LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (LOCF) FOR POSTGRADUATE PROGRAMMES

(with effect from 2022-23)

M.Sc. Biotechnology

Department of Plant Biology and Biotechnology

LOYOLA COLLEGE (AUTONOMOUS)

CHENNAI - 600 034

PREFACE

Biotechnology is the study of the application of biological systems for the benefit of all forms of life and the environment. Biotechnology delves into the cellular and subcellular level as well as process technology for large scale production of industrial products. It encompasses Microbiology, Plant and Animal Science using scientific principles and technology to solve challenges in all sectors – such as health and medicine, environment, agriculture and animal husbandry.

The learning outcomes-based curriculum framework (LOCF) for the M.Sc. Biotechnology programme is designed to equip students with clear objectives and outcomes to achieve theoretical knowledge and practical skills necessary to pursue a career in Biotechnology.

The M.Sc. Biotechnology course is designed with substantial laboratory-based papers to ensure students develop practical skills essential for a Biotechnologist. Students learn to apply their theoretical knowledge and gain practical expertise in all areas of Biotechnology, such as Cell and Molecular Biology, Microbiology and Fermentation, Plant and Animal Biotechnology.

The course includes a significant research project component during the final semester that provides students with an opportunity to hone their research skills. Students are given a platform to be innovative and integrate academic content with real world challenges for the betterment of life and society.

The course is structured for students to have sufficient choice to deepen their knowledge in a particular area of interest such as Nanotechnology and Oncology. Further, the course includes an internship at renowned institutes or industries that gives student industrial training.

The main objective of the M.Sc. Biotechnology curriculum is to develop students who would be able to recognize needs in society and meet societal needs by employing current techniques in Biotechnology.

The LOCF model is designed such that the curriculum, teaching pedagogy and assessment methods are in accordance with cogitative levels of the BLOOM's taxonomy thus catering to the development of a wide range of strengths and encourage students achieve the necessary outcomes.

CONTENTS

VISION AND MISSION OF LOYOLA COLLEGE

VISION

Towards holistic formation of youth, grounded in excellence, through accompaniment to serve the humanity.

MISSION

- To provide inclusive education through an integral and holistic formative pedagogy.
- To promote skills that prepare them for the future.
- To kindle in young minds the spirit of social and environmental justice with a blend of academic excellence and empathy.
- To stimulate critical and conscientious scholarship leading to meaningful and innovative human capital.

CORE VALUES

- *Cura Personalis*
- Pursuit of Excellence
- Moral Rectitude
- Social Equity
- Fostering solidarity
- Global Vision
- Spiritual Quotient

VISION AND MISSION OF
THE DEPARTMENT OF PLANT BIOLOGY AND BIOTECHNOLOGY

VISION

Developing students with sound knowledge in Plant Sciences and Biotechnology for effective utilization and management of biological resources towards sustainable development.

MISSION

Disseminating knowledge and imparting skills for employability, innovation in research and entrepreneurship in Plant Sciences and Biotechnology.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)
School of Life Sciences

PEO1	**Academic Excellence, Core Competency and Lifelong learning** To achieve academic excellence through teaching and research by building core competencies in the realm of Life Sciences for lifelong learning.
PEO 2	**Globally Relevant Curriculum, Learning Environment** To provide a conducive learning environment to the stakeholders and consistently innovate and upgrade the curriculum by employing modern instructional methodologies to make Life Sciences teaching and learning relevant to the global context.
PEO3	**Effective Communication, Teamwork and Leadership skills** To demonstrate team-building skills and leadership qualities for effective communication and collaboration through scientific research and publications and enhance the spirit of teamwork and leadership skills.
PEO4	**Environmental sustainability, social responsibility and solidarity** To instil values in environmental sustainability and social responsibility to become socially responsible scientists.
PEO5	**Technical and professional skills, Entrepreneurship and Empowerment** To equip students with technical and professional skills in Life Sciences to be empowered citizens through entrepreneurial ventures and contribute toward national priorities.
PEO6	**Equity, Equality, Gender sensitization and Scientific temperament** To create a campus culture that prepares the students with a strong scientific temperament who are proactive to the needs of the disadvantaged sections of society and demonstrate the principles of equity, equality, and gender sensitization.

PROGRAMME OUTCOMES (POs)
School of Life sciences

PO1	**Disciplinary knowledge** Students will apply the knowledge acquired in the subject domain and become skilled professionals with a competency that matches global standards.
PO2	**Communication Skills, Teamwork and leadership qualities** Students will be able to pursue research in Life Sciences and offer solutions to environmental issues and conservation strategies through scientific practices, communication, teamwork and exemplary leadership.
PO3	**Critical thinking, problem-solving and analytical reasoning** Students will demonstrate skills in analytical reasoning, problem-solving, scientific understanding, and reflective thinking in the frontiers of life sciences.
PO4	**Research-related skills and Scientific reasoning** Students will acquire skills for scientific research to update and expand the existing knowledge and make conceptual contributions to theoretical biology and create workable prototypes for applied biology.
PO5	**Skill development, entrepreneurship and lifelong learning** Students will be able to apply the skills learned during the study for lifelong learning to be an entrepreneur, academics or industrialist.
PO6	**Environment and ethical awareness** Students will be ethically grounded individuals who will understand and contextualize environmental and ethical issues and contribute toward the betterment of the environment to achieve sustainable growth.
PO7	**Digital literacy and self-directed learning** Students will engage in self-paced and self-directed lifelong learning through digital literacy for personal development, professional accomplishment and the welfare of society.

PROGRAMME SPECIFIC OUTCOME (PSOs)
M.Sc. Biotechnology

PSO 1	Students will have sound knowledge in the principles of Biotechnology and contribute to ethical scientific advancement and global sustainable development.
PSO 2	Students will demonstrate an understanding of the structure, function and networking of biologically important molecules and cellular processes to relate it to the interdisciplinary nature of Biotechnology.
PSO 3	Students will apply principles of Biological processes to understand the biology of diseases, defective metabolic pathways, genetic disorders and design / recommended methods for diagnosis and treatment.
PSO 4	Students will acquire technical skills, critically analyse challenging issues in the field of biotechnology and recognize the importance of bioethics and IPR.
PSO 5	Students will be able to design, execute and report results of scientific experiments and articulate cause – effect relationships both independently and collaboratively.
PSO 6	Students will demonstrate and uphold ethical principles in Science and Technology and contribute to social, health, safety and legal issues and practice his / her responsibilities as a Biotechnologist.
PSO 7	Students will be able to apply interdisciplinary aspects of Biotechnology in academia or industry.

Correlation Rubrics

High	Moderate	Low	No Correlation
3	2	1	0

Mapping of PEOs with Vision and Mission

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
Vision	3	3	3	3	3	3
Mission	3	3	3	3	3	3

Mapping of POs with PEOs

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PO1	3	2	3	3	3	2
PO2	3	3	3	3	3	2
PO3	3	3	3	3	3	3
PO4	3	3	3	3	3	3
PO5	3	3	3	3	3	3
PO6	3	3	2	3	3	2
PO7	3	3	3	3	3	3

Mapping of PSOs with PEOs

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PSO1	3	3	3	3	3	3
PSO2	3	3	3	3	3	2
PSO3	3	3	3	3	3	3
PSO4	3	3	3	3	3	3
PSO5	3	3	3	3	3	3
PSO6	3	3	3	3	3	3
PSO7	3	3	3	3	3	3

Mapping of PSOs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PSO1	3	3	3	3	3	3	3
PSO2	3	3	3	3	3	3	3
PSO3	3	3	3	3	3	3	3
PSO4	3	3	3	3	3	3	3
PSO5	3	3	3	3	3	3	3
PSO6	3	3	3	3	3	3	3
PSO7	3	3	3	3	3	3	3

M. Sc. Biotechnology Restructured LOCF curriculum effective from June 2022

PART	SEMESTER I	SEMESTER II	SEMESTER III	SEMESTER IV
MC	Cell Biology & Molecular Genetics (5c/5h)	Bioanalytical Techniques (4c/4h)	Plant Biotechnology (5c/5h)	
	Biomolecules and Metabolism (5c/5h)	Recombinant DNA Technology (4c/4h)	Animal Biotechnology (4c/4h)	
	Applied Microbiology (5c/5h)	Bioinformatics & Computational Biology (4c/4h)	Bioprocess and Enzyme Technology (4c/4h)	
	Immunology & Immunotechnology (5c/5h)	Research Methodology & Biostatistics (2c/3h)	**Lab - V** (Plant Biotechnology) (2c/3h)	
	Lab-I (CBM & Biomolecules) (4c/5h)	**Lab – III** (Bioanalytical & Rec. DNA) (2c/4h)	**Lab - VI** (Animal Biotech & Bioprocess & Enz Tech) (3c/4h)	
	Lab-II (Appl Micro & Imm & Imm. Tech) (4c/5h)	**Lab - IV** (RM, Biostat & Bioinfo, Comp Biol (2c/4h)		
ME		(2c/4h) *****	(2c/4h) *****	
ID			Principles of Food Processing (3c/6h)	
MO		(2c/2h) ##		
LS		(1c/2h) #		
SK			(1c/2h) #	
CD		(1c/3h)		
VA			(1c/2h) #	
SI		3 to 4 weeks (1c) #		
SL			(1c/2h) #	

PJ				Project (30h/20c)
C/Hr	**28C/30H**	**21C/30H** **+** **2C # +2C##**	**23C/30H** **+** **3C #**	**20C/30H**

MC – Major Core; **ME**-Major Elective; **ID**-Inter-Disciplinary; **MO**- MOOCS; **LS**- Life Skills; **SK**-Soft Skills; **CD**-Cross Disciplinary;
VA- Value Added; **SI**-Summer Internship; **SL**-Service Learning; **PJ**-Project

***** Two Courses offered from a pool of electives based on the student's choice # Outside Class Hours ##Additional Credits

LOYOLA COLLEGE (AUTONOMOUS), CHENNAI
DEPARTMENT OF PLANT BIOLOGY AND PLANT BIOTECHNOLOGY
OVERALL COURSE STRUCTURE
M.Sc. Biotechnology
(Effective from 2022 -2023)

Sem	Sub Cod	Course	T/L/P	Cat	Cr	Hrs
I	PBT1MC01	Cell Biology & Molecular Genetics	T	MC	5	5
I	PBT1MC02	Biomolecules and Metabolism	T	MC	5	5
I	PBT1MC03	Applied Microbiology	T	MC	5	5
I	PBT1MC04	Immunology & Immunotechnology	T	MC	5	5
I	PBT1MC05	**Lab-I** (CBM & Biomolecules)	L	MC	4	5
I	PBT1MC06	**Lab-II** (Applied Microbiology & Immunology & Immuno Tech.)	L	MC	4	5
II	PBT2MC01	Bioanalytical Techniques	T	MC	4	4
II	PBT2MC02	Recombinant DNA Technology	T	MC	4	4
II	PBT2MC03	Bioinformatics & Computational Biology	T	MC	4	4
II	PBT2MC04	Research Methodology & Biostatistics	T	MC	2	3
II	PBT2MC05	**Lab - III** (Bioanalytical Tech.& Recombinant DNA Tech.)	L	MC	2	4
II	PBT2MC06	**Lab - IV** (Research Methodology & Biostatistics and Bioinformatics & Computational Biology)	L	MC	2	4
II		Based on students' preference two courses will be offered	T	SE	2	4
II	PBT2MO01	MOOCS ##	T	MO	2	2
II	PBT2LS01	Life Skills #	T	LS	1	2
II		Cross Disciplinary from other schools	T	CD	1	3
II	PBT2SI01	Summer Internship (3 to 4 weeks) #	P	SI	1	-
III	PBT3MC01	Plant Biotechnology	T	MC	5	5
III	PBT3MC02	Animal Biotechnology	T	MC	4	4
III	PBT3MC03	Bioprocess & Enzyme Technology	T	MC	4	4
III	PBT3MC04	**Lab - V** (Plant Biotechnology)	L	MC	2	3
III	PBT3MC05	**Lab - VI** (Animal Biotech & Bioprocess)	L	MC	3	4
III		Based on students' preference two courses will be offered	T	SE	4	2
III	PBT3ID01	Principles of Food Processing	T	ID	3	6
III	PBT3SK01	Soft Skills #	T	SS	1	2
III	PBT3SL01	Service Learning (LEAP through outreach) #	T	SL	1	2

III	PBT3VA01	Value Added Course #	T	VA	1	2
IV	PBT4PJ01	Project	P	PJ	20	30

Major Elective (ME)

Sem	Sub Code	Course	T/L/P	Cat	Cr	Hrs
II	PBT2ME01	Cancer Biology	T	ME	2	4
II	PBT2ME02	Drug Discovery & Development	T	ME	2	4
II	PBT2ME03	Forensic Science	T	ME	2	4
II	PBT2ME04	Stem Cell Biology	T	ME	2	4
II	PBT2ME05	Public Health Management	T	ME	2	4
III	PBT3ME01	Developmental Biology	T	ME	2	4
III	PBT3ME02	Pharmaceutical Biotechnology	T	ME	2	4
III	PBT3ME03	Marine Biotechnology	T	ME	2	4
III	PBT3ME04	Environmental Biotechnology	T	ME	2	4
III	PBT3ME05	Nanobiotechnology	T	ME	2	4

Courses offered to other Departments

Sem	Sub Code	Course	T/L/P	Cat	Credits	Hrs
II	PBT2CD01	Biotechnology and Health	T	CD	2	3
III	PBT3VA01	Medicinal Plants and Society	T	VA	1	2

MC – Major Core; ME - Major Elective; ID - Inter-Disciplinary; MO - MOOCS; LS- Soft Skill; SK - Soft Skills; CD - Cross Disciplinary; VA - Value Added; SI-Summer Internship; SL-Service Learning; PJ-Project

#Outside Class Hours
Additional Credits

Course Code	PBT1MC01
Course Title	**CELL BIOLOGY AND MOLECULAR GENETICS**
Credits	5
Hours/Week	5
Category	Major Core (MC) – Theory
Semester	I
Regulation	2022

Course Overview

1. The focus of Cell Biology is the study of the structure, function and communication between cells.
2. The course focuses on Eukaryotic cell biology, covering topics such as membrane structure and composition, transport, and trafficking; the cytoskeleton and cell movement etc.
3. In addition to preparing the student for a diverse range of career paths, understanding cell biology and molecular genetics will help make sound decisions that benefit diet and health.
4. This course also covers genetics of prokaryotes, eukaryotes and viruses.
5. The molecular basis of replication, repair, recombination, and gene expression will also be covered.
6. The course aims at providing an introduction to principles of molecular genetics of prokaryotic and eukaryotic organisms.

Course Objectives

1. The objective of the course is learning and understanding the fundamentals of molecular biology and cellular signaling.
2. To sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules.
3. To understand the cellular components underlying mitotic cell division.
4. To apply knowledge of cell biology to selected examples of changes or losses in cell function.
5. To focus on fundamental molecular concepts and their implications on disease processes.
6. To impart thorough knowledge of the human genome and its structure and expression.
7. To be able to explain methods used in molecular genetics and research.

Prerequisites	Basic knowledge on Plant and Animal Sciences

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Dynamic Organization of Cell:** Evolution of life on earth - Universal features of cells; cell chemistry and biosynthesis. Cellular organization - compartmentalization – Homeostasis - Cell transport and trafficking - Posttranslational modification of proteins - Cytoskeleton - Dynamics of actin assembly - Myosin powered cell movements - Microtubules - Microfilaments and Intermediate filaments Molecules: Structure and Dynamics – Nuclear structure and dynamics - Transport mechanism in prokaryotic cells, entry of viruses and toxins into the cell - Cell division - Mitosis – Meiosis and regulation - Cell cycle - control of cell cycle and cell death - Cascade of phosphorylation and dephosphorylation associated with cell cycle progress - Kinases, cyclins and related proteins	**15**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Cellular Adhesion and Signaling Mechanisms:** Cellular adhesion and cell migration - Intercellular junctions – gap junctions. Plasma membrane receptors. Signaling mechanism in animals - JAK STAT pathway – Hedgehog signaling pathway – Wnt signaling pathway – TGF beta signaling pathway - Bacterial signaling systems - Bacterial chemotaxis and quorum sensing - Signaling in plants - Two component signaling pathway – Cell signaling in response to biotic stress.	**15**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**

III	**Protein Trafficking, Membrane structure and function:** Protein trafficking - Targeting proteins to endoplasmic reticulum, signal recognition particle, signal recognition particle receptor - Protein folding and processing in ER, protein export from ER, Protein sorting and export from Golgi apparatus - SNARE hypothesis; Protein import into Mitochondria, Import and sorting of chloroplast protein - Membrane Structure and Functions – Membrane Dynamics - Membrane Pumps -Membrane Carriers - Membrane Channels - Membrane Physiology.	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Overview of molecular genetics:** Nature, structure and organization of genetic material – Double helix structure – Chargaff's Rule Replication in Prokaryotes and Eukaryotes - Transcription - Translation – Protein biosynthesis Packaging of nucleic acids – Gene mutations – Molecular basis of mutation – Gene expression analysis - Molecular chaperone - DNA and Non -DNA Repair Mechanisms – Gene regulation in bacteria, viruses and eukaryotes RNA Editing - RNA Splicing - RNA Editing - Chromosome Walking - Chromosome Jumping/Hopping - Chromosome Landing	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Human Genetics, Epigenetics and Transmission Genetics:** Human Genetics Variation and Disease - Human Genetic Variability and its Consequences - Genetic Mapping of Mendelian Characters. Identifying Human Disease Genes - lod score for genetic disorders - Ethical, legal and social issues in Human genetics. Epigenetic Patterns and variations - DNA Methylation in Bacteria,	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	animals and plants. Mendelism down to molecular level - Principle of segregation – Mendelian Laws - morphological and molecular phenotypes. Segregation of single gene - Segregation of two or more genes – Gene Linkage and Crossing Over *Incomplete dominance and Epistasis.			

Text Books

1. Pollard, T.D., Earnshaw, W.C. and Lippincott-Schwartz, J. (2017). Cell Biology, 3rd Edition, Elsevier Publishers, Amsterdam, Netherlands.
2. Miglani, G.S. (2015). Essentials of Molecular Genetics, Alpha Science Int, Oxford Publishers Oxford, U.K.
3. Alberts, B., Bray, D., Hopkin, K., Lewis, J., Johnson A.D., Raff, M., Roberts, K., and Walter P, (2019). Essential Cell Biology. Norton W.W Publishers New York, U.S.
4. Watson, D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., and Losick, R. (2014). Molecular Biology of the Gene, 7th Edition, Pearson, London, U.K.
5. Strachan, T., and Read, A. (2018). Human Molecular Genetics 5th Edition, Garland Science, New York, U.S.

Suggested Readings

1. Becker, M.W, Kleinsmith L.J., and Hardin, J. (2007). The World of the Cell, 6th Edition, Tata McGraw Hill Publications, India
2. Karp, G. (1998). Cell and Molecular Biology, 2nd edition, John Wiley and Sons, Inc, New Jersey, U.S.
3. Lodish, H, Berk, A, Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Martin, K. (2016). Molecular Cell Biology, 8th Edition, Freeman and Company, New York.
4. Alberts, B., Johnson A.D.,Lewis, J., Raff, M.,Roberts, K. and Walter, P. (2002). Molecular Biology of the Cell. 4thEdition, Garland Science, New York, U.S.
5. Synder, L., Peters, J.E., Henkin, M. and Champness, W. (2013). Molecular Genetics of Bacteria, 4th Edition, ASM Press. U.S.
6. Plopper, G. (2016). Principles of Cell Biology.2nd edition. Jones and Barlett, U.S.

Web Resources

1. https://academic.oup.com/jmcb
2. https://www.nature.com/ncb/
3. https://www.cell.com/trends/cell-biology/homehttps://www.journals.elsevier.com/european-journal-of-cell-biology
4. https://sites.google.com/dhtepdy.edu.in/igcascellbiology/web-links

5. https://libguides.alfaisal.edu/BIO357/web/resources
6. www.springer.com

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Recollect the fundamentals of cell biology and basic structure of cell and knowledge on various diseases in humans	K1, K2
CO 2	Students get broader understanding of molecular genetics and to relate modern DNA technology for disease	K3
CO 3	Understanding of functions of cell organelles and to relate cell functions	K4
CO 4	Summarise cell movements, signaling mechanisms and how it regulates cellular functions	K5
CO 5	Describe protein trafficking, membrane structure and function	K6

C**ourse Code**	PBT1MC02
Course Title	**BIOMOLECULES AND METABOLISM**
Credits	5
Hours/Week	5
Category	Major Core (MC) – Theory
Semester	I
Regulation	2022

Course Overview

1. Biomolecules and metabolism deals with interactions of biological macromolecules.
2. This course aims at imparting knowledge on the classification of biomolecules.
3. Metabolisms like carbohydrates, proteins and fats are dealt with in detail.
4. This course highlights metabolic diseases and disorders related to biomolecules.
5. This course focuses on bioenergetics and biological oxidation processes.

Course Objectives

1. To focus on various biomolecules at structure and functional level.
2. To understand the metabolic pathways and their disorders.
3. To interpret molecular structure and interactions present in proteins, carbohydrates and lipids.
4. To distinguish between biochemical defects and metabolic disorders.
5. To understand the fundamental concept of energetics of biochemical processes.

