



PONDICHERRY UNIVERSITY

SCHOOL OF LIFE SCIENCES
DEPARTMENT OF BIOCHEMISTRY
& MOLECULAR BIOLOGY



CURRICULUM & SYLLABUS
of
M.Sc. PROGRAMME
in
BIOCHEMISTRY & MOLECULAR BIOLOGY

2025-2026 Onwards

PONDICHERRY UNIVERSITY
SCHOOL OF LIFE SCIENCES
DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY
MASTER OF SCIENCE
IN
BIOCHEMISTRY AND MOLECULAR BIOLOGY

About the Department

The Department of Biochemistry & Molecular Biology was started as Department of Biological Sciences under School of Life Sciences in 1987 and had been offering M.Sc., M.Phil. and Ph.D. degrees in Life Sciences. In 2004, the Department was renamed as Department of Biochemistry & Molecular Biology. Since then, this Department has been offering M.Sc. and Ph.D. courses in Biochemistry and Molecular Biology.

The Department offers a congenial environment for knowledge development, research training and for individual growth. The Department has an excellent complement of teaching by the faculty who are involved in basic and applied research in different areas of Biochemistry and Molecular Biology.

Vision:

“To be a globally recognized center of excellence in higher education and research, empowering future generations of scientists and scholars to unravel the intricacies of science and drive transformative solutions for the betterment of humanity. Through state-of-the-art infrastructure, cutting-edge technology-assisted education, and interdisciplinary collaborations, we aim to expand the horizons of knowledge in various spheres of life. Our vision is to serve as a catalyst for societal transformation, addressing ever-changing needs of society and industries, while upholding the highest ethical standards in teaching, research, and administration.”

Mission:

The Department of Biochemistry & Molecular Biology at Pondicherry University is dedicated to advancing knowledge, innovation, and discovery in the fields of Biochemistry and Molecular Biology.

Our mission is threefold:

Academic Excellence: We strive to provide exceptional education and training, equipping students with a comprehensive understanding of fundamental principles and cutting-edge techniques in Biochemistry and Molecular Biology. By fostering critical thinking, problem-solving skills, and a passion for scientific exploration, we aim to nurture the next generation of brilliant minds who will push the boundaries of scientific research.

Ground breaking Research: We are committed to conducting pioneering research in Biochemistry and Molecular biology, addressing fundamental questions about the molecular mechanisms underlying life processes and diseases. Through interdisciplinary collaborations, state-of-the-art facilities, and a supportive research environment, we endeavour to make ground breaking discoveries that impact global health, environment, Biotechnology, and beyond.

Societal Impact: We recognize the crucial role of science in addressing societal challenges. Our department seeks to translate scientific knowledge into practical applications that improve human health, environmental sustainability, and overall well-being. By actively engaging with industry, government agencies, and the public, we aim to contribute to evidence-based policymaking and foster a deeper understanding of the significance of Biochemistry and Molecular Biology in our everyday lives.

Core Values:

Excellence: Striving for the highest standards of academic and research achievements, continuously seeking improvement and innovation.

Integrity: Upholding honesty, transparency, and ethical principles in all aspects of our work and interactions.

Collaboration: Fostering a culture of teamwork, cooperation, and interdisciplinary collaboration to maximize the impact of our research and education efforts.

Inclusivity: Embracing diversity in all forms and creating a welcoming, supportive environment for students, faculty, staff, and the broader community.

Impact: Focusing on research and education with tangible and meaningful contributions to society, driving positive change for the betterment of humanity.

With this vision, mission, and core values, the Department of Biochemistry & Molecular Biology at Pondicherry University aims to be at the forefront of scientific progress, shaping the future of life sciences and making a lasting impact on the world.

