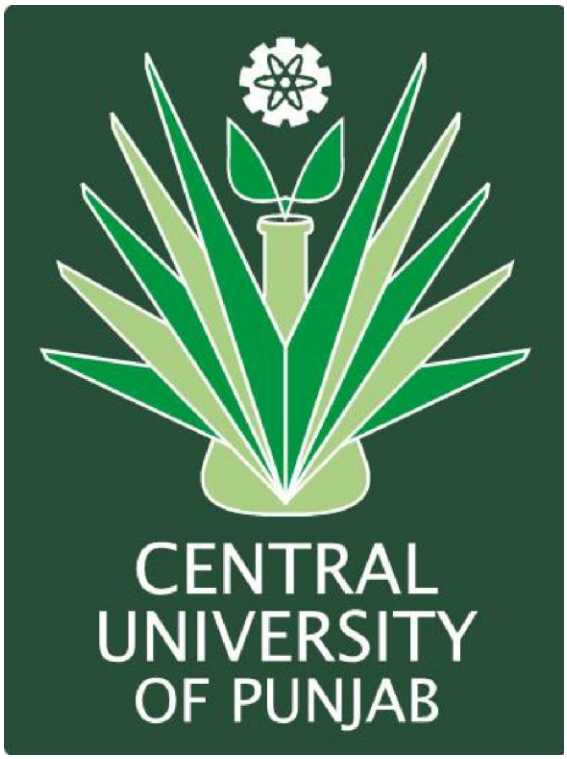
Central University of Punjab



M.Sc. Program in Biochemistry

Session - 2021-23

Department of Biochemistry

School of Basic Sciences

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 have higher order 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

Semester – I

Course Code	Course Title	Course Type	Contact Hours			Credit Hours
			L	T	P	Total
BCH.506	Bioanalytical Techniques	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
Discipline Elective courses (select one)						
BCH.511	Genetics	DE	3	0	0	3
BCH.512	Animal Cell Culture Technology	DE	3	0	0	3
BOT.554	Evolutionary Biology	DE	3	0	0	3
ZOL.525	Nanobiology	DE	2	1	0	3
Interdisciplinary course offered for the other departments						
BCH.513	Basics of Biochemistry	IDC	2	0	0	2
BCH.514	Principles of Biotechnology	IDC	2	0	0	2
XXX	Choose from IDC courses offered by other Departments	IDC	2	0	0	2

	Total Credits	**20**

Semester – II

Course Code	**Course Title**	**Course Type**	**ContactHours**			**Credit Hours**
			L		**P**	**Total**
BCH.521	Immunology	Core	3	0	0	3
BCH.522	Enzymology	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
BCH.526	Entrepreneurship	Compulsory Foundation	1	0	0	1
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
ZOL.552	Cancer Biology	DE	2	1	0	3
MIC.524	Environmental Microbiology	DE	3	0	0	3
MIC.525	Microbial Pathogenicity	DE	3	0	0	3
MME.528	Molecular and Cellular Oncology	DE	3	0	0	3
MME.525	Stem Cell and Regenerative Medicine	DE	3	0	0	3

XXX	Value Added Course (From other Departments)	VAC	2		0	2
BCH.503	Forensic and Molecular Diagnostics	VAC	2		0	2
				Total Credits		**22**

Semester – III

Course Code	Course Title	Course Type	Contact Hours			Credit Hours
			L	T	P	Total
BCH.551	Biostatistics	Compulsory Foundation	3	0	0	3
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
	Discipline Elective courses (Select only one)					
BCH.556	Human Physiology	DE	3	0	0	3
BCH.557	Clinical Diagnostics	DE	3	0	0	3
MIC.557	Pharmaceutical Microbiology	DE	3	0	0	3
BOT.555	Molecular Stress Physiology	DE	3	0	0	3
BCH.558	Recent Advances in Life Sciences	DEC	2	0	0	2
BCH.600	Research proposal	Skill Based	0	0	8	4
					Total Credits	**24**

Semester – IV

Course	Course Title	Course Type	Contact Hours	Credit Hours

Code			**L**	**T**	**P**	**Total**
BCH.600	Dissertation	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

A. Continuous Assessment (Course-wise): [25 Marks]
Two or more of the given methods (Surprise Tests, in-depth interview, unstructured interview, Jigsaw method, Think-Pair Share, Students Teams Achievement Division (STAD), Rubrics, portfolios, case based evaluation, video based evaluation, Kahoot, Padlet, Directed paraphrasing, Approximate analogies, one sentence summary, Pro and con grid, student generated questions, case analysis, simulated problem solving, media assisted evaluation, Application cards, Minute paper, open book techniques, classroom assignments, homework assignments, term paper).

