Central University of Punjab

M.Sc. Program in Biochemistry

Batch - 2023

Department of Biochemistry

Graduate Attributes

Students graduating from the program will benefit the society by adding to the highly skilled scientific workforce, in biomedical and agricultural sectors, in academia, industry and research institutions. They will develop critical thinking skills and capabilities aligned to the science driven changing needs to resolve emerging regional, national and international problems in health, agriculture and environment.

Course Structure of the Program
M.Sc. Biochemistry

Semester – I

Course Code	Course Title	Course Type	Contact Hours			Credit Hours
			L	T	P	Total
BCH.506	Enzymology	Core	3	0	0	3
BCH.507	Cell Biology	Core	3	0	0	3
BCH.508	Biomolecules and Bioenergetics	Core	3	0	0	3
BCH.509	Research Methodology	Compulsory Foundation	3	0	0	3
BCH.510	Biochemistry Practical-I	Skill Based	0	0	6	3
	Integrated Education Program/ Tutorials	Non-credit	0	2	0	0
Discipline Elective courses (select one)						
BCH.511	Genetics	DE	3	0	0	3
BCH.512	Animal Cell Culture Technology	DE	3	0	0	3
BIM.511	Protein Engineering	DE	3	0	0	3
ZOL.525	Nanobiology	DE	3	0	0	3
Total Credits						**18**

M.Sc. Biochemistry

Semester – II

Course Code	Course Title	Course Type	Contact Hours			Credit Hours
			L	T	P	Total
BCH.551	Biostatistics	Compulsory Foundation	3	0	0	3
BCH.521	Immunology	Core	3	0	0	3
BCH.522	Bioanalytical Techniques	Core	3	0	0	3
BCH.523	Metabolism	Core	3	0	0	3
BCH.524	Molecular Biology	Core	3	0	0	3
BCH.525	Biochemistry Practical-II	Skill Based	0	0	8	4
	Integrated Education Program/ Tutorials	Non-credit	0	2	0	0
Discipline Elective courses (select one)						
BCH.527	Developmental Biology	DE	3	0	0	3
BCH.528	Secondary Metabolites and Xenobiotics Metabolism	DE	3	0	0	3
BIM.521	Big Data Analytics in Bioinformatics and Health Care	DE	3	0	0	3
MIC.525	Microbial Pathogenicity	DE	3	0	0	3
MME.527	Stem Cell and Regenerative Medicine	DE	3	0	0	3
BCH.513	Basics of Biochemistry	IDC	2	0	0	2
BCH.514	Principles of Biotechnology	IDC	2	0	0	2
					Total Credits	**24**

M.Sc. Biochemistry

Semester – III

Course Code	Course Title	Course Type	Contact Hours			Credit Hours
			L	T	P	Total
BCH.552	Clinical Biochemistry	Core	3	0	0	3
BCH.553	Plant and Microbial Biochemistry	Core	3	0	0	3
BCH.554	Genetic Engineering	Core	3	0	0	3
BCH.555	Biochemistry Practical III	Skill Based	0	0	6	3
BCH.526	Innovation, Skill Development and Entrepreneurship	Compulsory Foundation	0	2	0	2
	Integrated Education Program/ Tutorials	Non-credit	0	2	0	0
	Discipline Elective courses (Select only one)					
BCH.556	Human Physiology	DE	3	0	0	3
BCH.557	Clinical Diagnostics	DE	3	0	0	3
BOT.571	Plant Metabolic Engineering	DE	3	0	0	3
BOT.555	Molecular Stress Physiology	DE	3	0	0	3
ZOL.552	Cancer Biology	DE	3	0	0	3
BCH.560	Analytical Biochemistry and Molecular Diagnostics	VAC	2	0	0	2
BCH.561	Environmental Biochemistry	VAC	2	0	0	2
BCH.600	Dissertation Part I	Skill Based	0	0	8	4
					Total Credits	**23**

M.Sc. Biochemistry

Semester – IV

Course Code	Course Title	Course Type	Contact Hours			Credit Hours
			L	T	P	Total
BCH.601	Dissertation Part II	Skill Based	0	0	40	20
					Total Credits	20

L: Lectures; T: Tutorial; P: Practical

MOOCs may be taken upto 40% of the total credits (excluding dissertation credits). MOOC may be taken in lieu of any course but content of that course should match a minimum 70%. Mapping will be done by the department and students will be informed accordingly.

Evaluation Criteria for Theory Courses

Formative Evaluation: Internal assessment shall be 25 marks using any two or more of the given methods: tests, open book examination, assignments, term paper, etc. The Mid-semester test shall be of descriptive type of 25 marks including short answer and essay type. The number of questions and distribution of marks shall be decided by the teachers.

Summative Evaluation: The End semester examination (50 marks) with 70% descriptive type and 30% objective type shall be conducted at the end of the semester. The objective type shall include one-word/sentence answers, fill-in the blanks, MCQs', and matching. The descriptive type shall include short answer and essay type questions. The number of questions and distribution of marks shall be decided by the teachers. Questions for exams and tests shall be designed to assess course learning outcomes along with focus on knowledge, understanding, application, analysis, synthesis, and evaluation.

The evaluation for IDC, VAC and entrepreneurship, innovation and skill development courses shall include MST (50 marks) and ESE (50 marks). The pattern of examination for both MST and ESE shall be the same as ESE described above for other courses.

Evaluation of dissertation proposals in the third semester shall include 50% weightage by supervisor and 50% by HoD and senior-most faculty of the department. The evaluation of dissertation in the fourth semester shall include 50% weightage for continuous evaluation by the supervisor for regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; 50% weightage based on average assessment scores by an external expert, HoD and senior-most faculty of the department. Distribution of marks is based on the report of dissertation (30%), presentation (10%), and final viva-voce (10%). The

external expert may attend final viva-voce through offline or online mode.

Examination pattern

Core, Discipline Elective, and Compulsory Foundation Courses			IDC, VAC, and Entrepreneurship, Innovation and Skill Development Courses	
	Marks	Evaluation	Marks	Evaluation
Internal Assessment	25	Various methods	-	-
Mid-semester test (MST)	25	Descriptive	50	Descriptive (70%) Objective (30%)
End-semester exam (ESE)	50	Descriptive (70%) Objective (30%)	50	Descriptive (70%) Objective (30%)

Dissertation Proposal (Third Semester)			Dissertation (Fourth Semester)		
	Marks	Evaluation		Marks	Evaluation
Supervisor	50	Dissertation proposal and presentation	Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report,

					presentation, final viva-voce
HoD and senior-most faculty of the department	50	Dissertation proposal and presentation	External expert, HoD and senior-most faculty of the department	50	Dissertation report (30), presentation (10), final viva-voce (10)

Marks for internship shall be given by the supervisor, HoD and senior-most faculty of the department.

SEMESTER – I

L	T	P	Cr
3	0	0	3

Course Code: BCH.522

Course Title: Enzymology

Total Hours: 45

Learning outcomes: Students will be able to

CLO1: Demonstrate a basic understanding of enzyme catalysis, their classification, structure, function and interaction with ligands.

CLO2: Develop a deeper understanding of data analysis in both written and oral forums related to enzyme kinetics.

CLO3: Demonstrate an understanding of enzyme inhibition and the basis of drug design

CLO4: Describe and correlate knowledge of enzymes in research, diagnostics and industrial biotransformation processes.

Unit/ Hours	Contents	Mapping with CLO
I 12 Hours	Systemic classification and nomenclature of enzymes, Enzyme kinetics: Factors affecting rates of enzyme catalyzed reactions, single substrate reactions, concept of Michaelis - Menten, Briggs - Haldane relationship, Determination and significance of kinetic constants, catalytic rate constant and specificity constant, Limitations of Michaelis-Menten Kinetics, Line weaver burk plot, Cooperativity phenomenon, Hill plots. Classification and kinetics of multisubstrate reactions, Isotopic exchange methods used to differentiate multisubstrate reaction mechanisms.	CLO1 & CLO2

	Learning activities: *Discussion on yeast as model system for Enzymes activity and its applications in drug design.*	
II 13 Hours	Enzyme catalysis: enzyme specificity and the concept of active site, determination of active site. Site-directed and Random mutagenesis techniques Stereospecificity of enzymes. Enzyme Assays, Mechanism of catalysis: Theories on mechanism of catalysis, Proximity and orientation effects, general acid-base catalysis, concerted acid - base catalysis, nucleophilic and electrophilic attacks, catalysis by distortion, metal ion catalysis. Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive inhibitors, determination of Inhibitor constants. Learning activities:*Classroom presentation on enzyme kinetics and enzyme numerical solving skills.*	CLO3 & CLO4
III 10 Hours	Coenzyme action: Role and mechanism of action of cofactors such as NAD+ /NADP+, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions with specific examples. Mechanism of enzymes action: mechanism of action of lysozyme, chymotrypsin, carboxypeptidase and DNA polymerase. Multienzyme system, Mechanism of action and regulation of pyruvate dehydrogenase and fatty acid synthetase complexes. Learning activities: *Group discussion on vitamins related diseases and identification*	CLO1

IV 10 Hours	Enzyme regulation: General mechanisms of enzyme regulation, Allosteric enzymes, sigmoidal kinetics and their physiological significance, Symmetric and sequential modes for action of allosteric enzymes. Reversible and irreversible covalent modifications of enzymes, cascade systems. Immobilized enzymes and their industrial applications. Learning activities: *Assignment on the application of enzymes in industry in real life.*	CLO4

Suggested Readings:

1. Yon-Kahn, J and Herve, G. (2016) *Molecular and Cellular Enzymology*, Springer.
2. Bailey, J.E. and Ollis, D.F. (2017). Biochemical Engineering Fundamentals. 2nd Edition. McGraw Hill, New York.
3. Segel, I. H. (2017). Enzyme kinetics, behavior and analysis of rapid equilibrium and steady-state enzyme systems. First Edition. Wiley.
4. Rodwell VW, Bender DA, Botham KA, Kennelly PJ and Weil PA. (2018). Harper's Illustrated Biochemistry 31/e, 31st Ed., McGraw Hill Professional
5. Palmer, T. (2007) *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry.* Second edition, Harwood Publishing.
6. Voet, D. and Voet, J.G. (2010) Biochemistry. 4th Edition, Wiley, Hoboken.

Web resources:

- https://www.youtube.com/watch?v=f7jRpniCsaw
- https://www.youtube.com/watch?v=26ho8zCSobI
- https://www.youtube.com/watch?v=Qk4SjxQ2rjA
- https://www.youtube.com/watch?v=KCG5fDKr9HQ
- https://www.youtube.com/watch?v=jUUeR4o_2-0
- https://www.youtube.com/watch?v=qJgEmewoPbw
- https://www.youtube.com/watch?v=pnoOtxIAk9g
- https://www.youtube.com/watch?v=f7jRpniCsaw
- https://www.youtube.com/watch?v=4cN60VBXNlw
- https://www.youtube.com/watch?v=oaWQWB1S5Q4
- https://nptel.ac.in/courses/102/102/102102033/
- https://www.youtube.com/watch?v=afvo3OaTiyU
- https://www.youtube.com/watch?v=05FGg4cCS4M
- https://www.youtube.com/watch?v=cbIeu1kt7nI

- https://www.youtube.com/watch?v=4cN60VBXNlw

Modes of transaction

-Lecture cum demonstration
-Self-learning
-Panel discussion
-Problem solving approach
-Team learning

Tools used

PPT, YouTube Video, Google meet, NPTEL

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L	T	P	Cr
3	0	0	3

Course Code: BCH. 507
Course Title: Cell Biology
Total Hours: 45

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

CLO1: Demonstrate the concept of structure and basic components of prokaryotic and eukaryotic cells, especially organelles and their related functions.
CLO2: Describe and correlate the various cellular processes critical for cell division and cell death.
CLO3: Apply and effectively communicate scientific reasoning and data analysis in both written and oral forms related to cellular structure and function.
CLO4: Explain the concept of protein trafficking in the subcellular organelles

Unit/ Hours	Contents	Mapping with CLO
I 12 Hours	**Structural Organization and Function of Intracellular Organelles**: Cell as a basic unit of living systems, the cell theory, precellular evolution, artificial creation of cells. Cell membrane and Membrane biology, Structure	CLO1

	and function of nucleus, Ribosomes, lysosomes, peroxisomes, Golgi apparatus, endoplasmic reticulum, mitochondria and chloroplast. **Learning Activities:** *Assignment on diseases of different organelles.*	
II 13 Hours	**Cell cycle and Apoptosis:** Evolution of the cell, Overview of the cell cycle and its control, The molecular mechanisms for regulating mitotic and meiotic events, Amitosis, Cell cycle control, Checkpoints in cell cycle regulation. Extrinsic and intrinsic pathways of apoptosis, Tumor suppressor genes, proto-oncogenes and oncogenes. **Learning Activities:** *Peer discussion on techniques of cell cycle determination and representation of cell cycle data.*	CLO2
III 10 Hours	**Cytoskeleton:** Nature of cytoskeleton, Intermediate filaments, Microtubules, Actin filaments, Cilia and centrioles, Organization of the cytoskeleton. Cell communication and cell signaling: Cell adhesions, Cell junctions and the extracellular matrix, Cell-cell adhesion and communication, Cell matrix adhesion, Collagen the fibrous protein of the matrix, Non-collagen component of the extracellular matrix. ***Learning activities:*** *Exercises on the role of extracellular matrix in different cancers.*	CLO3
IV 10 Hours	**Protein Trafficking:** Organelle biogenesis and protein secretion, synthesis and targeting. Intracellular traffic, vesicular traffic in the secretory pathway, protein sorting in the Golgi bodies, traffic in the endocytic pathway, exocytosis. **Learning activities:** *Student seminars.*	CLO4

Suggested Readings:

1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell*. 7th Edition. W. W. Norton & Company.
2. Karp, G., Iwasa, J., Marshall, W. (2020). *Karp's Cell and Molecular Biology*. 8th Edition. John Wiley & Sons.
3. De Robertis, E.D.P. and De Robertis, E.M.F. (2017). *Cell and Molecular Biology*. 8th Edition (South Asian Edition). Lippincott Williams and Wilkins, Philadelphia.