About the Course

The Department of Biochemistry and Molecular Biology is committed to excellence in education, research and scientific innovation. The programme provides an integrated learning environment that combines fundamental principles of biochemistry and molecular biology with contemporary developments in life sciences. The curriculum is designed to provide students with a strong theoretical foundation, practical laboratory skills and research-oriented training required to understand biological processes at the molecular and cellular levels. Biochemistry and Molecular Biology are central disciplines for understanding the molecular basis of life, encompassing the structure and function of biomolecules, cellular organization, metabolic

regulation, genetic information and its expression, and molecular mechanisms underlying health and disease. The interdisciplinary nature of these fields connects biochemical and molecular principles with cell biology, genetics, genomics, immunology, proteomics, biotechnology and biomedical sciences. The rapid advancement of analytical technologies, genome-based approaches and molecular techniques has considerably expanded the scope of Biochemistry and Molecular Biology in modern biological research and biotechnology. The M.Sc. Biochemistry and Molecular Biology programme is structured to provide progressive learning from fundamental concepts to advanced and application-oriented areas. The first semester focuses on core foundations including Analytical Biochemistry and Biophysics, Biomolecules and Bioenergetics, Cell Biology, Enzymology and Molecular Biology, supported by practical laboratory courses that provide hands-on training in biochemical, cellular and molecular techniques. The second semester extends this foundation through Biostatistics and Scientific Writing, Genomics, Metabolism and Regulation, Molecular Endocrinology and Molecular Genetics, together with practical training in microbiology and metabolic studies. These courses develop students' abilities in biological data analysis, scientific communication, genome analysis, metabolic regulation and molecular genetics. The third semester emphasizes advanced areas including Genetic Engineering, Immunology and Proteomics, complemented by practical training in genetic engineering and immunological techniques. The programme further provides opportunities to explore specialized areas through soft-core courses such as Cancer Biology, Clinical Biochemistry, Stem Cell and Regenerative Biology, Clinical Research and Regulations, Developmental and Ageing Biology, Neurobiology, Industrial Convergence in Life Sciences, Nanobiotechnology, General Microbiology, Human Physiology and Plant Biochemistry and Biotechnology. A distinctive feature of the programme is its integration of theory, practical training, scientific communication, seminar presentation and dissertation-based research. Through this combination, students develop critical thinking, analytical and problem-solving abilities, independent research skills and competence in applying biochemical and molecular approaches to biological and biomedical questions. The programme ultimately prepares students for careers and further training in research, higher education, biotechnology, biomedical sciences and related interdisciplinary fields.

Courses

1. The courses offered under MSc Biochemistry and Molecular Biology are designated as Hard Core and Soft-Core courses.
2. A course designated as Hard-Core course must invariably be completed by students to receive the degree.
3. In addition to Hard Core courses, students are required to earn a minimum number of credits from Soft Core courses to receive the degree.
4. Soft Core courses can be chosen from
 - (a) a list of Soft-Core courses offered in the Department
 - (b) any course offered by other Centre/Department/School under CBCS as Soft-Core course, with the advice of Faculty Advisor.
5. While choosing a Soft-Core course students should keep in mind that the chosen course will
 - (a) support the discipline of study
 - (b) provide an expanded scope
 - (c) enable an exposure to some other discipline/domain

(d) nurture the student's proficiency/skill.

6. Students may opt for approved online courses through the SWAYAM platform as Soft-Core Electives, subject to the prior approval of the Departmental Programme Committee.

Contact Hours

1. One credit shall mean one period of teaching for theory or two periods for laboratory /practical course per week in a semester having about 15 weeks of teaching.
2. One teaching period shall be for 60 minutes duration including 10 minutes for discussion/movement.
3. Field training course conducted by faculty members will carry one credit for every one week of such training.
4. Internship/Training for one month in an institution/ company/ organization approved by the Programme Committee will carry 2 credits.
5. One Tutorial hour per week may be conducted in addition to regular contact hours for both Hard core and soft-core theory Courses