B. Mid Semester Test: Based on Subjective Type Test [25 Marks]

C. End-Term Exam: Based on Objective Type Tests [50 Marks]: 70% subjective type and 30% objective type.

The objective type will include one word answers, fill-in the blank, sentence completion, true/false, MCQs', and matching, analogies. The subjective type will include a very short answer (1-2 lines), short answer (one paragraph), essay type with restricted response, and essay type with extended response.

Core, Discipline Elective, Compulsory Foundation, Value Added and Interdisciplinary Courses			Discipline Enrichment Course		Entrepreneurship Course	
	Marks	Evaluation	Marks	Evaluation	Marks	Evaluation

Internal Assessment	25	Various	-	-	-	-
Mid-semester test (MST)	25	Subjective	50	Objective	25	Objective
End-semester test (EST)	50	Subjective (70%) Objective (30%)	50	Objective	25	Subjective

SEMESTER – I

L	T	P	Cr
3	0	0	3

Course Code: BCH.506
Course Title: Bioanalytical Techniques
Total Hours: 45

Learning outcomes: Students will be able to

- Demonstrate the utility of bioanalytical techniques.
- Apply the knowledge gained in this course to understand advanced concepts of biochemistry.
- Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to bioanalytical techniques.

Unit I **12 Hours**

Spectrophotometry, Centrifugation and Biophysical Techniques: Visible and UV Spectroscopy and its applications; Beer-Lambert's law, extinction coefficient and its importance, 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.

Seminars on application of the techniques in bioscience research.

Unit 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.

Group discussion on the importance of gel electrophoresis and chromatography in biochemistry lab.

Unit III **12 Hours**

Microscopy: Principles and applications of Light, Phase-contrast and Electron-Microscopy, Scanning electron microscope, Transmission electron microscope and Immune electron microscopy.

Radioisotopic Tracer Techniques: Detection and measurement of isotopes, Geiger–Müller, Scintillation Counter, Autoradiography, Fluorography, Applications in biology.

Student seminars on application of the techniques in research and life.

Unit 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.

Peer group discussion on use of the immune-techniques in research and health care.

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

Modes of transaction

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

-Team learning

Tools used

PPT, You tube Video, Google meet, NPTEL

L	T	P	Cr
3	0	0	3

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

Learning outcomes: Students will be able to

- Demonstrate the concept of structure and basic components of prokaryotic and eukaryotic cells, especially organelles and their related functions.
- Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to cellular structure and function.
- Describe and correlate the various cellular processes critical for cell growth and development, and function.

Unit 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. Structure and function of nucleus, Ribosomes, lysosomes, peroxisomes, Golgi apparatus, endoplasmic reticulum, mitochondria and chloroplast. *Assignment on diseases of different organelles.*

Unit 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.
Peer discussion on techniques of cell cycle determination and representation of cell cycle data.

Unit 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, Noncollagen component of the extracellular matrix.
Exercises on the role of extracellular matrix in different cancers.

Unit 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.
Student seminars.

Suggested Readings:

1. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2014). *Molecular Biology of the Cell*. 6th Edition. Garland Science publishers.
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*. VIII Edition (South Asian Edition). Lippincott Williams and Wilkins, Philadelphia.
4. Lodish H, Berk A, Kaiser CA, Krieger A, *et al.* (2016). *Molecular Cell Biology*, 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

- Demonstrate the concepts of biomolecules and bioenergetics, various components of cells which are essential for energy generation and their biosynthesis.
- Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to biomolecules and energetics of biochemical processes.
- Describe and correlate biomolecules and bioenergetics

Unit I **10 Hours**

Carbohydrate: Classification, structure, stereochemistry, chemical properties epimerization, anomerization and mutarotation and reaction of carbohydrates, 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, lipoproteins, proteolipids, phosphatidopeptides, lipopolysaccharides.

Peer discussion on the existence of these biomolecules in different organisms.

Unit 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, ionization of amino acids and proteins, measurement of pH. Classification and properties of proteins, sequencing of proteins Primary (peptide conformation, N- and C- terminal, peptide cleavage), Secondary (α-helix, sheet, random coil, Ramachandran plot), Tertiary and Quaternary structures of proteins. Thermodynamics of Protein folding, coagulation and denaturation of proteins.