4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Martin, K. C., Yaffe, M. & Amon A. (2021). *Molecular Cell Biology*, 9th Edition W. H. Freeman; USA
5. Alberts B, Hopkin K, Johnson AD *et al.* (2019) *Essential Cell Biology*, 5th Ed., W W Norton & Company.

Web resources:

- https://www.ncbi.nlm.nih.gov/books/NBK26873/
- https://www.ncbi.nlm.nih.gov/books/NBK21466/
- https://ocw.mit.edu/courses/biology/7-012-introduction-to-biology-fall-2004/video-lectures/lecture-19-cell-cycle-signaling/
- http://docs.abcam.com/pdf/protocols/Introduction_to_flow_cytometry_May_10.pdf

Modes of transaction

- Lecture
- Problem solving approach
- Group discussion
- Learning centric activity
- Self-learning
- Peer learning

Tools used

PPT, Video, Google meet, Animations, WhatsApp, NPTEL

L	T	P	Cr
3	0	0	3

Course Code: BCH.508
Course Title: Biomolecules and Bioenergetics
Total Hours: 45

Learning outcomes: Students will be able to

CLO1: Demonstrate the concepts of biomolecules as components of cells from structural and functional which are essential for energy generation and their biosynthesis.

CLO2: Understand the role of proteins and DNA as biological molecules with reference to the physiological milieu they work in.

CLO3: Describe and apply basic concepts of thermodynamics and bioenergetics in correlation with biomolecules

Unit/ Hours	Contents	Mapping with CLO

I/ 10 Hours	**Carbohydrate:** Classification, structure, and stereochemistry, functions of polysaccharides starch, glycogen, cellulose and chitin, complex carbohydrates; amino sugars, proteoglycans and glycoproteins. **Lipids:** Classification, structure, properties and functions of fats and fatty acids, essential fatty acids, phospholipids, sphingolipids, cerebrosides, steroids, bile acids, prostaglandins. **Vitamins**: Fat and water soluble vitamins structure and function **Learning Activities:** *Peer discussion on the existence of these biomolecules in different organisms.*	CLO1
II/ 12 Hours	**Buffers and Proteins:** Classification, structure and properties of amino acids. The concept of pH, dissociation and ionization of acids and bases, pKa, buffers and buffering mechanism, Henderson Hasselbalch equation, and ionization of amino acids. Classification and properties of proteins. Primary, Secondary, Tertiary and Quaternary structures of proteins. Peptide cleavage. Thermodynamics of Protein folding, coagulation and denaturation of proteins. **Learning Activities:** *Presentations on buffers and proteins properties and its constituents.*	CLO2
III/ 10 Hours	**Nucleic acids**: Structure of purines, pyrimidines, nucleosides and nucleotides. Structure, types and biological role of RNA and DNA. Primary, secondary, and tertiary structure of nucleic acids, DNA forms and conformations, UV absorption and Denaturation of DNA, C-value paradox, Cot curve analysis. **Learning activities:** *In depth discussion on the role of DNA modification and its effects.*	CLO2
IV/ 10 Hours	**Bioenergetics:** Laws of Thermodynamics, Concept of free energy, standard free energy, determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, standard free energy change in coupled reactions. Biological oxidation-reduction reactions, redox potentials, relation	CLO3

	between standard reduction potentials & free energy change. High energy phosphate compounds, phosphate group transfer, and free energy of hydrolysis of ATP. **Learning activities:** *Group discussion on analysis of thermodynamic parameters*	

Suggested Readings:

1. Outlines of Biochemistry. Eric E. Conn and Paul K. Stumpf (2006). 5th edition John Wiley and Sons, India edition.
2. Davidson, VL and Sittman, DB (1999) *Biochemistry* NMS, 4th ed. Lippincott. Willams and Wilkins.
3. Voet, D and Voet JG (2010) *Biochemistry*, 4th ed. Wiley
4. Rodwell V, Bender D, Botham KM, Kennelly PJ and Weil PA (2018) *Harper's Illustrated Biochemistry.* 31st ed. McGraw Hill.
5. Berg JM, Stryer L, Tymoczko JL, Gatto GJ (2018) *Biochemistry*, WH Freeman, 9th ed.
6. Lodish, H, Birk, A, et al. (2016) *Molecular Cell Biology*. 8th ed. WH Freeman.
7. Nelson DL and Cox MM (2017) *Lehninger's Principles of Biochemistry*, 7th ed. WH Freeman.

Web resources:

- https://nptel.ac.in/courses/104/103/104103121/
- https://www.youtube.com/watch?v=iuW3nk5EADg
- https://www.youtube.com/watch?v=ZqoX2W1N6l0
- https://www.youtube.com/watch?v=DhwAp6yQHQI
- https://www.youtube.com/watch?v=jLyi2K-29xU
- https://www.youtube.com/watch?v=C0ky85Kk2Zc
- https://www.youtube.com/watch?v=Fp1wKo72b2A
- https://www.youtube.com/watch?v=zOO5qdpl24I

Modes of transaction

-Lecture cum Demonstration
-Problem solving approach
-Self-Learning
-Inquiry training
-Co-operative learning

Tools used

PPT, YouTube Video, Google meet, NPTEL

L	T	P	Cr
3	0	0	3

Course Code: BCH.509
Course Title: Research Methodology
Total Hours: 45

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

CLO1: Demonstrate various aspects of research methods, scientific writings and literature search.
CLO2: Apply their knowledge regarding cell culture techniques
CLO3: Discuss the safety and ethical issues associated with scientific research
CLO4: Assess how research promotes innovation and the importance of filing patents

Unit/ Hours	Contents	Mapping with CLO
I 10 Hours	**General Principles of Research:** Meaning and importance of research, critical thinking, formulating hypothesis and development of research plan, review of literature, interpretation of results and discussion. Scientific writing: writing synopsis, research manuscript and dissertation. Literature search and survey, e-Library, web-based literature search engines. Research presentation and poster preparation, plagiarism and open access publishing. **Learning Activities:** *Evaluation of research proposals.*	CLO1
II 13 Hours	**Cell culture techniques**: Application of animal cell culture. Equipment and material for animal cell culture lab, Aseptic Techniques, Primary and established cell line cultures, Introduction to growth medium. Role of carbon dioxide. Role of serum and supplements. Basic techniques of mammalian cell culture in vitro, maintenance of cell culture, validation of cell lines and cryopreservation. Contamination. Measurement of viability and cytotoxicity. Scale up of animal cultures. **Learning Activities:** *Assignment on cell culture-based discoveries.*	CLO2

III 10 Hours	**Biosafety and Bioethics:** Orientation to biorisk management—biosafety and biosecurity, Assessment, Mitigation and Performance (AMP) model, case studies Good Laboratory Practices, Genetic pollution, Risk and safety assessment of genetically engineered organisms, Sterilization techniques, decontamination and disposal of biological waste. Bioterrorism, Social and ethical implication of biological weapons. Cyber security. Ethical theories, Ethical considerations during research, Brief introduction of model organisms (rat and mouse) Ethical issues related to animal testing and human subjects. ***Learning activities:*** *Discussion on bioethics in a fictional situation.*	CLO3
IV 12 Hours	**Intellectual property rights:** Introduction and basic concepts of Intellectual property rights (IPRs), Different types of IP, Basic requirements of patentability, patentable subject matter, Introduction to Indian Patent Law. World Trade Organization and its related intellectual property provisions. WTO agreement and TRIPS, Patent Cooperation treaty. **Learning activities:** *Dummy filing of a patent application.*	CLO4

Suggested Readings:

1. Freshney, R. I. (2021). Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 8th Edition. Wiley-Blackwell
2. Bently, L., Sherman, B., Gangjee, D., & Johnson, P. (2022). Intellectual Property Law, 6th edition. Oxford University Press
3. Gurumani, N. (2021). Scientific Thesis Writing and Paper Presentation. Mjp Publisher.
4. Saramäki, J. (2018). How to Write a Scientific Paper: An Academic Self-Help Guide for PhD Students. Independently Published.
5. Salerno, R. M., & Gaudioso, J. M. (2021). Laboratory Biorisk Management: Biosafety and Biosecurity. CRC Press.
6. WHO (2019). *Laboratory Biosafety Manual*. 4th Edition. World Health Organization.
7. Sateesh, M. K. (2020). Bioethics and Biosafety. Dreamtech Press
8. Vaughn, L. (2022). Bioethics: Principles, Issues, and Cases. Oxford University Press, USA.

Web Resources:

- https://nptel.ac.in/courses/110/106/110106081/
- https://nptel.ac.in/courses/110/105/110105139/
- https://www.youtube.com/watch?v=PC51Z5FKZXQ
- https://www.youtube.com/watch?v=ON2e1VsBhJk
- https://www.youtube.com/watch?v=tCNtKrxlZPs
- https://www.youtube.com/watch?v=4HxqQOHifkU
- https://www.youtube.com/watch?v=RuRgCRASzpo

Modes of transaction

-Demonstration
-Lecture cum demonstration
-Inquiry training
-Problem solving approach
-Self- directed learning

Tools used

PPT, YouTube Video, WhatsApp, Animations, Google meet, NPTEL

L	T	P	Cr
0	0	8	4

Course Code: BCH.510
Course Title: Biochemistry Practical-I
Total Hours: 120

Course learning outcomes: After the completion of this course, the students will be able to

CLO1: Perform experiments pertaining to biomolecules and bioanalytical techniques, and cell biology.

CLO2: Apply the scientific method to the processes of experimentation and hypothesis testing.

Part	Contents	Mapping with CLO
A	**Enzymology** 1. Enzyme assay for salivary amylase i. Activity ii. Determination of optimum pH iii. Determination of optimum temperature iv. Determination of Km v. Determination of specific activity	CLO1 & CLO2

	2. Acid phosphatase activity in plant tissue 3. Enzyme inhibition assays	
B	**Biomolecules** 1. Preparation of Chromic acid for glassware cleaning. 2. Preparation of solutions, buffers, pH setting etc. 3. Colour reactions for amino acids 4. Osazone formation test. 5. Qualitative tests 1. pentose, and hexoses 2. ribose sugars. 6. Preparation of calibration curves. 7. Quantitative estimation of total lipids. 8. Isolation of protein from biological sample 9. Quantitative estimation of phenolic compounds. 10. Determination of protein by Biuret and Lowry's method. 11. Determination of protein by Bradford method. 12. Quantitative estimation of glucose using glucose oxidase method 13. Estimation of fructose and glucose in honey 14. Isolation of casein from milk and its quantification 15. Isolation of gluten and gliadin from wheat.	CLO1 & CLO2
C	**Cell Biology** 1. Training with a light microscope to observe morphology of bacterial, plant and animal cells 2. To learn the use of micrometers to measure the length and breadth of a given cell sample. 3. To observe different stages of mitosis in onion root-tip cells 4. Cell counting and cell viability assays using Trypan blue and haemocytometer 5. Depicting nature of biological membranes: Osmosis, Hypertonicity, Hypotonicity, Isotonicity 6. Subcellular fractionation to separate nuclear/cytoplasmic fractions 7. Demonstration of cell cycle analysis using flow cytometry	CLO1 & CLO2

Modes of transaction

-Lecture cum demonstration

-Problem solving approach

-Self-Learning
-Inquiry training
-Team teaching

Tools used

PPT, YouTube Video, Google

Evaluation Criteria for Practical Courses:

Students are evaluated for a total of 100 marks for
-Maintaining the lab records/notebooks (10MM)
-Continuous assessment (20MM)
-Attendance (10MM)
-Final practical examination (30MM)
-Viva-voce (30MM)

L	T	P	Cr
3	0	0	3

Course Code: BCH.511
Course Title: Genetics
Total Hours: 45

Learning outcomes: Students will be able to

CLO1: Demonstrate the principles of inheritance at the molecular, cellular and organismal levels.

CLO2: Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to concepts of genetics.