Prerequisites	Basic knowledge in general Biochemistry

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Chemical basis of life:** Classification of carbohydrates - Monosaccharides, Disaccharides and Polysaccharides – structure and function Classification of amino acids and properties Classification of proteins- Primary, Secondary, Tertiary and Quaternary structure. Functions and biotechnological applications of proteins. Classification of lipids and fatty acids- Cholesterol and cell membranes. Nucleic acids – structure and synthesis	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Bioenergetics and Biological Oxidation:** Chemiosmotic theory, High energy compounds, ATP synthesis, Electron transport chain (ETC), Biological oxidation, Electron carriers. Endergonic and exergonic reactions, Phosphorylation - Mechanism of Oxidative phosphorylation, Principles of thermodynamics. Glycerol phosphate Shuttle, Malate aspartate Shuttle. Photosynthesis - Light and dark reactions	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Metabolism of biomolecules:** Carbohydrate metabolism - Glycolysis, Role of enzymes in glycolysis, Pyruvate metabolisms, Regulation of glycolysis, Citric acid cycle, Gluconeogenesis and energetics Amino acid metabolism - Transamination, Deamination, Metabolism of ammonia, Urea cycle, Biosynthesis of amino acids- Tyrosine, Phenylalanine synthesis. Fatty acid metabolism - Hormones role in	**17**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	the release of fatty Acids from adipose tissue Fatty acid oxidation - Oxidation-Energetics of fatty acid oxidation, Ketone bodies, Ketogenesis, Biosynthesis of fatty acids, Regulation of fatty acid synthesis			
IV	**Biomolecules and Disease:** Disorders of carbohydrate metabolism - Diabetes mellitus – Types and diagnosis, Biochemical aspects of *Diabetes mellitus* - GTT, assay of insulin, glycosylated haemoglobin. Glycogen storage diseases, galactosemia. Disorders of lipid metabolism - Sphingolipidosis, hypercholesterolemia and atherosclerosis. Lipoproteins and hyperlipoproteinemia, LCAT deficiency, gallstones, gout, tropical sprue. Disorders of amino acid-Disorders of tyrosine, phenylalanine, heme metabolism Disorders of protein and nucleic acid metabolism - Inborn errors of amino acid metabolism, rheumatoid factors, multiple myeloma. Disorders of blood - Blood Agranulocytosis, Thrombocytopenia, β Thalassemias, anemias, haemoglobinopathies, disorders of blood clotting mechanism	**18**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Hormones:** Mechanism of action and physiological effects. Nutrition and food assimilation, macronutrients and micronutrients, vitamins and trace elements. Chemistry and metabolism of purines and pyrimidines.	**10**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Chatterjea, M.N. and Ranashinde. (2005). Textbook of Medical Biochemistry, 6th edition. Jaypee Brothers Medical Publishers, India
2. David, L. N. and Michael, M. C. (2017). Lehninger Principles of Biochemistry, 7th edition, Freeman & Co, New York, U.S.
3. Donald, V., Judith, G. and Charlotte, W. P. (2016). Fundamentals of Biochemistry: Life at the Molecular Level", 5thedition, John Wiley & Sons, New York, U.S.
4. Jeremy, M.B., John, L.T., Gregory, J.G. and Lubert, S. (2015). Biochemistry, 8th edition, Mc Millan Publishers, New York, U.S.
5. Moran, L.A., Horton, R.A., Scrimgeour, G., Perry, M. and Rawn, D. (2013). Principles of Biochemistry, 5th edition, Pearson Education Ltd, London, U.K.

Suggested Readings

1. Champe, P.C. and Harvey, R.A. (2014). Lippincott's Illustrated Biochemistry. 6th edition. Williams and Winkins Publishers, Amsterdam, U.S.
2. David, B., Kathleen, M., Botham, and Robert M. (2012). Harpers Illustrated Biochemistry. 29th edition, McGraw-Hill Publishers, New York, U.S.
3. Garrett, R.H. andGrisham, C.M. (2012). Biochemistry, 5th edition. Brooks Cole, Utah, U.S.
4. Robert, A. and Horton. (2011). Principles of Biochemistry. 5th edition, Pearson Education, London, U.K.
5. Devlin, T.M. (2010). Textbook of Biochemistry with Clinical Correlations, 7thedition. Wiley Publishers, New Jersey, U.S.

Web Resources

1. https://www.elearning.panchakotmv.in/files/AD6F0DCD15865853992.pdf
2. http://homepage.ufp.pt/pedros/bq/integration.htm
3. https://www.uwyo.edu/molecbio/courses/molb-3610/files/3610%20chpts%201-2%20notes.pdf
4. https://www.webmd.com/a-to-z-guides/inherited-metabolic-disorder-types-and-treatments
5. https://opentextbc.ca/biology/chapter/2-3-biological-molecules/
6. https://nios.ac.in/media/documents/SrSec313NEW/313_Chemistry_Eng/313_Chemistry_Eng_Lesson29.pdf

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe the structure and functions of biomolecules	K1, K2
CO 2	Relate synthesis of biomolecules to metabolic pathways/regulation	K3, K4
CO 3	Explain and/or compare metabolic pathways/processes essential to life	K4
CO 4	Summarise the role of biomolecules in metabolic diseases and disorders	K5
CO 5	Compile information on metabolic disorders for the improvement of health	K6

Course Code	PBT1MC03
Course Title	**APPLIED MICROBIOLOGY**
Credits	5
Hours/Week	5
Category	Major Core (MC) – Theory
Semester	I
Regulation	2022

Course Overview

1. The course examines the principles of applied microbiology providing a perspective of the role of microorganisms for the benefit of humans and the environment.
2. The course gives an overview on the utilization and application of microbes.
3. It provides an understanding on the role of microbes in the environment and the modern tools for microbial ecologists.
4. To provide a comprehensive understanding on application oriented microbial concepts.

Course Objectives

1. To enhance the students' knowledge and impress upon them the important applications of microorganisms.
2. To understand the appropriate use of antimicrobial agents and common mechanisms of antimicrobial action and resistance.
3. To provide in depth information on soil microbial diversity and the role of microorganisms in biogeochemical cycling of elements like C, N, and P.
4. To acquaint the students with the role of microbes in the environment.
5. To inculcate a sense of scientific responsibility and social and environment awareness.

Prerequisites	Introductory knowledge of microorganisms

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Soil and Agricultural Microbiology:** Soil Ecology, Biological nitrogen inputs- Biological nitrogenfixation, free living and associative nitrogen fixing bacteria, phototrophic bacteria, symbiotic nitrogen fixing associations between legumes and rhizobia. Biological Cycling of inorganic nutrients and metals in soil and their role in soil biogeochemistry. Biofertilisers - Nitrogen-Fixing microorganisms as Biofertilisers, Phosphate solubilising microorganisms as Biofertilisers PGPB (Plant Growth Promoting Bacteria): Plant Growth Promoters. Biopesticides - Bio-weedicides, Bioinsecticides, Biofungicides. Biorational Pesticides of Microbial Origin - Bacterial Secondary Metabolites as Agrochemicals, Agroactive compounds from Actinomycetes, Fungal Secondary Metabolites as agrochemical	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Water and Air Microbiology:** Microbial flora of aquatic environments, Nutrients in aquatic environments, water pollution and waterborne diseases, water treatment, water quality assays. Diversity of microorganisms in air, outdoor and indoor microflora, airborne transmission of diseases, aeroallergens and aeroallergy Biofilms - Dynamics of bacterial biofilm formation, Genetic responses of bacteria	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	at surfaces, biochemical reactions and the establishment of gradients within biofilms, protection of bacterial biofilms from antimicrobial agents. Biofilms and inert surfaces – biofilm development in purified water systems, microbially influenced corrosion, microbial consortia in industrial wastewater treatment.			
III	**Environmental Microbiology:** Microbes in Biome: Extremophiles and its types, application of microbes from various ecological niches – Hydrothermal vent, unexplored forest soil and marine sediments. Culture-Dependent Analyses of Microbial Communities - Enrichment Culture Microbiology, Classical Procedures for Isolating Microbes, Selective Single-Cell Isolation: Laser Tweezers, Flow Cytometry. Culture-Independent Microscopic Analyses of Microbial Communities - General Staining Methods, Microscopic Specificity: Fluorescence In Situ Hybridization (FISH). Culture-Independent molecular analysis of Microbial Communities - PCR Methods of Microbial Community Analysis. Microbial Bioremediation - In Situ bioremediation by Microbes - Ex Situ bioremediation by Microbes	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Medical Microbiology:** Emerging and re-emerging infectious diseases and pathogens including X-MDR M. tuberculosis, MRSA, SARS virus, Bird flu, HIV, Dengue, Hemorrhagic Fever, Chlamydia and opportunistic fungal pathogens. Mechanisms of action of Antimicrobial	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	drugs - selective toxicity, inhibition of - cell wall synthesis,inhibitors of protein synthesis and nucleic acid synthesis, competitive inhibitors of essential metabolites. Resistance to antimicrobial drugs - Multidrug efflux pumps, extended spectrum β-lactamases (ESBL) and implications on public health. Anti-mycobacterial antibiotics, antifungal, antiviral, anti-protozoan drugs; effectiveness of chemotherapeutic agents, novel methods to combat increasing antimicrobial resistance			
V	**Recent Developments in Microbiology:** Development of nanomaterials for optical sensing of various human pathogens Progresses in the development of analytical methods for the analysis of microbial secondary metabolites. Utilization of LAMP for the diagnosis of viruses, bacteria, and allergens in food. Advances in mass spectrometry for microbial proteome analysis. Recent trends in using zebra fish as a model organism to assess probiotics influence on growth and development Metagenomics for bio prospective approach	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Ahmed, M. and Basumatary, S. (2019). Applied Microbiology,MJP Publishers, Chennai, India.
2. Eldor A Paul (2015). Soil Microbiology, Ecology and biochemistry, 4th edition, Elsevier USA.
3. Glazer, A.N. and Nikaido, H. (2007). Microbial Biotechnology: Fundamentals of Applied Microbiology, Cambridge University Press, Cambridge, United Kingdom.
4. Jan Dirk van Elsas, Jack T. Trevors, Alexandre Soares Rosado, Paolo Nannipieri (2021). Modern Soil Microbiology,3rd edition,CRC press,USA.
5. NadukaOkafor (2011). Environmental Microbiology of aquatic and waste system, Springer,USA.

6. Reidel, S., Morse, S. A., Mietzner, A. and Miller, S. (2019). Jawetz,Melnick,Adelberg's Medical Microbiology, Twenty Eighth Edition, Mc Graw Hill, New York, United States.

Suggested Readings

1. Cowan, M.K. (2017). Microbiology A systems approach. Mc Graw-Hill, New York, United States.
2. Hurst, C.J., Crawford, R.L., Knudsen, G.R., Mc Inerney, M.J. and Stetzenbach, L.D. (2002). Manual of Environmental Microbiology, Second Edition, ASM Press, Washington DC, United States.
3. Madigan, M.T., Martinko, J.M., Dunlap, P.V. and Clark, D.P. (2008). Brock Biology of Microorganisms, Twelfth Edition, Benjamin Cummings, San Francisco, United States.
4. Mc Feters, G.A. (2013) Drinking Water Microbiology: Progress and Recent Developments, Springer, Berlin, Germany.
5. Rittman, B. and McCarty, P. (2000). Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, New York, United States.
6. Stanier, R., Ingraham, J, Wheelis, M. and Painter, P. (2005).General Microbiology, Palgrave Macmillan, London, United Kingdom.
7. Tortora, G.J., Funke, B.R. and Case, C.L., Weber, D. (2019). Microbiology: An Introduction, Thirteenth Edition, Pearson, London, United Kingdom.
8. Viswanath, B. (2020). Recent Developments in Applied Microbiology and Biochemistry, First Edition. Academic Press, Cambridge, United Kingdom

Web Resources

1. https://asm.org/
2. http://www.protocol-online.org/forums/forum/4-microbiology/
3. https://bmcmicrobiol.biomedcentral.com/
4. https://www.feedspot.com/infiniterss.php?_src=feed_title&followfeedid=5264398&q=site:https%3A%2F%2Fmicrobenotes.com%2Ffeed%2F
5. http://www.sfam.org.uk/en/journals/microbial-
6. https://www.ncbi.nlm.nih.gov/pubmed/10631778

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Understand the role of microbes in the environment and humans	K1, K2
CO 2	Explain the various kinds of positive and negative interactions of different microbes	K3, K4
CO 3	Relate the importance and applications of microbes	K4
CO 4	Compile methods of analysis of microbes	K5
CO 5	Comprehend knowledge of the activity of microorganisms for applications in biotechnology	K6

Course Code	PBT1MC04
Course Title	**IMMUNOLOGY AND IMMUNOTECHNOLOGY**
Credits	05
Hours/Week	05
Category	Major Core (MC) – Theory
Semester	I
Regulation	2022

Course Overview

1. Immunology and Immunotechnology deals with the immune system and techniques used in immunodiagnostics.
2. This course aims at imparting knowledge in immunogenetics, immunity and application of biotechnology in clinical therapeutics and diagnostics.
3. The cells and organs of the immune system is studied.
4. This course also covers disorders of the immune system.
5. This course also highlights the importance of the immune system and the role of biotechnology in the prevention, diagnosis and treatment of disease.

Course Objectives

1. To understand the scope and function of the immune system.
2. To describe the role and function of the cells of the immune system.
3. To relate immunogenetics to health and disease.
4. To understand the disorders of the immune system.
5. To gain knowledge in vaccine technology, hybridoma technology and current immuno techniques.
6. To apply immunotechnology in clinical applications.

Prerequisites	Basic knowledge in Biology and Genetics.

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**The Immune System and Immunity:** Defence mechanisms of the human body – physical and chemical barriers, non-specific and specific mechanisms. Cellsof the immune system – Haematopoiesis Innate immunity, the Complement System; Adaptive Immunity – T-cells and B-cells Organs of the immune system- primary and secondary lymphoid organs.	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Immunogenetics:** Multigene organization of immunoglobulin genes; Genetic basis of antibody diversity; Immunoglobulins- structure, classes & subclasses of immunoglobulins, primary and secondary response; Nature and biology of antigens and superantigens: haptens, adjuvants, carriers, epitopes; Major histocompatibility complex - MHC genes, Antigen processing and presentation	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Immune system disorders:** Allergy and hypersensitivity, Autoimmunity – organ specific (Type 1 diabetes and myasthenia gravis) and systemic (Systemic lupus erythematosus, Rheumatoid arthritis) Immunodeficiency disorders – Primary (ADA and SCID) and Secondary (AIDS), Transplantation - Process of graft acceptance and rejection; HLA typing, Immunosuppressive therapy	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Immunization and Vaccine Technology:** History of vaccines, Vaccine ingredients and administration, Active immunity, Passive immunity, Herd immunity and its significance.	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	Vaccine technology - Types of vaccines – inactivated vaccine, live attenuated vaccine, mRNA vaccines, Subunit, recombinant, polysaccharide, and conjugate vaccines, toxoid and viral vector vaccines. COVID and Ebola vaccines - types and challenges. Vaccine safety and emerging technologies in vaccine development			
V	**Immunotechnology in clinical applications:** Immunotechniques - Particle methods – Agglutination, Immunoprecipitation Immunoelectrophoresis, Immunoturbidimetry; Label methods – Radioimmunoassay, Enzyme-linked immunosorbent assay, immunoblotting, immunofluorescence; Surface Plasmon resonance and biosensor assays for ligand receptor interaction, Current methods of cancer immunotherapy – CAR T-cell technology; Monoclonal antibodies - Hybridoma technology and application, Catalytic and recombinant antibodies	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Abbas, A. K., Lichtman, A. H. and Pillai, S. (2019). Basic Immunology: Functions and Disorders of the Immune System, Sixth Edition, Elsevier, India.
2. Martin, S. J., Burton, D. R., Roitt, M. and Delver, P. J. (2017). Roitt's Essential Immunology, Thirteenth Edition. Wiley-Blackwell, New Jersey.
3. Punt, J., Stranford, S., Jones, P and Owen, J. A. (2018). Kuby Immunology, Ninth Edition. WH Freeman, New York.
4. Sompayrac, L. M. (2019). How the Immune System Works, Sixth Edition Wiley-Blackwell, New Jersey, USA.
5. Weyand, C. M., Corry, D. B., Schroeder, H. W., Puck, J. M., Rich, R. R., Fleisher, T. A. (2022). Clinical Immunology Principles and Practice, Elsevier Health Sciences, Amsterdam, Netherlands.

Suggested Readings

1. Abbas, A. K., Lichtman, A. H. and Pillai, S. (2021). Cellular and Molecular

Immunology, Tenth Edition. Elsevier, Amsterdam, Netherlands.
2. Doan, T., Melvold, R., Viselli, S., Waltenbaugh, C. (2012). Lippincott's Illustrated Reviews Immunology, Wolters Kluwer Pvt. Ltd, India.
3. Goering, R., Dockrell, H., Zuckerman, M. and Chiodini, P. (2018). Mims Medical Microbiology and Immunology, Sixth Edition. Elsevier, Amsterdam, Netherlands.
4. Gupta, S. K. (2017). Essentials of Immunology, Arya Publications, India
5. Murphy, K. and Weaver, C. (2022).Janeway's Immunobiology, Tenth Edition, Garland Science, New York.
6. Razaei, N. (2020). Cancer Immunology: Bench to Bedside Immunotherapy of Cancers, Springer, Berlin, Germany.
7. Todd, I., Spickett, G. and Fairclough, L. (2016).Immunology, Seventh Edition. Wiley-Blackwell, New Jersey.

Web Resources

1. https://www.frontiersin.org/articles/10.3389/fimmu.2020.583077/full
2. https://thehill.com/changing-america/well-being/prevention-cures/501677-what-is-sterilizing-immunity-and-do-we-need-it
3. https://www.historyofvaccines.org/activities
4. https://www.medicine.mcgill.ca/physio/vlab/immun/vlabmenuimmun.htm
5. https://www.hhs.gov/immunization/index.html
6. https://www.hopkinsmedicine.org/health/conditions-and-diseases/the-immune-system
7. https://www.immunology.org/public-information/bitesized-immunology

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe the role of the immune system in the context of medical development and human welfare	K1, K2
CO 2	Relate the principles of immunology to disease susceptibility and clinical applications	K3
CO 3	Compare processes/methods in immunology immunotechnology	K4
CO 4	Assess challenges in the field of immunology and recommend solutions using biotechnology	K5
CO 5	Integrate biotechnological methods for the prevention, diagnosis and treatment of disease	K6

Course Code	PBT1MC05
Course Title	**LAB I - Cell Biology & Molecular Genetics and Biomolecules & Metabolism**
Credits	4
Hours/Week	5
Category	Major Core (MC) – Practical
Semester	I
Regulation	2022

Course Overview

1. The course aims to consolidate and extend basic knowledge on cells interaction and differentiation.
2. To help the learners to perform biochemical assays and procedures by exposing them to many analytical and separation techniques in biochemistry.
3. The course makes them well equipped for jobs in research and development.
4. Introduces the students to topics like yeast and bacterial DNA isolation, bacterial transformation.

Course Objectives

1. To prepare stains, buffers, standard solutions for various biochemical assays.
2. To separate pigments and amino acids from a mixture of samples using chromatographic techniques
3. To understand the principle of cell division.
4. To gain knowledge in gene cloning and screening of transformants.
5. To equip the students for industrial jobs.

Prerequisites	Basic knowledge in Biology and Biochemistry

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Periodic Acid Schiff (PAS) Reaction Methyl-Green Pyronin Y staining of DNA Feulgen staining method for DNA Isolation of mitochondria Assay for succinate dehydrogenase Cytochrome C oxidase manometric analysis Isolation of chloroplasts	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	Isolation of Barr bodies from buccal smear Mitosis using onion root tips Meiosis in grasshopper testis Sectioning of plant stem for observation of different cell types Isolation of yeast genomic DNA	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	Buffers and buffering capacity – pKa of conjugate acids and bases TLC of amino acids/ sugars Qualitative analysis of Carbohydrate Determination of total carbohydrate by Anthrone method	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	Protein estimation by Bradford Method SDS-PAGE Extraction and enzyme kinetics of Acid phosphatase from potato tubers	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	Effect of pH on Acid Phosphatase Estimation of total free amino acids Qualitative analysis of amino acid	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Hall, J.E. (2016). Guyton and Hall Textbook of Medical Physiology, Elsevier Publishers, Amsterdam, Netherlands.
2. Lodish, H., Berk, A., Kaiser, C. A.,Krieger, M., Bretscher, A., Ploegh, H., Amon, A.

and Scott, M. P. (2013). Molecular Cell Biology, Seventh Edition, Freeman and Company, New York, United States.
3. Palanivelu, P. (2004). Laboratory Manual for Analytical Biochemistry Separation Technique. 3rd Edition. Twenty First Century Publications, Punjab, India.
4. Rajendiran, S., Dhima, P. (2019). Biochemistry Practical Manual, Elsevier, India.
5. Sadasivam, S. and Manickam, A. (1996). Biochemical Methods. Wiley Eastern Limited, India.

Suggested Readings

1. Furnis, B. S., Hannaford, A. J., Smith, P.W.G., and Tatchell, A.R. (2005). Vogel's Textbook of Practical Organic Chemistry. Pearson India.
2. Geetha, K. (2016). Practical Biochemistry.Second Edition, Jaypee Brothers Medical Publishers, Chennai, India.
3. Gerstein, A. (2007). Molecular Biology Problem Solver: A Laboratory Guide. 1st Edition.Wiley Publishers, New York, United States.
4. Haynes, B. (1966). Organic Qualitative Analysis, Second Edition, Palgrave Publishers, London, United Kingdom.
5. Jayaraman, J. (1981). Laboratory Manual in Biochemistry. 1st Edition. New Age International Ltd. Publisher, Chennai, India.

Web Resources

1. https://vlab.amrita.edu/?sub=3&brch=63
2. https://www.academia.edu/4312334/Virtual_Laboratories_in_Chemistry_Biochemistry_and_Molecular_Biology
3. https://sjce.ac.in/wp-content/uploads/2018/04/Cell-Biology-Genetics-Laboratory-Manual-17-18.pdf
4. https://www.deanza.edu/faculty/heyerbruce/b6b_pdf/Bio6B-Manual_W19.pdf
5. https://webstor.srmist.edu.in/web_assets/downloads/2021/20BTC501J-lab-manual.pdf
6. http://isca.co.in/BIO_SCI/lab_manual/IeP-BS-LM-2013-003.pdf
7. https://kau.in/sites/default/files/documents/prsvkm_laboratory_manual_of_biochemistry.pdf
8. https://ttk.elte.hu/dstore/document/871/book.pdf
9. http://14.139.51.37/centrallibrary/admin/book/EXP_BIO_CHEM.pdf

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Practical knowledge of preparation of buffers	K1, K2
CO 2	Ability to relate various interrelated physiological and metabolic events	K3
CO 3	Test the skill in different biochemical techniques	K4
CO 4	Apply basic principles of chemistry to biological systems and molecular biology	K5
CO 5	Explain and interpret DNA staining techniques, chloroplast isolation and anatomical studies in living organisms	K6

Course Code	PBT1MC06
Course Title	**LAB II – (APPLIED MICROBIOLOGY AND IMMUNOLOGY & IMMUNOTECHNOLOGY)**
Credits	4
Hours/Week	5
Category	Major Core (MC) – Lab
Semester	I
Regulation	2022

Course Overview

1. The course enables students to develop skills in isolation and identification of microorganisms.
2. It helps students to study the characteristics of microorganisms.
3. The course provides hands-on experience in experimental and diagnostics tests in Immunology.
4. It provides skill training in experimental design to understand principles in Immunology.

Course Objectives

1. To demonstrate proficiency and use of the isolation techniques.
2. Bacterial staining techniques; wet mounts; and proper culture handling.
3. Understand and explain environmental factors that influence microbes.
4. To develop practical skills necessary to understand immunological concepts.
5. To perform, analyses, interpret and discuss results using immunological techniques.