Presentations on buffers and proteins properties and its constituents.

Unit 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.

In depth discussion on the role of DNA modification and its effects.

Unit 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 between standard reduction potentials & free energy change. High energy phosphate compounds – introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates along with reasons for high ΔG.
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, You tube Video, Google meet, NPTEL

L	T	P	Cr
3	0	0	3

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

Learning outcomes: Students will be able to

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

Unit 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.

Evaluation of research proposals.

Unit 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.

Assignment on cell culture based discoveries.

Unit III **10 Hours**

Biosafety and Bioethics: Good Laboratory Practices, Sterilization techniques, Biosafety for human health and environment. Biosafety issues for using cloned genes. Bioterrorism, Social and ethical implication of biological weapons. Genetic pollution, Risk and safety assessment of genetically engineered organisms. Ethical theories, Ethical considerations during research, Ethical issues related to animal testing and human subjects.

Discussion on bioethics in a fictional situation.

Unit 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.

Dummy filing of a patent application.

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. Kothari, C.R. (2008). *Research Methodology (s).* New Age International (p) Limited. New Delhi.
4. Fleming, D. O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.
5. Rockman, H. B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.
6. Shannon, T. A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.
7. Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases.* Oxford University Press, UK.
8. WHO (2019). *Laboratory Biosafety Manual*. 4th Edition. World Health Organization.

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, You tube 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

Learning outcomes: Students will be able to

- Perform experiments pertaining to biomolecules and bioanalytical techniques, and cell biology.
- Apply the scientific method to the processes of experimentation and hypothesis testing.

Part A. Biomolecules and bioanalytical techniques

1. Introduction to Biochemistry Laboratory
2. Instrumentation of spectrophotometry, chromatographic techniques.
3. Preparation of solutions, buffers, pH setting etc.
4. Preparation of Chromic acid for glassware cleaning.
5. Colour reactions for amino acids
6. Osazone formation test.
7. Qualitative tests for pentose, and hexoses
8. Qualitative tests for ribose sugars.
9. Preparation of calibration curves.
10. Quantitative estimation of total lipids.
11. Isolation of protein from biological sample
12. Quantitative estimation of phenolic compounds.
13. Determination of protein by Biuret and Lowry's method.
14. Determination of protein by Bradford method.
15. Quantitative estimation of glucose by glucose oxidase method
16. Estimation of fructose and glucose in honey
17. Isolation of casein from milk and its quantification
18. Isolation of gluten and gliadin from wheat.

Part B. Cell Biology

1. Training with a light microscope: 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. Quantification and viability assays: cell counts and viability
4. To study structure of cell organelles through electron micrographs
5. Isolation and functional organelles specific assays: Mitochondria, nuclear/cytoplasmic cellular fractions
6. Depicting nature of biological membranes: Osmosis, Hypertonicity, Hypotonicity, Isotonicity

7. Cell division and cell cycle: Growth curve of eukaryotic cells using haemocytometer, mitosis and cytokinesis with demonstration of different stages of cell cycle in onion root-tip cells
8. Use of cell specific surface markers to discriminate between different cells. Differentiating T and B lymphocytes by FACS and Immunofluorescence microscopy

Modes of transaction

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

Tools used

PPT, You tube 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

- Demonstrate the principles of inheritance at the molecular, cellular and organismal levels.
- Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to concepts genetics.
- Describe and correlate hereditary information and their application to real life situations.

Unit 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.

Extra-Chromosomal Inheritance: Chloroplast and Mitochondrial inheritance; Cytoplasmic inheritance (Coiling in Snails).

Apply Punnett squares to solve problems in Genetics.

Unit II **12 Hours**

Gene Mapping Methods: 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.

Human Genetics: Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders.

Quantitative Genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.

Flipped classroom for understanding concepts in genetic mapping.

Unit III **10 Hours**

Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal vs somatic mutants, insertional mutagenesis, applications in reverse and forward Genetics; Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications; Hardy Weinberg equilibrium. Molecular basis of spontaneous and induced mutations.

Problem solving using Hardy Weinberg law.

Unit IV **10 Hours**

Microbial Genetics: Microbes as tools for genetic studies. Organization of genetic material in bacteria; and viruses, Gene transfer mechanisms, F plasmid; Lambda phage: structure, genetic makeup and life cycle (lytic and lysogeny); Natural transformation and competence; Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Bacterial Conjugation- Properties of the F plasmid, F+ x F - mating, F' x F- conjugation. Transduction- Generalized and specialized transduction, virus life cycle and replication.