CLO3: Describe and correlate hereditary information and their application to real life situations.

Unit/ Hours	Contents	Mapping with CLO
I 13 Hours	**Mendelian Principles:** Dominance, segregation, independent assortment, Allele, multiple alleles, pseudoallele, complementation tests. **Extensions of Mendelian Principles:** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.	CLO1 & CLO3

	Extra-Chromosomal Inheritance: Chloroplast and Mitochondrial inheritance; Cytoplasmic inheritance (Coiling in Snails). **Learning Activity:** *Apply Punnett squares to solve problems in Genetics.*	
II 12 Hours	**Mapping:** Molecular markers: RAPD, RFLP, SSR, SNP, ISSR, and SCAR; Linkage maps, tetrad analysis in *Neurospora*, mapping with molecular markers, development of mapping population in plants, association mapping, linkage disequilibrium mapping, integration of genetic and physical maps, chromosome walking and chromosome landing . **Human Genetics:** Pedigree analysis, karyotypes, genetic disorders. **Quantitative Genetics:** Polygenic inheritance, heritability and its measurements, QTL mapping. **Learning Activity:** *Flipped classroom for understanding concepts in genetic mapping.*	CLO1 & CLO2
III 10 Hours	**Mutations and Mutagenesis:** Types, Reverse and forward Genetics and their applications; Recombination and transposition; In vitro evolution **Population Genetics:** Genetic drift, Hardy-Weinberg law; Natural selection and modern synthesis; Differences within and among populations and gene flow; Migration and adaptation **Learning Activity:** *Problem solving using Hardy-Weinberg law.*	CLO2 & CLO3
IV 10 Hours	**Microbial Genetics**: Organization of genetic material in bacteria, fungi, protozoa, viruses; Gene transfer mechanisms; Natural transformation and competence; Bacterial conjugation, transduction (generalized and specialized) and transformation; Microbiomes: Humans, plant and soil. **Learning Activity***: Visualization of animations assembled by student teams.*	CLO3

Suggested Readings:

1. Snustad, D.P., Simmons, M. J. (2015). *Principles of Genetics*. 7th Edition, John Wiley & Sons, New York.
2. Raven P, Johnson GB, Mason KA, Losos JB, Duncan T (2020). *Biology*, 12th Edition, McGraw-Hill, USA.

3. Griffiths AJF, Doebley J, Peichel C, Wassarman, DA. (2020). *An introduction to Genetic Analysis*. 12th Edition W.H. Freeman publication, USA.
4. Henkin, T.M., Joseph E. (2020). *Snyder and Champness Molecular Genetics of Bacteria*, 5th Edition. ASM Press. ISBN: 978-1-683-67357-6
5. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2017). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.

Web Resources:

- https://www.genome.gov/about-genomics/teaching-tools/Genomics-Education-Websites
- e-PG Pathshala resources on Genetics

Modes of transaction

-Lecture cum Demonstration
-Problem solving approach
-Self-Learning
-Inquiry training
-Co-operative learning
-Flipped learning

Tools used: PPT, Animations, YouTube, Google Drive, Google Classroom

L	T	P	Cr
3	0	0	3

Course Code: BCH.512
Course Title: Animal Cell Culture Technology
Total Hours: 45

Learning outcomes: Students will be able to
CLO1: Understand the basic requirements for animal cell culture
CLO2: Correlate and apply the concepts to initiate animal cell culture experiments in the research and life science industry.

Unit/ Hours	Contents	Mapping with CLO
I 15 Hours	**Introduction to animal cell cultivation:** Basics terms and definitions, historical background, Importance of animal cell culture technology, laboratory	CLO1

	facilities-design, equipment and safety parameters, waste disposal in a cell culture set-up. Aseptic techniques for animal cell cultivation. Cell culture technology: Basic requirement for growing animal cells - Cell culture reagents, media, media supplements, media preparation and sterilization, Defined-Undefined media, Complete-Incomplete media, Importance of Serum and Serum free Media, culture conditions. Maintenance of cell culture: Culturing, sub-culturing, passaging, cell metabolism during culture.	
II 10 Hours	**Cell culture types**: Primary and Continuous culture, *in vitro* transformation of animal cells, anchorage-dependence, monolayer and suspension culture, normal cells and transformed cells. Scaling up-techniques for cells in suspension and in monolayer. Cell line preservation and authentication: cryopreservation and cell revival. Contamination check and prevention: bacterial, yeast, fungal, mycoplasma, viral testing. Important parameters for growing animal cell lines. **Learning Activities:** *Collection of information about cell line banks and cell culture databases*	CLO2
III 10 Hours	**Cell Culture technology for Studying biological systems:** Functional assays based on cell culture: Cell morphology, Quantitation, Growth pattern, DNA content and cell cycle, Cytotoxicity assays, Study of Cell Death: senescence, apoptosis and necrosis, Cell proliferation, Cell viability measurements, Karyotype analysis, FISH. Immunolabeling of cells to study molecular expression patterns: Microscopy, Flow Cytometry, Cytospin, Immunohistochemistry, Transfection, Transient and stable cell line generation. **Learning activities:** *Mindmap of the cell assays and nature of information derived from in vitro grown cell cultures*	CLO2
IV 15 Hours	**Animal Cell and Tissue culture: Trends and Breakthroughs:** The first products of animal cell technology: hybridoma technology for monoclonal antibody production, production of genetically-engineered cells and their applications, use of cell cultures in the production of biologicals, Insect	CLO2

	Cell Culture and its application. Vaccine and cell culture technology. ES cells and Adult stem cells: differences between stem cells and differentiated cells, embryonic stem cells and adult stem cells for therapy. Tissue engineering, Three-dimensional culture: multicellular tumor spheroids (MCTS) - mono and co-cultures, re-aggregate organ cultures, drug testing *in-vitro.* Translation value and application of ES and Adult stem cells. **Learning activities:** *Discussion on each topic in a learner centric manner through term paper presentation*	

Suggested Readings:

1. Freshney, R. I. (2016). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 7th Edition. Wiley-Blackwell
2. Butler, M. (2004). Animal cell culture and technology: the basics (2nd edition) Taylor & Francis
3. John R.W. Masters (2000) *Animal Cell Culture-A Practical Approach*, (3rd Edition) Oxford University Press
4. Glick BJ, Patten CL. (2017) *Molecular Biotechnology: Principles and Applications of Recombinant DNA.* 5th Edition, American Society for Microbiology
5. WHO (2019). *Laboratory Biosafety Manual.* 4th Edition. World Health Organization.

Web resources:

- https://www.vanderbilt.edu › viibre › CellCulture
- https://www.thermofisher.com/in/en/home/references/gibco-cell-culture-basics

Modes of transaction

-Lecture cum Demonstration
-Brain storming driven by latest in research
-Problem solving approach
-Team Learning
-Students centric presentations and discussions on specific topics

Tools used: PPT, Video, Google Drive

SEMESTER II

L	T	P	Cr
3	0	0	3

Course Code: BCH.551
Course Title: Biostatistics
Total Hours: 45

Learning outcomes: Students will be able to
CLO1: Apply statistics for biological data analysis.
CLO2: Describe and correlate experimental data using statistical tools.

Units/ Hours	Contents	Mapping with CLO
I 11 Hours	**Basics of Biostatistics**: Critical Thinking, Scientific Methodology, Types of Studies, Observational Studies. Experimental Studies, Based on Data Analysis, Levels of Measurements, Variables, Levels of Measurements, Permissible transforms and permissible statistics, Summarizing Data: Tabular Presentation,	CLO1

	Introduction to Data Summarization, Frequency Distribution Tables, Contingency Tables and Summary Tables, Summarizing Data: Graphical Presentation, Frequency Distribution Graphs, Univariate Graphs, Multivariate and Specialist Graphs, Charting with excel, Descriptive Statistics: Point Estimates, Mean, Median and Mode, Percentiles. **Learning activities:** *Testing with experimental data.*	
II 11 Hours	**Representation of statistical analysis:** Descriptive Statistics: Interval Estimates, Range, IQR, MAD, Variance and Standard Deviation, SEM, CV and CD, Error Bars, Overview of various error bars, Moments, Normality Tests and Outliers, Moments, Normality Tests, Outliers, Concepts of Population, Sample and Confidence Intervals, Theory of CI and CI of Mean, CI of Standard Deviation, Statistical Hypothesis Testing, Statistical Hypothesis Testing, False positive and false negative, Statistical Significance and P Values, Relationship between Confidence Intervals and Statistical Significance, Statistical Power and choosing the right Sample Size, Statistical Power, Computing Required Sample Size to compare two group means. **Learning activities:** *Peer discussion in teams and presentation.*	CLO1
III 11 Hours	**Sample Distribution and correlation:** Gaussian, Lognormal, Binomial, and Poisson Distributions, Pearson's correlation, Multiple Correlation and PCA, Simple Linear Regression, Non-Linear regression, Multiple regression, and Logistic regression. Permutations and combinations, Probability, Addition Rule and Mathematical Expectation, Conditional Probability, Likelihood and Bayes' theorem, Probability Trees. **Learning activities:** *Web-based exercises.*	CLO2
IV 12 Hours	**Statistical Tools:** t-Distribution and tests of significance based on t-distribution, F-distribution and tests of significance based on F distribution, Post Hoc Tests, x^2 Distribution and tests of significance based on x^2 distribution, Comparing Proportions, Proportions, Rates, Risk, NNT, Odds Ratio, Fisher's Exact test and Binomial test, Non-parametric tests (Mann-Whitney U Test and Wilcoxon matched-pairs	CLO2

	signed-rank test, Kruskal-Wallis Test and Spearman's Rank Correlation Test), Statistics with Microsoft Excel and GraphPad Prism, Key concepts of statistics and statistical pitfalls to avoid. **Learning activities:** *Application of statistical tools.*	

Suggested Readings:

1. Norman, G. and Streiner, D. (2014). *Biostatistics: The Bare Essentials*, Decker Inc. USA, 4th edition.
2. Samuels, M.L., Witmer, J., Schaffner, A. (2016). *Statistics for the Life Sciences*, 5th edition, Prentice Hall publishers.
3. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research.* W.H. Freeman publishers. 3rd edition.
4. Emden, H.F. (2019). *Statistics for Terrified Biologists*. Blackwell Publishers.
5. Rao Nageswara G. (2018) Biostatistics & Research Methodology, 1st Ed. PharmaMed Press

Modes of transaction

-Demonstration
-Lecture cum demonstration
-Inquiry training
-Panel discussion
-Problem solving approach
-Self-learning

Web References:

- https://libguides.alfaisal.edu/biostat/web/resources
- https://bms.ucsf.edu/resources-learning-biostatistics

Tools used

PPT, YouTube Videos, Google, recorded lectures

L	T	P	Cr
3	0	0	3

Course Code: BCH.521
Course Title: Immunology
Total Hours: 45

Learning outcomes: Students will be able to
CLO1: Demonstrate the basic concepts related to the Immune System.

CLO1: Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to immunological concepts in health and diseases.
CLO1: Understand and correlate immunology with its clinical implications

Unit/ Hours	Contents	Mapping with CLO
I/ 13 Hours	**Immune system and cells involved in immune response:** Innate and acquired immunity. Structure and functions of primary and secondary lymphoid organs. Immune Cells- mononuclear cells (Phagocytic cells and their killing mechanisms), granulocytic cells (neutrophils, eosinophils and basophils), mast cells and dendritic cells, B-lymphocytes, T-lymphocytes and Null cells, and their diversity. **Learning Activities:** *A diagrammatic representation with origin, percentages and absolute number of different immune cells.*	CLO1
II/ 12 Hours	**Antigen and Antibody:** Immunogenicity vs antigenicity, factors influencing immunogenicity, epitopes, haptens, adjuvants and mitogens. Classification, fine structure and functions of immunoglobulins, antigenic determinants on immunoglobulins, isotypic, allotypic and idiotypic variants. Clonal selection theory– concept of antigen specific receptor. Organization of immunoglobulin genes: generation of antibody diversity, monoclonal and polyclonal antibodies; hybridoma technology, antibody engineering, abzymes, immunotoxins. **Learning Activities:** *Group discussion on salient structural and functional features of antibodies exploited in varied antibody-based applications*	CLO2
III/ 10 Hours	**Immune effector responses and Cell Mediated Immunity:** Kinetics of primary and secondary immune responses, complement activation and its biological consequences such as agglutination, precipitation and opsonization. Cytokines and co-stimulatory molecules and their role in immune response, hypersensitivity	CLO2

	(Types I, II, III, IV). Cell mediated immunity. T-cell receptor diversity, Antigen processing and presentation, Major Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA). Polymorphism of MHC genes, MHC antigens in transplantation. ***Learning activities:*** *Video demonstration of an effector T cell in real time*	
IV/ 10 Hours	**The Immune system in health and disease:** Immune-response and Microbial diseases, Vaccines: Sub-unit vaccines; Recombinant DNA and protein-based vaccines, conjugate vaccines; Passive Immunization, Transfusion of immuno-competent cells. Immune tolerance and its breakdown, Autoimmunity and related disease, Cancer immunology, Congenital Immunodeficiencies and related disease, Acquired immunodeficiencies and related disease. **Learning activities:** *Term paper-based discussion and team learning*	CLO3

Suggested Readings:

1. Punt, J., Stranford, S., Jones, P., and Owen, J.A. (2018). *Kuby Immunology* 8th Edition. W.H. Freeman, USA.
2. Abbas, A., Lichtman, A.H. and Pillai S. (2017). *Cellular and Molecular Immunology*. 9th Edition. CBS Publishers & Distributors, India.
3. Murphy, K. and Weaver, C. (2017). Janeway's *Immunobiology: The immune system in health and disease.* 9th Edition. Garland Science.
4. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. (2017). *Roitt's Essential Immunology.* Wiley-Blackwell Publishers, USA.
5. Tizard (2013). *Immunology: An Introduction*. 5th edition. Brooks/Cole.

