receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modeling; 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.

Unit 2 (10 lectures)

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).

Unit 3 (10 lectures)

Targeted Drug Delivery Systems: Concept, Event and Biological process involved in drug targeting, Tumor targeting specific delivery, Brain targeting Specific Delivery, Targeting Methods: Nanoparticle: production, Preparation, Evaluation, Liposomes: Introduction, Preparation, Evaluation, Microcapsules / Microspheres, Microsphere: Introduction, Types, preparation, Evaluation, Monoclonal Antibodies: Introduction, preparation, Application, Niosomes: Introduction, preparation. Application, Aquasomes: Introduction, preparation, Application

Unit 4 (10 lectures)

Phytosome: Introduction, preparation. Application, Electrosomes: Introduction, preparation. Application, Pulmonary Drug Delivery System, Aerosol, Propellants, Containers Type, Preparation and evaluation of Aerosol, Intra Nasal Route Delivery systems: Types, Preparation and Evaluation, Nucleic acid based therapeutic delivery system: Gene Therapy, Introduction (Ex-vivo & in-vivo gene therapy). Potential target diseases for gene therapy (inherited disorder and cancer). Gene Expression System (viral & non-viral gene transfer), Liposomal gene delivery system, Biodistribution. Pharmacological, Knowledge therapeutics of Antisense molecules aptamers as drug of future.

Recommended Textbooks and References:

1.Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press.

2.Kuhse, H. (2010). Bioethics: Anthology. Malden, MA: Blackwell.

3.Nally, J.D.(2006) GMP for Pharmaceuticals.6th edition. CRC Press

4.Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press.

5.Y. W. Chien, Novel Drug Delivery Systems, 2nd edition, revised and expanded, Marcel Dekker, Inc., New York, 1992.

6.Robinson, J. R., Lee V. H. L, Controlled Drug Delivery Systems, Marcel Dekker, Inc., New York, 1992.

7.Encyclopedia of controlled delivery, Editor- Edith Mathiowitz, Published by Wiley Interscience Publication, John Wiley and Sons, Inc., New York! Chichester Weinheim.

8.N.K. Jain, Controlled and Novel Drug Delivery, CBS Publishers & Distributors, New Delhi, First edition 1997 (reprint in 2001).

9.S.P. Vyas and R.K. Khar, Controlled Drug Delivery - concepts and advances, Vallabh Prakashan, New Delhi, First edition 2002.

***The compulsory co-curricular courses will be offered as per university guidelines.**

Semester Seven

Molecular Cell Biology

Course Objectives and Outcomes:

The course aims to an extensive coverage of molecular cell biology and shall enable the student to comprehend problems and latest research in the area. Layering a problem-oriented approach to learning will lead to independent learning of advanced cell biology concepts.

Unit I

Membrane lipids: Physical properties of lipids and their interaction with water to form membranes. Concept of fluidity and factors causing variations in fluidity. Micelles and lipid bilayers. Lipids rafts. Membrane asymmetry Modification of lipids fluidity by membrane proteins. Arrangement of proteins within lipids bilayers. Hydropathy plots and prediction of membrane spanning domains. Membrane transport: Channels, transporters and pumps. Active and passive transport. P-and F-type pumps and ABC transporters. Ion channels and electrical properties of membranes. Voltage and ligand gated channels.

Unit II

Cytoskeleton: Actin microfilaments, microtubules and intermediate fiber assemblies. Actin and tubulin dynamics and roles of modifying accessory proteins. Roles of microfilaments and microtubules in cellular structure and function. Control of assembly through signaling processes.

Unit III

Cell Signaling: General principles of signaling switches. Receptor characteristics. Identification and characteristics of receptor proteins, G -proteins and receptor tyrosine kinase mediated signaling Ca2+ flux and its interpretation in cytoplasm, role of Ca2+ binding proteins.

Unit IV

Intracellular vesicular trafficking: Import of proteins into ER and processing in the ER and Golgi. Mechanism of vesicle formation and fusion. Import of relevant nuclear encoded proteins into chloroplasts and mitochondria. Cell Cycle and cancer: Overview and control. Cyclins, CDKs and Ubiquitin-proteasome dependent control of cell cycle. Checkpoints. Transition from normal to cancerous cell growth. Genetic instability and mutations as causative Agents. Oncogenes and retroviruses P 53 and associated proteins as tumor suppressors
Apoptosis: The role of programmed cell death in maintaining the social order of cells and in

tissue sculpting. Pathways and hallmarks of apoptosis. Role of caspases and Bcl2 family proteins.

Suggested Practicals

1. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, esophagus, stomach, pancreas, intestine, kidney, ovary, testes.
2. Cell division in onion root tip/ insect gonads.
3. Preparation of Nuclear, Mitochondrial & cytoplasmic fractions.

Suggested Reading:

• Molecular Biology of the Cell-Alberts et al

• Molecular Cell Biology-Lodish et al

• Cells-Lewin

• Becker's World of Cell-Hardin et al

• The Cell: A molecular Approach-Cooper and Hausmann

Biophysical Techniques

Course Objectives and Outcomes

• The course is designed to provide a broad exposure to basic techniques used in Modern Biology research.

• The goal is to impart basic conceptual understanding of principles of these techniques and emphasize biochemical utility of the same.

• Students are expected to have a clear understanding of all analytical techniques such that the barrier to implement the same is abated to a great extent.

• Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell.

Unit I:

Electrochemistry: Ionization of water and its interaction with acids and bases, Buffers and buffering capacity. Determination of pH: theory and instrumentation. Electrophoresis: Separation of biomolecules on electrophoretic gels: PAGE and agarose gels. Native PAGE, SDS-PAGE, Isoelectric focusing, 2D-PAGE,

Unit II:

Centrifugation: Basic principle of sedimentation, centrifuge and their uses. Rotors. Preparative and analytical centrifugation and their application in biochemistry. Chromatography: Partition coefficient, Retention, Resolution, Capacity factor, theoretical plate, van Deemter curve, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, Hydrophobic interaction chromatography, Paper chromatography, Thin layer chromatography, Fundamentals of high-performance chromatography.

Unit III:

Spectroscopic techniques: Basic concepts of molecular bonding and spectroscopy. Energy Levels. Theory of interaction of biomolecules with energy. Principle, instrumentation and applications of atomic absorption and emission spectroscopy. Concepts and applications of UV-Visible and fluorescence spectrophotometry, EPR, XRD, NMR, MS.

Unit IV:

Optical methods for determination of molecular structure: Absorption of polarized light, optical rotatory dispersion, hypochromism, circular dichroism in relation to composition and structure of biomolecules. Biosensors: Basic techniques, enzyme electrode, organic salt electrode, neuroelectrodes, microbial biosensors. Tracer techniques. Detection and measurement of isotopes and biological applications.