Visualization of animations assembled by student teams.

Suggested Readings:

1. Snusted, 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. Snyder L, Peters JE, Henkin TM, Champness W. (2013) *Molecular Genetics of Bacteria*, 4th edition; ASM Press.
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
- https://projects.ncsu.edu/cals/course/gn411/net-resources.html

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

- Understand the basic requirement for animal cell culture
- Correlate and apply the concepts to initiate animal cell culture experiments in the research and life science industry.

Unit I **15 Hours**

Introduction to animal cell cultivation: Basics terms and definitions, historical background, Importance of animal cell culture technology, laboratory 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. Flow diagram of the basic requirements for a cell culture facility.

Unit 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. Available cell line banks and cell culture databases.

Unit 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. Mindmap of the cell assays and nature of information derived from *in vitro* grown cell cultures.

Unit 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 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.
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

Course Code: BCH.513

L	T	P	Cr
2	0	0	2

Course Title: Basics of Biochemistry
Total Hours: 30

Learning outcomes: Students will be able to

- Demonstrate a basic understanding of biomolecules, their structure, composition and function.
- Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to basic biochemistry.

Unit 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.

Correlate daily consumed/used items with biomolecules.

Unit II **8 Hours**

Catabolic and anabolic reactions, Energy rich phosphate compound, Glycolysis, Kreb's Cycle, electron transport chain, Glycogenesis, Glycogenolysis.

Correlate daily consumed items with metabolism.

Unit III **8 Hours**

Photosynthesis and pigment system, Calvin-C3 cycle, ammonia assimilation, urea cycle, Nitrogen fixation and nitrate uptake.

Discussion on how light is essential for plant and animal life.

Unit 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. *Discussion on the important applications of enzymes in industry.*

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, You tube 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

➢ Demonstrate a basic understanding of biotechnology.

- ➢ Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to basic biotechnology and its applications.

Unit 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.

Flow diagram of different steps involved in recombinant DNA cloning experiment with tools and techniques required to perform the experiment.

Unit II **8 Hours**

Manipulating cells and organisms: Exploitation of microorganisms, animals cells, and plant system. Manipulating microorganisms, Animal cell lines, Organ culture, Plant tissue culture, protoplast culture, protoplast fusion.

Discussion on most commonly used model organisms for genetic manipulation.

Unit III **8 Hours**

Applications and prospects of Biotechnology: Microbial system, Plant system and Animals. Fermentation technology – production of alcohols, antibiotics, steroids and enzymes, industrially 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.

Term paper based discussion and brain-storming sessions.

Unit 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.

Term paper based discussion and brain-storming sessions.

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 II

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

- Demonstrate the basic concepts related to the Immune System.
- Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to immunological concepts in health and diseases.
- Understand and correlate immunology with its clinical implications

Unit 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. *A diagrammatic representation with origin, percentages and absolute number of different immune cells in the body.*

Unit 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.
Group discussion on salient structural and functional features of antibodies exploited in varied antibody based applications.

Unit 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 (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.
Video demonstration of an effector T cell in real time.

Unit 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, Congenital Immunodeficiencies and related disease, Acquired immunodeficiencies and related disease.
Term paper based discussion and team learning.

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. Charles, A. and Janeway, J.R. (2006). *Immunobiology: The immune system in health and disease.* 6th 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, Video, Google

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

- Develop basic understanding of enzymes catalysis, their classification, structure, function and interaction with ligands.
- Develop a deeper understanding of data analysis in both written and oral forums related to enzyme kinetics.
- Demonstrate an understanding of enzyme inhibition and the basis of drug design.
- Describe and correlate knowledge of enzymes in research, diagnostics and industrial biotransformation processes.

Unit I **12 Hours**

Systemic classification and nomenclature of enzymes, Enzyme kinetics: Factors affecting rates of enzyme catalyzed reactions, unisubstrate 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, Cooperativity phenomenon, Hill plots. Classification and kinetics of multisubstrate reactions, methods used to differentiate multisubstrate reaction mechanisms.

Classroom presentation on enzyme kinetics and developing problem solving skills.

Unit II **13 Hours**

Enzyme catalysis: enzyme specificity and the concept of active site, determination of active site. Stereospecificity of enzymes. 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, Inhibitor constants. Theories on mechanism of catalysis.

Discussion on analysis of enzymes that exist in yeast and its applications in drug design.

Unit 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.