Registration

1. Each student, on admission shall be assigned to a Faculty Advisor. With the advice and consent of the Faculty Advisor the student shall register for a set of courses in each Semester.
2. The student has to seek the consent of each teacher offering the courses for registration. No student shall be permitted to register for courses exceeding 30 credits per semester. However, registration for repeat courses is allowed in excess of this limit.
3. A student, to retain status, should register for at least 12 credits in a semester while registering within normal duration of 2-year PG Programmes.
4. Students shall have to register for the courses within first week of a semester. The maximum number of students to be registered in each course shall depend upon the physical facilities available.
5. Registration for Hard Core course offered by the Department is also open to students of other departments provided they meet the pre-requisites.
6. The information on list of courses offered by every Department/Centre shall be made available in the SAMARTH portal.
7. The Reference books for registration shall be given to the students of the department for whom the course is a Hard-core course.
8. The registration for Soft Core course shall be on first come first served basis, provided the student fulfils pre-requisites for that course, if any.
9. The number of students to be registered shall be based on the class room and laboratory capacity.
10. Every effort will be made by the Department to accommodate as many students as possible.
11. No soft-core course shall be offered unless a minimum of 5 students are registered.

12. After registration, the students shall be permitted to drop courses within the time limit prescribed in the Academic Calendar.

Teaching and Learning Methods

Lectures, tutorials and seminars form the main methods of course delivery. To support students with varying learning needs, remedial coaching is provided for slow learners to help them improve academically, while fast learners are motivated to explore research opportunities and engage in skill-based initiatives to enhance their knowledge and expertise.

Assessment Methods

Assessment will be through Choice Based Credit System (CBCS) through session by continuous assessment (class tests, open book test, quiz, discussion, assignments, seminars, laboratory works and project work and report) and end semester examinations. A thesis written for the project/dissertation will be evaluated by an expert followed by viva-voce.

All teaching, learning and evaluations will follow Choice Based Credit System (CBCS) as per the Pondicherry University guidelines.

Evaluation

Breakup of Internal/ External End Semester Exams:

All subjects in a PG programme carry

Internal Assessment Mark	End Semester Mark
40	60

Break up of Internal Assessment Marks

Each teacher shall organize a continuous assessment of each of the courses assigned to him/her. The internal assessment marks shall be given as per the following breakup: (Table 1)

Table 1: Breakup of Internal Assessment Marks

Break up of Internal Assessment	Marks Distribution
Internal Assessment Tests / Term Papers / Quizzes (two)	2 x 15 = 30
Seminars/ Assignments/ Case Demos/ Presentations/ Write ups/ Viva, etc.	1x 10 = 10
Internal Total	40

Internal Assessments

A schedule of Internal Assessment tests shall be prepared at the very beginning of the semester. Internal Assessment marks shall be displayed within a week from the date of conduct of examination and all corrected answer papers shall be given back to students with comments, if any. It is mandatory for all students to participate in all the Internal Assessment tests and in various course-work related activities for award of the above marks.

End-semester examinations

1. An End Semester examination shall be conducted for all courses offered in the department. The duration of the end semester examination shall be for 3 hours.
2. A schedule of End Semester examinations be prepared and displayed by the department at least one- month ahead of the conduct of the examination.
3. No student who has less than 70% attendance in any course shall be permitted to attend the end-semester examination and he/she shall be given FA grade– failure due to lack of attendance. He/she shall be required to repeat that course.
4. Each teacher shall prepare a model question paper, a Panel of External examiners and submit the same to the Head of the Department by 6th week of the Semester. The question paper should cover all the units of syllabus. Head of the Department shall coordinate the question paper setting.

The department shall display the provisional grades within 15 days. If a student wishes to look at the evaluated answer scripts, he/ she can approach the concerned teacher within a week of declaration of the provisional results.

Letter Grades

The performances of students in each paper are expressed in terms of marks as well as in Letter Grades. In case of fractions the marks shall be rounded off to nearest integer. The class interval for the purpose of awarding the grades can be arrived at by dividing the difference between the highest mark secured and the minimum pass mark by 6 as there are six passing grades. The formula is given below:

$$K = (X-50)/6$$

Where, K = class interval, X= the highest mark in the subject. The grades may be awarded as given in the Table 2.