Suggested Practicals

1. Preparative Centrifugation

2. Nativ Gel Electrophoresis

3 SDS-PAGE Electrophoresis

4.Agarose Gel Electrophoresis

Suggested Reading:

•Physical Chemistry for the Life Sciences (2 nd Revised Edition). Atkins, de Paula. (2015).•Biophysical Chemistry, Allen Cooper, (2011), Royal Society of Chemistry
•Principles of Physical Biochemistry, K. E. van Holde, C. Johnson, P. S. Ho. (2010) 3rd Edn., Prentice Hall

• C.R. Cantor and P.R. Schimmel (1982) Biophysical Chemistry (Part 1-3), 2nd Edn.

Plant Biotechnology

Course Objectives:

1. Explain the developmental processes operating in plants
2. Demonstrate plant tissue culture methods
3. Analyze biotechnological tools for engineering plants in agriculture and industry

Expected Course Outcome:

1. Outline the importance and fundamentals of plant tissue culture
2. Summarize the applications of tissue culture
3. Design vectors for plant transformation
4. Create clean and green transformation protocols
5. Measure the suitability of transgenics to consumers, industrialists, and environment
6. Apply tissue culture techniques and get employed in a plant biotechnology-based industry

UNIT 1 (10 lectures)

Introduction, Cryo and organogenic differentiation, Types of culture: Seed, Embryo, Callus, Organs, Cell and Protoplast culture. Micropopagation Axillary bud proliferation, Meristem and shoot tip culture, cud culture, organogenesis, embryogenesis, advantages and disadvantages of micropropagation.

UNIT 2 (10 lectures)

In-vitro haploid production Androgenic methods: Anther culture, Microspore culture androgenesis Significance and

use of haploids. Ploidy level and chromosome doubling, diplodization, Gynogenic haploids, factors affecting gynogenesis, chromosome elimination techniques for production of haploids in cereals.

UNIT 3 (10 lectures)

Protoplast Isolation and fusion Methods of protoplast isolation, Protoplast development, Somatic hybridization, identification and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations. Somaclonal variation Nomenclature, methods, applications basis and disadvantages.

Unit 4 (10 lectures)

Plant Growth Promoting bacteria Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation, Biocontrol of pathogens, Growth promotion by free-living bacteria.

PRACTICALS

1. Preparation of simple growth nutrient (Knop's medium), full strength, half strength, solid and liquid.
2. Preparation of complex nutrient medium (Murashige & Skoog Medium)
3. Selection, Prune, sterilize and prepare an explant for culture.
4. Significance of growth hormones in culture medium. 5. To demonstrate various steps of Micropropagation.

SUGGESTED READING

1.Bhojwani, S.S. and Razdan MK 2004 Plant Tissue Culture and Practice. 2.Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication. 3.Gardner, E.J. Simmons, M.J. Snustad, D.P. 2008 8 th edition Principles of Genetics. Wiley India.

4. Raven, P.H., Johnson, GB. Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
5. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.
6. Russell, P.J. 2009 Genetics – A Molecular Approach. 3 rd edition. Benjamin Co.
7. Sambrook & Russel. Molecular Cloning: A laboratory manual. (3rd edition)
8. Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.

Fermentation for Plant and Animal Products

Course Objectives:

Fermented foods help to address the societal, environmental, cultural and economic aspects of sustainability. In poorer regions, production of fermented foods such as yogurt provides access to safe and healthy food, creates demand for local produce, and provides employment and income opportunities.

Expected Course Outcome:

Students will be able to understand the basics of fermented products and their production. Students will be

enlightened with ideas for innovations and startups.

Unit I (10 lectures)

History and scope of fermented foods; definition and importance of fermented foods; Organisms used for production of fermented food products; Environmental parameters for fermentation process; Classification of fermentation processes for fermented foods.

Unit II (10 lectures)

Fermented beverages- production of different types of wine and beer; Fermented foods of vegetables and fruits- Processing, microbiology, starter cultures, biochemistry, food safety of sauerkraut, pickles, Kimchi; Cereal and legume based fermented products bread, Soya Sauce, Koji, Tempeh, Miso, Natto, Tofu, Angkkak; Indian products

like Idly, Dosa, Bada.

Unit III (10 lectures)

Microbiology of Fermented Dairy Products (Product Characteristics, Processing, Starter culture, Growth, Genetics) Buttermilk; Yogurt (probiotics, prebiotics, synbiotics); Acidophilus Milk; Bifidus Milk, Bulgarian milk; acidophilus milk; Kefir; Kumiss; Cheeses; Properties and beneficial effects of probiotic and prebiotic.

Unit IV (10 lectures)

Fermented meat and fish products; Microbial fermentation of tea, coffee and cacao. health aspects of fermented foods.

Suggested Practical

1. Modeling the kinetics in Fermentation Process
2. Preservation of fermentation products

Suggested Readings

1. Kosikowski, F.V. 1997. Cheese and fermented milk foods. Frank Kosikowski and Vikram Mistry, Brooktondale, N.Y.
2. Fox, P.F. 1993. Cheese : chemistry, physics, and microbiology, London ; New York: Chapman & Hall,.
3. Wood, J. B. 1985. Microbiology of fermented foods. Volumes I and II. . Elsevier Applied Science Publishers. London, England
4. Joshi, V.K. and Pandey, A. Ed. 1999. Biotechnology. Food Fermentation, (2 Vol. set). Education Publ. New Delhi
5. R.C. Dubey and D.K. Maheshwari. Practical Microbiology
6. Jay, J.M. (2008) Modern Food Microbiology (Sixth Edition).Aspen Publishers, Inc. Gaithersburg, Maryland.
7. National Research Council (US) Panel on the Applications of Biotechnology to Traditional Fermented Foods. Washington (DC): National Academies Press (US); 1992.

8.Advances in Fermented Foods and Beverages, Gopal Kumar Sharma, Anil Dutt Semwal, Janifer Raj Xavier, Imprint NIPA, ISBN9789390175697, Year of Publishing 2021

 # Minor Elective (From other Faculty) –will be offered as per electives offered by university

Semester Eight

Enzymology

Course Objectives

1. Relate basic knowledge of enzymology with its useful applications in health care, Environment and industries
2. Illustrate enzyme kinetics and parameters of enzymatic reactions through a practical approach
3. Apply knowledge on mechanistic enzymology.