Web resources:

- https://www.immunopaedia.org.za/
- https://www.fun-mooc.fr/en/courses

Modes of transaction

-Lecture cum Demonstration
-Inquiry training
-Panel discussion
-Problem solving approach
-Self learning
-Team learning

Tools used

PPT, YouTube Video, Google meet, NPTEL

L	T	P	Cr
3	0	0	3

Course Code: BCH.522
Course Title: Bioanalytical Techniques
Total Hours: 45

Course Learning Outcomes (CLO):

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

CLO1: Demonstrate the utility of electromagnetic radiation-based techniques.

CLO2: Demonstrate the ability to understand proteins and DNA based techniques

CLO3: Apply microscopy and radioisotopes-based techniques in both written and oral forums related to biochemistry.

CLO4: Demonstrate the utility of immunological techniques

Unit/ Hours	Contents	Mapping with CLO

I 12 Hours	**Spectrophotometry, Centrifugation and Biophysical Techniques**: Visible and UV Spectroscopy and its applications; Beer-Lambert's law, extinction coefficient and its importance, IR spectrometry, FT-IR, design of colorimeter, spectrometer and spectrophotometer. Sedimentation velocity and RCF, differential and density gradient centrifugation, subcellular fractionation, analytical and preparative ultracentrifugation techniques. Optical rotatory dispersion (ORD), Circular Dichroism (CD), X-ray diffraction, X-ray absorption, Nuclear magnetic resonance spectroscopy, Mass spectrometry. **Learning Activities:** *Seminars on application of the techniques in bioscience research*	CLO1
II 10 Hours	**Gel Electrophoresis:** Agarose gel electrophoresis for DNA and RNA analysis; Rocket electrophoresis; Polyacrylamide gel electrophoresis for DNA and protein analysis; IEF and SDS-PAGE. **Chromatography:** Principles and applications of different types of chromatography. Thin layer, ion-exchange, hydrophobic-interaction, size-exclusion, Adsorption, Partition, Ion-Exchange, Chromatofocusing, Reverse Phase, and affinity chromatography. Molecular weight determination of macromolecules (in particular proteins) by size exclusion chromatography. High performance liquid chromatography and its types, GC-MS. **Learning Activities:** *Group discussion on the importance of gel electrophoresis and chromatography in biochemistry lab.*	CLO2
III 12 Hours	**Microscopy:** Principles and applications of Light, Phase-contrast and Electron-Microscopy, Scanning electron microscope, Transmission electron microscope and Immune electron microscopy.	CLO3

	Radioisotopic Tracer Techniques: Detection and measurement of isotopes, Geiger–Müller, Scintillation Counter, Autoradiography, Applications in biology. **Learning activities:** *Student seminars on application of the techniques in research and life.*	
IV 11 Hours	**Immunological Techniques**: Measurement and Characterization of antigens and antibodies, Specificity and Cross reactivity, Precipitation and Agglutination reactions, Gel Diffusion, Immunoelectrophoresis, Ouchterlony, Radioimmunoassay, ELISA, Immunoblotting, Immunoprecipitation and coimmunoprecipitation, Application in Microscopy, Imaging-Immunohistochemistry and Flow cytometry. **Learning activities:** *Peer group discussion on use of the immune-techniques in research and health care.*	CLO4

Transaction Mode: Lecture cum Demonstration, Problem solving approach, Self-learning, Inquiry training, Team learning

Tools used

PPT, YouTube Video, Google meet, NPTEL

Suggested Readings:

1. Berg, J.M., Stryer, L., Tymoczko, J., Gatto, G. (2019). Biochemistry. WH Freeman. 9th ed.
2. Nelson DL, Cox MM and A. Hoskins (2021). Lehninger's Principles of Biochemistry, 8th ed. WH Freeman.
3. Wilson, K., Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology. 8th Edition, Andreas Hofmann and Samuel Clokie, Cambridge University Press.
4. Iain D Campbell (2012). Biophysical Techniques, Oxford University Press.
5. Shourie, A., Chapadgaonkar, S.S. (2015). Bioanalytical Techniques. TERI, New Delhi.

Web resources:

- https://www.youtube.com/watch?v=siXdckB1HzU
- https://www.youtube.com/watch?v=WP6JpnHZJlQ
- https://www.youtube.com/watch?v=pjG4FTdMsEY
- https://nptel.ac.in/courses/102/103/102103044/
- https://nptel.ac.in/courses/102/101/102101007/
- https://www.youtube.com/watch?v=yl3EZX5kKbM
- https://www.youtube.com/watch?v=yl3EZX5kKbM
- https://www.youtube.com/watch?v=eH7UkTB7m8U

- https://www.youtube.com/watch?v=vMzs4NyVvuc
- https://www.youtube.com/watch?v=ZN7euA1fS4Y

L	T	P	Cr
3	0	0	3

Course Code: BCH.523
Course Title: Metabolism

On completion of this course, students will be able to:
CLO1: Demonstrate an understanding of metabolism of carbohydrates.
CLO2: Demonstrate an understanding of metabolism of lipids.
CLO3: Demonstrate an understanding of metabolism of amino acids.
CLO4: Demonstrate an understanding of metabolism of nucleic acids.
CLO5: Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to the course content.

Unit/ Hours	Contents	Mapping with CLO
I 13 Hours	**Carbohydrates:** Glycolysis, citric acid cycle, its function in energy generation and biosynthesis of energy rich bond, pentose phosphate pathway. Gluconeogenesis, glyoxylate and gamma aminobutyrate shunt pathways, Cori cycle, anaplerotic reactions, Entner-Doudoroff pathway, glucuronate pathway. **Learning activities:** *Classroom discussion on carbohydrate metabolism.*	CLO1 & CLO5
II 12 Hours	**Lipids:** Fatty acid oxidation (α-, β-, ω-oxidation). Oxidation of odd numbered fatty acids – fate of propionate, role of carnitine, degradation of complex lipids. Fatty acid biosynthesis of triacylglycerols, phosphoglycerides, sphingomyelin and prostaglandins. **Learning activities:** *Assignment and term papers-based discussion.*	CLO2 & CLO5
III 10 Hours	**Amino Acids**: General reactions of amino acid metabolism - Transamination, decarboxylation, oxidative & non-oxidative deamination of amino acids. Special metabolism of methionine, histidine, phenylalanine, tyrosine, tryptophan, lysine, valine, leucine, isoleucine and polyamines. Urea cycle and its regulation.	CLO3 & CLO5

	Learning activities: *Classroom discussion on amino acid metabolism.*	
IV 10 Hours	**Nucleic Acids:** Biosynthesis and degradation of purine and pyrimidine nucleotides and its regulation. Purine salvage pathway. Role of ribonucleotide reductase. Biosynthesis of deoxyribonucleotides and polynucleotides including inhibitors of nucleic acid biosynthesis. **Learning activities:** *Assignment and term papers-based discussion.*	CLO4 & CLO5

Suggested Readings:

1. Satyanarayana, U. (2013) Biochemistry, Publisher: Elsevier; Fourth edition ISBN-9788131236017.
2. Berg JM, Stryer L, Tymoczko JL, Gatto GJ (2018) Biochemistry, WH Freeman, 9th ed.
3. Nelson, D. and Cox, M.M. (2017). Lehninger Principles of Biochemistry. 7th edition. WH Freeman.
4. Karp, G., Iwasa, J., Marshall, W. (2020). Karp's Cell and Molecular Biology. 8th Edition. John Wiley & Sons.
5. Satyanarayana, U. (2014) Biochemistry, Publisher: Elsevier; Fourth edition ISBN-9788131236017.

Web Resources:

- https://www.cell.com/cell-metabolism/libraries/resources
- https://academic.oup.com/database/article/doi/10.1093/database/bav068/2433201
- https://metacyc.org/
- https://www.journals.elsevier.com/metabolism

Modes of transaction

- Lecture
- Problem solving approach
- Group discussion
- Learning centric activity
- Self-learning
- Peer learning

Tools used

PPT, Video, Google meet, Animations, WhatsApp, NPTEL

L	T	P	Cr

3	0	0	3

Course Code: BCH.524
Course Title: Molecular Biology
Total Hours: 45

Learning outcome: Students will be able to

CLO1: Demonstrate the molecular processes in a cell and how they are related to biochemical processes in microbes and higher organisms.

CLO2: Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to molecular biology.

CLO3: Apply molecular biology to societal needs with reference to agriculture, environment, and health.

Unit/ Hours	Contents	Mapping with CLO
I 12 Hours	**Genome organization:** Gene structure, Genome composition and dynamics, repetitive DNA. **Molecular Techniques:** Classical and emerging techniques and their applications. **DNA Replication and Repair:** Prokaryotic and eukaryotic DNA replication, Replication errors, DNA damage and repair **Learning activities:** *Team presentations demonstrating the applications of molecular techniques to real life issues.*	CLO1 & CLO3
II 12 Hours	**Recombination:** Site-specific, homologous, DNA transposition, retrotransposition and non-homologous end joining. **Transcription and mRNA Processing:** Prokaryotic & eukaryotic transcription; Post-transcriptional changes: Capping, Polyadenylation, Splicing, RNA editing. **Learning activities:** *Group discussion on applications in agriculture and human health.*	CLO1 & CLO3
III 10 Hours	**Translation:** Prokaryotic and eukaryotic translation, co- and post-translational modifications, mechanism of translation inhibition by antibiotics. **Learning activities:** *Quiz based on animations.*	CLO1 & CLO3
IV 11 Hours	**Gene Regulation:** Prokaryotic gene regulation: lac and trp operons, lambda gene regulation during lysogeny	CLO1, CLO2 &

	and lytic cycles; Eukaryotic gene regulation: yeast and higher eukaryotes, spatial and temporal regulation, hormonal regulation of genes, epigenetic regulation, RNA interference; Gene regulation during cancer. **Learning activities:** *Student-driven analysis of recent trends.*	CLO3

Suggested Readings:

1. Watson, J.D., Baker,T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2017). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.
2. Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. (2017). *Lewin's Genes XII.* Jones & Bartlett Learning, USA.
3. Craig, N.L., Green, R.R., Greider, C.C., Storz, G.G., Wolberger, C., Cohen-Fix, O. (2021). *Molecular Biology: Principles of Genome Function.* 3rd Edition, Oxford University Press.
4. David P. Clark, Nanette J. Pazdernik and Michelle R. McGehee (2018) Molecular Biology, 3rd Ed., Elsevier.

Web Resources:

- https://www.genome.gov/about-genomics/teaching-tools/Genomics-Education-Websites
- e-PG Pathshala on Molecular Biology
- Videos and animations on YouTube and other web sites

Modes of transaction

-Lecture cum Demonstration
-Problem solving approach
-Self-Learning
-Inquiry training
-Co-operative learning

Tools used

YouTube Videos, Google Drive, Google Classroom, Animations, PPT

L	T	P	Cr
0	0	8	4

Course Code: BCH.525
Course Title: Biochemistry Practical-II
Total Hours: 120

Course learning outcome: After the completion of this course, the students will be able to

CLO1: Perform experiments pertaining to enzymology, immunology and molecular biology.

CLO2: Apply the scientific method to the processes of experimentation and hypothesis testing.