Prerequisites	Basic knowledge in Microbiology and Immunology

SYLLABUS

Unit	Content	Hours	COs	Cognitive level
I	Isolation & purification of microbial cultures Bacterial Staining methods - simple, Gram's, acid fast, flagella, capsule and spore. Fungal Staining methods - Lacto-phenol cotton blue. Motility of bacteria.	**13**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	Biochemical characterization of microorganisms Extracellular enzymatic activities of microorganisms Isolation of antibiotic producing microorganisms Determination of antimicrobial spectrum of isolate			
II	Isolation of *Rhizobium* from legume root nodule Isolation of *Azotobacter* from soil Isolation of *Azospirillum* from roots Isolation of Blue Green Algae	**13**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	Determination of growth - growth curve Estimation of growth - membranefilter. Screening and isolation of Pesticide degrading microorganisms from soil. Preparation of blood smear and Giemsa staining Isolation of lymphocytes, Differential count of lymphocytes ABO Blood Grouping and Rh typing by haemagglutination test	**13**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	Purification of Immunoglobulins Single Radial Immunodiffusion Ouchterlony Double Diffusion Rocket Immunoelectrophoresis	**13**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	Detection of Rheumatoid Factor Widal Test – slide Latex Agglutination Test for *Streptococci* Dot/Competitive ELISA HBs Antigen detection using a commercial kit	**13**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Aneja, K. R. (2005). Experiments in Microbiology, Plant Pathology and Biotechnology. Fourth Edition, New Age International Publishers, Chennai, India.
2. Cappuccino, J. G., and Sherman, N. (2004). Microbiology: A Laboratory Manual, 6th Ed. Pearson Education, London, United Kingdom.
3. Kannan, N. (2003). Handbook of Laboratory Culture Media, Reagents, Stains and Buffers. Panima Publishing Corporation, New Delhi.
4. Rajan, S. and Christy, S. (2011). Experimental procedures in Life Sciences. Anjana Book House, Bhubaneswar, India.

5. Sam-Yellowe, T. (2021). Immunology: Overview and Laboratory Manual, Springer, Berlin, Germany.

Suggested Readings

1. Benson, H. J. (1998). Microbiological Applications - Laboratory Manual in General Microbiology, Seventh Edition, McGraw Hill, New York, United States.
2. Dubey, R.C. and Maheswari, D. K. (2004). Practical Microbiology 1st edition, S. Chand & Company Ltd., New Delhi.
3. Hay, F. C. and Westwood, O.M. R. (2008). Practical Immunology, Wiley-Blackwell, New York, United States.
4. Kannan, N. (1996). Laboratory Manual in General Microbiology, 1st edition, Palani Paramount Publications, Chennai, India.
5. Lefkovitz, I (1996). Immunology Methods Manual: The Comprehensive Sourcebook of Techniques: 003 (Immunology Methods Manuals), Academic Press, Cambridge, United Kingdom.
6. Speshock, J. (2017). Immunology Lab Manual, Kendall Hunt Publishing, Iowa, United States.

Web Resources

1. https://vlab.amrita.edu/?sub=3&brch=73
2. https://mvi-au.vlabs.ac.in/
3. https://learn.chm.msu.edu/vibl/
4. https://www.medicine.mcgill.ca/physio/vlab/immun/vlabmenuimmun.htm
5. https://www.immunology.org/public-information/bitesized-immunology
6. https://www.sigmaaldrich.com/US/en/applications/research-disease-areas/immunology-research

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Identification and description of concepts in Microbiology/Immunology	K1, K2
CO 2	Demonstrate experimental skills in Microbiology/Immunology	K3
CO 3	Perform experiments and analyse data from experiments related to Microbiology/Immunology	K4
CO 4	Recommend appropriate methods related to Microbiology/Immunology	K5
CO 5	Design and/or assess microbiological/immunological tests	K6

Course Code	PBT2MC01
Course Title	**BIOANALYTICAL TECHNIQUES**
Credits	4
Hours/Week	4
Category	Major Core (MC) – Theory
Semester	II
Regulation	2022

Course Overview

1. This course is designed to introduce fundamental principles of bioinstrumentation commonly used in biological sciences and biotechnology.
2. The course begins with basic bioanalytical techniques like preparation of plant and animal tissues and microscopy.
3. The curriculum for this course has been designed with special emphasis on working of instruments.
4. This course also gives an introduction to the principles and methods of analytical technique as they relate to quantitative measures of determination.
5. This course contains bioanalytical techniques along with their theory, working principle, common instrumentation and possible applications.

Course Objectives

1. The primary objective of this course is to develop the skills to understand the theory and practice of bioanalytical techniques.
2. To provide scientific understanding of analytical techniques and detailed interpretation.
3. To expose the students to various biological techniques and their applications in identification, isolation of different biological molecules.
4. To help students to gain knowledge in analytical instruments like HPLC, GC, FRET, MALDI-TOF and NMR etc.
5. To implement and understand the use of these techniques in biological research and in discovering new products/compounds.
6. To gain knowledge in advanced techniques like X- ray crystallography and radioisotope techniques.

Prerequisites	Basic knowledge in Physics, Chemistry and Biology

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Tissue preparation, Microscopy and Cell Membrane Techniques:** Plant and animal tissue preparation – Histological tissue preparation and types – Microtomy and types – Microtome knives – Paraffin method of sectioning - Properties of good fixative – Types of fixative – Physical methods of fixation – Chemical methods of fixation – Factors affecting quality of fixation – Tissue processing (Basic principle and steps) – Commonly used staining solutions - Microscopy in Biotechnology – principle, sample preparation, working and applications: Optical microscopy - Atomic Force Microscopy - Scanning Tunneling Microscopy - Transmission electron microscopy and Scanning electron microscopy - Advanced fluorescence techniques (FRET)	**12**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Centrifugation, Electrophoretic Techniques and Biosensors:** Principle of Centrifugation - Principles of Sedimentation, Working and Types of Centrifuges - Sample Preparation for Centrifuge - differential - rate-zonal, isopycnic and density gradient centrifugation - Safe handling of the centrifuge – imbalance – causes and prevention - Analytical ultracentrifuge - Fractionation and Analysis of macromolecules and macromolecular complexes - Rate-zonal (sedimentation-velocity) banding of proteins and ribonucleoproteins - Viruses. Plasma lipoproteins - Application of centrifugation - Agarose gel electrophoresis - Polyacrylamide gel electrophoresis - Rocket immunoelectrophoresis – Pulsed field electrophoresis - Isoelectric focussing –	**12**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**

	2D electrophoresis – Biosensors - Microbial biosensors, Fibre optical biosensors and Piezoelectric sensors			
III	**Chromatography:** Principle - Types of chromatography - Sample Preparation -Protein Precipitation - Principle, working and applications: Paper and thin layerchromatography, and Column chromatography – 2D liquid chromatography - High-Performance Liquid Chromatography (HPLC) - Solvent Delivery System - Mass Spectrometric Detection – Derivatization of HPLC - Gas Chromatography - Principles of GC – Instrumentation - GC-MS and LCMS - Ion exchange chromatography – Molecular size exclusion chromatography – Affinity chromatography	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
IV	**Spectroscopy Techniques:** Study of biomolecules using Electromagnetic radiation – wave properties, particle properties, electromagnetic spectrum – Absorption Laws – Beer's Law – Lambert's Law - Principles, instrumentation, sampling and application of Infrared Spectroscopy - Colorimeter and Photoelectric colorimeter - UV Spectroscopy - Fluorescence spectroscopy – NMR Spectroscopy - Raman Spectroscopy- Electron Spin Resonance - Atomic Absorption Spectroscopy - instrumentation and application - Mass spectrometry-ESI and MALDI-TOF - FTIR and Orbitrap - Fragmentation of peptides	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
V	**X-Ray Crystallography and Radioisotope techniques:** Protein crystallization, solving the structure of crystal applications of X-ray crystallography - X-ray crystallography and single-particle cryo-electron microscopy – determination of structure of biomolecules - Properties of atomic nuclei – Nuclear terminologies- Systematics of nuclei – Radioactivity – Nature of β and γ radiations - Radiation dosimetry - Instrumentation and operation of G.M counter and	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

	Liquid scintillation counter – Radioimmunoassay (RIA) - Radioactive isotopes of importance in biotechnology- Radioisotopes in hydrobiology - Radioisotopes in Agriculture – Radioisotopes in environmental studies- Autoradiography			

Text Books

1. Gauglitz, G. and Moore, D.S. (2014). Handbook of Spectroscopy, 2nd edition, Wiley Publishers, New York, United Sates.
2. Hübschmann.H.J. (2015). Handbook of GC-MS: Fundamentals and Applications. 3rd edition. Wiley Publishers, New York, United Sates.
3. Lottspeich, F. and Engels, J. W. (2018). Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley Publishers, New York, United Sates.
4. Shourie, A. and Chapadgaonkar, S.S. (2015) Bioanalytical Techniques. TERI Press, New Delhi, India.
5. Reed, R., Holmes, D., Weyers, J. and Jones, A. (2016). Practical Skills in Bimolecular Sciences. 5th edition. Pearson Publishers, London, United Kingdom.

Suggested Readings

1. Hammes, G.G. (2005). Spectroscopy for the Biological Sciences. Wiley Publishers, New York, United States.
2. Majors, R.E. (2013). Sample Preparation Fundamental for Chromatography, Agilent Technologies, California, United States.
3. Ramesh, V. (2019). Biomolecular and Bioanalytical Techniques. Wiley Publishers, New York, United States.
4. Srivatsava, M.L. (2008). Bioanalytical Techniques, Narosa Publication, New Delhi, India.
5. Wilson, K. and Walker, J. (2018). Principles and techniques of Practical Biochemistry. Eighth Edition. Cambridge University Press, Cambridge, United Kingdom

Web Resources

1. https://www.microscopyu.com/
2. https://www.nature.com/articles/nmeth.3700
3. https://www.sigmaaldrich.com/IN/en/technical-documents/technical-article/protein-biology/protein-pulldown/centrifugation-separations
4. https://www.agilent.com/

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Understanding basic principles of instrumentation techniques used in biotechnology	K1, K2
CO 2	Apply the theoretical principles of various analytical techniques and methods in biotechnology industries	K3
CO 3	Compare and contrast the strengths, limitations and use of techniques for problem-solving	K4
CO 4	Develop methods for separation of various biomolecules	K5
CO 5	Explain the working and applications of techniques used in the field of biotechnology	K6

Course Code	PBT2MC02
Course Title	**RECOMBINANT DNA TECHNOLOGY**
Credits	4
Hours/Week	4
Category	Major Core (MC) – Theory
Semester	II
Regulation	2022

Course Overview

1. Recombinant DNA technology deals with genetic tools, cloning strategies, isolation, and screening techniques.
2. This course conceptualizes properties and applications of versatile DNA modifying enzymes, vector types, host genotype specificities for selection and screening of recombinant clones.
3. DNA sequencing and analysis is dealt with in detail.
4. This course also provides knowledge on screening of recombinants in detail.
5. Topics in bioethics deals with social responsibility, regulatory framework, and the release of modified organisms into the environment.
6. The importance of Gene therapy for ADA and cystic fibrosis is also dealt with.
7. This course also highlights the biotechnological applications in medical, forensic and therapeutic products.

Course Objectives

1. To illustrate creative use of modern tools and techniques for manipulation and analysis of genomic sequences.
2. To understand and explain the concept of genetic engineering including the techniques, applications and limitations.
3. To understand the safety concerns in biotechnological applications.
4. To gain knowledge in research methodologies employing genetic engineering techniques.
5. To apply recombinant DNA technology in biotechnological research.

Prerequisites	Basic knowledge in Molecular Biology

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Genetic Engineering Tools:** History of genetic engineering, vectors used in genetic engineering of microbes, plants and animals DNA modifying enzymes- Restriction enzymes, DNA Polymerases, Reverse Transcriptase, Terminal Transferases, T4 Polynucleotide kinases and Alkaline phosphatase, DNA dependent RNA polymerases, DNA ligases Nucleases: - Bal 31, S1 nucleases, DNase I, Mungbean nucleases, Ribonucleases, EXO III. PCR: optimization of PCR, gene specific and degenerate primer design, automated DNA sequencing, pyrosequencing, high throughput sequencing	12	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Construction of Gene Libraries:** Cloning strategies - DNA cloning - Sticky ends, Blunt ends, Homopolymeric tailing, Use of adapters and linkers Construction of cDNA library, PCR based cDNA library, subtractive cDNA library, normalized cDNA library, genomic DNA library, BAC library and YAC library Screening of recombinants: Antibiotic resistance, lacZ complementation (Blue-white selection), fluorescent markers (e.g., GFP). Preparation of radiolabelled/non-radiolabelled DNA and RNA probes Southern/Northern blot and Zoo/garden blot Screening of genomic libraries with oligo-probe	12	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Gene and Promoter Isolation:** Screening the library by using probes, cloning of genes by PCR (gene specific and degenerate primers), nested PCR, 5' and 3' RACE-PCR, inverse PCR, hybrid PCR, TAIL PCR, differential display, positional cloning Promoter identification - promoter isolation by	12	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	screening, promoter isolation by PCR, promoter deletion studies DNA sequencing- Principle of chemical and enzymatic methods. Automated DNA sequencing, high throughput Pyrosequencing, next generation sequencing, Real-Time DNA sequencing			
IV	**Biotechnological Applications:** Synthesis and purification of proteins from cloned genes- Native and fusion proteins Therapeutic products for use in human health care- insulin, growth hormones, Hepatitis B vaccine and Factor VIII Treatment using rDNA technology- gene therapy. Gene therapy for ADA and cystic fibrosis Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy	12	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Transgenics and Bioethics:** Gene replacement; gene targeting; creation of transgenic. Ethical issues in genetic engineering, patenting genes, cloning, genetic testing and screening Biotechnology and social responsibility; legal and socio-economic impact of Biotechnology Biosafety regulatory framework for GMOs Use of genetically modified organisms and their release into the environment. Cartagena Protocol on biosafety	12	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Brown, T.A. (2020). Gene Cloning and DNA Analysis: An Introduction, 8th Edition, Wiley-Blackwell, New York, United States.
2. Nicholl, D.S.T.(2008). An introduction to Genetic Engineering, 3rd edition, Cambridge University Press, United Kingdom.
3. Fleming, D. O. and Hunt, D.L. (2002). Biological safety Principles &Practices, 3rd edition, ASM Press, United States.
4. Lodge, J., Lund, P. and Minchin, S. (2006). Gene Cloning, Routledge, United

Kingdom.
5. Primrose, S.B. and Twyman, R.M. (2009). Principles of Gene Manipulation and Genomics, 7th edition, John Wiley, New York, United States.

Suggested Readings

1. Michal, J. (2011). Next-Generation Genome Sequencing. Wiley-Blackwell Publications. Germany.
2. Sambrook, J. and Russell, D.W. (2001). Molecular cloning: A Laboratory Manual, 3rd edition, Cold Spring Harbor, New York.
3. Monika, J. (2014). Recombinant DNA Techniques: A Text book, Narosa Publishers, India.
4. Sure, C. and Dominique, R. (2005). Manipulation and Expression of Recombinant DNA California, USA.
5. Thomas, J.A. and Fush, R.L. (2002). Biotechnology &Safety Assessment, Academic press, U.S.

Web Resources

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5178364/
2. https://iastate.pressbooks.pub/genagbiotech/chapter/recombinant-dna-technology/
3. https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinant-dna/
4. https://ncert.nic.in/textbook/pdf/lebo112.pdf
5. https://bio.libretexts.org/Bookshelves/Biochemistry/Supplemental_Modules_(Biochemistry)/
6. https://unacademy.com/lesson/tools-techniques-of-genetic-engineering-part-1/7F3JKIXR
7. http://www.heavenlyfuel.com/jbframework/uploads/2017/06/Molecular-Biotechnology.pdf

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe principles and techniques in recombinant DNA technology	K1, K2
CO 2	Discuss molecular tools and strategies employed in the field of biotechnology	K3
CO 3	Application of principles and methods of recombinant DNA technology in medical research	K4
CO 4	Conceptualization of molecular biology techniques in medical and forensic science	K5
CO 5	Summarize concepts/methods of rDNA technology upholding ethics and safety regulations	K6

Course Code	PBT2MC03
Course Title	**BIOINFORMATICS AND COMPUTATIONAL BIOLOGY**
Credits	4
Hours/Week	4
Category	Major Core (MC) – Theory
Semester	II
Regulation	2022

Course Overview

1. Bioinformatics is the application of computational methods to biological data analysis and discovery.
2. This course aims at familiarizing students with the bioinformatics databases and their applications in Biotechnology.
3. Genomic mapping and phylogenetic data analysis are dealt with in detail.
4. This course also provides fundamental knowledge in biotechnology-based applications in medical databases.
5. Topics on expressed sequence tags, sequence alignment, and database searching are given importance.
6. This course also highlights Perl for bioinformatics and file handling.

Course Objectives

1. To gain knowledge in the basic concepts of bioinformatics and its significance in biological data analysis.
2. To understand the various techniques, algorithms and tools used for phylogenetic analysis.
3. To get exposed to computational methods, tools, and algorithms employed for biological data interpretation.
4. To distinguish between different types of biological databases.
5. To understand the basics of sequence alignment and analysis.
6. To gain knowledge on different types of proteins and other organism specific databases.
7. To know the concept of pairwise sequence alignment, algorithms and tools for pairwise alignment.

Prerequisites	Basic knowledge in Molecular Biology and Databases

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Databases and Biological databases:** Bioinformatics significance, Applications of bioinformatics.Uses of biological databases, Primary sequence databases, Nucleotide, Protein sequence database, Primary structure databases, PDB file format, Fasta, GCG, VFF Secondary databases: secondary sequence databases, secondary structure databases, SCOP, CATH Composite protein databases, metabolic databases, SNP databases Whole genome, Mendelian disease databases, chemical structure databases, and bibliographic databases	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Sequence alignment:** Global Pairwise Alignment Algorithm, Local Pairwise Alignment Algorithm Database searching- BLAST and FASTA Multiple Sequence Alignment - Progressive and Iterative Alignment, Tools for pairwise alignment and multiple sequence alignment Application of Multiple Sequence Alignment and Databases of Multiple Alignment. Molecular Phylogeny- Methods of phylogeny, types of trees, Tools for phylogeny, PAM and BLOSUM	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Motifs and Patterns prediction**: Databases for motif prediction, Databases for patterns and blocks. Secondary Database Searching, Secondary structure prediction, Tools for secondary structure prediction Tertiary structure prediction, Comparative modelling, Abinitio modelling. Validation of tertiary structure - tools for homology modelling, tools for structure validation. Structure visualization tools, rasmol. Chemical structure building tools, file formats for small molecules, file format conversion tools	**14**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

IV	**Python and text editors:** String data type, Tuples data type, Lists data type, Flow control: If else, For loop, While loop, Reading and Writing files Modules in Python, Functions, Regular expressions: Syntax, Regex examples, Biopython. Advantages of python in bioinformatics, Components of biopython: Alphabet, Seq, Seq object, SeqUtils Align and clustalw with Biopython, BLAST Running and Processing with Biopython	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
V	**NCBI Data Model:** Human genome project and HapMap project-Database The NCBI data model: Introduction, SEQ-Ids, BIOSEQs and BIOSEQ-SETs, SEQ-ANNOT and SEQ-DESCR Genbank database, Genbank Flat file, Sequence submission to Genbank, Online and offline tools, Entrez , INSDC	**10**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

Text Books

1. Andreas, D. and Baxevanis, A.D. (2002). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 2nd ed., John Wiley, New Jersey, United States.
2. Attwood, T. K. and Parry-Smith, D. J. (2005). Introduction to Bioinformatics, First Edition,Pearson Education, London, United Kingdom.
3. Jin, X. (2006). Essential Bioinformatics, Cambridge University Press, Cambridge, United Kingdom.
4. Sebastian, B. (2017). Python for Bioinformatics, Second Edition, CRC Press, Florida, United States.
5. Arthur, M. L. (2008). Introduction to Bioinformatics by Oxford University Press, Oxford, United Kingdom.

Suggested Readings

1. Baldi, P. and Brunak, S. (2003). Bioinformatics: The Machine Learning Approach, 2nd edition, MIT Press, London, U.K.
2. Baxevanis, A.D. and Ouellette B.F.F. (2005). Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins, 3rdedition, Wiley's Publications, New York, U.S.
3. Choudhuri, S. (2014). Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools, 1stedition, Academic Press, Cambridge, United Kingdom.

4. Durbin, R., Eddy, S., Krogh, A. and Mitchinson, G.(2002). Biological Sequence Analysis: Probabilistic. Models of Proteins and Nucleic Acids. Cambridge University Press, Cambridge, United Kingdom.
5. Setubal, J. C. and Meidanis, J. (2007). Introduction to Computational Molecular Biology, PWS Publishing Company, U.K.

Web Resources

1. https://www.ncbi.nlm.nih.gov/books/N BK21117/
2. https://www.ncbi.nlm.nih.gov/books/N BK21116/
3. https://www.ncbi.nlm.nih.gov/books/NBK21136/#A6613
4. https://guides.lib.berkeley.edu/bioinformatics
5. http://home.thep.lu.se/~mattias/teaching/bnf072/docs/Chapt0-2.pdf

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Understand the applications of bioinformatics to build databases for sequence interpretation	K1, K2
CO 2	Explain the concepts and tools to build alignment between similar sequences of DNA or Protein	K3
CO 3	Recognize the pattern of lineages and evolution	K4
CO 4	Summarise various databases used for protein structure prediction.	K5
CO 5	Construct methods in computational biology	K6

Course Code	PBT2MC04
Course Title	**RESEARCH METHODOLOGY AND BIOSATISTICS**
Credits	02
Hours/Week	03
Category	Major Core (MC) – Theory
Semester	II
Regulation	2022

Course Overview

1. This course offers an overview of basic concepts employed in quantitative and qualitative research methods.
2. The course aims to give students a broad understanding basic research designs and research ethics.
3. The course aims to give students skills for critical reading of peer reviewed literature and for developing a research proposal for a master's thesis project.
4. The topics helps the students to become competent in planning, conducting, evaluating and presenting a research project.

Course Objectives

1. To develop skills in the critical evaluation and basic methodologies of research and to discuss commonly used statistical tests.
2. To understand and compute the descriptive statistical measures that appear in the scientific articles.
3. To help the students identify appropriate research topics, select and define appropriate research problem and parameters, prepare a project proposal (to undertake a project).
4. To develop the ability to apply statistical methods while working on a research project work.
5. To understand the methodology writing a research proposal and research thesis.