Expected Course Outcome:

1. Summarize structure, function, and properties of enzymes
2. Define rate equations for enzyme-catalyzed reaction and how key factors affect enzyme reactions rates

3. Classify the types of enzyme inhibitions and their mechanisms
4. Evaluate enzyme activity and its regulation in maintaining cellular structure and function
5. Analyze enzyme mutations and their role in protein engineering
6. Solve industrial problems using enzymes

Unit 1 (10 lectures)

Importance of enzymes, the nature of the enzyme, functional organization of enzyme- domains, (multi-enzyme complex), active site of enzyme- standard features. IUBMB, Kinases, phosphatases, Oxido-reductases, transferases, hydrolases, lyases, isomerases and ligases

Unit 2 (10 lectures)

Free energy, activation energy, enzyme-substrate complex, transition state, binding energy, enzyme reaction coordinate diagram. Kinetics- Michaelis – Menten kinetics; kinetic parameters- Km, Vmax, Kcat; Lineweaver Burk plot, Factors affecting enzyme activity, Enzyme inhibition –types of inhibition

Unit 3 (10 lectures)

Catalytic strategies- covalent, general acid-base, approximation, metal ions, protease, restriction endonuclease, kinase, and phosphatase, Mechanisms of enzyme regulation in metabolism- - reversible covalent modification, allosteric regulation, proteolytic cleavage, isozymes, compartmentalization

Unit 4 (10 lectures)

Methods to obtain mutant enzymes with desired features: Methods to induce mutations and screening in microorganisms, Site-directed mutagenesis. Application of enzymes: Industrial processes, molecular biology, diagnostics and therapeutics

Suggested Practicals

1. Determination of the activity of Enzymes: Protease, amylase, lipase
2. Determination of the specific activity of alkaline phosphatase.
3. Glucose estimation using glucose oxidase.
4. Determination of Vmax and Km for a given enzyme
5. Effect of pH on Enzyme activity - pH 2- 10 6. Effect of temperature on Enzyme activity (10- 80°C)
6. Effect of Inhibitors (PMSF, EDTA, Iodoacetate) on enzyme activity
7. Effect of Substrate concentration on enzyme

Suggested Readings

1. Gray N, Calvin M, and Bhatia SC (2010) Enzymes Biotechnology CBS Publishers and Distributors Pvt Limited Edition

2. Nelson, D.L., and Cox MM. (2012) Lehninger's Principles of Biochemistry, Sixth Edition, WH Freeman, New York.

3. Shanmugam S, Sathishkumar T, and Shanmuga Prakash M (2012) Enzyme technology 2nd edition IK international publishing House Pvt. Ltd

Advanced Agricultural Biotechnology

Course Objectives:

To develop an awareness of continuous learning in relation with modern technology and find out new methods to improve his/her knowledge. To enable student to apply biological concepts to personal, social, economical, technological and ethical issues

Expected Course Outcome:

1. Evaluate possible potentials of plant biotechnology in agriculture 2.Define and manipulate advanced concepts of Biology in a specialized way
3. Understand relevant research methodologies and techniques and their appropriate application within his/her research field,

4. Develop an awareness of continuous learning in relation with modern technology 5.Find out new methods to improve his/her knowledge.

6. Apply biological concepts to personal, social, economical, technological and ethical issues

Unit 1 (10 lectures)

Agrobacterium-plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid, Agrobacterium-mediated gene delivery, Cointegrate and binary vectors and their utility; Floral dip transformation, Direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; Screenable and selectable markers; Monocot transformation, Promoters and poly A signals, Characterization of transgenics; Chloroplast transformation: advantages, vectors and successes; Marker-free methodologies; Gene stability and gene silencing, gene stacking

Unit 2 (10 lectures)

Bacterial resistance, Viral resistance: coat protein mediated, nucleocapsid gene, Fungal diseases: chitinase, 1-3 beta glucanase, RIP, antifungal proteins, thionins, PR proteins, Insect pests resistance: Bt genes, Non-Bt like protease inhibitors, alpha amylase inhibitor, nematodes resistance and herbicide resistance: phosphinothricin, glyphosate, sulfonylurea, atrazine, Drought, salinity, thermal stress, flooding and submergence tolerance,post-harvest losses, long shelf life of fruits and flowers: use of ACC synthase, Polygalacturonase, ACC oxidase, male sterile lines: bar and barnase system.

Unit 3 (10 lectures)

Genetic engineering for increasing crop productivity: enhancing photosynthetic, nutrient use and nitrogen fixing efficiencies of plants, manipulation of plant architecture and flowering behavior, Jatropha biotechnology, (cultivation and biodiesel Extraction methods) production of primary and secondary metabolites by microbes. (Ethanol by yeast, citric acid by Aspergillus niger, penicillin)

Unit 4 (10 lectures)

Genetic Engineering for quality improvement: Seed storage proteins; essential amino acids, Vitamins and minerals, heterologous protein production in transgenic plants for agriculture, industry and pharmaceuticals uses, biodegradable plastics, Plants as biofactories, Role of antisense and RNAi in crop improvement, regulated and tissue specific expression of transgenes for crop improvement, Terminator gene technology, Environmental issues associated with transgenic crops, food safety issues and risk assessment of transgenic food crops.

Suggested Practicals

1. Isolation of plasmids with reporter (gus) gene,

2. Preparation of microprojectiles, transformation using a particle gun, GUS staining.

3. Leaf disc transformation using Agrobacterium, establishment of transgenic plants, and GUS staining or GFP viewing.

4. DNA extraction from transgenic plants, DNA estimation, PCR analysis,

5. Southern blot analysis to prove T-DNA integration,

6. RTPCR to study transgene expression,

7. Western blotting to study the accumulation of transgene-encoded protein.

Suggested Readings

1. Adrian Slater, Nigel Scott and Mark Fowler, Plant Biotechnology: The genetic manipulation of plants, 1st Edition, Oxford University Press, 2003

2. Edited by BR Jordan, 2nd Edition, The Molecular Biology and Biotechnology of Flowering, CABI, 2006.

3.Jaiwal PK & Singh RP (eds) Plant Genetic Engineering Vol-1 to Vol. 9. Studium Press, USA

Vaccines

Course Objectives:

This course provides students about the importance of immunization programs and how vaccines work. It gives information about the relationship between vaccine coverage, adverse events and disease spread.

Expected Course Outcome:

Upon successful completion of this course students will be able to:

- Understand the process of the function and development of vaccines.
- Know the use of adjuvants in vaccines.
- Understand the controversies on vaccines.
- Know the approach to the use of vaccines for the eradication of diseases.
- Assess the controversies on vaccines include anti-vaccine groups.
- Be exposed to several approaches to risk communication surrounding vaccines.