Group discussion on coenzyme and mechanism of enzyme action.

Unit 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. Immobilised enzymes and their industrial applications.

Assignment on the application of enzymes in industry in real life.

Suggested Readings:

1. Yon-Kahn, J and Herve, G. (2010) *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. (2001) *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry.* Fifth 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, You tube Video, Google meet, NPTEL

L	T	P	Cr
3	0	0	3

Course Code: BCH.523
Course Title: Metabolism

Learning outcomes: Students will be able to

- Demonstrate an understanding of metabolism of carbohydrates, lipids, amino acids and nucleic acids.
- Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to the course content.

Unit 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.
Classroom discussion on carbohydrate metabolism.

Unit 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.
Assignment and term papers based discussion.

Unit 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. *Classroom discussion on amino acid metabolism.*

Unit 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.

Assignment and term papers based discussion.

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

- Demonstrate the molecular processes in a cell and how they are related to biochemical processes in microbes and higher organisms.
- Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to molecular biology.

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

Unit I **10 Hours**

Genome organization: Chromosome Structure, Chromatin and its regulation, nucleosome and its assembly, repetitive DNA.

Molecular Techniques: Restriction enzymes, Cloning vectors (Plasmids and BACs), Transformation and Selection, genomic and cDNA library construction, cloning, Southern, Northern, Western, hybridization, DNA fingerprinting, PCR, real-time PCR, DNA sequencing including NGS, microarrays, chromatin immunoprecipitation, metabolomics, proteomics, biological databases and searches, analysis of genomic and proteomic data, DNA-protein interactions, protein-protein interactions, protein sequencing, emerging techniques.

Team presentations demonstrating the applications of molecular techniques to real life issues.

Unit II **14 Hours**

DNA Replication and Repair: Prokaryotic and eukaryotic DNA replication, Mechanism of DNA replication, Enzymes and accessory proteins involved in DNA replication, Replication errors, DNA damage and repair, gene editing.

Recombination: Site-specific, homologous, DNA transposition, retrotransposition and non-homologous end joining (NHEJ).

Transcription and mRNA Processing: Types of RNA, Prokaryotic & eukaryotic transcription, general and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, Transcriptional and posttranscriptional gene silencing: Initiation, Elongation & Termination of transcription, Capping, Polyadenylation, Splicing, editing, mRNA stability, RNA interference and microarray analysis, RNA editing.

Group discussion on applications in agriculture and human health.

Unit III **10 Hours**

Translation: Genetic code, prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co-and post- translational modifications, mode of action of antibiotics.

Quiz based on animations.

Unit IV **11 Hours**

Gene Regulation: Prokaryotic – lac, trp, gal and ara operons, lambda gene regulation during lysogeny and lytic cycle; Eukaryotic – yeast, higher eukaryotes, hormonal regulation of genes, epigenetic regulation; Gene network analysis, coexpression.

Student-driven analysis of recent trends.

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. (2020). *Molecular Biology: Principles of Genome Function.* 3rd Edition, Oxford University Press.
4. Green, M.R., Sambrook, J. (2013). *Molecular cloning: A laboratory manual.* 4th Edition. Cold Spring Harbor Laboratory Press, New York.
5. 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
- https://projects.ncsu.edu/cals/course/gn411/net-resources.html

Modes of transaction

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

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

Learning outcome: Students will be able to

- Perform experiments pertaining to enzymology, immunology and molecular biology.
- Apply the scientific method to the processes of experimentation and hypothesis testing.

Part 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

2. Acid phosphatase activity in plant tissue
3. Enzyme inhibition assays

Part B. Immunology

1. To perform total leukocyte count of the given blood sample.
2. To perform differential leukocyte count of the given blood sample.
3. Double immunodiffusion test using specific antibody and antigen.
4. To perform immunoelectrophoresis using specific antibodies and antigen.
5. Dot immunoblot assay (DIBA).
6. ELISA
7. Isolation of mononuclear cells from peripheral blood and viability test by dye exclusion method.
8. Immunohistochemistry: H & E staining, Fluorescent staining, Fluorescent Microscopy, Confocal Microscopy

Part C. Molecular Biology

1. Estimation of Ribonucleic acid and Deoxyribonucleic acid. Isolation of genomic DNA
2. Cloning: RE digestion of vector and insert, Ligation and *E. coli* transformation, plating, and colony screening
3. Isolation of plasmid DNA, restriction enzyme digestion and agarose gel Electrophoresis
4. DNA amplification by Polymerase Chain Reaction (PCR) and agarose gel electrophoresis
5. RNA isolation from biological samples; cDNA synthesis and real time PCR (qPCR).
6. NCBI BLAST search and Primer design.
7. Multiple Sequence Alignment and Phylogenetic analysis using MEGA
8. Protein-protein interactions using STRING; Introduction to KEGG and Metacyc databases