Part	Contents	Mapping with CLO
A	**Bioanalytical techniques** 1. To perform DNA Gel electrophoresis. 2. To perform differential centrifugation of plant extract 3. Spectrometric estimation of DNA/Protein 4. To perform thin-layer chromatography of lipids 5. To perform cell staining/GFP analysis using fluorescence microscope	CLO1 & CLO2
B	**Immunology** 6. To perform total leukocyte count of the given blood sample. 7. To perform differential leukocyte count of the given blood sample. 8. Double immunodiffusion test using specific antibody and antigen. 9. To perform immunoelectrophoresis using specific antibodies and antigen. 10. Dot immunoblot assay (DIBA). 11. ELISA 12. Isolation of mononuclear cells from peripheral blood and viability test by dye exclusion method. 13. Immunohistochemistry: H & E staining, Fluorescent staining, Fluorescent Microscopy, Confocal Microscopy	CLO1 & CLO2
C	**Molecular Biology** 1. Isolation of genomic DNA using phenol-chloroform method 2. Isolation of total RNA using Trizol 3. Quantification of nucleic acids 4. Retrieving gene, transcript and protein sequences from NCBI and Ensembl databases	CLO1 & CLO2

	5. Primer design and amplification of a specific gene using Polymerase Chain Reaction (PCR) 6. Agarose gel electrophoresis for genomic DNA, RNA, plasmid and PCR product 7. Isolation of plasmid DNA 8. Restriction digestion of DNA (vector and insert) 9. Ligation of vector and insert DNA 10. Preparation of competent cells, transformation and screening of transformed colonies 11. NCBI BLAST, Multiple Sequence Alignment and Phylogenetic analysis using MEGA 12. Demonstration of Real Time PCR	

Modes of transaction:

-Lecture cum demonstration
-Experimentation
-Problem solving approach
-Self-directed learning
-Team teaching

Software tools

BLAST, MEGA

Web Resources:

- https://media.hhmi.org/biointeractive/vlabs/immunology/index.html
- https://www.thermofisher.com/in/en/home/life-science/antibodies/immunoassays/elisa-kits
- https://www.youtube.com/watch?v=Fnx5CkGRBEM
- https://www.vlab.co.in/broad-area-biotechnology-and-biomedical-engineering

Evaluation Criteria for Practical Courses:

Students are evaluated for a total of 100 marks for
-Maintaining the lab records/notebooks (10MM
-Continuous assessment (20MM)
-Attendance during day to day practical (10MM)
-Final practical examination (30MM)
-Viva-voce (30MM)

L	T	P	Cr
3	0	0	3

Course Code: BCH.527
Course Title: Developmental Biology

Total Hours: 45

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

CL01: Understand the concept of cell growth, cell cycle and cell division

CL02: Understand the principles of development processes as observed in human beings

CL03: Effectively communicate scientific reasoning related to the specific developmental phenomena observed in predominantly utilized model organisms.

CL04: Understand the developmental processes specific to plants

Unit/ Hours	Contents	Mapping with CLO
I 13 Hours	**Cell cycle and basic concepts of development:** Introduction to cell cycle, its regulation and methods to assess cell cycle status in cells, Mitosis and Meiosis, Basic concepts of development: Potency, Commitment, types of Specification, Induction, Competence, Determination and Differentiation, cytoplasmic determinants, Morphogenetic gradients, Cell fate and cell lineages, Stem cells, Genomic equivalence and genomic imprinting; importance of mutants and transgenics in analysis of development. **Learning activities:** *Assignment on diseases resulting from developmental disorders.*	CLO1
II 10 Hours	**Gametogenesis, fertilization and embryogenesis:** Production of gametes, Cell surface molecules in sperm-egg recognition in animals; prevention of polyspermy, zygote formation, cleavage, blastula formation, gastrulation- the formation of germ layers and neurulation in animals; embryogenesis. **Learning activities:** *Debate on ethical issues on experimentation of human embryos for research.*	CLO2
III 12 Hours	**Morphogenesis and organogenesis in animals:** Model organisms in developmental biology (*Drosophila, C. elegans, Zebrafish, Xenopus*). Cell aggregation and differentiation in *Dictyostelium*, axes and pattern formation in *Drosophila,* Organogenesis: vulva formation in *C. elegans*, eye lens induction, limb development and regeneration in vertebrates; Cell-Cell Communication and Signaling. **Learning activities:** *Student Seminar.*	CLO3

IV 10 Hours	**Basic Concepts of Plant Development:** Shoot, root and leaf development; floral meristems and development in plants. Embryogenesis and establishment of symmetry in plants, Seed formation, and double fertilization in plants. Apoptosis and its importance in animal/plant development. Medical implications of developmental biology. **Learning activities:** C*ollect plant leaves at different stages of development.*	CLO4

Suggested Readings:

1. Barresi M.J.F and Gilbert, S.F. (2023). *Developmental Biology*. 13th Ed. Sinauer Associates, Inc. USA.
2. Slack, J.M.W. and Dale, L. (2021). *Essential Developmental Biology*, 4th Ed. Wiley-Blackwell, USA.

Web resources:

- https://www.ncbi.nlm.nih.gov/books/NBK21371
- http://www.geochembio.com/metamicrobe/dicty/%20%EF%81%B1%20
- http://www.devbio.biology.gatech.edu/?page_id=34
- http://www.wormbook.org/chapters/www_vulvaldev/vulvaldev.html
- http://www.wormatlas.org/
- https://nptel.ac.in/courses/102/107/102107075/

Modes of transaction

-Demonstration
-Lecture cum demonstration
-Inquiry training
-Problem solving approach
-Self- directed learning

Tools used

PPT, Video, Google meet, Animation, WhatsApp, NPTEL

L	T	P	Cr
3	0	0	3

Course Code: BCH.528
Course Title: Secondary Metabolites and Xenobiotics Metabolism
Total Hours: 45

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

CLO1: Demonstrate an understanding of principles of secondary metabolite synthesis in plants and microbes.
CLO2: Describe and correlate secondary metabolite synthesis in plants and microbes, and their role in species survival.
CLO3: Demonstrate an understanding of metabolic engineering of secondary metabolites
CLO4: Describe and correlate xenobiotic metabolism, and their role in health sciences.

Unit/ Hours	**Contents**	**Mapping with CLO**
I 12 hours	**Secondary Metabolites in Plants:** Terpenoids-Mevalonate pathway and Methylerythritol phosphate pathway, Monoterpenes (C10), Sesquiterpenes (C15), Triterpenes (C30), Diterpenes (C20), Tetraterpenes (C40) and Polyterpenoids; Phenolics-shikimic acid pathway and Malonic acid Pathway, Simple Phenolics (*trans*-cinnamic acid, *p*-coumaric acid and their derivatives), Complex Phenolics (Lignin), Flavonoids, Tannins (Condensed tannin and Hydrolyzable tannins); Nitrogen containing compounds- Alkaloids (Cocaine, Nicotine, Morphine, Caffeine, pyrrolizidine alkaloids), Cyanogenic Glycosides; Glucosinolates. **Learning activities:** *Discussion on real life examples of plant secondary metabolites.*	CLO1 & CLO2
II 12 hours	**Secondary Metabolites in Microbes:** Organic Metabolites-Ethanol, Acetone; Citric acid, Acetic acid, Lactic acid, Gluconic acid, Itaconic acid, Amino acids; Enzymes- Amylases, Glucose Isomerase, L Asparaginase, Proteases, Renin, Penicillin acylases, Lactases, Pectinases, Lipases; Vitamins- Vitamin B12, Riboflavin, B carotene; Antibiotics: beta-Lactam antibiotics; Amino acid and peptide antibiotics; Carbohydrate antibiotics; Tetracycline and anthracyclines; Nucleoside antibiotics; Aromatic antibiotics. **Learning activities:** *Discussion on real life examples of microbial secondary metabolites.*	*CLO1 & CLO2*
III 10 hours	**Metabolic Engineering:** Concept and importance of metabolic engineering for secondary metabolite production, metabolite regulation of metabolic	CLO3

	pathways, basic metabolic control analysis (MCA), metabolic fluxes and basic flux balance analysis (FBA). **Learning activities:** *Case study discussion sessions.*	
IV 11 hours	**Xenobiotics Metabolism:** Concepts and principles, Phase I and Phase II metabolism, Biotransformation and its importance, Bioavailability, Drug sensitivity, Cytochrome-P450 system: History and classification, Chemical carcinogenesis. Application in health sciences. **Learning activities:** *Discussion on xenobiotics taking real life examples.*	CLO4

Suggested Readings:

1. Dey, P.M., Harborne, J.B. (2000). *Plant Biochemistry*. Academic Press, UK.
2. Goodwin, T.W., Mercer, E.I. (2003). *Introduction to Plant Biochemistry*. CBS Publishers & Distributors, New Delhi, India.
3. Crueger, W., Crueger, A. (1990). *Biotechnology. A Textbook of Industrial Microbiology*. Sinauer Associates., USA.
4. Demain, A., Solomon, N.A. (1950). *Biology of Industrial microorganisms*. Menlo Park, Calif.: Benjamin/Cummings Pub. Co., Advanced Book Program, CA.
5. Fell, D. (1997) Understanding the Control of Metabolism, Portland Press, London.
6. Segel, I.H. (1993) Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems. ISBN: 978-0-471-30309-1, 992 pages, Wiley Publication.
7. Stephanopoulos, G., Aristidou. A.A., Nielsen. J., (1998). Metabolic Engineering: Principles & Methodologies, Published by CBSPD
8. Lee, SY, Papoutsakis, ET. (1999). *Metabolic Engineering,* CRC Press
9. Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2018). *Plant Physiology and Development* 6th edition. Sinauer Associates Inc., USA
10. Satyanarayana, U. (2014) *Biochemistry*, Publisher: Elsevier; Fourth edition ISBN-9788131236017.

Web Resources:

- https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecy.2621
- https://www.cell.com/trends/biotechnology/fulltext/S0167-7799(00)01454-2
- https://jgi.doe.gov/first-public-resource-for-secondary-metabolites-searches/
- https://searchworks.stanford.edu/view/12476239
- https://pubs.rsc.org/en/content/articlehtml/2021/RA/D0RA10322E

Modes of transaction

- Lecture
- Problem solving approach
- Group discussion
- Learning centric activity
- Self-learning
- Peer learning

Tools used

PPT, Video, Google meet, Animations, WhatsApp, NPTEL

L	T	P	Cr
2	0	0	2

Course Code: BCH.513
Course Title: Basics of Biochemistry
Total Hours: 30

Learning outcomes: Students will be able to

CLO1: Demonstrate a basic understanding of biomolecules, their structure, composition and function.
CLO2: Describe and explain basic concept of biological metabolism
CLO3: Describe biological catalyst and their role in metabolism

Unit/ Hours	Contents	Mapping with CLO
I 7 hours	Biomolecules: Water, pH, Buffer. Structure and Function of Biomolecules: Carbohydrates, Lipids, Proteins Primary, Secondary, Tertiary and Quaternary structures, Nucleic acids and Vitamins. **Learning Activities:** *Correlate daily consumed/ used items with biomolecules.*	CLO1
II 8 hours	Catabolic and anabolic reactions, Energy rich phosphate compound, Glycolysis, Kreb's Cycle,	CLO2

	electron transport chain, Glycogenesis, Glycogenolysis. **Learning Activities:** *Correlate daily consumed items with metabolism.*	
III 8 hours	Photosynthesis and pigment system, Calvin-C3 cycle, ammonia assimilation, urea cycle, Nitrogen fixation and nitrate uptake. **Learning Activities:** *Discussion on how light is essential for plant and animal life.*	CLO2
IV 7 hours	Classification of enzymes, Basics of enzyme catalysis, Effect of pH and temperature on enzyme activity, Application of enzymes in diagnosis and industry. **Learning Activities:** *Discussion on the important applications of enzymes in industry.*	CLO3

Suggested Readings:

1. Berg JM, Stryer L, Tymoczko JL, Gatto GJ (2018) *Biochemistry*, WH Freeman, 9th ed.
2. Nelson, D. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry*. 7th edition. WH Freeman.
3. Karp, G., Iwasa, J., Marshall, W. (2020). *Karp's Cell and Molecular Biology*. 8th Edition. John Wiley & Sons.
4. Satyanarayana, U. (2014) *Biochemistry*, Publisher: Elsevier; Fourth edition ISBN-9788131236017.

Web resources:

- https://nptel.ac.in/courses/104/102/104102016/
- https://nptel.ac.in/courses/104/103/104103121/
- https://www.youtube.com/watch?v=iuW3nk5EADg
- https://www.youtube.com/watch?v=ZqoX2W1N6l0
- https://www.youtube.com/watch?v=DhwAp6yQHQI
- https://www.youtube.com/watch?v=jLyi2K-29xU
- https://www.youtube.com/watch?v=C0ky85Kk2Zc

Modes of transaction

-Lecture cum demonstration
-Self-learning
-Panel discussion
-Problem solving approach
-Team learning

Tools used

PPT, YouTube Video, Google meet, NPTEL

L	T	P	Cr
2	0	0	2

Course Code: BCH. 514
Course Title: Principles of Biotechnology (IDC)
Total Hours: 30

Learning outcomes: Students will be able to
CLO1: Demonstrate a basic understanding of biotechnology.
CLO2: Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to basic biotechnology and its applications.