Table 2:

Sl No.	Range of Marks in %	Letter Grade	Points for Calculation of SGPA
1	X to (X-K)+1	O	10
2	(X-K) to (X-2K)+1	A+	9
3	(X-2K) to (X-3K)+1	A	8

4	(X-3K) to (X-4K)+1	B+	7
5	(X-4K) to (X-5K)+1	B	6
6	(X-5K) to 50	C	5
7	Below 50	F	
8	Failure due to lack of attendance	FA	

K should not be rounded off to less than two decimal places. The numbers given in Range of Marks column, (X-K), (X-2K), (X-3K), etc., can be rounded off to the nearest whole number. In courses where the number of students who have secured 50 marks and above is less than 10 then grading may be given based on the Table 3.

Table 3:

Sl. No.	Range of Marks in %	Letter Grade	Points for Calculation of SGPA
1	81-100	O	10
2	71-80	A+	9
3	66-70	A	8
4	61-65	B+	7
5	56-60	B	6
6	50-55	C	5
7	Below 50	F	
8	Failure due to lack of attendance	FA	

Semester Grade Point Average (SGPA) will be calculated as weighted average of points secured by the student in all the papers registered by him /her. The weights are the number of credits for each paper. For example, if a student gets A grade in 4 credit course, B+ grade in a 2-credit course, A+ grade in a 3-credit course and F grade in a 3-credit course during a semester, S GPA will be calculated = $73/9 = 8.11$ out of 10.0; SGPA =8.11. Hence, the credits earned by the student in the semester will be 9, and SGPA will be 8.11. Cumulative Grade Point Average (CGPA) shall be calculated as weighted average of SGPA and credits earned by the student in consecutive semesters. Students with a CGPA of 9.0 and above and did not fail in any of the courses taken by him/ her shall be awarded Distinction. A CGPA of 6.0 and above shall be

placed in First class. Student who has secured less than 50% marks in any paper gets F Grade and he is treated as failed in that paper.

M.Sc. Biochemistry & Molecular Biology, School of Life Sciences

PROGRAMME OBJECTIVES

The M.Sc. programme in Biochemistry and Molecular Biology will:

- (1) Provide training and understanding of basic concepts as well as cutting edge advancement in the field of Biochemistry and Molecular Biology.
- (2) Impart practical skills through laboratory courses and understanding of modern scientific techniques.
- (3) Enhance analytical, statistical and validation skills through hands on training.
- (4) Expose students to various aspects of research through dissertation.
- (5) Introduce applications of Biochemistry and Molecular Biology in order to prepare highly trained and skilled workforce for teaching, research and entrepreneurship.

PROGRAMME OUTCOMES

By the end of the program students will:

- (1) have an in-depth understanding of the basic and recent developments in the field of Life Sciences.
- (2) acquire skills of critical, analytical and problem solving to enable them to be successful in various national and international examinations.
- (3) possess skills for independent thinking and in writing scientific proposal and presentations.
- (4) capable of becoming successful academicians/researchers and/or entrepreneurs.

PROGRAMME SPECIFIC OUTCOMES

- (1) To have profound knowledge and the insight in basic concepts and advancements in the field of Biochemistry and Molecular Biology and allied interdisciplinary areas.
- (2) To be able to use the knowledge, insight, and techniques and apply them in an integrated way to solve complex problems in the domain and allied interdisciplinary areas.
- (3) To be able to set up independent projects addressing knowledge gaps in the field of Biochemistry and Molecular Biology, based on well formulated hypothesis to the societal needs.

(4) To generate highly skilled human resources with global competence standards in the field of biochemistry and molecular biology to contribute in nation building thorough meeting the challenges of sustainable developmental goals.

PONDICHERRY UNIVERSITY
SCHOOL OF LIFE SCIENCES
DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY

SYLLABUS FOR M.Sc. BIOCHEMISTRY AND MOLECULAR BIOLOGY
2025-26 onwards

CODE	NAME OF THE COURSE	CREDIT	PAGE NO.
FIRST SEMESTER			
BCMB 430	ANALYTICAL BIOCHEMISTRY & BIOPHYSICS	3	1
BCMB 431	BIOMOLECULES & BIOENERGETICS	3	3
BCMB 432	CELL BIOLOGY	3	5
BCMB 433	ENZYMOLGY	3	7
BCMB 434	MOLECULAR BIOLOGY	3	9
BCMB 480	ANALYTICAL BIOCHEMISTRY & BIOPHYSICS LAB	1	11
BCMB 481	BIOMOLECULES LAB	1	12
BCMB 482	CELL BIOLOGY LAB	1	13
BCMB 483	ENZYMOLGY LAB	1	14
BCMB 484	MOLECULAR BIOLOGY LAB	1	15
	SOFT CORE / ONLINE COURSES*		
SECOND SEMESTER			
BCMB 435	BIOSTATISTICS AND SCIENTIFIC WRITING	3	17
BCMB 436	GENOMICS	3	19