Unit 1 (8 lectures)

Introduction to Vaccinology, History of Vaccination, Key Developments, and Ongoing Challenges, Vaccine Design, Development, and Safety, Study Designs: Clinical Trials to Evaluate Vaccines, Concepts in Vaccine Immunology, How Vaccines Protect Individuals: Quantitative Methods for Measuring Vaccine Efficacy (VE), Sex Differences and Vaccines

Unit 2 (8 lectures)

How Vaccines Protect Populations I: Understanding Quantitative Concepts in Vaccinology: Susceptibility, R0, Contact Rate, Critical Vaccination Fraction, Case Study: Influenza vaccination, How Vaccines Protect Populations II: Infectious Disease Transmission Dynamics and Community Immunity, How Vaccines Protect Populations III: Indirect, Total, and Overall Effects

Unit 3 (12 lectures)

Maternal and Infant Vaccination: Successes and Challenges, Adolescent and Adult Vaccination, Ethical Consideration for Vaccines, Communication Strategies for Public Health Controversies, Epi Study Designs for Assessing the Direct and Indirect Effect of Vaccines: Household-Based Study Designs and Cluster- Based Study Designs including Stepped-Wedge Designs, Test- Negative Designs and Challenges Studies, Challenges of Developing and Testing New Vaccines, Epi Study Designs: Serological Surveys and Sero- Epidemiology, Surrogate Endpoints for Evaluating Vaccines, Global Challenges in Vaccine Delivery: Disparities in Access, Vaccine Preventable Diseases Globally: Future Outlook

Unit 4 (12 lectures)

Novel Vaccine Platforms- SARS CoV2 , Vaccines Against Diarrheal Diseases, Salmonella Vaccines, Malaria Vaccines, Influenza, Cholera: Bench-to-Bedside, Maternal/Neonatal Immunization, Vaccines Against STI, Vaccines Against Neglected Parasitic Diseases, Pediatric and Adult vaccines, Nonspecific Effects of Vaccines, Conjugate Vaccines, Dengue Vaccines, Systems Vaccinology

Suggested Readings

1. Vaccinology: Principles and Practice. Editor(s): W. John W. Morrow PhD, DSc, FRCPath,, Nadeem A. Sheik PhD,, Clint S. Schmidt PhD,, D. Huw Davies PhD, First published:20 June 2012. Print ISBN:9781405185745|Online ISBN:9781118345313 |DOI:10.1002/9781118345313Copyright © 2012 Blackwell Publishing Ltd.
2. Introduction to Molecular Vaccinology, Matthias Giese

Biomaterials

Course Objectives

To teach the chemistry and engineering skills needed to solve challenges in the biomaterials and tissue engineering area.

Expected Course Outcome

After successfully completing this course, students will be able to:

1. Understand the fundamental principles in biomedical engineering, material science and chemistry, and how they contribute to biomaterial development and performance
2. Apply the math, science, and engineering knowledge gained in the course to biomaterial selection and design
3. Critically review papers from the scientific literature and identify areas of research opportunities

Unit 1 (10 lectures)

Introduction to Biomaterials. Background history. Property requirement of biomaterials. Mechanical properties. Resorbability, biodegradation. Resorbability, biodegradation. Biofilm, Concept of biocompatibility. Structure and properties of biological cells & tissues, cell- material interactions and foreign body response

Unit 2 (8 lectures)

Assessment of biocompatibility of biomaterials, in vitro biochemical assays (cellular adhesion, cellular viability using MTT, osteogenic differentiation using ALP assay, Biomineralisation using Osteocalcin assay). In vivo testing and histocompatibility assessment, genotoxicity assessment (Physical damage to DNA by biomaterial eluates),

Unit 3(12 lectures)

Important bimetallic alloys Ti-based, stainless steels, Co-Cr-Mo alloys; Bioinert, Bioactive and resorbable ceramics. Processing and properties of different bioceramic materials with emphasize on hydroxyapatite, synthesis of biocompatible coatings on structural implant materials; plasma spraying of carbon nanotube reinforced hydroxyapatite on Ti-6Al-4V substrate;

Unit 4 (10 lectures)

Microstructure and properties of glass-ceramics; biodegradable polymers; Design concept of developing new materials for bio-implant applications.

Suggested Reading

1. Biomaterials: An introduction to Materials in Medicine, Second edition. Buddy D. Ratner. Academic Press. ISBN:9780125824637

2. Biomaterials Science and Biocompatibility, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

3. Biological Performance of Materials: Fundamentals of Biocompatibility, Janathan Black, Marcel Dekker, Inc., New York and Basel, 1981.

4. Basic Cell Culture: A Practical Approach, Edited by J.M. Davis, IRL Press, Oxford University Press, New York, 1994.

Semester Nine

In vitro Culture Techniques

Course Objectives:

The course should provide the student with knowledge such that the student can carry out basic cell-culture techniques properly and safely, and explain factors of significance in the cultivation of cells in vitro.

Expected Course Outcome:

The student should be able to: -

1. account, at a general level, for the structure and function and maintenance of an LAF/sterile bench and be able to work in this with a good sterilization technique.

2. account for different preventive measures to avoid contamination of cell cultures and how a contaminated cell culture may be treated - explain how mycoplasma contamination affects eukaryotic cells

3. account in detail for sterilization equipment and different sterilization techniques

4. account for different cell-culture media and important components in the media –

5. explain the concept of transformation and describe different transformation methods

6. be able to apply basic cell-culture techniques, such as calculation and harvesting of cells

7. explain different factors of significance in the cultivation of cells in vitro

Unit 1 (10 lectures)

Introduction: Definition, Concept of cellular totipotency, history, Composition of different culture Media, Role of chemicals and growth regulators in plant tissue culture, Sterilization of media, tissues and other accessories, Inoculation of cultures, Suspension culture, Protoplast isolation, culture and fusion, In vitro pollination and fertilization, Wide hybridization and Embryo rescue, Androgenesis: Anther and pollen culture, Gynogenesis-ovule and ovary culture, dihaploids, their applications in genetics and plant breeding; Protoplast isolation and purification; Protoplast viability test; Protoplast culture and regeneration; Somatic hybridization - methods and applications; Cybrids, Somaclonal and gametoclonal variations,

Unit 2 (10 lectures)

In-vitro selection. Large-scale production of alkaloids and other secondary metabolites through cell culture techniques; high yielding cell lines, factors affecting production, Biotransformation, elicitors induced production, Hairy root culture and production of secondary metabolites. Immobilization of plant cells. Clonal propagation: Shoot-tip and axillary bud culture, Techniques of cell and tissue culture: Preparation of explant materials, initiation of cultures, micropropagation through organogenesis and embryogenesis, artificial seeds and embryo culture, Anther Culture: Development of haploids, diploidization and its applications. Somaclonal variation and in vitro selection for crop improvement.

Unit 3 (10 lectures)

Introduction to Animal Cell Culture: Historical background. Good Laboratory Practices (GLP), sterilization methods and techniques. Biology of animal cell and cell-cell interactions, growth environment and culture requirement. Primary culture, subculture, cell line, cell strain, cell clone. Importance of serum and serum-free media, culturing and subculturing of animal cells, in vitro transfection of animal cells, cell-based assays, cell differentiation and movement, animal cell culture facility. Cell Culture Types and Characterization: Primary cell culture, tissue culture, organ culture, cell line immortalization, cell line preservation & characterization, karyotype analysis, cellular markers, commercial cell lines, and insect cell culture.