Unit/ Hours	Contents	Mapping with CLO
I 7 Hours	**Introduction to tools and techniques**: Basic concept of recombinant DNA Technology, Protein Engineering, Metabolic Engineering. Gene Cloning, Recombinant protein expression, Tools for altering genes and proteins. Concept of transgenics, knockdowns and knockouts. **Learning Activities:** *Flow diagram of different steps involved in recombinant DNA cloning experiment with tools and techniques required to perform the experiment.*	CLO1
II 8 Hours	**Manipulating cells and organisms:** Exploitation of microorganisms, animal cells, and plant system. Manipulating microorganisms, Animal cell lines, Organ culture, Plant tissue culture, protoplast culture, protoplast fusion. **Learning Activities:** *Discussion on most commonly used model organisms for genetic manipulation.*	CLO2
III 8 Hours	**Applications and prospects of Biotechnology:** Microbial system, Plant system and Animals. Fermentation technology – production of alcohols, antibiotics, steroids and enzymes, industrially	CLO3

	important metabolites, biotransformation, biomass production of single cell protein, Biodegradation by microorganisms. Applications in plant systems-enhancing photosynthetic efficacy, nitrogen fixation efficiency and resistance to environmental stresses, prospects of improving crop productivity, genetically modified foods, Animals and animal products with desirable characteristics. **Learning Activities:** *Term paper-based discussion and brain-storming sessions.*	
IV 7 Hours	**Biotechnology applications in health and disease:** Medical application of rDNA technology, therapies of Genetic diseases, disease diagnostics, Hybridoma technology to produce Monoclonal antibodies, Antibody Engineering, Vaccines, Immunotoxins, Engineering immune cells, stem cells, organ regeneration. **Learning Activities:** *Term paper- based discussion and brain-storming sessions.*	CLO4

Suggested Readings:

1. Primrose SB, Twyman R. (2014) *Principles of Gene Manipulation and Genomics*. 7th edition, Wiley-Blackwell.
2. Glick BJ, Patten CL. (2017) *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. 5th Edition, American Society for Microbiology
3. Balasubramanian, D, Bryce, CFA, Dharmalingam, K, Green J, Jayaraman K. (2004) Concepts in Biotechnology Universities Press
4. Davinport C (2018). Principles of Biotechnology, 1st Ed., Syrawood Publishing House

Web resources:

http://www.mrrottbiology.com/genetic-engineering--biotechnology.html
https://www.nature.com › subjects › genetic engineering

Modes of transaction

-Lecture
-Brain storming
-Problem solving approach

Tools used

PPT, YouTube Video, Google meet, NPTEL

SEMESTER – III

L	T	P	Cr
3	0	0	3

Course Code: BCH.552
Course Name: Clinical Biochemistry
Total Hours: 45

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

CLO1: Demonstrate the biological basis of clinical biochemistry and the components related to health.

CLO2: Apply and effectively communicate scientific reasoning and data analysis related to clinical biochemistry and understand the biochemical changes in metabolism that lead to diverse clinical diseases.

CLO3: Describe and correlate the importance of clinical biochemistry in the causation, progression, and treatment of different disease conditions based on established guidelines and treatment protocols.

Unit/ Hours	Contents	Mapping with CLO
I 12 Hours	**Disorders of Carbohydrate metabolism**: Diabetes mellitus, Insulin and glucose secretion, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia. **Learning activities:** *Peer discussion in teams and presentation.*	CLO1, CLO2 & CLO3
II 12 Hours	**Disorders of Lipid metabolism**: Plasma lipoproteins (VLDL, IDL, LDL and IDL), Cholesterol, Triglycerides & Phospholipids in health and disease, Apo-lipoproteins, Atherosclerosis. Hyperlipidemia, Hyperlipoproteinemia, Gaucher's disease, Tay-Sachs and Niemann-Pick disease, Abetalipoproteinemia. **Learning activities:** *Assignment and term paper based discussion.*	CLO1, CLO2 & CLO3

III 11 Hours	**Inborn Errors of Metabolism and Diagnostic Enzymes:** Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, Histidinemia. Enzymes in health and diseases. Biochemical diagnosis of diseases by enzyme assays – SGOT, SGPT, CPK, cholinesterase, LDH. **Learning activities:** *Peer discussion in teams and presentation.*	CLO1, CLO2 & CLO3
IV 10 Hours	**Other metabolic disorders:** Jaundice, Fatty liver, Normal and abnormal functions of liver and kidney. Uremia, Hyperuricemia, Porphyria, Albinism, Sickle cell anemia, Thalassemia. **Learning activities:** *Discussion on management of the other metabolic disorders.*	CLO1, CLO2 & CLO3

Suggested Readings:

1. Murphy MJ, Srivastava R, and Deans K (2018) *Clinical Biochemistry:* An Illustrated Colour Text. 6th Ed. Publisher: Churchill Livingstone.
2. Luxton, R (2008) *Clinical Biochemistry*. 2nd Ed. Scion Publishing Ltd.
3. Hall, JE (2019) *A textbook of Medical Physiology*, 2nd South Asia Ed. Publisher: Saunders.
4. Maheshwari, N (2017) *Clinical Biochemistry*. 2nd Ed. Publisher: JPB.
5. Henry, Bernard J et al. (2002). *Clinical diagnosis & Management by laboratory methods.* W.B. Saunders, New York
6. Gradwohls (2000) *Clinical Laboratory Methods and Diagnosis.* (ed) Sonnenwirth AC, and Jarret L, M.D.B.I. Publications, New Delhi
7. Coleman, W. B. and Tsongalis, G. J. (2009). *Molecular Pathology: The Molecular Basis of Human Disease.* Academic Press.
8. Nussbaum, R.L., McInnes, R. Mc., Willard, H.F. (2009). *Genetics in Medicine*. Elsevier Inc., Philadelphia.
9. Read A and Donnai D (2007). *New Clinical Genetics.* Scion Publishing Ltd., Oxfordshire, UK.
10. Patch, H. S. C. (2009). *Genetics for the Health Sciences*. Scion Publishing Ltd., UK.
11. Milunsky, A., Milunsky, J. (2015). *Genetic Disorders and the Fetus: Diagnosis, Prevention and Treatment*, 7th Edition. Wiley-Blackwell Publishers.
12. Ahmed N (2017) Clinical Biochemistry, 2nd Ed., Oxford University Press

Web Resources:

- https://global.oup.com/uk/orc/biosciences/biomed/ahmed2e/
- https://www.aacb.asn.au/resources/resources
- https://guides.lib.utexas.edu/biochemistry

- https://themedicalbiochemistrypage.org/
- https://www.internetchemistry.com/chemistry/clinical-chemistry.php

Modes of transaction

- Lecture
- Problem solving approach
- Group discussion
- Learning centric activity
- Self-learning
- Peer learning

Tools used

PPT, Video, Google meet, Animations, WhatsApp, NPTEL

Course Code: BCH.553
Course Title: Plant and Microbial Biochemistry

L	T	P	Cr
3	0	0	3

Total Hours: 45

Learning outcomes: Students will be able to
CLO1: Develop an understanding of basic concepts of light driven biochemical processes, nitrogen fixation and plant hormones
CLO2: Describe and correlate plant biochemistry with agriculture and related aspects.
CLO3: Correlate microbial biochemistry with industrially important metabolites production.

Unit/ Hours	Contents	Mapping with CLO
I 12 Hours	**Photosynthesis:** Ultrastructure and organisation of chloroplast, lipid composition of chloroplast membranes, chloroplast genome, Light reaction, electron transport chain. Thylakoid membrane protein complexes. Benson-Calvin cycle, its regulation, Biochemistry of RUBP carboxylase/oxygenase, activation of RUBISCO, stereochemistry of RUBISCO, oxygenation reaction, photorespiration and CO2 compensation point, C4 photosynthesis - Hatch and	CLO1

	slack pathway, CAM plants and regulation of CAM pathway. **Learning activities:** *Assignment on the above topics.*	
II 10 Hours	**Nitrogen Metabolism:** Nitrogen fixation, nitrogenase complex, mechanism of action of nitrogenase. Nitrate Assimilation: Enzymes of nitrate assimilation, nitrate reductase and nitrite reductase, Ammonium assimilation. Phytohormones: Biosynthesis, storage, breakdown and transport, physiological effects and mechanisms of action. **Learning activities:** *Classroom presentation and discussion on the topic*	CLO2
II 13 Hours	**Microbial Growth, Nutrition and Physiology:** Microbial carbon metabolism and energy generation, nutrient uptake and transport, Bacteriological media, biochemical basis of using different media helpful in isolation and identification of different bacteria, microbial growth kinetics, Measurement of growth and growth yields, growth curve and kinetic models, Synchronous growth, batch, fed-batch and continuous culture, factors affecting growth. **Learning activities:** *Developing SOP to grow a particular microorganism of interest.*	CLO3
IV 10 Hours	**Microbial Metabolism:** Metabolic pathways specific to microbes and their application for metabolic engineering, strain improvements for the production of primary and secondary metabolites, antibiotics, enzymes and other industrially important metabolites, alcohol/lactate fermentation, microbial biotransformation, microbial biomolecules in the infectious process, bacterial toxins, their classification and mode of action, principle of food spoilage and its control. **Learning activities:** *Classroom discussion.*	CLO3

Suggested Readings:

1. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). *Biochemistry and Molecular Biology of Plants.* 2nd Ed. Wiley-Blackwell.
2. Campbell, M.K., Farrell, S.O. and McDougal OM. (2016). *Biochemistry.* 9th Ed. Brooks/Cole, USA.
3. Dey, P.M., Harborne, J.B. (1997). *Plant Biochemistry*. Academic Press, UK.
4. Goodwin, T.W., Mercer, E.I. (2005). *Introduction to Plant Biochemistry*. 2nd Ed. CBS Publishers & Distributors, New Delhi, India.
5. Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2018). *Plant Physiology and Development* 6th edition. Sinauer Associates Inc., USA.
6. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019.
7. Microbial Biochemistry by G.N. Cohen. 2nd edition. Springer, Germany. 2014.
8. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 6th edition. W. H. Freeman, UK. 2012.
9. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond and C. Fuqua. 4th edition. Oxford University Press, UK. 2011.

Web Resources:

- https://www.youtube.com/watch?v=bsqSELXsmLA
- https://www.youtube.com/watch?v=slm6D2VEXYs
- https://www.youtube.com/watch?v=GR2GA7chA_c
- https://www.youtube.com/watch?v=7ynX_F-SwNY
- https://www.youtube.com/watch?v=nz0PmLL78e4
- https://www.youtube.com/watch?v=LdHp4Na3X_0
- https://www.youtube.com/watch?v=orHqYE_1CLI
- https://www.youtube.com/watch?v=fmQNlF_X-6E
- https://www.youtube.com/watch?v=MsPZp7lM16A

Modes of transaction:

-Lecture cum Demonstration
-Problem solving approach
-Self-Learning
-Inquiry training
-Team teaching

Tools used

PPT, YouTube Videos, Google meet, Google classroom

L	T	P	Cr
3	0	0	3

Course Code: BCH.554
Course Title: Genetic Engineering

Total Hours: 45

Learning outcomes: Students will be able to

CLO1: Demonstrate basic concepts and various vectors used in genetic engineering.
CLO2: Demonstrate utility of gene cloning and its applications utilizing microbes.
CLO3: Demonstrate current application of Genetic Engineering
CLO4: Demonstrate functional assessment of genes and application of GMO.

Unit/ Hours	**Contents**	**Mapping with CLO**
I 11 Hours	**Tools of Genetic Engineering:** Enzymes in genetic engineering, Cloning vectors, Expression vectors and their features (Plasmid Vectors, Vectors based on Lambda Bacteriophage, Cosmids, M13 Vectors, Expression Vectors, Vectors for Cloning Large DNA Molecules, Transformation and Selection, genomic and cDNA library construction, Site-directed mutagenesis. **Learning activities:** *Inquiry training on usage and advantages/disadvantages of different vector systems.*	CLO1
II 11 Hours	**Gene Cloning and Expression in Microbial and Eukaryotic Systems**: Cloning in *E. coli*, in Gram-positive bacteria, in Streptomycetes, in *Saccharomyces cerevisiae* and *Pichia pastoris*, in Insect Cells, in Mammalian Cells expression system, Fusion proteins, Transcriptional & Translational Fusions, Adding Tags and Signals. **Learning activities:** *Discussion on usage and advantages/disadvantages of different host systems.*	CLO2
III 12 Hours	**Applications of Recombinant DNA Technology:** Vaccines (attenuated, subunit vaccine, recombinant protein, recombinant live vaccines, DNA and mRNA based vaccines, multi-epitope vaccines), Metabolic Engineering with examples from microbial, plant and animal systems. Protein Engineering and protein augmentation therapy: Antibody Engineering, Immunotoxins, Enzymes, Antibiotics, Abzymes, Therapies for Genetic Diseases, Bioremediation.	CLO3
IV 11 Hours	**Genetic Manipulation and functional assessment:** Functional genomics: Forward and reverse Genetics,	CLO4

	Model organisms, Genetically modified plants and animals, Creating Transgenics, Knockouts, Knockdowns, RNAi technology, CRISPR technology. Generation of Transient and stable cell lines. **Learning activities:** *Self-learning and classroom discussion.*	

Suggested Readings:

1. Glick BJ, Patten CL. (2017) *Molecular Biotechnology: Principles and Applications of Recombinant DNA.* 5th edition, American Society for Microbiology
2. Kurnaz IA. (2015) *Techniques in Genetic Engineering.*1st edition, CRC Press.
3. Primrose SB, Twyman R. (2014) *Principles of Gene Manipulation and Genomics*. 7th edition, Wiley-Blackwell.
4. Green MR, Sambrook J. (2013). *Molecular cloning: A laboratory manual*. 4th edition, Cold Spring Harbor Laboratory Press, New York.