BCMB 437	METABOLISM & REGULATION	3	21
BCMB 438	MOLECULAR ENDOCRINOLOGY	3	23
BCMB 439	MOLECULAR GENETICS	3	25
BCMB 485	GENERAL MICROBIOLOGY LAB	1	27
BCMB 486	METABOLISM & REGULATION LAB	1	28
	SOFT CORE / ONLINE COURSES*		

CODE	NAME OF THE COURSE	CREDIT	PAGE NO.
THIRD SEMESTER			
BCMB 536	GENETIC ENGINEERING	3	29
BCMB 537	IMMUNOLOGY	3	31
BCMB 538	PROTEOMICS	3	33
BCMB 560	GENETIC ENGINEERING LAB	1	35
BCMB 561	IMMUNOLOGY LAB	1	36
	SOFT CORE / ONLINE COURSES*		
FOURTH SEMESTER			
	SOFT CORE / ONLINE COURSES*		
<u>SOFT CORE COURSES</u>			
BCMB 441	GENERAL MICROBIOLOGY	3	37
BCMB 442	HUMAN PHYSIOLOGY	3	39

BCMB 443	PLANT BIOCHEMISTRY & BIOTECHNOLOGY	3	41
BCMB 541	CANCER BIOLOGY	3	43
BCMB 542	CLINICAL BIOCHEMISTRY	3	45
BCMB 543	STEM CELL & REGENERATIVE BIOLOGY	3	47
BCMB 544	CLINICAL RESEARCH AND REGULATIONS	3	49
BCMB 545	DEVELOPMENTAL & AGEING BIOLOGY	3	51
BCMB 546	NEUROBIOLOGY	3	53
BCMB 547	INDUSTRIAL CONVERGENCE IN LIFE SCIENCES	2	55
BCMB 548	NANOBIOTECHNOLOGY	3	58
BCMB 580	SEMINAR PRESENTATION	1	60
BCMB 581	DISSERTATION	4	61

**Online Courses recognized by UGC can be opted for with the approval of the Department.*

Total credit requirements: 72

BCMB 430 - ANALYTICAL BIOCHEMISTRY AND BIOPHYSICS

3 Credits

COURSE OBJECTIVES: *To understand the principles of physical sciences that form the basis of the techniques and instrumentation used in biological science*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Electrochemical techniques & Photometry **11h**

Basic principles of electrochemistry- pH electrode- ion-selective- gas- sensing and oxygen electrodes- Elementary details of Biosensors. Principles and techniques of colorimetry & spectrophotometry- Beer-Lambert's Law- instrumentation- hypo and hyperchromicity- Fluorimetry- Flow cytometry- atomic absorption spectrometry- Circular Dichroism- Optical rotatory Dispersion- Nuclear Magnetic Resonance Spectroscopy- Infrared Spectroscopy.

UNIT- II - Microscopy **8h**

Microscopy- Basic principles and applications- Light- Compound- Phase contrast- Dark Field- Fluorescence Microscopy Scanning Electron Microscopy- Transmission Electron Microscopy (TEM)- Scanning Tunnelling Microscopy (STM)- Confocal Microscopy.

UNIT- III – Centrifugation **8h**

Basic principles of Centrifugation- instrumentation, centrifugation units- Types of centrifuges- rotors, accessories- centrifugation methods- sedimentation velocity- sedimentation equilibrium- colloids- cell fractionation methods.