Prerequisites	Basic Mathematics

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Concepts of Research:** Research - Definition, meaning, need, process and types of research (Qualitative and Quantitative). Research design - Definition, types, Principles, identification and formulation of problem, components and criteria. Sampling Design - Census and sample survey, Implications of a sample design, Steps in sampling design, Criteria of selecting a sampling procedure, characteristics of a Good Sample Design, Types of Sample Designs, Random Sample from an Infinite Universe, Complex Random Sampling Designs	**8**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Data Analysis of Interpretation:** Methods of data collection. Analysis of biological data , Types of biological variables, Probability, Basic concepts of hypothesis testing, confounding variables	**9**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Testing of Hypothesis:** Tests for one measurement variable - Student's t–test for one sample ,Student's t–test for two samples, Independence, Normality, Homoscedasticity and heteroscedasticity, Data transformations,One-way anova ,Kruskal–Wallis test,Nested anova,Two-way anova, Paired t–test,Wilcoxon signed-rank test	**9**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Types of research articles & Report Writing:** Types of Articles (review, letters). Scientific paper format (Abstract,	**10**	**CO 1** **CO 2** **CO 3** **CO 4**	**K1, K2, K3, K4, K5, K6**

	Introduction, Materials and Methods, Results, Discussion). Writing (ethical Vs. unethical), evaluating, presenting, and publishing the results of scientific research in the academic press (journals, conferences). Choosing the appropriate journal (Sources, Information, Instructions to authors, peer review system, journal evaluation) Case studies of areas of current research. Formulating a research plan and its presentation. Style Manuals –MLA, APA, citation.		**CO 5**	
V	**Ethics in Research:** Ethics and responsibility in scientific research Principles to guide the conduct of ethical research: Social and clinical value, Scientific validity, Fair subject selection, Favorable risk-benefit ratio, Independent review, Informed consent, Respect for potential and enrolled subjects Publication Technicalities -Flow chart of publication, Journal selection, Impact factor, Open access model. Predatory journal & publisher, Instruction to authors, Submission in journal, ORCID , Researcher ID , Publons, Peer review types, Plagiarism	**9**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Gupta, S. (2006). Research Methodology and Statistical Techniques, Deep and Deep Publications, Pvt. Ltd, New Delhi, India.
2. Gurumani.N. (2019). Research Methodology: For Biological Sciences,MJP Publishers, Chennai, India.
3. John H. Mcdonald (2014), Handbook of Biological Statistics,3rd edition, Sparky House Publishing, Baltimore, Maryland, U.S.A.
4. Kothari, C. R. (2006).Research Methodology Methods and Techniques, 2nd edition, New Age International Publishers, Chennai, India.

5. Wayne W. Daniel, Chad L. Cross. (2018). Biostatistics: A Foundation for Analysis in the Health Sciences, 11th Edition, John Wiley and Sons, USA.

Suggested Readings

1. Arora, P.N. and Malhan, P.K (2018). Bioatatistics, Himalayan Publishing House, New Delhi, India.
2. Bendat, J. S., Piersol, A. G. (2011). Random Data: Analysis and Measurement Procedures, Fourth Edition. Wiley, New Jersey, United States.
3. Creswell, J. (2013). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Ed. SAGE, California, United States.
4. Dawson, C. (2010). Introduction to research methods: a practical guide for anyone undertaking a research project, Little, Brown Book Group, Boston, United States.
5. Forthofer, R., Lee, F., Hernandez, M. (2006). Biostatistics: A Guide to Design, Analysis and Discovery, Second Edition, Elsevier, Amsterdam, Netherlands.
6. Valiela, I.(2001). Doing science: Design, analysis, and communication of scientific research. Oxford University Press, Oxford, United Kingdom.

Web Resources

1. https://www.statisticshowto.com/probability-and-statistics/hypothesis-testing/
2. http://www.ihmgwalior.net/pdf/research_methodology.pdf
3. https://www.subhartidde.com/slms/Research%20Methodology_Final%20MBA-202.pdf
4. https://faculty.franklin.uga.edu/dhall/sites/faculty.franklin.uga.edu.dhall/files/lec1.pdf
5. http://www.hstathome.com/tjziyuan/Introductory%20Biostatistics%20Le%20C.T.%20%20(Wiley,%202003)(T)(551s).pdf

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Identify and explain and prepare the key elements of research	K1, K2
CO 2	Compare and contrast types of research	K3,K4
CO 3	Apply biostatistics in research in biotechnology	K4
CO 4	Demonstrate knowledge and understanding of statistical theory and select appropriate study designs to address research problems.	K5
CO 5	Defend and uphold the rationale for research ethics	K6

Course Code	PBT2MC05
Course Title	**LAB III – (BIOANALYTICAL TECHNIQUES AND RECOMBINANT DNA TECHNOLOGY)**
Credits	2
Hours/Week	4
Category	Major Core (MC) – Lab
Semester	II
Regulation	2022

Course Overview

1. The topics of this course would cover the operation of basic laboratory equipment used in the field of biotechnology (i.e. pH meter, analytical balance, spectrophotometer, etc.).
2. To demonstrate the principle involved in various instrumentation techniques.
3. The lab course provides practical skill for better understanding through first-hand experience
4. It provides exposure and practical training in techniques used in rDNA technology.

Course Objectives

1. To apply introductory analytical techniques for quantifying chemical concentrations.
2. To develop observational skill in the form of identifying and locating desired parts in specimen.
3. To develop manipulative skills in arranging and handling the apparatus and instruments and taking readings.
4. To impart the skills to perform experiments in molecular biology.
5. To report, analyze and discuss results of experiments in rDNA technology.

Prerequisites	Basic understanding of instruments and molecular biology

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Preparation of temporary mount for xylem and phloem for microscopic observation Negative staining of *Bacillus subtilis* Separation of biomolecules by density gradient centrifugation Isolation of mitochondria by differential centrifugation	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	Detection of amino acid by paper chromatography Separation of proteins by column chromatography Estimation of mixture of acids by conductometric titration Estimation of nitrate using UV Spectrophotometer method	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	Isolation of bacterial genomic DNA Quantification of DNA Isolation of plasmid DNA PCR amplification of gene of interest	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	Restriction digestion Ligation Competent cell preparation Bacterial transformation	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	Restriction Mapping 16s rRNA PCR RAPD Single Nucleotide Polymorphism	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Green, M. R. and Sambrook, J. (2012). Molecular cloning: A Laboratory Manual, 4th edition, Cold Spring Harbor Laboratory Press, New York.
2. Fletcher, L., Goss, E., Phelps, P., Wheeler, A. and Grady, S.O. (2011). Introduction to Biotechnology-Lab Manual.
3. Mahesh, R., Sajeev, C.N. and Sridhar. (2003). Laboratory manual on Instrumental Methods of Analysis – EDD Notes. 4th edition.
4. Sharma, B.K. (2014). Instrumental Method of Chemical Analysis", Krishna

Prakashan Media (P) Ltd.
5. Siedman, L.A., Moore, C.J., and Mowery, J. (2022). Basic Laboratory Methods for Biotechnology-Textbook and Laboratory Reference. CRC Press, UK.

Suggested Readings

1. Maddocks, S. and Jenkins, R. (2016). Understanding PCR: A Practical Bench-Top Guide, Academic Press, Cambridge, United Kingdom.
2. Seidman, LA. And Moore, CJ. (2000) Basic Laboratory Methods for Biotechnology Pearson Publishers. US.
3. Seidman, LA. And Moore, CJ. (2000) Basic Laboratory Methods for Biotechnology Pearson Publishers. US
4. Tait, R.C. (2000). Introductory Experiments in Recombinant DNA- Current Issues in Molecular Biology, Caister Academic Press, US
5. Webster, J.G. (2004). Bioinstrumentation, John Wiley & Sons Inc, UK.

Web Resources

1. https://onlinelibrary.wiley.com
2. https://www.elsevier.com/books/recombinant-dna-laboratory-manual/zyskind/978-0-12-784400-8
3. https://springer.com
4. www.blackwellsynergy.com
5. www.sciencedirect.com
6. https://www.elsevier.com/books/recombinant-dna-laboratory-manual-revised-edition/zyskind/978-0-12-784401-5

Course Outcomes (COs) and Cognitive Level Mapping

Cos	CO Description	Cognitive Level
CO 1	Apply skills to design and conduct experiments and analyze data	K1, K2
CO 2	Apply various techniques of isolation and identification	K3
CO 3	Analyze and interpret results and assess experiments using genetic material	K4
CO 4	Understand the separation and purification of various biological compounds	K5
CO 5	Evaluate the basic principles of microscopy, spectroscopy and chromatography	K6

Course Code	PBT2MC06
Course Title	**LAB IV (RESEARCH METHODOLOGY AND BIOINFORMATICS & COMPUTATIONAL BIOLOGY)**
Credits	2
Hours/Week	4
Category	Major Core (MC) - Lab
Semester	II
Regulation	2022

Course Overview

1. To provide knowledge on the application of statistical tools to biological problems.
2. Locate and use the main databases at the NCBI and EBI resources.
3. Know the difference between databases, tools, repositories and be able to use each one to extract specific information.
4. Extract data from specific databases using accession numbers, gene names etc.
5. Use selected tools at NCBI and EBI to run simple analyses on genomic sequences.

Course Objectives

1. To understand the application of statistical software.
2. To view and use the various bioinformatics databases and their applications in research.
3. To access and utilize databases such as Entrez Nucleotide, BlastN, ClustalW, and Structure.
4. To relate sequence homology to evolution.
5. To visualize how simple changes in DNA can cause serious disease.

Prerequisites	Basic background of Statistics and Molecular Biology

SYLLABUS

Unit	Content	Hours	COs	Cognitive level
I	Data Entry and Manipulation Enter categorical and continuous data Define and label variables Add variables and cases Transform, recode and compute variables Select appropriate simple plots and descriptive statistics	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	Cross tabulation and the chi-square test			
II	Paired Samples Independent Samples Inference About a Proportion Cross-Tabulated Counts	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	Biological Databases with reference to Expasy and NCBI. Similarity searches using tools like BLAST and interpretation of results. Pairwise sequence alignment using BLAST. Multiple sequence alignment using ClustalW Phylogenetic analysis of protein and nucleotide sequences.	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	Use of various primer designing and restriction site prediction tools. Use of gene prediction methods (GRAIL, Genscan, Glimmer) Using RNA structure prediction tools Molecular docking	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	Construction and study of protein structures. Use of different protein structure prediction databases (PDB, SCOP, and CATH). Use of miRNA prediction, designing and target prediction tools.	12	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Andreas, D. B., and Francis, B. F. (2002). Bioinformatics- A practical guide to analysis of Genes & Proteins, John Wiley, New York.
2. Jin, X. (2006). Essential Bioinformatics, Cambridge University Press, New York.
3. Mount, D. (2004). "Bioinformatics: Sequence and Genome Analysis", 2nd Edition, Cold Spring Harbor Laboratory Press, New York.
4. Rosner, B.(2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press, England
5. Peter Allen; Kellie Bennett; Brody Heritage. (2019).SPSS statistics: a practical guide.Cengage Learning, Australia.

Suggested Readings

1. Attwood, T.K. and Parry-Smith, D.J.(2005). Introduction to Bioinformatics, Pearson Education, England.
2. Kailasam, C. and. Gangaiselvi, R. (2010). Applied Statistics, Kalyani Publishers. Ludhiana.
3. Pevsner, J. (2015). "Bioinformatics and Functional Genomics", 3rd edition, Wiley-Blackwell Publishers, USA.
4. Sabin, L., and Brian, S. E. 2004. A Handbook of Statistical Analyses using SPSS. CRC Press, UK.
5. Sharma, K.V.S. (2010). Statistics Made Simple: Do it yourself on PC, Prentice Hall of India. New Delhi.
6. Sundar, R., Richard, P.H. and Richard, J.(2003). An Introduction to Bio-statistics, Prentice Hall of India, New Delhi.

Web Resources

1. www.stats.gla.ac.uk/steps/glossary/index.html
2. http://www.stattrek.com/
3. http://www.stat-help.com
4. www.statsci.org/jourlist.html
5. https://learn.chm.msu.edu/vibl/
6. https://www.muhlenberg.edu/academics/biology/biologycurriculum/majorcourses/bioinformaticslab/#:~:text=To%20visualize%20the%20connection%20between,BlastN%2C%20ClustalW%2C%20and%20Structure.
7. https://vlab.amrita.edu/index.php?sub=3&brch=273
8. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5506686/

Course Outcomes (COs) and Cognitive Level Mapping

Cos	CO Description	Cognitive Level
CO 1	Develop the ability to apply the methods while working on a research project work	K1, K2
CO 2	Prediction of structure from sequence and subsequently testing the accuracy of predicted structures	K3
CO 3	Determine the protein function from sequence through analysis of data	K4
CO 4	Develop skill in data analysis, presentation and critical thinking	K5
CO 5	Application of probabilistic model to determine important patterns	K6

Course Code	PBT3MC01
Course Title	**PLANT BIOTECHNOLOGY**
Credits	5
Hours/Week	5
Category	Major Core (MC) - Theory
Semester	III
Regulation	2022

Course Overview

1. The course is designed to give an understanding of the concepts in plant biotechnology with also an introduction of molecular markers and their application in crop improvement
2. Provides learners with an understanding of biosynthesis of phytochemical compounds and also on herbal drugs
3. It imparts knowledge of role and biosynthesis of growth hormones and secondary metabolism and photobioreactors
4. It also provides an insight into how plant cells can be used and manipulated under *in vitro* cultures
5. The course introduces the various gene transfer methods for plant transformation and also the applications of transgenic plants
6. The course winds up with an insight into the modern gene editing tools like ZFNs, TALENs and CRISPR-Cas9

Course Objectives

1. To introduce concepts in plant biotechnology and molecular marker techniques
2. To understand the importance of plant genome and phytochemical compounds produced by plants
3. To gain knowledge on IPR and patents
4. To introduce the students to plant tissue culture techniques
5. To impart knowledge in the field of plant genetic transformation and GM crops
6. To give an understanding of gene editing tools in plant biotechnology

Prerequisites	Basic knowledge on Plant Biology and Molecular Biology

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Plant Tissue Culture :** History of Tissue Culture technique, Totipotency. Requirements and setting up of Plant Tissue Culture lab - Plant tissue culture media and composition - plant growth hormones Methods of sterilization and sterilization of media - Plant tissue culture – Totipotency – Plant cell culture media Organogenesis and Somatic embryogenesis and hardening of plants - anther (Double Haploid Production and Its Applications in Crop Improvement), embryo and ovule culture – Meristem culture for virus free plants Protoplast isolation, culture and regeneration of plants - Commercial Micropropagation of Some Economically Important Crops for increasing productivity Encapsulation Technology - Callus Culture - Somaclonal variations, isolation of somaclonal variants Application of plant tissue culture in Forestry - Traditional systems of medicine and Industrial plant products	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
II	**Concepts in Plant Molecular Biology:** Development of biotechnology in India – Asepsis and maintenance – Cybrids - Germplasm conservation – Syn seeds – Cryopreservation DNA banks – DNA library - genetic stability assessment Plant genomics and transcriptomics - Plant proteomics - Plant metabolomics Structure, organization and expression of Plant Nuclear genome, Chloroplast genome and Mitochondrial genome, Cytoplasmic male sterility. Biochemistry and molecular biology of nod and nif genes	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

	Molecular Marker-aided Breeding: RFLP maps, linkage analysis, RAPD markers, STS, Microsatellites, SCAR (Sequence Characterized Amplified Regions), SSCP (Single Strand Conformational Polymorphism), AFLP, QTL, map based cloning, molecular marker assisted selection Recent techniques such as TILLING (Targeting Induced Local Lesions In Genomes) GURT			
III	**Transgenic Plants:** Marker assisted selection and breeding – Selectable markers, reporter genes and promoters used in plant vectors Gene transfer methods - *Agrobacterium* mediated-gene transfer, Gene gun method and Microinjection technique - SAAT and floral dip transformation technique in *Arabidopsis* - Gene knock-out and knock-in technology Barcoding in crop plants - Crop improvement, productivity, performance and fortification of agricultural products Genetic engineering in India (Bt cotton, Bt brinjal, Bt mustard) - Herbicide resistance, viral resistance, bacterial resistance, fungal resistance crops - Genetic engineering for oil modification - Current status of transgenic plants in India and other countries RNAi and its applications in plants - Antisense RNA technology (ACC synthase gene and polygalactoronase) Genome editing tools- ZFNs, TALENs and CRISPR-Cas9	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Plant derived Pharmaceuticals:** Pharmaceutically important compounds - Formulation of Biotechnological Products - Drug Delivery - Examples of some Biotechnological products in clinical development – Benefits of herbal drugs over other therapeutic approaches - Current Research on herbal drug development - Role of FDA, ICH Guidelines - Regulation of Pharmaceutical Biotechnological Products and Ethical Issues - Biosynthesis of phenolic compounds - Biosynthesis of	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	alkaloids - Biosynthesis of terpenes (Monoterpenes, sesquiterpenes, carotenoids) - Mevalonic acid pathway and Shikimic acid pathway in plants - Photobioreactors – Algal production – Nutraceutical values of algae			
V	**IPR & Patenting:** Intellectual Property Right (IPR) - Plant Genetic Resources (PGR) - National and international regulation: National Biodiversity Act - Protection of Plant varieties and Farmer's Right Act Nagoya Protocol on Access of Bioresources and Benefit sharing Patenting of biological material: International conventions, international corporations, patent applications, implication of patenting of higher plants, patenting transgenic organisms and isolated genes, patenting of genes and DNA sequences Biosafety – Regulatory agencies - Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture - Bioethics in Biodiversity Ethical issues and Resilience of GM crops – Risks of transgenics - Experimental protocol approvals, levels of containment - Guidelines for research in transgenic plants	**15**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Ignacimuthu, S. (2005). Plant Biotechnology, Oxford and IBH Publishers, New Delhi, India.
2. Slater, A., Scott, N. W. and Fowler, M. R. (2008). Plant Biotechnology - The Genetic Manipulation of Plants, Second Edition, Oxford University Press, Oxford, United Kingdom.
3. Nigel Halford. (2014). Plant Biotechnology – Current and Future Applications of Genetically Modified Crops, Wiley, New Jersey, United States.
4. Chawla, H.S. (2020). Introduction to Plant Biotechnology, 3rd edition. Oxford and IBH Publishers, New Delhi, India.
5. Raaman, N. (2006). Phytochemical Techniques, New India Publishers, New Delhi, India.

6. Zingare, A.K. (2013). Biotechnology in Plant Improvement, Satyam Publishers, Chennai, India.

Suggested Readings

1. Prasad, B.D., Sahni, S. and Kumar, P. (2021). Plant Biotechnology- Principles, Techniques, and Applications, Apple Academics Press and CRC Press, Florida, United States.
2. Sahni, S., Prasad, B.D. and Kumar, P. (2021). Plant Biotechnology- Transgenics, Stress Management, and Biosafety Issues, Apple Academics Press and CRC Press, Florida, United States.
3. Ignacimuthu, S. (2012). Biotechnology-An Introduction, Alpha Science International.
4. Christou, P. (2010). Handbook of Plant Biotechnology, Wiley, New York, United States.
5. Glick, B.R. (2014). Methods in Plant Molecular Biology and Biotechnology, CRC Press, Florida, United States.
6. Mishra, R.C. (2010). Plant Biotechnology, ABD Publishers.
7. Bhatia, S., Sharma, K., Dahiya, R. and Bera, T. (2015). Modern Applications of Plant Biotechnology in Pharmaceutical Sciences, 1st edition, Academic Press, Cambridge, United States.
8. Bahadur, B., Venkat Rajam., Sahijram, L. and Krishnamurthy, K.V. (2015). Plant Biology and Biotechnology- Plant Genomics and Biotechnology, Springer, Berlin, Germany.
9. Altman, A. and Hasegawa, M.P. (2011). Plant Biotechnology and Agriculture: Prospects for the 21st Century, 1stedition, Academic Press, Cambridge, United States.

Web Resources

1. https://www.isaaa.org/
2. https://www.icrisat.org/
3. https://www.springer.com/in
4. https://www.scientist.com/
5. https://onlinelibrary.wiley.com/
6. https://www.blackwell-synergy.com/
7. https://www.springer.com/journal/11240
8. https://www.banglajol.info/index.php/PTCB
9. https://www.mdpi.com/journal/ijms
10. https://www.mdpi.com/journal/plants
11. http://www.bioonepublishing.org/

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Recall the basic concepts in plant biotechnology	K1, K2
CO 2	Differentiate various types of intellectual property rights, patents and report measures for conservation of biodiversity	K3
CO 3	Explain the biosynthesis and phytochemical extraction processes and methods used for separation of biomolecules	K4
CO 4	Determine factors influencing plant cell differentiation and execute proper techniques/ procedures for the maintenance of sterile condition and proper plant growth	K5
CO 5	Compare and summarize the pros and cons of transgenic plants on environment and how biotechnology is used for plant improvement and discuss the ethical implications	K6

Course Code	PBT3MC02
Course Title	**ANIMAL BIOTECHNOLOGY**
Credits	04
Hours/Week	04
Category	Major Core (MC) - Theory
Semester	III
Regulation	2022

Course Overview

1. The Animal Biotechnology course centers on the application of the principles of biotechnology in animal and medical science.
2. This course aims at imparting knowledge in animal and medical biotechnology with respect to the history, applications, research and development and current challenges in the field.
3. Techniques to maintain animal cell cultures, scale-up of culture and assessment of viability are discussed in detail.
4. The course includes the application and significance of stem cells and gene therapy in medicine.
5. Ethical issues in animal biotechnology are discussed.
6. This course highlights the contribution and significance of biotechnology to improve health and for the welfare of society.

Objectives

1. To understand techniques in animal cell culture and the significance of Animal Biotechnology.
2. To apply animal cell culture techniques in the fields of animal science.
3. To relate and discuss the industrial applications of Animal Biotechnology.
4. To understand methods of producing transgenic animals and discuss their applications.
5. To apply stem cell biology, molecular and biotechnological techniques for the health and welfare of society.
6. To discuss challenges and ethical and legal issues in animal and medical biotechnology.

Prerequisites	Knowledge in the fundamentals of Cell Biology

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Animal cell culture:** Landmarks in animal cell culture and Animal Biotechnology-Overview of an Animal Cell Culture Laboratory, aseptic practices in an animal cell culture facility - Cell Culture environment - Phases of cell growth and characteristics of finite and continuous cells Cytogenetic analysis of cultured cells – chromosome preparation for characterization of cell lines, G banding technique and fluorescence in situ hybridization Commercial scale production of animal cells; Scale-up in suspension - Perfused suspension cultures, Scale-up in monolayers – multi-surface propagators, roller bottle culture, Microcarriers	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
II	**Cell culture, cloning and DNA barcoding:** Establishing a primary culture, subculture of cells – adherent cells and suspension cells and cryopreservation Microbial contamination of cell culture - cell viability tests for cells in culture Methods in animal cloning - somatic cell nuclear transfer and embryo splitting, embryo transfer technology DNA barcoding of animal species – methodology and species conservation	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
III	**Regenerative Medicine:** Stem cell types based on potency - characteristics and properties of stem cells, spheroids and organoids Induced pluripotency of adult stem cells and its applications Tissue engineering – types of scaffolds; Scaffold fabrication methods Current practices in regenerative medicine - tissue engineered skin and tissue engineered urinary bladder, Challenges in regenerative medicine	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

IV	**Pharming, Gene Therapy and Ethics:** Pharming - production of pharmaceutical proteins using transgenic animals, Methods of producing transgenic animals - microinjection, nuclear transfer and retrovirus *In vivo* and *ex vivo* approaches to gene delivery, advantages and disadvantages of gene delivery systems, Ethical and legal issues in genetic engineering, ethics in human stem cell research, ethics in gene therapy and genome editing in animals and humans Ethics and legal issues in Biotechnology, John Moore case study	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
V	**Reproductive techniques and molecular methods :** *In vitro* fertilization and embryo culture Prenatal testing for genetic abnormalities - chorionic villus sampling and amniocentesis Application of RNA interference and DNA microarray in medicine. Pharmacogenomics and personalized medicine	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

Text Books

1. Atala, A., Lanza, R., Mikos, T. and Nerem, R. (2018). Principles of Regenerative Medicine, Third Edition, Academic Press, Cambridge, United States.
2. Freshney, I. R. and Capes-Davis, A. (2021). Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Eighth Edition, Wiley-Blackwell, New York, United States.
3. Lanza, R. and Atala, A. (2014). Essentials of Stem Cell Biology, Third Edition, Academic Press, Cambridge, United States.
4. Maiti, S. K. (2020). Stem Cell Research in Lab Animals, New India Publishing Agency, India.
5. Verma, A. S. and Singh, A. (2020). Animal Biotechnology Models and Translation, Second Edition, Academic Press, Cambridge, United States.