Unit 4 (10 lectures)

Applications of Animal Cell Culture: Cancer Research, vaccine manufacture, gene and stem cell therapy, production of recombinant proteins, IVF Technology, toxicology studies. Translational Research Applications: Rodent and murine models in scientific research associated with cancer and neurodegenerative diseases. Animal cells as the applicable products (recombinants, hybridomas, stem cells and transplants).cell culture reactors, scale up in suspension and monolayers, membrane perfusion.

Suggested Practicals

1. Subculturing Adherent Cells

2. Subculturing Adherent Insect Cells

3. Subculturing Suspension Cells
4. Subculturing Suspension Insect Cells
5. Freezing Cells Cryopreservation
6. Thawing Frozen Cells
7. Counting Cells in a Hemocytometer
8. Trypan Blue Exclusion Assay
9. Concentrating Cells

Suggested Reading

1 Freshney, R.I. (2010). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley-Blackwell, 2010. 6th Edition.

2. Davis, J. M. (2008). Basic Cell Culture. Oxford University Press. New Delhi.
3. Butler, M. q (Michael) Animal cell culture and technology 2. ed. : London : BIOS Scientific Pub., Pub., c 2 - xii, 244 p. ISBN:1-85996-049-9 (pbk.) LIBRIS-ID:9050534
4. Davis, J. M. (2011). Animal Cell Culture. John Willy and Sons Ltd. USA.
5. Butler, M. (2004). Animal Cell Culture and Technology. Taylor and Francis. New York, USA.
6. Verma, A.S. and Singh, A.(2014).Animal Biotechnology. Academic Press, Elsevier, USA.
7. Cartwright, E. J. (2009). Transgenesis Techniques. Humana Press. London, UK.
8. McArthur, R. A. and Borsini, F. (2008). Animal and Translational Models for CNS Drug Discovery. Elsevier. London, UK.
9. Freshney R. I. (2005). Culture of Animal Cells. John Willy and Sons Ltd. USA.

Research Methodology and Academic Writing

Course Objectives:

1. Identify the essential components of research
2. Design the various strategies involved in experimental research
3. Recommend the importance of statistical analysis in research

Expected Course Outcome:

- Developing a hypothesis, a research problem and related questions
- Framing the problem with the correct research methodology
- Collecting data that accurately addresses the research problem
- Measuring the effectiveness of a program
- Using data to make decisions
- Evaluating feasibility of research proposals
- Presenting data to support programs to decision makers and other consumers

UNIT 1 (10 lectures)

Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process, Problem Identification & Formulation – Research Question –

Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance, Research Design: Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

UNIT 2

Qualitative and Quantitative Research: Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches. Measurement: Concept of measurement– what is measured? Problems in measurement in research – Validity and Reliability. Levels of measurement – Nominal, Ordinal, Interval, Ratio, Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample – Practical considerations in sampling and sample size.

Unit 3 (10 lectures)

Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association. Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases for Science Discipline, Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software, Software for paper formatting, Software for detection of Plagiarism, Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Introduction; principles of effective writing, Cut the clutter, Practicing cutting clutter, Use the active voice, Is it really OK to use "We" and "I", Write with verbs, Experiment with punctuation, Practice, colon and dash, Parallelism, Paragraphs,

Unit 4 (10 lectures)

Overview of the writing process, The prewriting step, The writing step, Revision, Checklist for the final draft, Tables and Figures, Results, Methods, Introduction, Discussion, Abstract, Citation Methods, Citation Rules. Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism, Authorship, The Submission Process, Doing a peer review, Predatory journals, Writing a review article, Grants, Writing letters of recommendation, Writing personal statements, Writing for general audiences, Writing a science news story, Interviewing a scientist, Social media.

Suggested Practicals

1.Conducting survey and asking questions: closed and open format questions/ questionnaire and survey method
2.Conducting interviews (structured, semi-structured and unstructured)
3.Observation
4.Focus groups
5.Case Study
6.Steps in analyzing qualitative data
7.Analysis of text, documents and discourse
8.Sampling

Suggested Readings

1.Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.

2.Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3.Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
4.Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5.Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.
6. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Edition, by John W. Creswell (Author)
7.Term Papers and Academic Writing by Clyde Coriel (Author) Publisher : Infinity Publishing (April 1, 2013), ISBN-10 : 0741481847 , ISBN-13 : 978-0741481849

Enzyme Kinetics & Regulation

Course Objectives and Outcome:
At the end of the course, students will be able to understand
advanced kinetics of enzymes especially those catalyzing bisubstrate reactions. They will learn classification, annotation and kinetics of bisubstrate reactions, its kinetics and properties of allosteric enzymes, various mechanisms of enzyme action by taking examples of some important enzymes catalyzing two substrate reactions.

Unit I

Two substrate systems: kinetic mechanisms, Sequential and ping pong pathways, Cleland representation and nomenclature, forms of initial rate equations for random, ordered and ping-pong pathways and their primary and secondary plots.

Unit II

Regulation of Enzyme activity: feedback inhibition, allosteric concept, qualitative description of concerted and sequential models, negative cooperativity and half-site reactivity, Hill and Scatchard plots

Unit III
Regulation of enzyme activity by covalent modification. Mechanisms of enzyme action:
Proximity orientation effect, strain and distortion theory, Acid-base catalysis, covalent catalysis.
Unit IV

Techniques for studying the mechanism of enzyme action; chemical modification, site directed mutagenesis, general mechanistic principles. Physicochemical properties and mechanism of action of enzymes, alcohol dehydrogenase, chymotrypsin, lysozyme and hexokinase.

Suggested Reading:

•Enzymes by Dixon M, Webb EC, 2 ND Ed., Academic Press
•Enzymes by Palmer, Woodhead Publishing Ltd., UK
•Biochemistry by Voet B and Voet JG, Wiley Publishers, USA
•Biochemistry 5th Revised edition by Lubert Stryer, Jeremy M. Berg, John L.
•Tymoczko, Macmillan Publishers, USA
•D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed.NewYork

Biofuels and Alcohol Technology

COURSE OBJECTIVE:
- To teach the concept and application biofuels and alcohol technology
- To develop understanding of different alcoholic fermentation techniques.
- To provide knowledge of the Biochemistry of alcohol production, recycling and quality control.
- Concepts of Biomass conversion to heat and power

COURSE OUTCOME:

On completion of this course, the students will be able to:
- Explain basic concepts of metabolism and importance of metabolic engineering
- Understand the production of metabolites and its regulatory mechanism
- Explain the applications, specificity and product inhibition of bioconversion.
- Regulation of enzyme production and strain improvement

Unit I
Introduction to Alcohol Technology, Raw Material of Alcohol Industry, Storage & handling of Raw material in detail, Study of different yeast strains used in alcohol industries, Study of yeast production as a single protein cell.
Unit II

Study of different alcoholic fermentation techniques, Batch fermentation, Continuous fermentation, Modern techniques of Continuous fermentation, Bio still fermentation, Encillium process, Wet milling of grain for alcohol production, Grain dry milling cooking for alcohol production, Use of cellulosic feedstocks for alcohol production, Scaling in distilleries, Fusel oil separation

Unit III

Study of different recycling processes, Biochemistry of alcohol production, The management of fermentation in the production of alcohol Alcohol distillation-The fundamental, Parameters & affecting alcoholic fermentations, By product of alcoholic fermentation, Distillery quality control, Alcoholometry

Unit IV

Various biofuels/ bioenergy from biomass. Biomass conversion to heat and power: thermal gasification of biomass, anaerobic digestion Biomass conversion to biofuel: thermochemical conversion, syngas fermentation.