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
1	0	0	1

Course Title: Entrepreneurship

Course Code: BCH.526

Total Hours: 15 Hours

Learning Outcomes: Students will be able to:

- ➢ Understand the basic concepts of entrepreneur, entrepreneurship and its importance.
- ➢ Comprehend the opportunities, challenges and strategies required in entrepreneurship.
- ➢ Develop capabilities of preparing proposals for starting small businesses.
- ➢ Bring innovative ideas and innovative services to the market and develop patents.

Unit I **3 Hours**

Introduction to Entrepreneur and Entrepreneurship: Characteristics of an entrepreneur; Characteristics of entrepreneurship; entrepreneurial traits and skills; innovation and entrepreneurship; Types of entrepreneurial ventures; enterprise and society in Indian context; Importance of women entrepreneurship. *Concept built with real examples.*

Unit II **4Hours**

Ventures and Start-Ups: Why to start a small business; 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, Establishing the venture

- building a preliminary project report, format for a detailed/final project report. *Project report preparation as a group activity.*

Unit 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, Knowledge centers and Technology transfer agencies. Understanding regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP). 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.
Mind map for laboratory to market transition.

Unit IV **4 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. Develop science-based ideas to business development within segments such as health & disease, agricultural, environmental and/or industrial value addition.
Case studies and discussion sessions with successful science-based entrepreneurs.

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.527
Course Title: Developmental Biology
Total Hours: 45

Learning outcomes:

- Understand the concept of cell growth, cell cycle and cell division
- Understand the principles of development processes as observed in human beings

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

Unit 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.

Assignment on diseases resulting from developmental disorders.

Unit 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.

Debate on ethical issues on experimentation of human embryos for research.

Unit III **12 Hours**

Morphogenesis and organogenesis in animals: Model organisms in developmental biology (*Drosophila, C. elegans, 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.

Student Seminar.

Unit 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.

Collect plant leaves at different stages of development.

Suggested Readings:

1. Barresi M.J.F and Gilbert, S.F. (2019). *Developmental Biology*. 12th Ed. Sinauer Associates, Inc. USA.
2. Slack, J.M.W. (2012). *Essential Developmental Biology*, 3rd Ed. Wiley-Blackwell, USA.
3. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, 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

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

L	T	P	Cr
3	0	0	3

Total Hours: 45

Learning outcomes:

- Demonstrate an understanding of principles of secondary metabolite synthesis in plants and microbes.
- Describe and correlate secondary metabolite synthesis in plants and microbes, and their role in species survival.
- Describe and correlate xenobiotic metabolism, and their role in health sciences.

Unit 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.
Discussion on real life examples of plant secondary metabolites.

Unit 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.

Discussion on real life examples of microbial secondary metabolites.

Unit III **10 Hours**

Metabolic Engineering: Concept and importance of metabolic engineering for secondary metabolite production, metabolite regulation of metabolic pathways, basic metabolic control analysis (MCA), metabolic fluxes and basic flux balance analysis (FBA).

Case study discussion sessions.

Unit 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.

Discussion on xenobiotics taking real life examples.

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.503
Course Title: Forensic and Molecular Diagnostics
Total Hours: 30

Learning Outcomes: Students will be able to

- Comprehend diverse methods in molecular diagnostics of human diseases and Forensic studies
- Understand and use the said approaches and techniques in related career paths

Unit I **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. Diagnosis – disease altered state, prognosis, Principles of validation of diagnostic assays, Validation and quality control of different molecular diagnostic methods.

Unit II **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 and polymorphism studies (SNP, RAPD, RFLP, VNTR, Mutation detection etc). Emphasis on interpretation of results and quality control.
Discussion on context dependent usage of different diagnostics tests available.
High-throughput Technologies in 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), Histopathology, Immunohistochemistry and Real-Time PCR. Microbiological Diagnosis and Hematology. Enzyme and hormone based diagnostic techniques.
Group discussion on disease specific application of different tools in real life scenario.