Suggested Readings

1. Baylis, F. (2019). Altered Inheritance – CRISPR and the Ethics of Human Genome Editing, Harvard University Press, Cambridge, United States.
2. Glick, B. R., Delovitch, T. L. and Patten, C. L. (2013). Medical Biotechnology Principles and Applications of Recombinant DNA, First Edition, ASM Press, Washington DC, United States.
3. Microcarrier Cell Culture Principles and Methods. (2013). GE Healthcare Bio-Sciences AB Björkgatan, Sweden.

4. Portner, R. (2020). Animal Cell Biotechnology Methods and Protocols. Springer, Berlin, Germany.
5. Singh, B., Gautam, S.K., Chauhan, M. S. and Singla, S.J. (2013). Textbook of Animal Biotechnology. TERI Press, India.

Web Resources

1. https://ibol.org/about/dna-barcoding/
2. https://www.thermofisher.com/
3. https://www.nibib.nih.gov/science-education/science-topics/tissue-engineering-and-regenerative-medicine
4. https://www.animal-ethics.org/
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3570985/
6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3624098/
7. https://ec.europa.eu/info/sites/default/files/research_and_innovation/ege/ege_ethics_of_genome_editing-opinion_publication.pdf
8. https://www.genome.gov/about-genomics/fact-sheets/DNA-Microarray-Technolog

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe the basic principles in animal biotechnology	K1, K2
CO 2	Apply scientific reasoning and techniques to overcome challenges in the field of animal biotechnology	K3, K5
CO 3	Compare and/or recommend techniques in animal biotechnology	K4
CO 4	Explain and/or critique scientific strategies, tools and techniques in animal biotechnology	K5
CO 5	Defend ethical principles in animal biotechnology	K6

Course Code	PBT3MC03
Course Title	**BIOPROCESS AND ENZYME TECHNOLOGY**
Credits	04
Hours/Week	04
Category	Major Core (MC) - Theory
Semester	III
Regulation	2022

Course Overview

1. Bioprocess and Enzyme Technology deals with the principles of fermentation and enzymology.
2. This course aims at imparting knowledge in industrial applications of biotechnology.
3. This course provides knowledge in bioreactor design and types of fermentation.
4. Biotechnological techniques used in upstream processing, fermentation and downstream processing are examined and discussed.
5. The course also covers microbial production of commercial significant products.
6. It includes the fundamentals of key industrial applications of enzyme technology.

Course Objectives

1. To understand the scope and significance of Bioprocess and Enzyme Technology.
2. To understand the parts of a bioreactors and its function.
3. To distinguish between upstream and downstream techniques.
4. To understand the properties of enzymes and mechanisms of enzyme regulation.
5. To gain knowledge in commercial production of microbial products.
6. To develop skills for the production of biofertilizers and industrially significant enzymes.

Prerequisites	Basic knowledge in Biochemistry.

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Principles of Bioprocess Technology:** Overview of bioprocess technology, Isolation, screening, strain improvement and maintenance of industrially important microbes. Significance of microbial growth kinetics in fermentation technology. Media formulation for industrial fermentation. Development of inoculum for industrial fermentations.	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
II	**Bioreactors and Fermentation Technology:** Basic design and components of a fermenter Types of Bioreactors – Stirred tank, Air lift bioreactor, Wave bioreactor, Photobioreactor, Immobilized cell bioreactors. Types of fermentation – Solid substrate, Submerged fermentations. Batch, fed batch and continuous culture	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
III	**Upstream and Downstream Processing:** Upstream processing - Media formulation; Sterilization, Aeration and agitation. Downstream processing - Cell separation techniques, Cell disruption- physical, chemical and enzymatic methods. Recovery – Centrifugation, flocculation, filtration, sedimentation, adsorption Purification by chromatographic techniques	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
IV	**Enzyme Technology:** Nomenclature and Classification of enzymes - Properties of enzymes – presence of species specificity, variation in activity and ability (effect of pH, temperature, ions) Mechanism of enzyme action – lock and key hypothesis and Daniel Koshland's induced fit model.Kinetics of enzyme action - factors that determine the rate of the enzymatic reaction - Michaelis Menten.. Regulation of enzyme biosynthesis – induction and repression	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

V	**Production and applications of enzymes in industry:** Production and application of industrially significant enzymes – Amylase and Lipase Production and application of – Cellulase, Protease Enzyme immobilisation and applications Medical applications of enzymes	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. El-Mansi, M. T., Nielsen, J., Mousdale, D., Allman, T. and Carlson, R. (2019). Fermentation Microbiology and Biotechnology, Fourth Edition. CRC Press, Florida, United States.
2. Kaliachelvan, P. T. and Pandi, I. A. (2019). Bioprocess Technology. MJP Publishers, Chennai, India.
3. Peppler H. J. and Perlma, D. (2014). Microbial Technology: Fermentation Technology. Academic Press, Massachusetts, United States.
4. Stanbury, P. F., Whitaker, A. and Hall, S. J. (2016). Principles of Fermentation Technology. Third Edition, Pergamon Press, Oxford, United Kingdom.
5. Wittmann, C., Liao, J. C., Lee, S. Y., Nielsen, J. and Stephanopoulos, G. (2017). Industrial Biotechnology: Products and Processes. Wiley-VCH, Weinheim, Germany.

Suggested Readings

1. Berenjian, A. (2019). Essentials in Fermentation Technology. Springer International Publishing, Switzerland.
2. Dubey, R. C. (2014). Advanced Biotechnology. S. Chand, New Delhi, India.
3. Duran, P. M. (2012). Bioprocess Engineering Principles. Academic Press, California, United States.
4. Komives, C, and Zhou, W. (2018). Bioprocessing Technology for Production of Biopharmaceuticals and Bioproducts. Wiley, New York, United States.
5. Kumaresan, V. (2015). Biotechnology. Saras Publication, Nagercoil, India
6. Lee, G. M., Kildegaard, H. F., Lee, S. Y., Nielsen, J. and Stephanopoulos, G. (2019). Cell Culture Engineering: Recombinant Protein Production, Wiley-VCH Weinheim, Germany.

Web Resources

1. https://www.eppendorf.com/IN-en/applications/bioprocess/
2. https://bioprocessing.weebly.com/bioprocess-technology.html
3. https://www.fnca.mext.go.jp/bf/bfm/pdf/Biofertilizer_Manual.pdf
4. https://www.thermofisher.com/blog/ask-a-scientist/what-is-chromatography/
5. https://handling-solutions.eppendorf.com/sample-handling/centrifugation/safe-use-of-centrifuges/basics-in-centrifugation/
6. https://www.agilent.com/en/academia/education/teaching-tools

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe the fundamentals of bioprocess technology	K1, K2
CO 2	Categorise methods and processes in bioprocess technology	K3
CO 3	Apply fermentation technology for the scale up of biological products	K4
CO 4	Integrate principles of biotechnology for the production of industrially significant products	K5
CO 5	Design/compile scientific methods for the production of industrially important biotechnology related products	K6

Course Code	PBT3MC04
Course Title	**LAB V (PLANT BIOTECHNOLOGY)**
Credits	2
Hours/Week	3
Category	Major Core (MC) - Practical
Semester	III
Regulation	2022

Course Overview

1. The course would equip the students with good practical knowledge and research capability.
2. To inculcate hands-on exposure in plant tissue transformation techniques.
3. To gain experience in raising suspension cultures and somatic embryo development in plants
4. The course also provides practical experience in plant tissue culture and its application in crop improvement.
5. To develop skills and provide an exposure to the field of genetic engineering technique.
6. Provides hands-on experience in various experiments like DNA isolation, Protoplast isolation, Micropropagation, Phytochemical extraction etc.

Course Objectives

1. To provide working knowledge of laboratory techniques used in plant biotechnology.
2. To understand aims of molecular background in plant biotechnology techniques to develop new products.
3. To give an exposure to plant tissue culture
4. To equip them in agrobacterium gene transfer techniques.
5. To understand the principle behind phytochemical techniques and chromatography techniques.
6. To encourage students to undertake research in plant biotechnology.

Prerequisites	Basic understanding of plants and molecular biology

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Preparation of Plant Tissue Culture Media Callus induction Micropropagation Cell suspension culture	**9**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	Somatic embryogenesis Synthetic seed production Protoplast isolation Isolation of plant DNA by CTAB method and agarose gel electrophoresis	**9**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	Isolation of RNA from plant samples Quantification of DNA and RNA in plant tissues Antibiotic sensitivity test for plant cells Agrobacterium mediated gene transformation Histochemical staining for GUS assay	**9**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	Screening test for effect of salinity on crop plants Analysis of soil organic carbon by volumetric analysis Determination of free acid in plant fertilisers by volumetric analysis. Screening, isolation and purification of pigments compounds from plants by column chromatography	**9**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	Separation of plant pigments by thin layer chromatography Assay for bioactive compounds (Qualitative estimation for alkaloids, carbohydrates, flavonoids, saponins, and phytosterols) Quantitative estimation of alkaloids by titrimetric method Analysis of chemical and organic fertilizers by vacuum desiccator method Determination of superoxide dismutase activity in plants	**9**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Kumar, A. (2018) Practical Manual of Plant Biotechnology. Jai Durga Printing Press, Jharkhand, India.
2. Sambrook, J. and Russel, D.W. (2001). Molecular Cloning: A Laboratory Manual. Vols 1-3, CSHL.
3. Santosh, N., and Madhavi, A. (2010). Practical Book of Biotechnology and Plant Tissue Culture. Chand, S. Company
4. Rao, M., Raghavendra A.S. and Reddy, K. (2006). Physiology and Molecular Biology of Stress Tolerance in Plants. Springer, Berlin, Germany.
5. Prasanta Dash (2016). Marker free transgenics and methods of transgene detection- Practical Manual. NRCPB.

Suggested Readings

1. Jaiwal, P.K and Singh, R.P. (2005). Plant Genetic Engineering. Vol 8. Stadium Press, New Delhi, India.
2. Khandelwal, S.K., Sharma A., Jain, D. and Joshi, A. (2018). Practical Manual Principles of Plant Biotechnology, Himanshu Publications, India.
3. Philip R., and White A (2018). Handbook of Plant Tissue Culture, Andesite Press.
4. Purohit, SS. (2015). A Laboratory Manual of Plant Biotechnology. Agrobios Publishers, Rajasthan, India.
5. Smith, R.H. (1992). Plant Tissue Culture: Techniques and Experiments, Academic Press, Cambridge, United States.

Web Resources

1. https://onlinelibrary.wiley.com
2. https://springer.com
3. www.wiley.com
4. www.plantcellreports.com
5. www.biologiaplantarum.com
6. www.plantcelltissueorganculture.com

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Understand the principle and techniques in plant genetic engineering	K1, K2
CO 2	Identify and purify bioactive compounds from plants	K3
CO 3	Illustrate the skills in various techniques of plant biotechnology and understand their applications in industries	K4
CO 4	Develop expertise in the field of plant tissue culture	K5
CO 5	Interpret the environmental stress in plants	K6

Course Code	PBT3MC05
Course Title	**LAB VI – (ANIMAL BIOTECHNOLOGY AND BIOPROCESS TECHNOLOGY)**
Credits	03
Hours/Week	04
Category	Major Core (MC) – Lab
Semester	III
Regulation	2022

Course Overview

1. This practical course aims to provide students with practical training in techniques in animal cell culture and fermentation technology.
2. Students will have hands-on experience in maintenance of animal cell culture.
3. The course covers cell counting and assessment of viability of an animal cell culture.
4. The course is designed to develop skills in industrial applications of microorganisms, experimenting with enzymes and to explore applications of enzymes.
5. Students will be trained in Chromatographic techniques.

Course Objectives

1. To maintain animal cell cultures and assess the concentration and viability.
2. To isolate DNA from animal tissue.
3. To use biotechnology methods and principles to detect pathogens.
4. To apply screening techniques for the isolation of industrially significant enzymes from an environmental sample.
5. To apply principles of fermentation and perform appropriate downstream techniques.

Prerequisites	Knowledge in Cell Biology, Instrumentation and Microbiology.

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	Preparation of media for animal cell culture Preparation of single cell suspension – warm trypsinisation	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	Cell counting using haemocytometer Viability test – Trypan Blue dye exclusion assay Subculturing of an adherent/suspension culture	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	Preparation of freezing medium Cryopreservation of animal cell line Isolation of DNA from spleen DNA Fingerprinting Screening of protease producers	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	Screening of amylase producers Isolation of lactic acid bacteria Effect of carbon source of growth of an isolate Hydrolysis of starch by immobilized amylase Effect of temperature and pH on amylase	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	Production of wine Liquid-liquid extraction of fermented broth Affinity Chromatography Gel Filtration Chromatography	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Freshney, I. R. and Capes-Davis, A. (2021). Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Eight Edition. Wiley-Blackwell, New York, USA.
2. Holčapek, M. and Byrdwell, W. C. (2017). Handbook of Advanced Chromatography/Mass Spectrometry Techniques, Academic Press and AOCS Press, Amsterdam, Europe.
3. Komives, C, and Zhou, W. (2018). Bioprocessing Technology for Production of Biopharmaceuticals and Bioproducts. Wiley, New York, United States.

4. Masters, J. R. W. (2000). Animal Cell Culture: A Practical Approach,Oxford University Press, USA.
5. Mell, C. and Hunt, J. (2020). Animal Cell Culture, Ed-Tech Press, Lond, United Kingdom.

Suggested Readings

1. Cox, M. M. and Philps, G. N. (2008). Handbook of Proteins: Structure, Function and Methods, Wiley, New York, United States.
2. Gangal, S. (2007). Principles and Practice of Animal Tissue Culture Universities Press, India
3. Portner, R. (2020). Animal Cell Biotechnology Methods and Protocols. Springer, United States.
4. Striegel, A. M., and Krikland, J. (2009). Modern Size-Exclusion Liquid Chromatography: Practice of Gel Permeation and Gel Filtration Chromatography, Wiley, New York, United States.
5. Verma, A. S. and Singh, A. (2020). Animal Biotechnology Models and Translation Second Edition. Academic Press, United States.
6. Vitha, M. F. (2016). Chromatography: Principles and Instrumentation, Wiley, New York, United States.

Web Resources

1. https://www.sigmaaldrich.com/IN/en
2. https://www.thermofisher.com/in/en/home/brands/gibco.html
3. https://www.bio-rad.com/
4. https://www.microbiologyresearch.org/
5. https://www.agilent.com/
6. https://ibol.org/

Course Outcomes (COs) and Cognitive Level Mapping

Cos	CO Description	Cognitive Level
CO 1	Identification and description of fundamentals in Animal Biotechnology/Bioprocess Technology	K1, K2
CO 2	Application of biotechnological principles to perform experiments in Animal Biotechnology/Bioprocess Technology	K3
CO 3	Analysis of data of experiments related to Animal Biotechnology/Bioprocess Technology	K4
CO 4	Recommend methods in Animal Biotechnology/Bioprocess Technology	K5
CO 5	Plan, evaluate and present scientific data of experiments conducted in Animal Biotechnology/Bioprocess Technology	K6

Course Code	**PBT4PJ01**
Course Title	**PROJECT**
Credits	20
Hours/Week	30
Category	Project (PJ)
Semester	IV
Regulation	2022

Course Overview

1. The purpose of this course is to help students to organize ideas, material and objectives for their dissertation and to develop communication skills.
2. To prepare the students to present their topic of research and explain its importance.
3. To develop the capability to critically and systematically integrate knowledge to identify issues that must be addressed within the framework

Course Objectives0

1. To prepare students to adapt to the research environment
2. To understand how research projects are executed in a research laboratory
3. The students will have an in-depth knowledge of the chosen area of research
4. To learn practical aspects of research
5. To develop the ability to conduct research independently and perform analytical techniques/experimental methods of specific thesis.

Prerequisites	Knowledge of the various disciplines of Biotechnology

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
	Planning & performing of experiments: Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. To systematically identify relevant theory and	**30**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K6**

	concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Understand the possible outcomes of each experiment. Thesis writing: At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.			

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Summarize research literature and outline the problem statement	K6
CO 2	Plan experimental design to solve the identified problem.	K6
CO 3	Evaluate the experimental results relate it to published literature	K6
CO 4	Interpret, discuss and communicate scientific results in oral and written form	K6
CO 5	Present and explain research findings to the audience effectively	K6

Course Code	PBT2ME01
Course Title	**CANCER BIOLOGY**
Credits	02
Hours/Week	04
Category	Major Elective (ME) – Theory
Semester	III
Regulation	2022

Course Overview

1. Cancer Biology is a course designed to understand the biology of cancer, risks factors, diagnosis, treatment and strategies to prevent cancer.
2. This course imparts knowledge in molecular biology of cancer – oncogenes and tumour suppressor genes.
3. The hallmarks of cancer are discussed.
4. The course covers the key principles of carcinogenesis.
5. This course also provides knowledge on staging and grading of cancers, diagnosis, treatment and prevention strategies.

Course Objectives

1. To describe the macroscopic and microscopic features of neoplasm.
2. To understand the risk factors, stages, diagnosis and treatment of common types of cancer.
3. To gain knowledge in the genetics of cancer biology and the role of oncogenes and tumour suppressor genes.
4. To understand the pathology of common cancers.
5. To describe metastasis and identify the major steps in the process of metastasis.
6. To understand the significance of early detection and the impact of lifestyle on cancer prevention.

Prerequisites	Basic knowledge in Cell Biology and Genetics.

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Neoplasm and Tumorigenesis:** Introduction to cancer - Forms of cancer - benign, malignant, Classification of cancers – (carcinoma, sarcoma, lymphoma, myeloma, leukaemia), Microscopic and macroscopic features of neoplasm Cell cycle and cancer, Hallmarks of cancer Mutations that cause changes in signal molecules Multistep tumorigenesis and the progression of cancer	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Principles of carcinogenesis:** Mutagens, carcinogens, tumour viruses, Principles of physical and chemical carcinogenesis Cancers induced by hormones Oxidative stress and cancer Cancer stem cells and their therapeutic implications Angiogenesis factors and inhibitors	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Genes involved in cancer:** Proto-oncogenes and oncogenes Tumour suppressor genes - p53 the guardian of the genome Metastasis suppressor and metastasis promoter genes, metastatic cascade DNA repair genes and cancer - *Xeroderma pigmentosum*	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Pathology of common human cancers:** Epidemiology, Risk Factors Cancer Pathology -Stage and grade of neoplasms, lung, breast, colorectal, liver and skin cancer Signal transduction pathways in cancer biology, G-protein coupled receptors – Tyrosine kinase pathway and JAK-STAT pathway in relation to cancer	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Cancer diagnosis, treatment and prevention:** Tumour markers and oncologic imaging, Cancer screening and detection – breast, cervical, colorectal and lung Chemotherapy – types of drugs; modes of action of anticancer drugs, side effect	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	Molecular oncolytic therapies - Immunotherapy, gene therapy, Hormonal therapy - Radiotherapy – Photodynamic therapy Lifestyle, diet and cancer prevention			

Text Books

1. Carlberg, C. and Velleuer, E. (2021).Cancer Biology: How Science Works, Springer Nature Switzerland, Europe.
2. Pezella, F., Tavassoli, M., and Kerr, D. (2019). Oxford Textbook of Cancer Biology, Oxford University Press, Oxford, UK.
3. Pieters, R.S., and Liebmann, J. (2015). Principles of Multidisciplinary Management. Cancer Concepts. University of Massachusetts Medical School, Worcester, Massachusetts, USA.
4. Stein, G. S., and Luebbers, K. P. (2019). Cancer: Prevention, Early Detection, Treatment and Recovery. Blackwell-Wiley, New Jersey, USA.
5. Weinberg, R. (2013). The Biology of Cancer, W. W. Norton & Company, New York, USA.

Suggested Readings

1. Kimber, C. (2020). The Biology of Cancer. Foster Academics, New York, USA.
2. Kleinsmith, L.J. (2016). Principles of Cancer Biology,Pearson Education, India.
3. Pelangaris, S. and Khan M. (2013). The Molecular Biology of Cancer, 2nd edition. Wiley Blackwell Publishers, New Jersey, USA.
4. Ruddon, R. W. (2007). Cancer Biology, Fourth Edition. Oxford University Press, United Kingdom.
5. Wagener, C., Stocking, C. and Müller, O. (2016). Cancer Signaling: From Molecular Biology to Targeted Therapy, Wiley-Blackwell Publishers.
6. Weinberg, R. (2007). The Biology of Cancer, Garland Science, Taylor & Francis Group, New York, USA.

Web Resources

1. https://www.who.int/news-room/fact-sheets/detail/cancer
2. https://www.wcrf.org/
3. https://canceratlas.cancer.org/
4. https://www.cancer.gov/about-cancer/understanding/what-is-cancer
5. https://www.cancer.org/cancer/cancer-basics.html
6. https://www.cdc.gov/cancer/index.htm

Course Outcomes (COs) and Cognitive Level Mapping

Cos	CO Description	Cognitive Level
CO 1	Describe key concepts in oncology	K1, K2
CO 2	Relate the principles of carcinogenesis to medical biotechnology	K2, K3
CO 3	Select biotechnology tools and techniques for the prevention, diagnosis and treatment cancer biology	K4
CO 4	Summarise the pathology of common cancers and recommend treatment options	K5
CO 5	Assess risk factors and compile preventative strategies for the betterment of health	K6

Course Code	PBT2ME02
Course Title	**DRUG DISCOVERY AND DEVELOPMENT**
Credits	02
Hours/Week	04
Category	Major Elective (ME) - Theory
Semester	II
Regulation	2022

Course Overview

1. Drug discovery deals with strategies for drug design and production.
2. This course aims at imparting knowledge on the screening methodologies in drug discovery.
3. Drug regulation and approval, computer-aided design of drugs is dealt with in detail.
4. This course also provides knowledge on drug applications in safety testing in animals-toxicity tests, teratogenicity and mutagenicity tests.