Suggested Practicals

1. Oil extraction
2. Oil viscosity
3. Biodiesel
4. Extracting sugar from sugar beet
5. Carbohydrate testing
6. Yeast fermentation
7. Fermentation of lignocelluloses
8. Bacterial cellulose
9. Culturing algae
10. Algae chromatography.

REFERENCE BOOKS:

1. Chemical Process Principles – Part I, Material and Energy Balances by Olaf A Hougen, Kwenneth M. Watson, and Roland A Ragatz, CBS Publishers and Distributors (1995).
2. The alcohol textbook by Kathryn AnnJacques, T. P. Lyons, D. R. Kelsall 2003
3. Product Recovery in Bioprocess Technology ", BIOTOL Series, VCH1990.
4. Shreve's Chemical Process Industries , 5th Ed. Reference 1984
5. Outlines of Chemical Technology by Charles E. Dryden 1973

Principles of Toxicology

Course Objectives and Expected Learning Outcomes

On completion of the course, the student should be able to:

- describe basic toxicological principles and describe how different chemicals are taken up by, processed in and eliminated from the body
- describe different the importance of different organs for detoxification/ toxification of chemicals, and describe mechanisms for chemically induced neurotoxicity and endocrine toxicity
- describe different behavior tests and their importance to discover of different neurological and endocrinological disturbances
- describe when different chemicals are most toxic, and mechanisms behind the effects. Be able to discuss when and how different chemicals can interact under the development to induce effects
- describe different genetic testing methods and injuries after various types of ionizing radiation
- apply different toxicological frameworks within the professional disciplines and have awareness about different risk assessment criteria

Unit 1

Introduction to Toxicology: Types of toxic substances and exposure, Routes of exposure, Dose-Response relationship, Detection of toxic responses; Toxicant Proceeding in Vivo: Absorption of toxic compounds, Distribution of toxic compounds, Excretion of toxic compounds, Metabolism of foreign compounds.

Unit 2

Drugs as Toxic Substances: Pharmaceutical: overdoses, interactions, Genetic aspects; Industrial Chemicals: Government Regulati of Chemicals, Ways of exposure, Toxic effects, Long-term consequences and developmental toxicity, Heavy metals, Plastics, Asbestos, Food Additives and Contaminants, Types of food additives, Preservatives, Saccharin.

Unit 3

Toxicants in Environment; Air Pollutants, Water and soil pollutants, Acid Rain, Lead Pollution, Mercury and methylmercury. Nanotoxicology, pesticides, cyanotoxins

Unit 4

Organ toxicity: Hepatotoxicity, Cardiotoxicity, Respiratory Toxicity, Toxicity of Male and Female Reproductive System, Neurotoxicity, Nephrotoxicity ,non-organ directed toxicity: chemical toxicology, genetic toxicology, developmental toxicology

Suggested Practical

1.Dose and Time in Toxicity
2 Threshold Limit Values
3Time Course of Toxic Reactions
4 Cell Membrane Toxicity – Minutes
5 Cell Metabolism Toxicity – Hours
6 Cell Proliferation Toxicity - Days

References

1. Klaassen, Curtis D.; Watkins, John B.; Casarett, Louis J. Casarett & Doull's essentials of toxicology 2nd ed.: New York: McGraw-Hill Medical, c2010
2. A Textbook of Modern Toxicology, Third Edition Editor(s): Ernest Hodgson. First published:30 January 2004 Print ISBN:9780471265085 |Online ISBN:9780471646778 |DOI:10.1002/0471646776 , Copyright © 2004 John Wiley & Sons, Inc.
3.Lu's Basic Toxicology :Fundamentals, Target Organs, and Risk Assessment, Seventh Edition. By Byung-Mu Lee, Sam Kacew, Hyung Sik Kim, Copyright Year 2017, ISBN 9781138032354, Published September 7, 2017 by CRC Press

Bioethics and Biosafety

Course Objectives and Outcomes:

- To provide basic knowledge on biosafety and bioethics and their implications in biological research.
- To become familiar with India's biosafety and bioethics policies.
- To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products.
- To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.

Unit I

Introduction to Biosafety; Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals.

Unit II

Biosafety guidelines – Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs.

Unit III

Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Unit IV

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.

Suggested Reading:

•Biosafety and bioethics (2006) Rajmohan Joshi. Gyan Publishing House.
•Laboratory biosafety manual. (2004). World Health Organization. WHO press, 2004.
•Biological safety: principles and practices (2000) Diane O. Fleming, Debra Long Hunt. ASM Press
•CRC handbook of laboratory safety. (2000) A. Keith Furr. CRC Press.
•Craig, W., Tepfer, M., Degrassi, G., Ripandelli, D. (2008). An Overview of General divisions/csurv/geac/annex-5.pdf 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
•Features of Risk Assessments of Genetically Modified Crops. Euphytica
•International Union for the Protection of New Varieties of Plants. http://www.upov.int
•Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences - Case
•Studies of Policy Challenges from New Technologies, MIT Press
•Kuhse, H. (2010). Bioethics: Anthology. Malden, MA: Blackwell.
•National Biodiversity Authority. http://www.nbaindia.org
•Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/

Semester Ten

Drug Metabolism

Course Objectives:

This course is designed to impart knowledge and skills necessary for dose calculations, dose adjustments and to apply biopharmaceutics theories in practical problem solving. Basic theoretical discussions of the principles of biopharmaceutics and pharmacokinetics are provided to help the students' to clarify the concepts.

Expected Course Outcome:

Upon completion of this course it is expected that students will be able understand,

1. The basic concepts in biopharmaceutics and pharmacokinetics.
2. They use raw data and derive the pharmacokinetic models and parameters that best describe the process of drug absorption, distribution, metabolism and elimination.
3. The critical evaluation of biopharmaceutic studies involving drug product equivalency.
4. The design and evaluation of dosage regimens of the drugs using pharmacokinetic and biopharmaceutic parameters.
5. The potential clinical pharmacokinetic problems and application of basics of pharmacokinetic.