Unit III **7 Hours**

Forensic diagnostics: Study of various body fluids such as semen, sweat, blood, saliva and urine. Blood group determination, genetics of ABO and Rh blood group. Significance of toxicological findings in forensics. Principles of fingerprinting, Principle of DNA fingerprinting (mitochondrial DNA & STR analysis), fingerprinting and diagnostics, application of DNA profiling in forensics. Limitations of DNA profiling.
Case studies as assignments: paternity cases, child swapping, rape cases.

Unit 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. Neonatal and Prenatal disease diagnostics.
Case studies.

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

SEMESTER – III

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

- Apply statistics for biological data analysis.
- Describe and correlate experimental data using statistical tools.

Unit 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, 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.

Testing with experimental data.

Unit 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.

Peer discussion in teams and presentation.

Unit 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.

Web-based exercises.

Unit 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 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.

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.552

Course Name: Clinical Biochemistry

Total Hours: 45

Learning outcomes: Students will be able to

- ➢ Demonstrate the biological basis of clinical biochemistry and the components related to health.
- 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.
- 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 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.
Peer discussion in teams and presentation.

Unit 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.
Assignment and term paper based discussion.

Unit III **13 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.
Peer discussion in teams and presentation.

Unit 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.
Discussion on management of the other metabolic disorders.

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

L	T	P	Cr
3	0	0	3

Course Code: BCH.553

Course Title: Plant and Microbial Biochemistry

Total Hours: 45

Learning outcomes: Students will be able to

- Develop an understanding of basic concepts of light driven biochemical processes, nitrogen fixation and plant hormones
- Apply and effectively communicate scientific reasoning and data analysis related to plant and microbial biochemistry.
- Describe and correlate plant biochemistry with agriculture and related aspects.
- Correlate microbial biochemistry with industrially important metabolites production.

Unit 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 slack pathway, CAM plants and regulation of CAM pathway.

Assignment on the above topics.

Unit 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.

Classroom presentation and discussion on the topic

Unit III **13 Hours**

Microbial Growth, Nutrition and Physiology:, Microbial growth, 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.

Developing SOP to grow a particular microorganism of interest.

Unit 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. *Classroom discussion.*

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

- Demonstrate basic concepts of genetic engineering and its use in medicine, industry, and agriculture.
- Apply and effectively communicate aspects related to genetic engineering and its applications.
- Understand and correlate basic concepts of genetic engineering with its application.

Unit 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.
Inquiry training on usage and advantages/ disadvantages of different vector systems.

Unit 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. *Discussion on usage and advantages/ disadvantages of different host systems.*

Unit 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.
Group discussions.

Unit IV **11 Hours**

Genetic Manipulation and functional assessment: Functional genomics: Forward and reverse Genetics, Model organisms, Genetically modified plants and

animals, Creating Transgenics, Knockouts, Knockdowns, RNAi technology, CRISPR technology. Generation of Transient and stable cell lines.
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

Learning outcomes: Students will be able to

- Proficient in laboratory techniques pertaining to clinical and plant biochemistry.
- Apply the scientific method to the processes of experimentation and hypothesis testing.

Part 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

Part B. Plant Biochemistry

1. Leaf chlorophyll estimation using spectrophotometer
2. Extraction and estimation of proteins, RNA and DNA from plant material
3. Design and construction of Plant binary vector
4. Transformation of plant using *Agrobacterium tumefaciens* EHA105
5. Estimation of plant antioxidants (phenolics, flavonoids etc.)
6. Antioxidant enzyme (SOD, Cat, GPx etc.) activity in plants

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
3	0	0	3

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

Learning outcomes: Students will be able to

- Demonstrate the function and regulation of physiological systems.
- Describe and correlate physiological systems and biochemistry.

Unit I **12 Hours**

Cardiovascular System: Haemopoiesis, haemoglobin Blood Coagulation-mechanism and regulation blood pressure and its regulation.

Respiratory System: Transport and exchange of CO_2 and O_2, role of 2,3-diphosphoglycerate, Bohr effect and chloride shift.

Self learning and classroom discussion.

Unit 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.

Assignment and term paper based discussion.

Unit III **11 Hours**

Excretory System: Structure of nephron, glomerular filtration, tubular reabsorption and secretion, Homeostatic regulation of water and electrolytes acid-base balance.

Self learning and classroom discussion.

Unit 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.

Group discussion.

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

- ➢ Comprehend diverse methods in clinical diagnosis of human diseases.
- ➢ Apply these techniques in various fields of biological research.

Unit 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 and quality control of polymerase chain reaction methods used for the diagnosis of infectious diseases.
Classroom discussion on sample type and applicable diagnostic assays with appropriate controls.