UNIT- IV – Chromatography **10h**

Types of chromatography- column, thin layer, paper, adsorption, partition, gas liquid ion exchange, affinity, High-Performance Liquid Chromatography -principles of each type- instrumentation and accessories- detection methods & systems- qualitative and quantitative aspects- applications.

UNIT- V –Electrophoresis **8h**

Types of Electrophoresis- paper and gel- agarose and PAGE- pulsed field- capillary- isoelectric focusing- blotting techniques: western, southern & northern. Applications.

Text Books

1. Wilson, K. and Walker, J. (2018) Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, Cambridge.
2. Freifelder, D.M. (1983) Physical Biochemistry- Application to Biochemistry and Molecular Biology, W.H. Freeman, New York.

3. David J. Holme and Hazel Peck. (1998)- Analytical Biochemistry, Pearson Education Ltd.
4. Mahin Basha. (2020)- Analytical Techniques in Biochemistry, Springer Protocols Handbooks.

Suggested Reading

1. Horst, F. (2010) Basic One and Two-dimensional NMR Spectroscopy, Wiley-VCH, New Jersey.
2. Murphy, D.B. and Davidson, M. W. (2012) Fundamentals of Light Microscopy and Electron Imaging, Wiley-Blackwell, New Jersey.

COURSE OUTCOME:

CO1: Students will understand the physical and chemical principles behind analytical techniques used in biological sciences.

CO2: Students will be able to explain and compare various modern instrumentation methods including microscopy, spectroscopy, and chromatography.

CO3: Students will demonstrate the ability to select and apply appropriate techniques such as centrifugation and electrophoresis for biological sample analysis.

CO4: Students will develop practical understanding of instrumentation applications in research, diagnostics, and biotechnology.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	+
CO2	+++	++	++	+
CO3	++	+++	++	+
CO4	++	++	+++	++

BMB 431 - BIOMOLECULES AND BIOENERGETICS**Credits 3**

COURSE OBJECTIVES: *To provide basic understanding of physical & chemical properties of macromolecules and principles of bioenergetics*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I– Biomolecules concepts and Bioenergetics**8h**

General concepts of biomolecules, bonding, and interactions. Bioenergetics: First and second laws of thermodynamics– entropy, enthalpy, standard free energy changes, standard reduction potentials, membrane potential. Mobile electron-carriers and role of electron transport chain in electron capture – Role of Fe-S clusters in proton gradient – ATP and high-energy phosphate compounds – Thermodynamics of coupled reaction. Energy terms and balance in intermediary metabolism (outline of glycolysis, tricarboxylic acid cycle, electron transport chain).

UNIT- II- Carbohydrates**8h**

Monosaccharides – stereochemistry, optical activity – Disaccharides – Oligosaccharides – N-linked, O-linked and GPI linked Oligosaccharides – Sugar derivatives. Homo- and heteropolysaccharides. Glycoproteins – Proteoglycans – Glycosaminoglycans – structures and biological functions. Blood group substances and Sialic acid. Sugar code - Lectins types and functions.

UNIT -III- Proteins and Amino acids**9h**

Amino acids classification and chemistry. Proteins– primary structure – secondary – tertiary – quaternary – super secondary structures. Sequence determination – Ramachandran plot – peptide synthesis (automated solid phase). Globular and fibrous proteins (triple helix collagen and haemoglobin structure). Protein folding and dynamics– Molecular chaperones – heat shock proteins. Protein denaturation (pH, temperature, chaotropic agents) – refolding.

UNIT-IV-Lipids**8h**

Lipids classification – structure and chemical properties – saturated and unsaturated fatty acids. Essential and non-essential fatty acids. Structure and functions of phospholipids – glycolipids – sphingolipids – lipid soluble vitamins. Lipoproteins types transport and functions. Biological functions of Terpenoids and carotenoids.

UNIT- V- Nucleic Acids**7h**

Nucleic acids types (A, B and Z forms) – Chemistry and structural organization –triple helix of DNA. Denaturation and renaturation of DNA – hyper and hypochromicity – T_m. Structure and functions of t-RNA – hnRNA – and non-coding regulatory RNAs (siRNA– miRNA, etc.).