Unit 1 (10 lectures)

Drug Absorption from the Gastrointestinal Tract: Gastrointestinal tract, Mechanism of drug absorption, Factors affecting drug absorption, pH–partition theory of drug absorption. Formulation and physicochemical factors: Dissolution rate, Dissolution process, Noyes– Whitney equation and drug dissolution, Factors affecting the dissolution rate. Gastrointestinal absorption: role of the dosage form: Solution (elixir, syrup and solution) as a dosage form, Suspension as a dosage form, Capsule as a dosage form, Tablet as a dosage form, Dissolution methods, Formulation and processing factors, Correlation of in vivo data with in vitro dissolution data. Transport model: Permeability-Solubility-Charge State and the pH Partition Hypothesis, Properties of the Gastrointestinal Tract (GIT), pH Microclimate Intracellular pH Environment, Tight-Junction Complex.

Unit 2 (10 lectures)

Biopharmaceutic considerations in drug product design and In Vitro Drug Product Performance: Introduction, biopharmaceutic factors affecting drug bioavailability, rate-limiting steps in drug absorption, physicochemical nature of the drug formulation factors affecting drug product performance, in vitro: dissolution and drug release testing, compendial methods of dissolution, alternative methods of dissolution testing, meeting dissolution requirements, problems of variable control in dissolution testing performance of drug products. In vitro–in vivo correlation, dissolution profile comparisons, drug product stability, considerations in the design of a drug product.

Unit 3 (10 lectures)

Pharmacokinetics: Basic considerations, pharmacokinetic models, compartment modeling: one compartment model- IV bolus IV infusion, extra-vascular. Multi compartment model: two compartment - model in brief, non-linear pharmacokinetics: cause of non-linearity, Michaelis – Menten equation, estimation of k max and v max. Drug interactions: introduction, the effect of protein binding interactions, the effect of tissue-binding interactions, cytochrome p450-based drug interactions, drug interactions linked to transporters.

Unit 4 (10 lectures)

Drug Product Performance, In Vivo: Bioavailability and Bioequivalence: drug product performance, purpose of bioavailability studies, relative and absolute availability. Methods for assessing bioavailability, bioequivalence studies, design and evaluation of bioequivalence studies, study designs, crossover study designs, evaluation of the data, bioequivalence example, study submission and drug review process. Biopharmaceutics classification system, methods. Permeability: In-vitro, in-situ and In-vivo methods. Generic biologics (biosimilar drug products), clinical significance of bioequivalence studies, special concerns in bioavailability and bioequivalence studies, generic substitution. Application of Pharmacokinetics: Modified-Release Drug Products, Targeted Drug Delivery Systems and Biotechnological Products. Introduction to Pharmacokinetics and pharmacodynamic, drug interactions. Pharmacokinetics and pharmacodynamics of biotechnology drugs. Introduction, Proteins and peptides, Monoclonal antibodies, Oligonucleotides, Vaccines (immunotherapy), Gene therapies.

Suggested Practicals

Immunoassay in pharmacokinetic and pharmacodynamic bioanalysis

Quantitative bioanalysis

In vitro techniques for investigating drug metabolism

Identification of drug metabolites in biological fluids using qualitative spectroscopic and chromatographic techniques

Suggested Readings

1.Biopharmaceutics and Clinical Pharmacokinetics by Milo Gibaldi, 4th edition, Philadelphia,Lea and Febiger, 1991
2.Biopharmaceutics and Pharmacokinetics, A. Treatise, D .M. Brahmankar and Sunil B. Jaiswal, Vallabh Prakashan, Pitampura, Delhi
3.Applied Biopharmaceutics and Pharmacokinetics by Shargel. Land YuABC, 2ndedition, Connecticut Appleton Century Crofts, 1985
4.Textbook of Biopharmaceutics and Pharmacokinetics, Dr. Shobha Rani R. Hiremath, PrismBook
5.Pharmacokinetics by Milo Gibaldi and D. Perrier, 2nd edition, Marcel Dekker Inc., New York,1982
6.Current Concepts in Pharmaceutical Sciences: Biopharmaceutics, Swarbrick. J, Leaand Febiger, Philadelphia, 1970

Nanobiotechnology

Course Objectives:

1. Recall the basics of nanotechnology
2. Explain potential applications of nanobiotechnology
3. Compare existing and new concepts, methodologies and research results and apply them in an academic or industrial research environment.
4. Gain a solid appreciation for the special significance of the word biomaterial as well as the rapid & exciting evolution & expansion of biomaterials science & its applications in medicine.

Expected Course Outcome:

1. Appraise students about basic concepts and theories of the subject
2. Demonstrate the applications of analytical techniques in examining nanostructures/ particles

3. illustrate the scope of biomacromolecules in nanotechnology
4. Explain the potential of nanotechnology in consumer applications and diagnostics
5. Create a necessary foundation for training in research
6. Infer the importance of risk assessment in the usage of nanostructures/particles in various applications

Unit 1 (10 lectures)

History and development of nanobiotechnology; Structure-property relationships. Self-assembly as in proteins, lipids, and nucleic acids; Polymeric nanoparticles; Inorganic nanoparticles- quantum dots, silica-based nanostructures; metallic nanoparticles like silver and gold; nanotubes, nanowires, and nanofibers.

Unit 2 (10 lectures)

Physical, Chemical, and Biological means of synthesis; Biomimetic approaches of production: case studies- ferritins, silica in diatoms, FeNPs in magnetosomes; Merits and demerits of bio- based approaches.

Unit 3 (10 lectures)

Optical techniques like UV-Vis and fluorescence spectroscopy; FTIR spectroscopy; electron microscopy (TEM and SEM); Atomic Force Microscopy, dynamic light scattering, zeta potential measurement, XRD (with emphasis on how these techniques to aid in characterizing nanoparticles). Strategies for chemical and biological functionalization;

Unit 4 (10 lectures)

Applications in tissue engineering & regenerative medicine. Nanoparticles as a reporter: metallic nanoparticles and quantum dots in rapid diagnostics tools; FRET and Molecular Beacons; SPR and SERS-based imaging. Routes of exposure; Fate of nanoparticles- short and long term; Cellular interaction; environmental safety; Risk assessment and regulatory mechanisms.

Suggested Practicals

Isolating RNA Sequences Capable of Binding to or Mediating the Formation of Inorganic Materials

Toxicity of Silica-Based Nanomaterials to Living Cells

Detecting Respiratory Syncytial Virus Using Nanoparticle-Amplified Immuno-PCR

Suggested Reading

1. Bhushan B (2010) Handbook of Nanotechnology, Springer-Verlag, Berlin, Heidelberg, Germany.
2. Xie Y (2012). The Nanobiotechnology Handbook CRC Press.
1. Eddy G and Poinern J (2014) A Laboratory Course in Nanoscience and Nanotechnology by CRC Press.