Unit 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.
Drawing out the similarities and dissimilarities along with advantages and disadvantages with reference to different diagnostic assays as part of group learning.

Unit 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 etc).
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, Immunohistochemistry and Real-Time PCR. Microbiological Diagnosis and Hematology. Enzyme and hormone based diagnostic techniques.
Group discussion of context specific use of different diagnostic assays.

Unit 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.
Case studies to be taken up by students covering different diseases as assignments.

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.558
Course Title: Recent Advances in Life Sciences (DEC)
Total Hours: 30

Learning outcomes: Students will be able to

- Demonstrate an understanding of study content related to courses such as cell biology, genetics, biochemistry, microbiology molecular biology, immunology, physiology, and developmental biology for the national level tests conducted by UGC, CSIR and other agencies in India.
- Apply analytical ability and critical thinking skills to solve questions in national level competitive examinations.

Unit I **8 Hours**

Biochemistry and Cell Biology: Revision and discussion of content related to Biochemistry and Cell Biology. Solve questions related to Biochemistry and Cell Biology based on exams of previous years employing critical thinking and analytical abilities.

Unit II **8 Hours**

Genetics and Molecular Biology: Revision and discussion of content related to Genetics and Molecular Biology. Solve questions related to Genetics and Molecular Biology based on exams of previous years employing critical thinking and analytical abilities.

Unit III **7 Hours**

Developmental Biology and Physiology: Revision and discussion of content related to Developmental Biology and Physiology. Solve questions related to Developmental Biology and Physiology based on exams of previous years employing critical thinking and analytical abilities.

Unit IV **7 Hours**

Immunology and Microbiology: Revision and discussion of content related to Immunology and Microbiology. Solve questions related to Immunology and Microbiology based on exams of previous years employing critical thinking and analytical abilities.

Suggested Readings:

1. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2014). *Molecular Biology of the Cell*. 6th Edition. Garland Science Publishers.
2. Karp, G., Iwasa, J., Marshall, W. (2020). *Karp's Cell and Molecular Biology*. 8th Edition. John Wiley & Sons.
3. Berg, J.M., Stryer, L., Tymoczko, J., Gatto, G. (2019). Biochemistry. WH Freeman. 9th ed.
4. Nelson DL, Cox MM and A. Hoskins (2021). Lehninger's Principles of Biochemistry, 8th ed. WH Freeman.
5. Wilson, K., Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology. 8th Edition, Andreas Hofmann and Samuel Clokie,Cambridge University Press.
6. 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.
7. Snusted, D.P., Simmons, M. J. (2015). *Principles of Genetics*. 7th Edition, John Wiley & Sons, New York.
8. Guyton. (2007). *Textbook of medical physiology*. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
9. Barresi M.J.F and Gilbert, S.F. (2019). *Developmental Biology*. 12th Ed. Sinauer Associates, Inc. USA.
10. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th Edition. McGraw Hill Higher Education, USA. 2019.
11. Charles, A. and Janeway, J.R. (2006). *Immunobiology: The immune system in health and disease.* 6th Edition. Garland Science.

12. Punt, J., Stranford, S., Jones, P., and Owen, J.A. (2018). *Kuby Immunology* 8th Edition. W.H. Freeman, USA.
13. Kumar P and Singh Satyendra (2013). MCQs Life Sciences - Biotechnology 5th Edition.

Web resources:

- www.csirhrdg.res.in

L	T	P	Cr
0	0	8	4

Course Code: BCH.600
Course Title: Research proposal
Total Hours: 120

Learning outcomes:

- Critically analyze, interpret, synthesize existing scientific knowledge based on literature review
- Demonstrate an understanding of the selected scientific problem and identify the knowledge gap
- 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.600
Course Title: Dissertation
Total Hours: 600

Learning outcomes:

- Demonstrate an in-depth knowledge of scientific research pertaining to the area of study
- Demonstrate experimental/theoretical research capabilities based on rigorous hands-on training
- Critically analyze, interpret and present the data in light of existing scientific knowledge to arrive at specific conclusions
- 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.

Evaluation Criteria:
The evaluation of dissertation in the fourth semester will be as follows: 50% weightage for continuous evaluation by the supervisor which includes 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 will be based on report of dissertation (30%), presentation (10%), and final viva-voce (10%). The final viva-voce will be through offline or online mode.

Dissertation (Fourth Semester)		
	Marks	Evaluation
Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce

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