Course Objectives

1. To understand the importance of research and discovery.
2. To understand the various types of strategies for drug design.
3. To gain knowledge on screening methodologies and the sources of therapeuticcompounds.
4. To understand the drug approval processes.
5. To gain knowledge in biopharmaceutical studies.

Prerequisites	Basic knowledge on drug development

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Research and discovery:** Drug discovery process, research activities in the development of new drugs Criteria to move a compound series onto the lead development stage Compound testing - Biochemical assays, Cell-based Assays, Animal testing, alternatives to animal testing Human clinical trials. Phases in clinical trials Effect of molecular structure on activity and bioavailability Drug side effects, and multiple drug interactions	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
II	**Target Identification:** Primary sequence and metabolic pathway, Crystallography and 2D NMR, Homology models and Protein folding in target identification Molecular dynamics simulations and Pharmacophore identification The drug design process for a known protein target: The structure-based design process Drug resistance - mechanisms of resistance to the drug. The drug design process for an unknown target The ligand-based design process. Drug design for other targets. Targets inside cells. Targets within the central nervous system	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
III	**Computational tools:** Homology model building. Importance of sequence similarity in homology modeling**,** Homology model building and importance of sequence similarity in homology modeling Homology model creation Homology model validation. Force fields for drug design Molecular docking:process, preparation of protein and ligand Analysis of docking results and docking software	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

IV	**Clinical trial design and Bioethics**: Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation Clinical safety studies: Adverse events and adverse drug reactions, clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation. Global regulatory affairs and different steps involved, Regulatory objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label vs. off-label drug use GCP and Requirements of GCP compliance, Ethical issues and compliance to current ethical guidelines, Animal ethical issues and compliance	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
V	**Drug applications:** Safety testing in animals- Toxicity tests, Teratogenicity and mutagenicity tests Biopharmaceutical studies- Pharmacokinetic investigation, dosage form development, tablets, Capsules, Other solid dosage forms, Liquid dosage forms, Semisolid dosage forms, Specialized dosage forms, Radiopharmaceuticals Obstacles in drug development Adverse reactions- Drug interactions, Drug patents	**10**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

Text Books

1. Young, (2009). Computational Drug Design: a Guide for Computational and Medicinal Chemists, Wiley Publishers, New Jersey.
2. Kerns, E.H. and Di, L. (2008). Drug-Like Properties: Concepts, Structure Design and Methods: from ADME to Toxicity Optimization, Academic Press, Oxford.
3. Wolff, M. E., and John, W. (2003). Burger's Medicinal Chemistry and Drug Discovery, 6th edition.Wiley Publishers, New Jersey,
4. Andrew, L. (1996). "Molecular Modeling: Principles and applications," 2nd edition, Pearson Education, England.

5. Rick, N.G. (2004). “Drugs: From Discovery to Approval, John Wiley & Sons, New Jersey.

Suggested Readings

1. Krogsgaard, L. (2007). Textbook of Drug Design and Discovery, 4th edition. CRC Press, United States.
2. Gad, S.C. (2008). Preclinical Development Handbook – ADME and Biopharmaceutical Properties, John Wiley and Sons, New Jersey.
3. Stromgaard, K., Krogsgaard-Larsen, P. and Madsen, U.(2016).Textbook of Drug Design and Discovery, 5thedition, CRC Press, United States.
4. Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA 4 and ICH Guidelines. Academic Press, United States.
5. Paul, S. C. (1997). Practical Application of Computer-Aided Drug Design,Marcel Dekker Inc., New York.

Web Resources

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3058157/
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6117650/
3. https://www.britannica.com/technology/pharmaceutical-industry/Drug-discovery-and-development
4. https://www.nature.com/articles/nrd.2017.232.pdf.

Course Outcomes (COs) and Cognitive Level Mapping

Cos	CO Description	Cognitive Level
CO 1	Analyze biological pathways for their potential as drug targets for disease	K1, K2
CO 2	Conceptualize the role of efficacy and toxicity i*n vitro* and *in vivo*	K3
CO 3	Understand critical features at each stage of pre-clinical drug development process	K4
CO 4	Summarize common natural sources of drugs and contemporary approaches to drug design and development	K5
CO 5	Relate computational methods of drug discovery	K6

Course Code	PBT2ME03
Course Title	**FORENSIC SCIENCE**
Credits	02
Hours/Week	04
Category	Major Subject (ME) - Theory
Semester	II
Regulation	2022

Course Overview

1. Forensics deals with general tools and techniques used in forensic investigation.
2. This course aims at imparting knowledge on DNA Fingerprinting and Polymorphism and its applications.
3. This course also provides knowledge in genetics and advanced DNA Forensics.
4. Human Genome Project deals with benefits, social, ethical and legal Issues.
5. This course also highlights the formation on molecular diagnosis for acquired, inherited, and infectious diseases and forensic science.

Course Objectives

1. To understand the modern tools employed to study DNA structure, identify variations in structure among individuals and the molecular basis of human diseases.
2. To understand the genetic abnormalities which can result in genetic diseases.
3. To gain knowledge on the basic principles of molecular biology and their relevance to the identification of disease-causing genes/mutations and the diagnosis of genetic disorders.
4. To distinguish between various mutations and genetic abnormalities which can result in genetic diseases.
5. To differentiate forensic examination types and techniques.
6. To gain knowledge on modern DNA technology to the application of disease gene identification and analysis and current molecular techniques in diagnostic testing.

Prerequisites	Basic knowledge on Forensics

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Laws and Principles:** The role of the Forensic Laboratory, History and development of Forensic Science in India and abroad, Pioneers in Forensic Science, Multidisciplinary nature, Forensic technology solving crimes with advanced technology Forensic Evidences: Concise of Forensic Physical, Biological, Chemical and Psychological evidences, Medico-Legal Cases Law of Exchange (Locard), Law of Individuality, Law of Comparison	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
II	**DNA Fingerprinting and Polymorphism:** Dactylography, Dermatoglyphics, and Dactyloscopy, basis for the science of fingerprints, Friction Ridge Skin, Morphogenesis of Friction Ridge Skin, Primary Dermal Ridge Development Fingerprint as forensic Evidence, Visible Fingermarks, Latent Fingermarks DNA Fingerprinting: Hybridization based DNA fingerprinting (RFLP) - radioactive, fluorescent and chemiluminescent methods; PCR-based DNA fingerprinting- single locus and multi locus DNA fingerprinting, RAPD, and AFLP Polymorphism of some genetic locus in relation to diseases Application of DNA Fingerprinting: Identification of genotype/ varieties, breeds, strains; criminal investigation, immigration, paternity dispute; identification of missing person	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
III	**General Tools and Techniques:** Microscopy: Theory and basic principles, setup and Forensic applications of Compound Electron Microscopy- Structure and Forensic applications of Scanning Electron microscope (SEM), Transmission Electron Microscope (TEM) Chromatography: Forensic applications	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

	Adsorption and Partition Chromatography Thin Layer Chromatography: Forensic applications			
IV	**Crime Scene Investigation**: Crime Scene Reconstruction (CSR): Nature and Importance of CSR Investigation of Road Accident crime scene: Examination of scene, Victim and the vehicle, Collection of the evidence, Tyre marks/prints and skid marks: Significance, Nature, location, collection and evaluation Forensic significance of Glass, Soil and Paint. Interpretations of Bloodstain Pattern Analysis (BPA): Biological and physical properties of human blood, Droplet Directionality from bloodstain patterns, Determination of Point of Convergence and Point of Origin, Impact spatter and mechanisms, Importance and Legal aspects of BPA	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
V	**Recent Trends in Forensic Science-Environmental Forensics:** Legal processes involving environmental forensic science. Geo-forensics Global Positioning System; Basic principles and applications Biometrics in personal identification: Concepts of Biometric Authentication, Role in person Identification, Bioterrorism: Concepts of Biosecurity and microbial forensics Forensic significance of DNA profiling: Applications in disputed paternity cases, child swapping, missing person's identity- civil immigration, veterinary, wildlife and agriculture cases, legal perspectives- legal standards for admissibility of DNA profiling, procedural and ethical concerns, status of development of DNA profiling in India and abroad Human Genome Project: Ethical and Legal Issues. DNA Forensic Databases, Ethical, Legal, and Social Issues Associated with DNA Data banking, Potential Benefits of DNA Data banking.	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

Text Books

1. Freefelder, D. (1985). Essentials of Molecular Biology. Narosa Publishing House. New Delhi.
2. Sue, J. and Adam, N. (2008). Clarke's Analytical Forensic Toxicology,1st edition, Pharmaceutical Press.
3. Kleiner, M. (2002). Handbook of Polygraph Testing. Academic Press.
4. Fowler, E.A. (1993). Techniques for Engineering Genes, Butterworth-Heinemann Ltd., UK.
5. Sharma, B.R. (2019). Forensic Science in Criminal Investigation and Trials,6th edition, Lexis Nexis.

Suggested Readings

1. Gupta, P. K. (1997). Cell and Molecular Biology. Rastogi Publishers.
2. Henry, R. J. (1984). Lab. applications of Plant Molecular Biology, Chapman and Hall Publishers, London.
3. Micklos, D.A. and Freyer, G.A. (1990). DNA Science, Cold Spring Harbor Lab Press, New York.
4. Stansfield, W.D. (1996). Theory and Problems of Molecular and Cell Biology. McGraw Hill Co. New York.
5. Weising, K. H., Nybom, H., Woff, K. and Meyer, W. (1995). DNA Fingerprinting in Plants and Fungi. CRC Press, USA.

Web Resources

1. http://www.personal.umd.umich.edu/~jcthomas/JCTHOMAS/Student%20Papers%201996/P.Adams.html
2. https://legaldesire.com/practical-applications-of-forensic-dna-fingerprinting/
3. https://www.promegaconnections.com/dna-forensic-analysis-9-11/
4. https://atdbio.com/nucleic-acids-book/Sequencing-forensic-analysis-and-genetic-analysis
5. http://aboutforensics.co.uk/case-studies/
6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5608170/

Course Outcomes (COs) and Cognitive Level Mapping

Cos	CO Description	Cognitive Level
CO 1	Demonstrate knowledge and understanding of some of the basic facts, concepts and techniques used in forensic science.	K1, K2
CO 2	Recall various sections of the law in forensic science	K3
CO 3	Analyze crime scene management techniques	K4
CO 4	Relate concepts behind forensic biological and serological analysis of evidence	K5
CO 5	Explain the organizational structures and procedures within forensic sciences	K6

Course Code	PBT2ME04
Course Title	**STEM CELL BIOLOGY**
Credits	02
Hours/Week	04
Category	Major Elective (ME) - Theory
Semester	II
Regulation	2022

Course Overview

1. Stem Cell Biology deals with the biology of stem cells and its applications in regenerative medicine.
2. This course aims at imparting knowledge in the different types of stem cells.
3. The characteristics of embryonic and adult stem cells are dealt with in detail.
4. This course highlights the applications of induced pluripotent stem cells and current challenges.
5. It also highlights the applications of stem cells in medicine as a potential cure to currently incurable diseases.

Course Objectives

1. To understand the scope and importance of stem cells in the human body.
2. To understand the various types of stem cells.
3. To gain knowledge in the characteristic features of stem cells.
4. To distinguish between the embryonic and adult stem cells.
5. To understand the ethics related to stem cell biology.
6. To know the significance of stem cells in medicine.

Prerequisites	Basic knowledge in Cell Biology.

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Stem Cell Biology:** Stem cells in the human body and their characteristics Types of stem cells based on sources and potency Stem cell isolation and culture "Stemness" - markers and their identification	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
II	**Embryonic Stem Cells:** Embryonic Stem Cells – establishing an embryonic stem cell line Characteristics of embryonic stem cells Generation and manipulation of human embryonic stem cells Therapeutic potential and ethical aspects of human embryonic stem cells	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
III	**Induced Pluripotent Stem Cell Technology:** Induced Pluripotent Stem (iPS) cell technology Yamanaka Factors and production of iPSCs Similarities and Differences of iPSCs and ESCs Scientific branches that emerged from the development of iPSCs, current clinical research using iPSCs, ethical aspects of cell reprogramming	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
IV	**Mesenchymal stem cells:** Isolation of mesenchymal stem cells (MSCs) from the umbilical cord Generation of spheroids and organoids Advantages and disadvantages of cord blood stem cells transplantation, cord blood banking Applications and challenges of cord stem cells	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
V	**Stem Cells in Medicine:** Cancer stem cell – characteristics of cancer stem cells and implication of cancer stem cell in cancer therapy Stem cell therapy for neurodegenerative diseases Haematopoietic stem cells as a method of treatment Ethical issues associated with stem cell biology – human stem cell safety and ethics	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

Text Books

1. Atala, A., Lanza, R., Mikos, T. and Nerem, R. (2018). Principles of Regenerative Medicine. Third Edition. Academic Press, USA.
2. Freshney, I. and Capes-Davis, A. (2021) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Eighth Edition. Wiley-Blackwell, United States.
3. Maiti, S. K. (2020). Stem Cell Research in Lab Animals, New India Publishing Agency- Nipa, India.
4. Lanza, R., and Atala, A. (2014). Essentials of Stem Cell Biology, Third edition. Academic press, USA.
5. Slack, J. (2018). The Science of Stem Cells. Wiley-Blackwell, New Jersey, USA.

Suggested Readings

1. Atala, A. and Lanza, R. (2012).Handbook of Stem Cells, Academic Press,Massachusetts, USA.
2. Bagnara, G. P., Bonsi, L. and Alviano, F. (2020). Stem Cells, Societa Editrice Esculapio, Bologna, Italy.
3. Portner, R. (2020). Animal Cell Biotechnology Methods and Protocols, Springer, USA.
4. Pham, P. V. and Rosemann, A. (2018) Safety, Ethics and Regulations (Stem Cells in Clinical Applications), Springer, Germany.
5. Riordan, N. (2017). Stem Cell Therapy: A Rising Tide: How Stem Cells Are Disrupting Medicine and Transforming Lives. Zaccheus Entertainment, India.
6. Stacey, G.N. and Davis, J. (2007). Medicines from animal cell culture. John Wiley and Sons, USA.

Web Resources

1. https://www.eurostemcell.org/
2. https://www.nibib.nih.gov/science-education/science-topics/tissue-engineering-and-regenerative-medicine
3. https://www.sciencedirect.com/science/article/pii/S2157171615310145
4. https://www.sciencedirect.com/science/article/pii/S1934590912002378
5. https://www.sigmaaldrich.com/IN/en/products/cell-culture-and-analysis/cell-lines-and-specialty-cell-culture/stem-cells
6. https://irp.nih.gov/our-research/scientific-focus-areas/stem-cell-biology
7. https://www.closerlookatstemcells.org/learn-about-stem-cells/types-of-stem-cells/
8. https://www.stemcell.com/

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe the characteristics of stem cells and concepts in stem cell biology	K1, K2
CO 2	Classify the different types of stem cells	K3
CO 3	Apply stem cell biology in medicine for the improvement of health	K4
CO 4	Assess challenges in stem cell biology and recommend solutions	K5
CO 5	Defend ethical principles in medical stem cell research	K6

Course Code	PBT2ME05
Course Title	**PUBLIC HEALTH MANAGEMENT**
Credits	2
Hours/Week	4
Category	Major Elective (ME) - Theory
Semester	II
Regulation	2022

Course Overview

1. The course introduces students to the discipline of public health
2. Gives an overview of the methods of prevention and health promotion
3. The course gives an understanding of the determinants and measures of disease and health related states
4. Gives an overview of the status of health and disease at global and national levels

Course Objectives

1. Provide students with the tools to think about the major ethical and related legal questions that arise in medicine and public health.
2. Understanding of the theories, concepts, and skills required to assess population health.
3. Understand health policy as it relates to the organization, financing, and provision of health care.
4. Communicate environmental health information to public and professional audiences.

Prerequisites	Basic knowledge on diseases and infections

SYLLABUS

Unit	Content	Hours	COs	Cognitive level
I	**Population and health:** Introduction to population and health: definition, scope, Concept of demography, Population components, Demographic transition theory Sources of demographic and Health data : Population census, Vital registration system, Sample Registration System, National Family Health Survey (NFHS), District Level Health Survey (DLHS), Annual Health Survey(AHS), National Sample Survey Organization	**12**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**

	(NSSO) (demonstrate the practical use of the data and its advantages and limitations.) Population composition: Levels and trends in the sex and age structure of the population of world and developing countries Concepts, definition, determinants and measurement of fertility, mortality and migration, population projection Life tables: Concept, importance and methods Population policy: Population policy linkages with health issues			
II	**Social Epidemiology** Social determinants of health: socio economic position, education, occupation, ethnicity and health, measurement of determinants, mechanisms and pathways through which income, education, and occupation affect health. Inequalities and disparities in Health: Poverty, discrimination, vulnerability, income inequality and impact on health outcome , measuring poverty, measuring health inequalities Ecological perspective in social epidemiology : Social capital, social cohesion, and health, community-level mechanisms/processes through which community social capital contributes to health improvement Concept of prevention in social epidemiology Public health strategies to reduce health disparities	**12**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Public Health in Disasters and Outbreaks** Epidemic control in India: integrated disease surveillance, legislation for the control of outbreak in India , international health regulations Disaster management - Introduction to Natural & man-made disasters, Disaster Preparedness Plan, Disaster preparedness for People and Infrastructure, Role of technology in disaster Preparedness Disaster Mitigation: Disaster Mitigation Strategies, Emerging Trends in Disaster Mitigation, Role of Team and Coordination,Rehabilitation, Reconstruction & Recovery Disaster Response : role and responsibilities of different governmental organizations at local, district, state and central level	**12**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**

IV	**Health Planning** Definition of Planning, Health Planning Models. History of Planning in India Development of National Health Policy: Evolution of Indian National Health Policies 1981-83, 2001 and 2017 Sustainable Development Goals -. Primary Health Care - Universal health coverage	**12**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Health Systems Management** Health Care Systems in India: Types of service providers, sources and methods of financing, and regulations. Model of health care system in India. Challenges in public health delivery system: with reference to delivery, performance, effectiveness, efficiency, and equity, discussion about the sources of problems and potential solutions..Human resource management in public health (HRM) : nature of human resource management, limitations Health management information system (HMIS): health information sources, challenges in HMIS, advantages and lacunas in current system, recommendations to improve utilization of current HMIS. Brief overview of evolution of management theories and tools and techniques used in management : SWOT, Log Frame, PERT, CPM**,**	**12**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Bhende, A. and Kanitkar, T. (2011).Principles of population Studies, Himalaya Publishers, India.
2. Fallon, L.F. and Zgodzinski, E.J. (2009). Public health management, Jones and Barlett Publishers, United kingdom.
3. Gupta, R.P. (2016). Health Care Reforms in India: Making Up for the Lost Decades, Elsevier Publishers, UK
4. SunderLal and Vikas. (2018).Public Health Management Principles and Practice, 2nd edition. CBS Publishers and Distributors, India.

Suggested Readings

1. Buchbinder andShanks, S.B.H. (2007). Introduction to health care management, Jones and Barlett Publishers, Massachusetts, United States.
2. Gordis, L.(2013). Epidemiology,Fifth Edition. Elsevier, Amsterda, Netherlands.
3. Lieber J.G. and McConnel, C. (2007). Management principles for health professionals, 7thedition, Jones and Barlett, Massachusetts, United States.
4. Schneider, D. and Lilienfeld, D.E. (2015). Lilienfeld's Foundations of Epidemiology. 4th edition, Oxford University Press, Oxford, United Kingdom.
5. Mann, J. and Truswell, S. (2017). Essentials of Human Nutrition. Oxford University Press, United Kingdom.
6. Poston, D. and Micklin, M. (2006). Handbook of Population, Springer, Berlin, Germany.

Web Resources

1. https://www.mphonline.org/public-health-online-resource-guide/
2. https://guides.himmelfarb.gwu.edu/hsml/online-resources
3. https://www.ahrq.gov/
4. https://phil.cdc.gov/default.aspx
5. https://nhm.gov.in/images/pdf/monitoring/crm/10th-crm/Report/10th_CRM_Main_Report.pdf
6. https://www.mphonline.org/public-health-online-resource-guide/

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Compare the organization, structure and function of health care, public health and regulatory systems across national and international settings	K1, K2
CO 2	Assess population needs, assets and capacities that affect communities' health	K3,K4
CO 3	Apply awareness of cultural values and practices to the design or implementation of public health policies or programs	K4
CO 4	Discuss multiple dimensions of the policy-making process, including the roles of ethics and evidence	K5
CO 5	Evaluate policies for their impact on public health and health equity	K6

Course Code	PBT3ME01
Course Title	**DEVELOPMENTAL BIOLOGY**
Credits	2
Hours/Week	4
Category	Major Elective (ME) - Theory
Semester	III
Regulation	2022

Course Overview

1. The course gives an overview of concepts of development, considering the underlying mechanism of major steps in development.
2. The course also compares and contrasts the early development of several model organisms, explores how germ layers give rise to different parts of the body
3. It also focuses on early developmental events and also would address how genes control behaviour and developmental fate in embryos.
4. The course also include interactions that govern pattern formation and body plan and inspire the students to study developmental processes
5. Topics on the developmental biology of seed, embryo, root, shoot and flower development in plants are included.
6. It also highlights the evolution process of plants and animals with regard to developmental biology.

Course Objectives

1. To understand the role of developmental genetics in defining biological processes.
2. Students will understand the language of development and effectively communicate principles.
3. To understand developmental biology of insects.
4. To provide a comprehensive understanding of the concepts of early animal development and also development in plants.
5. To gain knowledge on the developmental mechanisms of evolutionary change.