Metabolic Processes

Course Outcome:
Students will be taught the metabolic pathways of carbohydrate, amino acid, lipid and coenzymes and their regulation. At the end of the they will be able to distinguish between different metabolic processes and their impact in metabolism of biomolecules.

Unit I
Control of carbohydrate metabolism, Regulation of glycolysis, Krebs' cycle, glycogen breakdown and glycogen synthesis.

Unit II
Biosynthesis of lipids: biosynthesis of triglycerides, glycerophospholipids, cerebrosides, ether lipids glycolipids and phospholipids. Control of lipid metabolism.

Unit III
Biosynthesis of amino acids; biosynthesis of α-ketoglutarate, oxaloacetate, pyruvate family amino acids and the control of their synthesis.

Unit IV

Biosynthesis of amino acids; biosynthesis of ribose-5 phosphate, 3 -phosphoglycerate and phosphoenolpyruvate plus erythrose-4-phosphate family amino acids and the control of their synthesis. Biosynthesis of coenzymes; Coenzyme A, NAD and NADP, FMN and FAD.

Suggested Reading:

- Geoffrey L. Zubey, Biochemistry, Fourth Edition: Wm.C. Brown Publishers, 1998
- Biochemistry by Robert Roskoski. W.B. Saunders, Philadelphia, ISBN 0-7216-5174-7
- D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed.NewYork.
- Biochemistry 5th Revised edition by Lubert Stryer, Jeremy M. Berg, John L. Tymoczko (ISBN: 8601300395166)

Genetic Testing and Sequencing Technologies

Course Objectives and Learning Outcomes

1. The field of genetic testing is expanding and evolving at an incredible rate, thanks to our growing knowledge of genetic conditions, dropping costs, and higher demand.

2.This rapid expansion has dramatically changed how we diagnose and screen for genetic conditions, who we test, and how informative the results are.

3. Learning about the recent advances in genetic testing and sequencing technologies has important implications for anyone working in health care and related sectors.

4. This course offers a unique way for professionals to learn about genetic testing and its applications.

Unit 1

Overview of Genetic Testing and Sequencing Technologies: What is Genetic Testing?, The Promise of Genetic Testing and Sequencing Technologies

Unit 2

Clinical Genetic Testing: Overview of Genetic Testing, Traditional Cytogenetics, Microarray Diagnostics, Biochemical Genetic Tests, Diagnostic Genetic Testing, Reproductive Genetic Testing, Predictive Genetic Testing, Clinical Linkage: Prenatal Genetic Testing

Unit 3

Sequencing Technologies: Sequencing Approaches, Polymerase Chain Reaction, Sanger Sequencing, Sequencing by Synthesis, Raw Data Analysis, Variant Identification and Classification,Variant reporting Errors, Clinical Linkage: Diagnostic Genetic Testing

Unit 4

Emerging Areas in Genetic Testing and Analysis: Non-coding Variants, DNA Methylation Testing, Improving Variant Classification, Complex Trait Variants, Determining Risk in Complex Traits, Long Read Sequencing, Single Cell Sequencing, Progress Towards Patient Customized Healthcare, The Future of Genetic Testing and Sequencing Technologies

Suggested Practicals

- Isolate genomic DNA from plant of choice
- Amplify gene of interest using PCR

- Purify PCR product
- Ligation of PCR product into pJet1.2 plasmid
- Transform ligated plasmid into bacteria
- Culture bacteria and grow minipreps
- Purify plasmid from minipreps
- Analyze plasmid by restriction digestion
- Electrophorese restriction digest reaction
- Sequence plasmid and analyze sequence data

Suggested Readings

- Next Generation Genome Sequencing: Towards Personalized Medicine Editor(s): Dr. Michal Janitz First published: 17 September 2008 Print ISBN:9783527320905 |Online ISBN:9783527625130 |DOI:10.1002/9783527625130 Copyright © 2008 Wiley-VCH Verlag GmbH & Co. KGaA .
- Procedures and Applications of DNA Sequencing by Tom Lee (Editor) , Publisher : CALLISTO REFERENCE; Illustrated edition (January 15, 2015) ISBN-10 : 1632395177 ; ISBN-13 : 978-1632395177

Intellectual Property Rights

Course objectives and Outcomes:
Detailed knowledge of various forms of intellectual property right such as patent, copyrights, geographical indications, industrial design, trade mark etc, filing of patent application, infringement of patent rights is very important for MSc. Students of life sciences as intellectual property rights and technological innovation have played an important role in improving the economy of Nations.

Unit I:
IPR: Definition, Basic Concepts, Types, Innovation, Invention, Importance in modern era.

Unit II:
Patents: Infringement of Patent Rights, Rights of Patent Owner, importance of patents in modern era.

Unit III:
Trademark and Copyright: definition, basic concepts, Infringement, Registration.

Unit IV:
Industrial design, Semiconductor Integrated circuits Layout design:Definition, basic concepts, Infringement, Registration. Geographical Indications, plant variety protection act and trade secrets.

Suggested Reading:
- Indian Patent Law. Kalyan C Kankanala ; Arun K. Narasani ; Vinita Radhakrishnan.Oxford University Press, New Delhi.
- Fundamentals of Intellectual Property. Dr.Kalyan C.Kankanala.Asia Law House
- Universal's Guide to Patents Law. Manish Arora.Universal Law Publishing House
- IPR, Biosafety and Bioethics, Deepa Goel &Shomini Parashar. Pearson Publication

Onco-Immunology

Course objectives and learning outcomes

Learn how the immune system is being harnessed to improve cancer treatment. Understanding how immune cells recognize and kill cancer cells, and what we can do to enhance their ability to fight cancer

Unit 1

Overview of Immuno-oncology, What is Cancer? The Promise of Immuno-oncology

Unit 2

Basic Tumor Immunology: The Biology of Cancer, Immune Recognition, Induction of the Immune Response: CD8+ T Cells, Induction of the Immune Response: CD4+ T Cells, Immune Response of NK Cells, Immune Evasion: T Cells, Immune Evasion: Other Cells, Clinical Linkage: Tumor Immunology

Unit 3

Checkpoint Blockade: Mechanisms of Checkpoint Blockade, Response of Different Tumor Types, Complications of Checkpoint Blockade, Clinical Linkage: Checkpoint Blockade Therapy in Melanoma

Unit 4

CAR T and Other Novel Therapies: Basics of Chimeric Antigen Receptor (CAR) T Cells, Complications of CAR T Cell Therapy, Bispecific T Cell Engagers (BiTEs), Tumor Vaccines, Oncolytic Viruses, Advances in Checkpoint Blockade Therapy, Novel CAR Cells, Combination Treatments, Other Therapies, Clinical Linkage: CAR T Cell Therapy, The Future of Immuno-oncology.