Web Resources:

- http://www.mrrottbiology.com/genetic-engineering--biotechnology.html
- https://www.nature.com › subjects › genetic engineering

Modes of transaction

-Lecture cum Demonstration
-Problem solving approach
-Self-Learning
-Inquiry training

L	T	P	Cr
0	0	6	3

Course Code: BCH. 555
Course Title: Biochemistry Practical-III
Hours: 90

Course learning outcome: After the completion of this course, the students will be able to

CLO1: Show proficiency in laboratory techniques pertaining to clinical and plant biochemistry.

CLO2: Apply the scientific method to the processes of experimentation and hypothesis testing.

Part	Contents	Mapping with CLO
A	**Clinical Biochemistry** 1. Estimation of cholesterol in biological tissue and cells. 2. Estimation and separation of serum/plasma proteins in blood 3. Estimation of blood/serum glucose 4. Estimation of serum total cholesterol 5. Tests for proteins, glucose, ketone bodies, bilirubin & urobilinogen in urine 6. Estimation of urea in blood (serum) 7. Determination of uric acid in serum 8. Estimation of serum bilirubin	CLO1 & CLO2
B	**Plant Biochemistry** 1. Leaf chlorophyll estimation using spectrophotometer 2. Extraction and estimation of DNA from plant source 3. Design and construction of Plant binary vector 4. Estimation of plant antioxidants (phenolics, flavonoids etc.) 5. Antioxidant enzyme (SOD, Cat, GPx etc.) activity in plants	CLO1 & CLO2

Modes of transaction:

-Lecture
-Demonstration
-Lecture cum demonstration
-Experimentation
-Problem solving approach

Web resources

- https://www.vlab.co.in/broad-area-biotechnology-and-biomedical-engineering

Evaluation Criteria for Practical Courses:

Students are evaluated for a total of 100 marks for
-Maintaining the lab records/notebooks (10MM
-Continuous assessment (20MM)
-Attendance during day to day practical (10MM)
-Final practical examination (30MM)
-Viva-voce (30MM)

L	T	P	Cr
2	0	0	2

Course Title: Innovations, Skill development, and Entrepreneurship

Course Code: BCH.526

Total Hours: 15 Hours

Learning Outcomes: Students will be able to:

CLO1: Bring innovative ideas and innovative services to the market and develop patents.
CLO2: Understand the basic concepts of entrepreneur, entrepreneurship and its importance.
CLO3: Develop capabilities of preparing proposals for starting small businesses.
CLO4: Comprehend the opportunities, challenges and skills required in biochemistry related entrepreneurship.

Unit/ Hours	Contents	Mapping with CLO
I 3 Hours	**Innovation and Value Creation:** Conceptualizing innovations from laboratory research for societal benefit and its impact assessment. Working towards enhanced innovation and partnership between academia, industry, investors and society as a whole. **Learning activities:** *Case studies and discussion sessions with successful science-based entrepreneurs.*	CLO1
II 4Hours	**Introduction to Entrepreneur and Entrepreneurship:** Characteristics of an entrepreneur; entrepreneurial traits, Types of entrepreneurial ventures; enterprise and society in Indian context; Importance of women entrepreneurship. **Ventures and Start-Ups:** How to start a small business; opportunity analysis, external environmental analysis, legal requirements for establishing a new unit, raising of funds financial management for procurement of capital Collaborations & partnership, **Learning activities:** *Concept built with real examples.*	CLO2

III 4 Hours	**Road map from Laboratory to the Market:** Familiarization with Entrepreneurial development programs of public and private agencies (MSME, DBT, BIRAC, Make in India); Technology assessment, development & upgradation, Managing Quality control and technology transfer, Challenges in bio business and market conditions in segments of interest; developing distribution channels, the nature, analysis and management of changing customer needs, strategic dimensions of patenting & commercialization. **Learning activities:** *Mind map for laboratory to market transition.*	CLO3
IV 4 Hours	**Skills developments:** Develop critical thinking and problem-solving skills: Practice analyzing data, identifying patterns, and drawing logical conclusions. Develop your ability to approach scientific problems systematically. Embrace technology and data analysis: Familiarize yourself with scientific software, data analysis tools, Learn how to analyze and interpret biological data. Develop analytical and problem-solving skills: Practice interpreting experimental results, analyzing data sets, and applying critical thinking to evaluate research findings.	CLO4

Suggested Readings:

1. Arora, R (2008). *Entrepreneurship and Small Business*, Dhanpat Rai & Sons Publications.
2. Chandra, P (2018). *Project Preparation, Appraisal, Implementation*, Tata Mc-Graw Hills.
3. Desai, V (2019). *Management of a Small Scale Industry*, Himalaya Publishing House.
4. Jain, P. C. (2015). *Handbook of New Entrepreneurs*, Oxford University Press.
5. Srivastava, S. B. (2009). *A Practical Guide to Industrial Entrepreneurs*, Sultan Chand & Sons.
6. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge, Routledge Studies in Innovation, Organizations and Technology (2018) 1st ed. Onetti, A, & Zucchella, A, CRC press, Taylor and Francis group. ISBN: 9781138616905.

7. Innovation, Commercialization, and Start-Ups in Life Sciences. (2014) 1st ed. Jordan, JF, CRC Press. Taylor and Francis group, ISBN: 9781482210125.
8. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences (2008) Adams, DJ, Sparrow JC, Bloxham, Scion, ISBN:1904842364.

Web resources:

- https://www.birac.nic.in
- https://wyss.harvard.edu/news/the-key-to-successful-entrepreneurship-in-the-life-sciences/
- https://www.thebalancesmb.com/essential-web-resources-for-entrepreneurs-1200706

Modes of transaction:

-Lectures and tutorials.
-Group-work
-Ideathons and design sprints
-Brain-storming sessions
-Group activities-learning by doing

Tools used

PPT, Video, Google drive, Animations, Google classroom

L	T	P	Cr
3	0	0	3

Course Code: BCH.556
Course Title: Human Physiology
Total Hours: 45

On completion of this course, students will be able to:
CLO1: Demonstrate the function and regulation of physiological systems.
CLO2: Describe and correlate physiological systems and biochemistry.

Unit/ Hours	Contents	Mapping with CLO
I 12 Hours	**Cardiovascular System:** Haemopoiesis, haemoglobin Blood Coagulation-mechanism and regulation blood pressure and its regulation.	CLO1 & CLO2

	Respiratory System: Transport and exchange of CO_2 and O_2, role of 2,3-diphosphoglycerate, Bohr effect and chloride shift. **Learning activities:** *Self learning and classroom discussion.*	
II 12 Hours	**Digestive System:** Composition, functions and regulation of saliva, gastric, pancreatic, intestinal and bile secretions. Digestion and absorption of carbohydrates, lipids, proteins, and nucleic acids. **Learning activities:** *Assignment and term paper based discussion.*	CLO1 & CLO2
III 11 Hours	**Excretory System:** Structure of nephron, glomerular filtration, tubular reabsorption and secretion, Homeostatic regulation of water and electrolytes acid-base balance. **Learning activities:** *Self learning and classroom discussion.*	CLO1 & CLO2
IV 10 Hours	**Muscle Physiology:** Organization of sarcomere, tropomyosins and troponin complex, Action potential, Role of calcium in muscle contraction and relaxation. **Endocrinology:** Secretion and functions of hormones of thyroid, pituitary and gonads, Mechanism of action of hormones. **Learning activities:** *Group discussion.*	CLO1 & CLO2

Suggested Readings:

1. Brody, T. (1998). *Nutritional Biochemistry*. Academic Press, USA.
2. Devlin, T.M. (2005). *Textbook of Biochemistry with clinical correlations*. John Wiley & Sons Inc. USA.
3. Guyton. (2007). *Textbook of medical physiology*. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
4. Hill, R.W, Wyse, G. A. and Anderson, M. (2008). *Animal physiology*. Sinauer Associates Inc. USA.
5. Murray, R.K. (2009). *Harper's illustrated biochemistry*. Jaypee Publishers, New Delhi, India.
6. Tyagi, P. (2009). *A textbook of Animal Physiology*. Dominant Publishers and distributors, New Delhi, India.
7. Cox C (2015) Nutritional Biochemistry: Current Topics in Nutrition Research, 1st Ed., CRC Press

Web Resources:

- https://rad.washington.edu/muscle-atlas/

- https://www.healthline.com/health/human-body-maps#circulatory-system
- http://apchute.com/
- https://www.nlm.nih.gov/research/visible/visible_human.html
- http://muscle.ucsd.edu/musintro/jump.shtml

Modes of transaction

- Lecture
- Problem solving approach
- Group discussion
- Learning centric activity
- Self-learning
- Peer learning

Tools used

PPT, Video, Google meet, Animations, WhatsApp, NPTEL

L	T	P	Cr
3	0	0	3

Course Code: BCH.557
Course Title: Clinical Diagnostics
Total Hours: 45
Learning Outcomes: Students will be able to
CLO1: Comprehend diverse methods in clinical diagnosis of human diseases.
CLO2: Apply these techniques in various fields of biological research.

Unit/ Hours	Contents	Mapping with CLO
I 11 Hours	**Introduction to Clinical Diagnostics:** Philosophy and general approach to clinical specimens, Sample collection (Blood, urine, spinal fluid, synovial fluid, amniotic fluid) - method of collection, preservation, transport and processing of samples. Diagnosis – disease altered state, prognosis, direct and indirect, concept of antigen and antibody. Principles of validation of diagnostic assays for infectious diseases, Validation	CLO1 & CLO2

	and quality control of polymerase chain reaction methods used for the diagnosis of infectious diseases. **Learning Activities:** *Classroom discussion on sample type and applicable diagnostic assays with appropriate controls*	
II 12 Hours	**Protein based Clinical Diagnostics:** Antigen – Antibody Interaction, Lattice Theory, Precipitin Curve, Simple Immunodiffusion (Radial Immunodiffusion – Qualitative, Quantitative); Double Diffusion (Mechanism of Reaction of Identity, Partial Identity, and Non-Identity); Rocket Electrophoresis, Immunoelectrophoresis; Western Blot, Immunofluorescence, Radioimmunoassay; ELISA – types and assay development; Agglutination – Antibody titer, Prozone Phenomenon, Direct and Indirect Agglutination, ABO Blood typing, Agglutination Inhibition; Advantages and limitation with respect to clinical diagnosis and research usage. Microparticle based antigen - Antibody interaction techniques. Monoclonal antibody – production, applications, novel approaches in detection, Humanized monoclonal antibodies. **Learning Activities:** *Drawing out the similarities and dissimilarities along with advantages and disadvantages with reference to different diagnostic assays as part of group learning*	CLO1 & CLO2
III 11 Hours	**DNA based Clinical Diagnostics:** Nucleic acid extraction from clinical samples, quantization, digestion, hybridization, Amplification by PCR (Inverse PCR, Multiplex PCR, Nested PCR, Alu-PCR, Hot-start, *In situ* PCR, Long-PCR, PCR-ELISA, iPCR, applications and limitations) DNA fingerprinting and polymorphism studies (SNP, RAPD, RFLP, VNTR, Mutation detection). **Learning Activities:** *Emphasis on interpretation of results and quality control.* **High-throughput Technologies and Diagnostics:** Microarray (protein, DNA), Real-Time PCR, Reporter assays. Biosensors – types, applications, examples (glucose etc), telemedicine. Fluorescence based techniques (FISH analysis, Flow cytometry, Fluorescent Microscopy) Mass spectrometry, Histopathology,	CLO1 & CLO3

	Immunohistochemistry and Real-Time PCR. Microbiological Diagnosis and Hematology. Enzyme and hormone based diagnostic techniques **Learning activities:** *Drawing out the similarities and dissimilarities along with advantages and disadvantages with reference to different diagnostic assays as part of group learning*	
IV 11 Hours	**Case Studies:** Diagnosis of Infectious and Emerging Diseases. Bacterial infection caused by *Coliforms, Salmonella, Shigella, Vibrio, and Mycobacterium tuberculosis*. Diagnosis of fungal infections. Dermatophytosis, Candidiasis and Aspergillosis. Diagnosis of DNA and RNA viruses. Pox viruses, Adenoviruses, Rhabdoviruses, Hepatitis Viruses and Retroviruses. Diagnosis of Protozoan diseases: Amoebiasis, Malaria, Trypanosomiasis, Leishmaniasis, Filariasis and Schistosomiasis. Medical Genetics: Organization of human genome, Human Genome Project, Identifying human disease genes. Genetic Counselling. Genetic disorders: Sickle cell anaemia, Duchenne muscular Dystrophy, Retinoblastoma, Cystic Fibrosis and Sex –linked inherited disorders. Neonatal and Prenatal disease diagnostics. **Learning activities:** *Case studies to be taken up by students covering different diseases as assignments*	CLO2

Suggested Readings:

1. Burtis, Carl A, Ashwood, Edward R, Bruns, David E., "*Tietz textbook of Clinical Chemistry & Molecular Diagnostics*" USA: Saunders, 2006.