Text Books

1. Nelson, D.L. and Cox, M.M. (2021) Lehninger's Principle of Biochemistry, W.H. Freeman, New York.
2. Voet, D. and Voet, J.G. (2011) Biochemistry. John Wiley and Sons Inc., New Jersey.

Suggested Reading

1. Garrett, R.H. and Grisham, C.M. (2016). Biochemistry, Cengage Learning, Mason. Ohio.
2. Berg, J.M., J, Jr.G.G., Hines, J.K., Tymoczko, J.L., Stryer, L (2023) Biochemistry (International Edition). New York, NY: W. H. Freeman and Co.
3. Harris, D.A. (1995) Bioenergetics at a glance. Willey J. and Sons Inc., New Jersey.

COURSE OUTCOME:

CO1: Students will able to understand the structural and functional properties of biomolecules, and apply the principles of thermodynamics and bioenergetics to biological systems.

CO2: Students will acquire knowledge to interpret structural and functional aspects of biomolecules at different levels.

CO3: Students will able to analyse the structure, classification and biological roles of carbohydrates proteins, lipids and nucleic acids.

CO4: Students will be skilled in different analytical techniques in understanding biomolecule to apply in diagnostics and biotechnology industry.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	+	+	+
CO2	+++	+	++	+
CO3	++	+	+++	++
CO4	+	+++	+++	+++

BCMB 432 - CELL BIOLOGY**3 Credits**

COURSE OBJECTIVES: *To understand structural and functional aspects of cells and basic mechanisms underlying cell signalling and cell division.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT-I - Cellular evolution and Bio-membrane**9h**

Assembly of macromolecules and origin of life, endosymbiotic theory, RNA world hypothesis - structural organization of prokaryotic and eukaryotic cells, Cell specialization- epithelia, connective tissue, nervous tissue, and muscle. **Bio-membranes** - Structural organization, models of plasma membrane, membrane permeability- transport across cell membranes.

UNIT-II – Cytoskeleton and cell signalling**9h**

The cytoskeleton - microtubules, microfilaments, and intermediate filaments. The extracellular matrix - collagen, integrin, elastin, fibrillin, fibronectin, laminin, and proteoglycans. Basics of cell signalling- transmembrane, cytosolic, and nuclear receptors, integrin, and tyrosine kinase signalling, GPCRs role of secondary messengers.

UNIT-III - Mitochondria and Ribosome**9h**

Molecular organization and function - components of respiratory chain- chemiosmotic theory- ATP formation- uncouplers of oxidative phosphorylation- mitochondrial DNA and semi autonomy; autophagy and necrosis. **Ribosomes**- biogenesis, structural organization, and functions.

UNIT-IV - Endomembrane system and Nucleus**9h**

Structure and function of endoplasmic reticulum and Golgi complex- post translational modifications, protein sorting, targeting and secretion; importance of proteasomes. Microbodies- peroxisomes, glyoxysomes, lysosomes, and their functions; Autophagy. **Nucleus** - internal organization- nuclear pore complex and transport- nucleosomes and chromatin organization

UNIT-V – Cell division and death**9h**

Stages of mitosis and meiosis- cohesins and condensins in chromosomes segregation, structure and functions of kinetochore, centrosomes and its functions, regulation of cell cycle- cyclin, CDKs, Control of the Cell Division: Molecular Regulation of the G2/M (Interphase/Mitosis) and G1/S Control Point. Modes of cell death - Apoptosis and Necrosis - mechanisms.

Text Books:

1. Alberts, B., Bray, D., Hopkin, K., Johnson, A.D., Morgan, D. Raff, M., Roberts, K., Walter, P. (2023) Essential Cell Biology, W. W. Norton and Company, San Francisco.
2. Raven, P.H., Johnson, G.B., Mason, K.A., Losos, J., Singer, S. (2016) Biology, McGraw Hill Education, St. Louis.
3. Mason, K.A., Losos, JB., Duncan T (2023) Biology, Thirteenth edition. McGraw Hill LLC, 1325 Avenue of the Americas, New York, NY 10019.