Prerequisites	Basic understanding of cellular and molecular biology

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Concepts of development and model organisms:** Potency, commitment, determination and differentiation - Specification – Autonomous specification, conditional specification, syncytial specification - Basics of induction and competence Morphogen and Morphogenic gradients - cell fate and cell lineages - Stem cells concept - genomic equivalence and the cytoplasmic determinants Embryonic development – Fertilisation – Oogenesis – Spermatogenesis - Cleavage- Blastula formation – Gastrulation and Neurulation Importance of model organisms (*Xenopus, Arabidopsis, Acetabularia*)	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Insect developmental biology:** Axis formation and specification in Drosophila – Early Drosophila development - Primary axis formation during oogenesis – Anterior posterior polarity in oocytes – Dorsal ventral patterning in oocyte The anterior organizing center: The Bicoid and Hunchback gradients - Segmentation genes – Segment Polarity genes - Homeotic selector genes – Homeobox genes Genetic Dissection of Eye Development in *Drosophila* - The Development of the Optic Lobe Determination of sexual phenotype: sex determination in *Drosophila*, Sex determination in *C. elegans*	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

III	**Animal developmental biology:** Early zebrafish development (cleavage, gastrulation, formation of germ layers) – Axis formation in zebrafish (Dorsal ventral axis formation Nieuwkoop centre, anterior posterior axis formation and coda) - Tetrapod Limb Development - FGF signaling Axis formation in birds - Early development in birds – Organogenesis - Mammalian fertilisation – Normal development (Preimplantation stage and post implantation stage) Cleavage in Animals - Organogenesis – vulva formation in *Caenorhabditis elegans* - eye lens induction, limb development	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
IV	**Biotechnological perspective of plant developmental biology:** Layout of dicot and monocot embryos, cell division and pattern formation in embryo Genetic and hormonal regulation in plant development (YUCCA genes) - Seed formation - cotyledon, endosperm and seed coat development Shoot development - Structure and function of shoot apical meristem (SAM) - initiation and maintenance of SAM Root development - Root apical meristem structure and function - lateral root development - adventitious root development Flower development: Transition from vegetative to reproductive stage, inflorescence meristem, floral whorls specification	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
V	**Evolution and development:** Evo-devo evolution of a new discipline – Anatomical network analysis in evo-devo Evolution of HOX genes Evo-devo lessons from honey bees and aphids - Evo-devo of social behaviour Co-evolution and macroevolution – evolution of angiosperms - Developmental exaptation Developmental plasticity – Developmental system drift – Developmental homology	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

Text Books

1. Baressi, M.J.F., and Gilbert, S.F. (2020). Developmental Biology, 12th edition, Oxford University Press, Oxford, United Kingdom.
2. De la Rosa, L.N., and Muller, G.B. (2021). Evolutionary Developmental Biology-A Reference Guide, Springer, Berlin, Germany.
3. Gilbert, S.F., and Baressi, M.J.F, (2016). Developmental Biology, 11th Edition Sinauer Associates, Inc., Massachusetts, United States.
4. Gilbert, S.F. (2010). Development Biology, Ninth Edition, Sinaure Associates Inc., Massachusetts, United States.
5. Slack, J.M.W. (2013). Essential Developmental Biology. Third Edition, Blackwell Publishers, New Jersey, United States.

Suggested Readings

1. Carlson, B.M. (2019). Human Embryology and Developmental Biology, Sixth Edition. Elsevier, Amsterdam, Netherlands.
2. Chong Pua, E., and Davey, M.R. (2010). Plant Developmental Biology-Biotechnology Perspectives. Springer, Berlin, Germany.
3. Mueller, W.A. (2012). Developmental Biology. Springer, Berlin, Germany.
4. Raven, P.H., Johnson, G.B., Losos, J.B., and Singer, S.R. (2006). Biology, 7th Edition, Tata McGraw Hill Publications, Chennai, India.
5. Wolpert, L., Tickle, C., Arias, A.M., Lawrence, P., and Locke, J. (2019). Principles of Development, Sixth Edition, Oxford University Press, Oxford, United Kingdom.

Web Resources

1. https://www.blackwell-synergy.com/
2. https://www.springer.com/journal/11240
3. https://onlinelibrary.wiley.com/
4. www.wiley.com
5. www.sciencedirect.com

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe the concepts and theories related to developmental biology	K1, K2
CO 2	Knowledge on the different model organisms used in developmental biology	K3
CO 3	Summarize cellular behaviors that lead to morphological change during development	K4
CO 4	Explain reproductive organs, gametogenesis, fertilization cleavage, blastulation and gastrulation	K5
CO 5	Describe the embryology and developmental processes in insects, animals and plants and to relate evolution and development	K6

Course Code	PBT3ME02
Course Title	**PHARMACEUTICAL BIOTECHNOLOGY**
Credits	02
Hours/Week	04
Category	Major Elective (ME) - Theory
Semester	III
Regulation	2022

Course Overview

1. Pharmaceutical Biotechnology deals with pharmacokinetics and principles of drug action.
2. This course aims at imparting knowledge in good manufacturing practices, genetic diseases, and gene therapy.
3. Drug nomenclature and introduction to clinical trials are dealt with in detail.
4. This course also provides knowledge on biopharmaceutical products, polyclonal and monoclonal antibodies.
5. Topic in Biotechnology in Medicine deals with production of human peptide hormones and biopharmaceutical products.

Course Objectives

1. To understand biopharmaceutical products, polyclonal and monoclonal antibodies.
2. To understand gene therapy, biomedical research and biotechnology, social and ethical issues and its scientific basis, and developed skills.
3. To gain knowledge in medical applications of specific biotech products categories.
4. To understand technological procedures for the commercial production of microbial and non-microbial products.
5. To gain knowledge on general principles of drug discovery and development.
6. To identify new types of biotechnological drugs.

Prerequisites	Basic knowledge in Microbiology and Molecular Biology.

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Drug Metabolism:** Biotransformation of drugs – microsomal and non-microsomal mechanisms and enzymes involved Mode of absorption and excretion – biliary/ fecal excretion, factors affecting drug metabolism. Drug metabolism in fetus and newborn Models to study drug metabolism, dose effect relationships, adverse drug reactions – toxic reactions, allergic reactions, idiosyncrasy, acute poisoning and treatment	**10**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**QSAR and Drug Design:** Drug Action – physicochemical properties and stereochemistry of compounds Isosterism and bioisosterism – metabolite, antagonist and structural variations Methods for variation – fibonacci search, topliss tree, craigsplot, simplex methods, and cluster analysis Rational drug design – phases of preclinical and clinical trials. Role of regulatory authorities Drug delivery system – basic concepts and novel advances Cell specific drug delivery, brain specific drug targeting strategies, and pulmonary delivery systems	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Pharmacokinetics:** Membrane transport, adsorption, bioavailability, distribution, metabolism and elimination Mechanism of drug action - factors affecting drug action, drug receptors, ion channels, and drug interaction Targeted drug delivery devices Principles of drug Action, mechanism of drug action- enzymes, ion channels, transporters, receptors Adverse drug effects - pharmacovigilance	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Biological Products:** Properties of biotechnology derived therapeutic	**12**	**CO 1** **CO 2**	**K1, K2, K3, K4, K5, K6**

	products Production of human insulin, interferons, somatotropin, human growth hormone, somatostatin Gene therapy, vaccines, monoclonal antibody based pharmaceuticals Recombinant human deoxyribonuclease		**CO 3** **CO 4** **CO 5**	
V	**Biotechnology in Medicine:** Production of human peptide hormones- insulin, somatotropin, somatostatin, human interferon, different types of vaccines, blood products and antibiotics Production of biopharmaceutical products Biopharmaceutical products from plants, animals and microbes; animal products through cell culture; pharmaceutical products through transgenic technology Blood substrates through transgenic animals	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Huge, W.B. and Russel, A.D. (1993). Pharmaceuticals Microbiology.
2. Innocenti, F. (2016). Pharmacogenomics: Methods and Protocols (Methods in Molecular Biology), Second Edition.Humana Press, United States.
3. Tripati, K.D. (2018). Essential of Medical Pharmacology, Eighth Edition,Jaypee Brothers Medical Publishers, India
4. Malik, K. A., Nasim, A., and Khalid, A. M. (1995). Biotechnology for sustainable development, NIBGE, Faisalabad, Pakistan.
5. Wing, Y., Lam, F., and Scott, S. (2018). Pharmacogenomics Challenges and Opportunities in Therapeutic Implementation, Second Edition, Academia Press, USA.

Suggested Readings

1. Leon, S., Andrew, Y., and Susanna, W. (2012). Applied Biopharmaceutics & Pharmacokinetics, 6th Edition, McGraw-Hill EducationMedical.
2. Loyd, V. A., Howard, and C., Ansel. (2013). Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Wolters Kluwer Health, Pennsylvania, United Sates.
3. Primrose, S. B. (1987). Modern Biotechnology, Blackwell Scientific Publications, New Jersey, United States.
4. Satoskar, R.S., Bhandarkar, S.D., Nirmala, N., and Satoskar, R.R. (2008). Pharmacology and Pharmacotherapeutics, 20th Edition Popular Prakashan (P) Ltd., Mumbai, India.

5. Venkateswarlu,V. (2004).Biopharmaceutics & Pharmacokinetic.Pharma Book Syndicate, Hyderabad, India.

Web Resources

1. https://www.who.int/news-room/questions-and-answers/item/medicines-good-manufacturing-
2. https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_(Boundless)/17%3A_Biotechnology_and_Genomics/17.1%3A_Biotechnology/17.1G%3A_Biotechnology_in_Medicine
3. https://www.thoughtco.com/genetic-variation-373457
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3525971/
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5156500/
6. https://www.who.int/medicines/areas/quality_safety/quality_assurance/TRS986annex2.pdf

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Understand the development and production of medicinal and pharmaceutical products	K1, K2
CO 2	Illustrate the process involved in manufacturing of pharmaceuticals	K3
CO 3	Analyze the significance of industrial applications of pharmaceutical biotechnology in human health care	K4
CO 4	Explain challenges and opportunities in development of biologicals and drugs in the pharmaceutical and biotechnology industry	K5
CO 5	Summarize the technologies for monoclonal antibody production and their therapeutic applications	K6

Course Code	PBT3ME03
Course Title	**MARINE BIOTECHNOLOGY**
Credits	2
Hours/Week	4
Category	Major Elective (ME) - Theory
Semester	III
Regulation	2022

Course Overview

1. The course provides an understanding of molecular structure, genetics, cell organization and the evolutionary processes of marine orgnaisms.
2. It imparts knowledge on the essential facts, concepts, principles and theories related to marine sciences and their relationship with other sciences.
3. It deals with structural and functional organization of marine organisms and their biological diversity.
4. This course also provides knowledge of basic principles in ecology, structure and function of ecosystems, developing it for the marine and coastal environment.
5. It also covers the pharmaceutical uses of marine organisms and toxicological effects of toxins produced by marine organisms.

Course Objectives

1. To understand the essential facts and concepts related to marine biotechnology.
2. To acquire the ability to analyze and determine those marine organisms useful in biotechnology.
3. To know and to apply biotechnology methodologies to the marine environment.
4. To acquire knowledge on the marine biotech companies and the legal aspects of marine biotechnology.
5. To create an interest in the students what are industrial products and practices that are followed in the production of various industrial products and processing and make them a valuable source for industries.

Prerequisites	Basic knowledge in marine organisms

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Microbial and micro-algal technologies in aquaculture:** Bio-floc technology; Aquaponics; Zero water exchange aquaculture system Aquamimicry; Hydroponics; Raceway system of aquaculture - Bioremediation in Aquaculture systems Bioremediation for soil and water quality improvement - Probiotics – Role of modified organisms in wastewater treatment Biotechnological approaches for production of important microalgae. Algal nutraceuticals - Biofuel production from microalgae Metabolic engineering of microalgae for biofuel production	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Industrial Aquaculture technology and cultivation of commercially important marine species :** Fish Feed Technology: Types of feed, conventional feed vs functional feeds- Use of natural and synthetic carotenoids; feed additives Feed evaluation - Feeding schedule to different aquatic organisms, check tray operation and feed management - Biomass calculation based on feed intake Detection of toxic substances and pathogenic microbes; biosensors for toxin detection Commercially important marine species (Seaweed, carp, Tilapia, Tuna) - Cultivation of shrimp and Carp	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

III	**Techniques in marine biotechnology :** Monitoring methods in biofouling – Bacterial biosensors - Protection methods and treatments- Quorum quenching Monitoring methods in biofilm - Protection methods and treatments Detection of invasive species – traditional techniques-molecular approaches – PCR based methods – Ecogenomic techniques Transgenic technology in marine organisms – Production and Characterisation - Recent advances in imaging techniques for marine organisms – Proteomics as potential tool for survey	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Marine Pharmacology and Marine Pollution:** Principles and mechanisms of drug action; Pharmacokinetics and pharmacodynamics - Marine derived pharmaceuticals Potential pharmaceuticals from soft and hard corals - Pharmaceutical potential of marine sponges Marine Toxins- Ciguatera fish toxin, scombroid fish toxin, palytoxin, tetrodotoxin and shellfish toxins – Sources and types of marine pollution Radioactive pollution and its treatment methods - Marine biotoxins and potential pharmacological uses of phyco-toxins Microplastic pollution in marine environment – Bioremediation of marine plastic pollution	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Marine Products :** Marine products in food sector- Varieties of fishes, shrimps, crabs and lobsters - Green fluorescent protein (GFP) & red fluorescent protein (RFP) characteristics and their applications Marine derived drugs in preclinical and clinical trials- Marine drugs- mode of action and uses Screening of drugs High-throughput Screening Assays (HTS) - Marine organisms for Biofuels and bioenergy, Bioremediation, Biofouling, Biosurfactants Marine natural products as cosmetics-cosmeceuticals - Algotherapy – Thalassotherapy -	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	Enzymes - food, supplement, nutrition and energy drinks - Gene manipulation to increase production			

Text Books

1. Fingerman, M. and Nagabhushanam, R. (2000). Recent Advances in Marine Biotechnology. Taylor & Francis Publishers.
2. Proksch, P., Werner, E.G., and Müller. (2006). Frontiers in Marine Biotechnology. First Edition, Taylor & Francis.
3. Bradach, J.E., Ryther, H.H., and Larney, M.C. (1972). Aquaculture, farming and husbandry and fresh and marine organisms. Wiley, New York, United States.
4. Krichman, D.L. (2000). Microbial ecology of the oceans. Wiley, New York, United States.
5. Kim, S.W. (2015). Handbook of Marine Biotechnology. Springer, Berlin, Germany.

Suggested Readings

1. Montet, D. and Ramesh, C. (2011). Ray Aquaculture Microbiology and Biotechnology, First Edition, Science Publishers, Chennai, India.
2. Rheinhemer, G. (1980). Aquatic Microbiology, John Wiley & Sons, New York, United States
3. Karleskint, G., Turner, R., and James. (2009). Small Introduction to Marine Biology, Third Edition. Brooks Cole Publishers.
4. Dewan, S., Bhakuni, and Rawat, D.S. (2010). Bioactive Marine Natural Products. Springer.
5. John Paul. (1999). Marine Microbiology. Elsevier, Amsterdam, Netherlands.
6. Munn and Munn. (1996) Marine Microbiology: Ecology and Applications. BIOS Scientific, Spring, United States.

Web Resources

1. https://www.springer.com/journal/10126
2. https://www.frontiersin.org/journals/all/sections/marine-biotechnology
3. https://www.isaaa.org/resources/publications/pocketk/52/default.asp
4. https://www.sciencedaily.com/new
5. http://aquafind.com/articles/Marine-Biotechnology.php

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe fundamental concepts in marine biotechnology	K1, K2
CO 2	Apply biotechnological techniques to produce commercially important marine products	K3
CO 3	Assess sources of marine pollution and recommend bioremediation strategies	K4
CO 4	Summarize key techniques in marine biotechnology	K5
CO 5	Compile strategies for protection of marine diversity and optimal utilization of marine resources	K6

Course Code	PBT3ME04
Course Title	**ENVIRONMENTAL BIOTECHNOLOGY**
Credits	2
Hours/Week	4
Category	Major Elective (ME) - Theory
Semester	III
Regulation	2022

Course Overview

1. The course introduces the students to various regional and global concerns regarding the role of microbes in environment sustainability.
2. It helps to address the various concerns of natural challenges, environmental pollutants and their effects.
3. Investigate some examples of different types of environmental pollution and their impacts.
4. To introduce specific examples and cases, and explain how chemical, biological and molecular sciences can be applied to identify and address issues of environmental concerns.

Course Objectives

1. To identify and explain the environmental factors responsible for the pollution.
2. To provide solutions for environmental problems and understand legal aspects related with environmental issues and environmental protection.
3. To select the appropriate method for the treatment of wastewater and solid waste management
4. To select and apply suitable bioremediation methods for the treatment.
5. To introduce the developments of diverse technologies to detect, study and address theconcerns of the changing environment.

Prerequisites	Basic Knowledge of Environmental Science

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Ecological Principles:** Ecosystem, concept of biosphere, Biodiversity and its conservation strategies, Natural resources Environmental Protection Acts and Legislations, Environmental planning for sustainable development. Resource exploitation by Microorganisms: Functions of various microbial groups relevant to environmental systems, including waste treatment and resource recovery, implications in biogeochemistry.	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Air, Water and Soil pollution:** Point and nonpoint source pollution, Air pollution control: particulate emission, control devices, control of Sulphur dioxide pollution and vehicular pollution. Water pollution control: primary, secondary and tertiary treatment. Solid waste and soil pollution management: waste monitoring, treatment and management of non-hazardous solid waste, non-degradable solid waste, colour codes, medical solid waste. Environmental Monitoring: Bioindicators –Biomarkers –Biosensors –Biomonitoring –Polluted environment – Short- and long-term monitoring of remediated sites	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Biodegradation, Bioconversion and Bioabsorption:** Carbon sequestration, Bioremediation: microorganisms and techniques Biomethanation , Biofertilizers and biopesticides, Composting: process and decomposition stages, vermicomposting, Biofuels: biogas; bioethanol; biodiesel; biohydrogen Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals Production of bioplastics; Production of	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	biosurfactants: bioemulsifiers Degradation of Xenobiotics, oil spill degradation - superbugs			
IV	**Environmental Sustainability**: Remedial Mechanisms of Industrial Problems -Pulp and paper industry: problems associated and treatment of pollutants Tannery industry: effluent characteristics and treatment, Distillary effluent treatment, Treatment methods for dye industry effluents Waste reduction and treatment of effluents from pharmaceutical, petroleum and dairy industries. Biodiversity- conservation – molecular methods	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Case Studies**: Evolution, Species Interactions, and Biological Communities - Natural Selection and the Galápagos Finches Biomes and Biodiversity - Forest Responses to Global Warming. Food and Agriculture - Farming the Cerrado Environmental Health and Toxicology -How Dangerous Is BPA? Climate - Shrinking Florida Air Pollution - The Delhi Smog Environmental Geology and Earth Resources - Mountain top Removal Mining	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Bruce, E., Rittman and McCarty, P. (2020).Environmental Biotechnology, Principles and Applications. McGrawhill Higher education, United States.
2. Dash, M. and Dash, S. (2009). Concepts of Ecology, 3rd Ed. McGraw Hill Education, United States.
3. Mohapatra. (2007). Text Book of Environmental Biotechnology, 1st Ed., I K International

Publishing House Pvt. Ltd , India.

4. Odum E.P. (2004) Fundamentals of Ecology,5th Ed. Brooks/Cole, Belmont.

Suggested Readings

1. Jordening, H. and Winter, J. (2005). Environmental Biotechnology – Concepts and Applications, Wiley- Blackwell, New Jersey,
2. Evans.G.M. and J. C. Furlong. (2003). Environmental Biotechnology: Theory and Applications, Wiley Publishers Hill Publishing Co Ltd, New Jersey.
3. Milton Wainwright. (2012). Introduction to Environmental Biotechnology.Springer, New York.
4. Santra.S.C. (2011). Environmental Science, Third Ed. New central Book Agency, India
5. Viswanath Buddolla, Environmental Biotechnology. (2017). Basic Concepts and Application. Alpha Science, New Delhi.

Web Resources

1. https://www.nature.com/subjects/environmental-biotechnology
2. https://journals.plos.org/plosone/browse/environmental_biotechnology
3. https://www.c2es.org/
4. http://www.wri.org/
5. http://www.envirolink.org/
6. http://conbio.net/vl/

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Identify Environmental problems	K1, K2
CO 2	Apply tools and techniques to monitor environmental pollution	K3, K4
CO 3	Design techniques for bioremediation process	K4
CO 4	Recognise the various remedial mechanisms of industrial concerns	K5
CO 5	Appreciate the scientific, ethical and/or social issues associated with certain applications of biotechnology for alleviating the environmental concerns	K6

Course Code	PBT3ME05
Course Title	**NANOBIOTECHNOLOGY**
Credits	2
Hours/Week	4
Category	Major Elective (ME) - Theory
Semester	III
Regulation	2022

Course Overview

1. The course covers concepts in nanomaterials and their use with biocomponents
2. It also deals with nanofilms, self-assembly of nanomaterials and nanoparticles used in drug delivery system
3. To provide an overview of nanomaterials and their toxic effects.
4. The course also provide technological impact of nanoscale systems, synthesis, and characterizations of nanoscale materials.
5. Nanobiotechnology also gives an insight into the use of biologically inspired nanomaterials in nature and 3D bioprinting
6. This course includes applications for visualization, biosensing, labeling, drug delivery, and cancer research.

Course Objectives

1. To review various types of nanomaterials and general terminologies used in Nanobiotechnology.
2. To understand the essential features of biology and nanotechnology that are converging to create the new area of Nanobiotechnology.
3. To recognize the structural and functional principles of Nanobiotechnology.
4. To explain interactions between cells, nucleic acids, proteins, and nanostructured biomaterials.
5. To employ bionanomaterials for analysis and sensing techniques.
6. To explain the applications of nanotechnology in various fields.

Prerequisites	Basic knowledge on Biological Sciences and Physics

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Introduction to Nanobiotechnology** Historical perspective of nanobiotechnology - Major themes in biology - Determining structures in biology – Dynamic cellular probes – Advances in structural biology (AFM, Quantum dots, Nanoparticle probes) Nanobiotechnology sensors – Biosensors – Plasmonic biosensors –- Cellular nanostructures - Different formats of nanomaterials - Cellular Nanostructures – Nanopores Biomolecular motors – Bioinspired Nanostructures Characterization of nanomaterials – Nanocapsules and their characterization - Future of nanobiotechnology	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Nanofilms, Nanoparticle extraction and synthesis** Thin films – Thin Film Characterization: Structural, Chemical, optical, electrical and magnetic properties - Colloidal nanostructures and Self Assembly Nanovesicles, Nanospheres - Nanoparticles for drug delivery - optimization of nanoparticle properties for suitability of administration through various routes of delivery Nanoparticle dendimers – nanorobots – nubot - nanoshell Nanoparticle extraction – Plant and microbial based nanoparticles - Synthesis – Extraction of nanoparticles from plants - Microbes used in synthesis of nanomaterials (Bacteria, Fungi, Yeast, Actinomycetes)	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Nanomaterials and Nanotoxicity** Nanomaterials for catalysis, development and characterization of nanobiocatalysts - Application of nanoscaffolds in synthesis - applications of nanobiocatalysis in the production of drugs and drug intermediates Introduction to safety of nanomaterials – FDA regulations - Basics of nanotoxicity - Toxicity and environmental risks of Nanomaterials Models and assays for nanotoxicity assessment - Fate of nanomaterials in different stratas of environment	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	Ecotoxicity - models and assays - Life Cycle Assessment – Containment			
IV	**Nanobiotechnology in nature and 3D bioprinting** Bionanomachines in action - Natural bionanomachinery - World of Bionanomachines - Modern Biomaterials Natural Bionanomachines composed of protein and nucleic acids Biomimetics - Lotus leaf effect - Gecko feet and superglue - Flow sensors based on blind fish hair structures - Butterfly wings – Pitcher plant - Shark skin History, principle, components and Classification of 3D bio-printing techniques Extrusion-based bio-printing, Droplet-based bio-printing, Laser-based bio-printing Computer-Aided Design Based Systems, 3D modelling softwares, Bio inks for 3D bio-printing - Applications of 3D Bio-printing and future trends	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**
V	**Applications of Nanobiotechnology** Medicine and healthcare – Diagnosis – Cancer therapy - Artificial nose biosensor –Microarrays – Nanobarcodes Nanotechnology applications in medical field - Imaging - Diagnostic imaging, In situ diagnostic devices - Therapy - Drug development and targeted drug delivery - Drug design and screening, siRNA drug delivery - Stimuli activated drug delivery Nanobioremediation - Environment Remediation and mitigation - Pollution prevention - Environment sensing Nanotechnology in plant protection and agriculture - nanoparticle based pesticides Application of nanoparticles in food industry - Food packaging and monitoring	**12**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2,** **K3, K4,** **K5, K6**

Text Books

1. Boisseau, P., and Marcel Lahmani. (2009). Nanoscience: Nanobiotechnology and Nanobiology. Springer, United States.
2. Christof, M., Niemeyer and Mirkin, C.A. (2004). Nanobiotechnology: Concepts, Applications and Perspectives. Wiley Publishers, New Jersey.
3. Lee, Y.C., and Moon, J.Y. (2020). Introduction to Bionanotechnology. Springer Publishers, United States.
4. Dawn, P., Karen, W.B., Byers. (2017). Biological Safety: Principles and Practices. 5th Edition. ASM Press Poole, C.P., Owens, F.J. (2020). Introduction to Nanoscience and Nanotechnology, An Indian Adaptation. Wiley Publishers, New Jersey.
5. Goodsell, D.S. (2004). Bionanotechnology: Lessons from Nature. Wiley Publishers, New Jersey.