2. World Organization for Animal Health: "*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals"* Volumes I & II, 6th Edition, 2010.

3. Rao, Juluri R, Fleming, Colin C., Moore, John E., "*Molecular Diagnostics: current technology and Applications"*, Horizon Bioscience, U. K., 2006.

4. Goldsby, Richard A., Kuby, Janis, "*Immunology*", New York: WH Freeman and Company, 2003.

5. Mahon, Connie R., Lehman, Donald C., Manuselis, G. "*Textbook of Diagnostic Microbiology*". USA: Saunders, 2007.

Web Resources:

- https://www.nap.edu/read/21794/chapter/7
- https://www.nature.com/subjects/medical-and-clinical-diagnostics
- https://gh.bmj.com/content/3/6/e000914

- https://www.sciencedirect.com/topics/medicine-and-dentistry/telediagnosis

Modes of transaction
-Lecture
-Problem Solving
-Self-Learning
- Case study
-Group discussions

L	T	P	Cr
2	0	0	2

Course Code: BCH.560
Course Title: Analytical Biochemistry and Molecular Diagnostics

Total Hours: 30

On completion of this course, students will be able to:
CLO1: Comprehend diverse methods in molecular diagnostics of human diseases and Forensic studies
CLO2: Understand and use the said approaches and techniques in related career paths

Unit/ Hours	Contents	Mapping with CLO
I 7 Hours	**Introduction to instrumentation used in biochemistry laboratory**- UV-spectrometry, chromatography, microscopy. **pH and buffers:** Concept of molarity, molality and normality, preparation of buffers and solutions in laboratory.	CLO1 & CLO2

	Sterilisation techniques: concept of sterilization; methods of sterilization- wet heat sterilization, dry heat sterilization, radiation sterilization, filter sterilization, Autoclave, Biosafety cabinets (LAF etc), Biosafety Levels **Learning activities:** *Brief exercises required for preparation of working solutions and physiological buffers*	
II 7 Hours	**Introduction to Clinical Diagnostics:** General approach to biological specimens, Sample collection (Blood, urine, spinal fluid, synovial fluid, amniotic fluid) - method of collection, preservation, transport and processing of samples. Blood group determination, genetics of ABO and Rh blood group.	CLO1 & CLO2
III 9 Hours	**Molecular Diagnostics:** Nucleic acid extraction from clinical samples, quantization, digestion, hybridization, Amplification by PCR (Inverse PCR, Multiplex PCR, Nested PCR, Alu-PCR, Hot-start, *In situ* PCR, Long-PCR, PCR-ELISA, iPCR, applications and limitations) DNA fingerprinting **High-throughput Technologies in Diagnostics:** Real-Time PCR, Biosensors – types, applications, examples (glucose etc), telemedicine. Fluorescence based techniques (FISH analysis, Flow cytometry, Fluorescent Microscopy). **Learning activities:** *Group discussion on disease specific application of different tools in real life scenario.*	CLO1 & CLO2

IV 7 Hours	**Medical diagnostics:** Diagnosis of Infectious Diseases – some specific examples of Diagnosis of bacterial infection, fungal infections, viral infections. Genetic Diseases: Organization of human genome, Human Genome Project, Identifying human disease genes. Genetic Counselling. Genetic disorders: Sickle cell anaemia, Duchenne muscular Dystrophy, Retinoblastoma, Cystic Fibrosis and Sex –linked inherited disorders. **Learning activities:** *Case studies.*	CLO1 & CLO2

Suggested Readings:

1. Burtis, Carl A, Ashwood, Edward R, Bruns, David E., "*Tietz textbook of Clinical Chemistry & Molecular Diagnostics*" USA: Saunders, 2006.

2. World Organization for Animal Health: "*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals"* Volumes I & II, 6th Edition, 2010.

3. Rao, Juluri R, Fleming, Colin C., Moore, John E., "*Molecular Diagnostics: current technology and Applications"*, Horizon Bioscience, U. K., 2006.42

4. Mahon, Connie R.; Lehman, Donald C. ; Manuselis, George "*Textbook of Diagnostic Microbiology*". USA: Saunders, 2007.

Web Resources:

- https://labtestsonline.org/articles/forensic-testing
- https://pubmed.ncbi.nlm.nih.gov/12138499/
- http://www.forensicsciencesimplified.org/

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
- Case study
-Case analysis

Tools used

PPT, Video, Google classroom, padlet

L	T	P	Cr
0	0	8	4

Web resources:

- www.csirhrdg.res.in

Course Code: BCH.561
Course Title: Environmental Biochemistry
Total Hours: 30
On completion of this course, students will be able to:
CLO1: Understand the importance and types of environmental pollution,
CLO2: Detection of mutagens.
CLO3: Biotechnological approaches to tackle environmental pollution.

Unit/ Hours	**Contents**	**Mapping with CLO**
I 7 Hours	**Environment pollution:** Introduction of environmental pollution, Different types of environmental pollution, Air pollution, criteria pollutants, estimation of NOx, SOx, and particulate matter, Major causes of air pollution**,** Industrial Emissions, Deforestation and Biomass Burning and Natural Sources, Air-borne diseases and pathogens Water pollution, various contaminants in water, BOD, COD, Major causes of water pollution**,** waterborne diseases and pathogens, MPN and MFT test; fecal coliform. **Learning activitie:** *Classroom discussion on air and water pollution*	CLO1

II 9 Hours	**Treatment methods:** Air pollutions treatments methods principle, Working, Types, scrubbers, separators and electrostatic precipitators. Water pollution treatments, study about primary, secondary, and tertiary treatment and process, activated sludge systems principle, trickling filters, Rotating Biological Contactors, 1. Introduction to genetic toxicology, Bacterial Ames test, DNA strand break measurements in cells (comet assay, alkaline unwinding and hydroxyapatite chromatography, alkaline elution), and cytogenetic assays (micronucleus and chromosomal aberration assays. 2. **Learning activities:** *Discussion on various methods of estimation of air and water pollutants.*	CLO2 & CLO3
III 7 Hours	**Solid waste management:** types and process of composting, Factor affecting composting, Sanitary landfill, E-Waste Management in India: Issues and Strategies, Management of lead acid battery, Biomedical waste management. Types and Methods of Biodegradation of organic pollutants Bioremediation: types, method and effect on the environment. **Learning activities:** *Case studies.*	CLO1 & CLO3

IV 7 Hours	**Plastic waste:** Study about Microplastics formation, Microplastics types, sources, distribution and fate. Effect of microplastics on the environment and human health. Study some alternatives to plastics, Biodegradable plastics production, types and benefits. Study different types of Challenges associated with preventive measures **Learning activities:** *Case studies.*	CLO1 & CLO2

Suggested Readings:

1. Brady, N.C. & Well, R.R. 2007.The Nature and Properties of Soils (13th edition), Pearson Education Inc.
2. Oldeman, L. R. 1994. The global extent of soil degradation. Soil resilience and sustainable land use, 9. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).
3. Jordening, H.J. & Winter J. 2005. Environmental Biotechnology: Concepts and Applications. John Wiley& Sons
4. Rittman, B.E. & McCarty, P.L. 2001. Environmental Biotechnology. Principles and Applications. McGraw-Hill, New York.
5. Wainwright, M. 1999. An Introduction to Environmental Biotechnology, Springer.
6. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2006. Environmental and Pollution Science. Elsevier Academic Press.
7. Purohit, S.S. & Ranjan, R. 2007. Ecology, Environment & Pollution. Agrobios Publications.
8. Hayes, A. W., & Kruger, C. L. (Eds.). (2014). *Hayes' principles and methods of toxicology*. Crc Press.
9. Crawford, C. B., & Quinn, B. (2016). *Microplastic pollutants*. Elsevier Limited
10. Goosey, M., Stevens, G., & Herman, H. (2009). *Electronic waste management* (Vol. 27). royal society of chemistry.

Web Resources:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8497872

https://www.nature.com/articles/s41578-021-00411-y

https://www.biologydiscussion.com/microbiology-2/treatment-of-solid.

https://www.sciencedirect.com/science/article/pii/S0048969721016582

Modes of transaction

-Lecture

-Problem-Solving

-Self-Learning

Course Code: BCH.600
Course Title: Dissertation Part I
Total Hours: 120

Learning outcomes:

CLO1: Critically analyze, interpret, synthesize existing scientific knowledge based on literature review
CLO2: Demonstrate an understanding of the selected scientific problem and identify the knowledge gap
CLO3: Formulate a hypothesis and design an experimental/theoretical work

Students will prepare a research proposal based on literature review and extensive student-mentor interactions involving discussions, meetings and presentations. Each student will submit a research/dissertation proposal of the research work planned for the M.Sc. dissertation with origin of the research problem, literature review, hypothesis, objectives and methodology to carry out the planned research work, expected outcomes and bibliography.

Students will have an option to carry out dissertation work in industry, national institutes or Universities in the top 100 NIRF ranking. Group dissertation may be opted, with a group consisting of a maximum of four students. These students may work using a single approach or multidisciplinary approach. Research projects can be taken up in collaboration with industry or in a group from within the discipline or across the discipline.

Evaluation Criteria:

The evaluation of the dissertation proposal will carry 50% weightage by supervisor and 50% by HoD and senior-most faculty of the department.

Dissertation Proposal (Third Semester)		
	Marks	Evaluation
Supervisor	50	Dissertation proposal and presentation

HoD and senior-most faculty of the department	50	Dissertation proposal and presentation

Modes of transaction

Group discussions and presentations; Self-Learning; Experimentation

SEMESTER IV

L	T	P	Cr
0	0	40	20

Course Code: BCH.601
Course Title: Dissertation Part II
Total Hours: 600

Learning outcomes:

CLO1: Demonstrate an in-depth knowledge of scientific research pertaining to the area of study

CLO2: Demonstrate experimental/theoretical research capabilities based on rigorous hands-on training

CLO3: Critically analyze, interpret and present the data in light of existing scientific knowledge to arrive at specific conclusions

CLO4: Develop higher order thinking skills required for pursuing higher studies (Ph.D.)/research-oriented career options

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor. The dissertation will include literature review, hypothesis, objectives, methodology, results, discussion, and bibliography.

Examination pattern and evaluation for Masters' students from 2023-24 session onwards

Formative Evaluation: Internal assessment shall be 25 marks using any two or more of the given methods: tests, open book examination, assignments, term paper, etc. The Mid-semester test shall be descriptive type of 25 marks including short answer and essay type. The number of questions and distribution of marks shall be decided by the teachers.

Summative Evaluation: The End semester examination (50 marks) with 70% descriptive type and 30% objective type shall be conducted at the end of the semester. The objective type shall include one-word/sentence answers, fill-in the blanks, MCQs', and matching. The descriptive type shall include short answer and essay type questions. The number of questions and distribution of marks shall be decided by the teachers. Questions for exams and tests shall be designed to assess course learning outcomes along with focus on knowledge, understanding, application, analysis, synthesis, and evaluation.

The evaluation for IDC, VAC and entrepreneurship, innovation and skill development courses shall include MST (50 marks) and ESE (50 marks). The pattern of examination for both MST and ESE shall be same as ESE described above for other courses.

Evaluation of dissertation proposal in the third semester shall include 50% weightage by supervisor and 50% by HoD and senior-most faculty of the department. The evaluation of dissertation in the fourth semester shall include 50% weightage for continuous evaluation by the supervisor for regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; 50% weightage based on average assessment scores by an external expert, HoD and senior-most faculty of the department. Distribution of marks is based on report of dissertation (30%), presentation (10%), and final viva-voce (10%). The external expert may attend final viva-voce through offline or online mode.

Examination pattern from 2022-23 session onwards

Core, Discipline Elective, and Compulsory Foundation Courses			IDC, VAC, and Entrepreneurship, Innovation and Skill Development Courses	
	Marks	Evaluation	Marks	Evaluation
Internal Assessment	25	Various methods	-	-
Mid-semester test (MST)	25	Descriptive	50	Descriptive (70%) Objective (30%)
End-semester exam (ESE)	50	Descriptive (70%) Objective (30%)	50	Descriptive (70%) Objective (30%)

Dissertation Proposal (Third Semester)			Dissertation (Fourth Semester)		
	Marks	Evaluation		Marks	Evaluation

Supervisor	50	Dissertation proposal and presentation	Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
HoD and senior-most faculty of the department	50	Dissertation proposal and presentation	External expert, HoD and senior-most faculty of the department	50	Dissertation report (30), presentation (10), final viva-voce (10)

Marks for internship shall be given by the supervisor, HoD and senior-most faculty of the department.

Some Guidelines for Internal Assessment

1. The components/pattern of internal assessment/evaluation should be made clear to students during the semester.

2. The results of the internal assessment must be shown to the students.

3. The question papers and answers of internal assessment should be discussed in the class.

4. The internal assessment shall be transparent and student-friendly and free from personal bias or influence.