Suggested Readings

1. Hillery, A.M., and Park, K. (2016). Drug delivery: Fundamentals and applications. (Eds.). CRC Press, India.
2. Jain, K.K. (2008). The Handbook of Nanomedicine. Humana Press, United States.
3. Niemeyer, C.M., and Mirkin, C.A. (2004). Nanobiotechnology Concepts, Applications and Perspectives. Wiley Publishers, New Jersey.
4. Shoseyov, O., and Levy, I. (2010). NanoBioTechnology: BioInspired Devices and Materials of the Future. Humana Press Publishers, United States.
5. Wang, B., Hu, L., and Siahaan, T.J. (2016). Drug delivery: Principles & applications. John Wiley & Sons, United States.

Web Resources

1. https://www.nanowerk.com/
2. https://www.azonano.com/aboutus.aspx
3. https://www.nano.gov/
4. https://www.nanotechmag.com/
5. https://www.sciencedirect.com/journal/nano-today
6. https://jnanobiotechnology.biomedcentral.com/

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Recognise the concepts in nanotechnology in relation to biology	K1, K2
CO 2	Students would gain knowledge about the use of nanofilms and how nanoparticle could be used for delivery of drugs	K3
CO 3	Students understand about the safety and harmful aspects of nanomaterials	K4
CO 4	Gain familiarity with working principles, tools and techniques in the field of nanomaterials and relate biologically inspired nanomaterials and the concept of 3D bioprinting	K5
CO 5	Critically evaluate the potential and ethical aspects of bionanotechnology	K6

Course Code	PBT3ID01
Course Title	**PRINCIPLES OF FOOD PROCESSING**
Credits	3
Hours/Week	6
Category	Inter departmental (ID) - Theory
Semester	2022
Regulation	PBT3ID01

Course Overview

1. The aim of this course is to provide information on the processing aspects and unit operations of cereals, pulses, oil seeds, fruits, vegetables, dairy, poultry and meat with its recent trends and future perspectives.
2. This course emphasize on the structure, composition and nutritional significance of food groups along with its post harvesting practices.
3. The course also covers up spices, and plantation crops and its processing and manufacturing.
4. The course will focus on dairy processing and preservation techniques required in dairy processing units with the commercial availability of value-added dairy products.
5. The course will also focus on creating human resources to the food processing sectors with the knowledge gained in Biotechnology

Course Objectives

1. To introduce the students about the processing aspects and unit operations of cereals, pulses, oilseeds, fruits, vegetables, beverages,basic information of spices and plantation and sea foods.
2. To understand the unit operations of food processing
3. To enable the students to better understand the processing operations of sea foods, poultry and livestock.
4. To expand the knowledge on the dairy processing sector and also to familiarize the students about the value-added dairy products.
5. To understand the concepts of food safety, hygiene practices and recent regulatory issues of food laws.

Prerequisites	Basic knowledge on food processing and unit operations

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Introduction to food processing :** Background: Scope and principles of food processing; and preservation. Unit operations in food processing –Heat transfer, fluid flow, Mass transfer, Mixing, Size adjustment; fluid-solid separation; filtration; membrane separation; drying, extrusion and crystallization, storage, packaging Novel processing techniques: Hurdle technology, Irradiation, Ultrasound, Dielectric heating. Food Safety: Introduction to food safety aspects and food related hazards – HACCP and ISO, FSSAI. Risk analysis framework for chemical and microbial hazards	**16**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Separation and Concentration Techniques:** Liquid Concentration – Evaporation, Membrane Separation, Membrane Systems, Cleaning and Sanitation, Food Quality in Membrane Operations, Freeze Concentration Dehydration - State of Water in Foods, Effects of Drying on Product Quality, Moisture Sorption and Desorption, Rate of Dehydration, Factors That Influence Drying, Drying Methods -Spray Drying, Freeze Drying Commercial Sterilization - Heating and Cooling of Food in a Container, Establishment of Process Times ,The Influence of Commercial Sterilization on Product Quality	**18**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

III	**Cereals,Pulse and Oilseeds Processing**: Cereals - Structure and nutrient composition of cereals and Millets, Processing: Milling, Parboiling, Rheological properties of processed and value added cereal products. Pulses And Legumes - Post harvest technology involved in pulse and legume processing, storage and structural composition of pulse, milling of pulses. Oil Seeds - Oil seeds processing- Refining methods involved- Clarification, degumming, neutralization, bleaching, deodorization techniques/process, blending of oils. Hydrogenation, Fractionation, Winterization	**18**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Fruits , Vegetables and Plantation Crops Processing:** Fruits And Vegetables - Composition and nutritive values of fruits and vegetables; Post harvest technology. Dehydration of fruits and vegetables: Conventional and modern methods. Different types of spoilages in fruits and vegetables and their prevention. General methods of preservation of whole fruits/vegetables and processed fruits and vegetables. Cocoa processing, Tea and Coffee.	**16**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Dairy, Meat, Fish and Poultry Processing:** **Meat and Poultry:** Milk - Milk collection, physical and chemical properties, Milk industry functioning in India,with its procurement and transport facilities, Thermal and Non thermal processing techniques used in milk processing. Fermented and Non fermented Milk products. Meat -Structure and composition of Meat, Factors affecting post-mortem changes in meat. Meat tenderization and preservation - aging; pickling; smoking. Dried,Cured meat and Canned meats.	**22**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

	Fish - Types of fish; composition; structure and spoilage factors of fish; Chilling of fish; Freezing and Individual quick freezing; canning, smoking and dehydration operations.Processed fish products. Egg - Structure; composition; nutritive value; calculation of nutritive value and functional properties of eggs; Preservation and maintenance of eggs; Egg grading; egg powder processing - Preservation of Albumin and yolk- powder production. .			

Text Books

1. Murano.P.S (2003) Understanding food science and technology, Thomson Wordsworth Publishers, United States.
2. Hirasa, K and Takemasa, M.(1998) Spice Science and Technology, Marcel Dekker, New York.
3. Pruthi, S. (1999). Quality Assurance in Spices and Spice Products (Modern methods of analysis), Allied Publishers, India.
4. Stephene Clark (2014); Food Processing: Principles and Applications,2nd Edition Wiley, New Jersey
5. Fellows P (2000); Food ProcessingTechnology: Principles and Practice,2nd Edition, Wood Head Publishing.Blackwell publications, New Jersey.

Suggested Readings

1. Kapoor, A. (2005). Dairy Science and Technology, Vishvabharti Publications, New Delhi.
2. Mead, G (2004) Poultry Meat Processing and Quality, Wodhead Publishing, England
3. Botana.M. Luis (2008) Seafood and Freshwater Toxins, Taylor & Francis Group, CRC Press, India
4. Shimdt, R. H. and Rodick, G. (2003) Food Safety Handbook, John Wiley and Sons Publications, UK.
5. Norman N. Potter, (2007) Food Science5th Edition,CBS Publishers, India.
6. Khetarpaul, N. (2005). Food Processing and Preservation, Daya Publications, New Delhi.
7. Berk, Z. (2009). Food Process Engineering and Technology. Academic Press,United States.

Web Resources

1. https://www.journals.elsevier.com/meat-science
2. https://www.seafoodsource.com
3. https://www.thepoultrysite.com
4. https://dairyprocessinghandbook.tetrapak.com
5. https://fruitandvegetable.ucdavis.edu

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Explain the background and scope of food processing sector	K1, K2
CO 2	Encompass the food safety, food laws and regulatory bodies.	K3
CO 3	Identify the role of unit operations in meat, poultry, fruits, vegetables, dairy and sea foods processing industries and to interpret its usage in shelf life studies.	K4
CO 4	Explain the post-harvest and post mortem changes in plant and animal products and optimizing the steps to conserve its nutritional, chemical properties	K5
CO 5	Relate concepts of novel food processing techniques and to explain the various value-added products obtained from processing the foods.	K6

Course Code	PBT2CD01
Course Title	**BIOTECHNOLOGY AND HEALTH**
Credits	2
Hours/Week	3
Category	Cross Disciplinary (CD) - Theory
Semester	II
Regulation	2022

Course Overview

1. The course provides education on health and diseases caused in human.
2. It imparts knowledge on vaccines, development and delivery methods.
3. It also covers the impact of genetically modified food on human health.
4. The role of micro and macro algae in providing health benefits would also be discussed in the course.
5. The course also covers emerging fields in health and biotechnology.

Course Objectives

1. To provide students with advanced knowledge and use the latest biotechnological methodologies for operating in the field of diagnostics, basic and applied research and therapeutic innovation.
2. To impart deep knowledge on the field of biotechnology and health
3. To gain knowledge in latest developments connected to use of biotechnology in improving health.
4. To inculcate social and moral values and sense of scientific responsibilities in students
5. Develop skills in relevant areas and awareness on public health

Prerequisites	Basic understanding of biological sciences and human health

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Health education** Nutrition: Balanced diet, deficiency disorders of various nutrients, their prevention and treatment Communicable diseases: The causative agents, modes of transmission of diseases Prevention of chickenpox, measles, tuberculosis, malaria, SARS	9	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Vaccine technology** Introduction to vaccines and development Classification of vaccines -Recombinant DNA and protein-based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines Conventional and non-tradition delivery methods Regulation of vaccines in developing countries, Vaccine safety and Legal issues	9	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Biotechnology and Food** Development of food through Modern biotechnology Impact of GM foods on health GMOs and environmental safety	9	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
IV	**Microbial and algal nutraceuticals** Concept of prebiotics and probiotics - principle, mechanism, production and technology involved Applications - examples of bacteria used as probiotics, use of prebiotics in maintaining the useful microflora - extraction from plant sources Algae as source of omega - 3 fatty acids, antioxidants and minerals - extraction and enrichment	9	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**
V	**Emerging Fields in Biotechnology and health** Developments in gene therapy Tissue Engineering Therapeutic Proteins Ethics and regulations in clinical research, licensing procedures in India	9	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Dimitris Dogramatsiz (2016) Healthcare Biotechnology, CRC Press, USA
2. Stanley A. Plotkin and Walter Orenstein & Paul A. Offit. (2013) Vaccines, 6th Edition. BMA
3. Judit Pongracz. (2008). Medical Biotechnology. Elsevier, USA
4. Barh D. (2022) Biotechnology in Health care: Technology and Innovations. Academic Press, United States.
5. Joshi, S., Mukherjee, S., and Nag, M. (2022)Contemporary Medical Biotechnology Research for Human Health. Elsevier Science, United States

Suggested Readings

1. Hawer, D. (2021). Public Health and Infectious Diseases. Elsevier, Amsterdam, Netherlands.
2. Gilliam, S., and Yates, J. (2021) Cambridge University Press, Cambridge, United Kingdom.
3. Khan, F.A. (2017) Biotechnology in Medical Sciences. CRC Press, USA
4. Gualberto, M. A., Rocha, T. M., Neri da Silva. H. J. (2021) Biotechnology and Public Health: Unraveling Science. Our Knowledge Publishers, India
5. Witten, M., and Vincent D.J. (1994) Computational Medicine, Public Health and Biotechnology

Web Resources

1. www.pubmed.com
2. www.wiley.com
3. www.springer.com
4. www.sciencedirect.com
5. www.elsevier.com
6. www.blackwellsynergy.com

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Define the fundamentals of biotechnology, microbiology, pharmacology, genetics, clinical testing associated with the health sector	K1, K2
CO 2	Explore scientific methods and experimental techniques in accordance with accepted principles of quality assurance and manufacturing in the biotech industry	K3, K4
CO 3	Examine the applications of biotechnology to the society	K4
CO 4	Compose the advantages of biotechnology in diagnostics, drug designing, stem cell biology	K5
CO 5	Develop an ability to identify, organize and answer problems in the field of health biotechnology	K6

Course Code	PBT3VA01
Course Title	**MEDICINAL PLANTS AND SOCIETY**
Credits	1
Hours/Week	2
Category	Value Added Course (VA) – Theory & Practical
Semester	III
Regulation	2022

Course Overview

1. The course introduces the students to most commonly used natural plant products and their complementary and alternative therapies for a healthy lifestyle
2. This course analyzes the importance of plants and the role plants have in the local and global community.
3. This course deals with basic phytopharmacognosy, providing information on medicinal, tonic and culinary uses of plants.
4. It also involves the use of technology in the manufacturing of value-added plant products like herbal cosmetics, nutraceuticals and herbal drugs.
5. The course provides and overview of natural plant products are the most commonly used complementary and alternative therapies for a healthy lifestyle.

Course Objectives

1. It would help students learn about medicinal plants and how humans have impacted the plant world though discussion-based activities
2. Students would evaluate the importance of plants as sources of bioactive chemicals
3. The course also examines the importance of medicinal plants.
4. To understand the importance of herbal nutraceuticals for a healthy lifestyle.
5. To learn about medicinal plant conservation methods.

Prerequisites	Basic understanding of plants and human health

SYLLABUS				
Unit	**Content**	**Hours**	**COs**	**Cognitive level**
I	**Herbal medicine** and **Phytochemical Analysis** Medicinal Plants – Importance and Scope - Importance of medicinal plants - Use of medicinal plants in indigenous / traditional systems of medicine - Siddha, Unani, Ayurveda and Homeopathy - Herbal remedies for holistic health - Collection - Processing of crude drugs and their marketing - Chemical nature of crude drugs – Extraction – Preparation - Preservation of crude drugs - Drug adulteration – deliberate and indeliberate adulteration - Types of adulterants	**6**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**
II	**Herbal cosmetics and Nutraceuticals** Herbal plants used in cosmetic formulations for skin care (cream, lotion and sunscreen), hair care (oil, shampoo, conditioner and dye) and oral care (toothpaste and mouthwash). Advantages of herbal formulations over synthetic cosmetics. Study of various oils used in aromatherapy with special reference to its applications in inhalation, local application and bath. Herbal nutraceuticals and their health benefits; culinary uses of herbs	**6**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**
III	**Conservation of medicinal plants** Conservation and sustainable use of medicinal plants - In-situ and ex-situ conservation methods - Centres for conservation of medicinal plants – CIMAP and FRLHT; TKDL - Plant tissue culture as a source of phytopharmaceuticals – *In vitro* culture of endangered medicinal plants - Regulatory status of herbal medicine in India	**6**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**
IV	Examination and study of medicinal plants, organoleptic characters, chemical constituents and medicinal uses of the following herbs: *Andrographis paniculata, Phyllanthus amarus, Vitex negundo, Ocimum sanctum, Coleus ambonicus and Catharanthus roseus.*	**6**	**CO 1 CO 2 CO 3 CO 4 CO 5**	**K1, K2, K3, K4, K5, K6**

V	Preparation of Kabasara kudineer - herbal formulation. Preparation of lemon grass medicinal tea. Preparation of herbal mouthwash. Preparation of medicinal sukku coffee	**6**	**CO 1** **CO 2** **CO 3** **CO 4** **CO 5**	**K1, K2, K3, K4, K5, K6**

Text Books

1. Faroogi, A.A.,and Sreeramu, B.S, 2004. Cultivation of medicinal and aromatic crops. Revised edition, Universities Press (India) Private Limited, Hyderabad
2. Bhattacharjee S.K (2009) Handbook of MAPs. Pointer Publishers, India
3. Trease and Evans. (2009). Pharmacognosy. 16th edition. W.B. Saunders Co. Ltd., London
4. Khandelwal, K.R. (2002). Practical Pharmacognosy: Techniques and Experiments. 9th edition. Nirali Prakashan, Pune.
5. Trease and Evans. (2009). Pharmacognosy. 16th edition. W.B. Saunders Co. Ltd., London

Suggested Readings

1. Veeresham. 2006. Medicinal Plants Biotechnology
2. Shiva, M.P. 2002. Aromatic and Medicinal Plants: Yielding Essential oil for Pharmaceutical Perfumery and Cosmetic Industry and Trade
3. Trease and Evans. 2009. Pharmacognosy. 16th edition. W.B. Saunders Co. Ltd., London
4. Bakhru, H.K. (2010). Foods That Heal: The Natural Way to Good Health. Orient Paperbacks, New Delhi.
5. Fuller, K.W., and Gallon, J.A. (1998). Plant Products and New Technology. Clarendon Press, New York

Web Resources

1. www.springer.com
2. www.sciencedirect.com
3. www.blackwellsynergy.com
4. https://link.springer.com/book/10.1007/978-3-030-58975-2
5. https://www.fnp.com/blog/what-are-the-health-benefits-of-medicinal-plants
6. https://tnsmpb.org/medicinal-plants.html
7. https://zeenews.india.com/health/medicinal-plants-in-tamil-nadu-may-be-introduced-for-commercial-cultivation-1978104
8. https://medlineplus.gov/herbalmedicine.html
9. https://www.hopkinsmedicine.org/health/wellness-and-prevention/herbal-medicine
10. https://www.urmc.rochester.edu/encyclopedia/content.aspx?contenttypeid=1&contentid=1169
11. https://rain-tree.com/plants.htm
12. https://naturalmedicines.therapeuticresearch.com/

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description
CO 1	Explain the importance of medicinal plants and explains how humans have used different plant parts.
CO 2	Analyze the importance of plants and their role in the local and global community.
CO 3	Identify how humans have shaped the plant world.
CO 4	Outline how plants are used and manipulated by people and conversely how plants have shaped human society.
CO 5	Evaluate the importance of plants as sources of bioactive chemicals such as drugs (including medicines) and beverages.

LOCF BASED DIRECT ASSESSMENTS

COGNITIVE LEVEL (CL) AND COURSE OUTCOME (CO) BASED CIA QUESTION PAPER FORMAT (PG)

SECTION		Q. NO	COGNITIVE LEVEL (CL)					
			K1	K2	K3	K4	K5	K6
A	(5 x 1 = 5) Answer ALL	1(a)	+					
		(b)	+					
		(c)	+					
		(d)	+					
		(e)	+					
	(5 x 1 = 5) Answer ALL	2(a)		+				
		(b)		+				
		(c)		+				
		(d)		+				
		(e)		+				
B	(1 x 8 = 8) Answer 1 out of 2	3			+			
		4			+			
C	(1 x 8 = 8) Answer 1 out of 2	5				+		
		6				+		
D	(1 x 12 = 12) Answer 1 out of 2	7					+	
		8					+	
E	(1 x 12 = 12) Answer 1 out of 2	9						+
		10						+
No. of CL based Questions with Max. marks			5 (5)	5 (5)	1 (8)	1 (8)	1 (12)	1 (12)
No. of CO based Questions with Max. marks			CO1		CO2	CO3	CO4	CO5
			10 (10)		1 (8)	1 (8)	1 (12)	1 (12)

Forms of questions of **Section A** shall be MCQ, Fill in the blanks, True or False, Match the following, Definition, Missing letters. Questions of **Sections B, C, D and E** could be Open Choice/ built in choice/with sub sections. Component III shall be exclusively for cognitive levels K5 and K5 with 20 marks each. CIA shall be conducted for 50 marks with 90 min duration.

COGNITIVE LEVEL (CL) AND COURSE OUTCOME (CO) BASED END SEMESTER EXAMINATION QUESTION PAPER FORMAT (PG)

SECTION		Q. NO	COGNITIVE LEVEL (CL)					
			K1	K2	K3	K4	K5	K6
A	(5 x 1 = 5) Answer ALL	1(a)	+					
		(b)	+					
		(c)	+					
		(d)	+					
		(e)	+					
	(5 x 1 = 5) Answer ALL	2(a)		+				
		(b)		+				
		(c)		+				
		(d)		+				
		(e)		+				
B	(3 x 10 = 30) Answer 3 out of 5	3			+			
		4			+			
		5			+			
		6			+			
		7			+			
C	(2 x 12.5 = 25) Answer 2 out of 4	8				+		
		9				+		
		10				+		
		11				+		
D	(1 x 15 = 15) Answer 1 out of 2	12					+	
		13					+	
E	(1 x 20 = 20) Answer 1 out of 2	14						+
		15						+
No. of CL based Questions with Max. marks			5 (5)	5 (5)	3 (30)	2 (25)	1 (15)	1 (20)
No. of CO based Questions with Max. marks			CO1		CO2	CO3	CO4	CO5
			10 (10)		3 (30)	2 (25)	1 (15)	1 (20)

IMPORTANT

- Forms of questions of **Section A** shall be MCQ, Fill in the blanks, True or False, Match the following, Definition, Missing letters.
- Questions of **Sections B, C, D and E** could be Open Choice/ built in choice/questions with sub divisions.
- Maximum sub divisions in questions of Sections B, C shall be 2 and 4 in Sections D, E).

TOTAL MARKS DISTRIBUTION OF DIRECT ASSESSMENTS BASED ON CL AND CO (PG)

Course Outcome	**CO1**		**CO2**	**CO3**	**CO4**	**CO5**	**TOTAL**
Cognitive Levels	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	
CIA 1	5	5	8	8	12	12	50
CIA 2	5	5	8	8	12	12	50
Comp III	-	-	-	-	20	20	40
Semester	5	5	30	25	15	20	100
Total Marks (CL)	**15 (6%)**	**15 (6%)**	**46 (19%)**	**41 (17%)**	**59 (25%)**	**64 (27%)**	**240**
Total Marks (CO)	**30 (12%)**		**46 (19%)**	**41 (17%)**	**59 (25%)**	**64 (27%)**	**240**