Suggested Reading:

1. Campbell, N.A. and Reece J.B. (2008) Biology, Pearson Benjamin Cummings, San Francisco.
2. Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Rebecca B. Orr, Neil A. Campbell. (2020) Campbell biology, Twelfth edition. New York, NY. Pearson.

COURSE OUTCOME:

CO1: Students will gain an understanding of cellular structure and communication mechanisms involved in signal transduction.

CO2: Students will be able to understand the structural organization of the cytoskeleton and extracellular matrix, and the basic mechanisms of cell signalling.

CO3: Students will develop an understanding of key organelles involved in cellular energy production, protein synthesis, and intracellular transport processes.

CO4: Students will understand the molecular mechanisms that govern cell division and cell death.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	+
CO2	+++	++	++	++
CO3	+++	++	++	++
CO4	+++	+++	++	++

BCMB 433 - ENZYMOLOGY**3 Credits**

COURSE OBJECTIVES: *To understand the principles of physical sciences in the techniques and instrumentation used in biological science*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Introduction to Enzymes**10h**

Historical perspective- Nomenclature and classification of enzymes – properties of enzymes, enzyme activity and units, specific activity, factors affecting enzyme activity - catalytic power and specificity, Hill's plot - Scatchard plot - Theories of specificity and catalysis - lock and key theory, induced fit model, transition state theory, strain theory of enzyme action. Enzyme kinetics- Michaelis-Menten equation- catalytic efficiency - analyses of kinetic data- Lineweaver-Burk plot- Eadie Hofstee, Hanes Woolf and Cornish Bowden plots - Haldane relationship.

UNIT- II – Bisubstrate reactions and enzyme inhibition**8h**

Bi-substrate reactions- Sequential – Ping-Pong reactions- rate equations, examples– Differentiating Bi-substrate mechanisms. Enzyme inhibition- Irreversible- Reversible- Competitive- Uncompetitive– Mixed and Non-Competitive inhibition- graphical analysis – Determination of K_i , enzyme inhibitors as drugs – Basic concepts of structure based/rational drug design - Properties of a lead compound – Lipinski's Rule of Five - IC_{50} , TD_{50} , LD_{50} , ED_{50} – Therapeutic Index - Structure activity relationships – Fragment based lead discovery - Quantitative structure activity relationships - Phases of clinical trials.

UNIT- III – Enzyme Catalysis**10h**

Acid-Base catalysis - Covalent catalysis - Metal ion catalysis - Electrostatic catalysis - Catalysis through proximity and orientation effects - Catalysis by transition state binding. Catalysis in model enzymes – ribonuclease A, chymotrypsin, carbonic anhydrase, lysozyme. Coenzymes – $NAD(P)^+$, FMN & FAD, CoA.SH, TPP, PLP, Biotin, THF, methyl cobalamin, ascorbate, menaquinone - structure & function.

UNIT- IV – Regulation of enzyme activity**9h**

Regulation by availability, importance of compartmentalization. Isoenzymes – Isoenzymes of clinical importance. Regulation by reversible covalent modification - proteolytic activation. Allosteric enzymes- allosteric binding in feedback regulation - Monod, Wyman and Changeux Model - Koshland, Nemethy & Filmer Model of allosteric enzymes - subunit interaction and regulation of enzyme activity in aspartate transcarboxylase and ribonucleotide reductase.

UNIT- V – Applications of Enzymology**8h**

Enzyme purification – methods and strategies. Test for catalytic activity – active site titrations – Overview of enzyme engineering - Immobilized enzymes- methods and applications in industry- medicine - enzyme electrodes in biosensors.

Text Books

- 1.Voet, D. and Voet, J.G. (2018) Biochemistry. John Wiley and Sons Inc., New Jersey.
- 2.Nelson, D.L. and Cox, M.M. (2021) Lehninger's Principle of Biochemistry, W.H. Freeman, New York.

Suggested Reading

1. Nicholas, P. and Lewis, S. (1999) Fundamentals of Enzymology: Cell & Molecular Biology of Catalytic Proteins. Oxford University Press.
2. Palmer T. and Bonner P. (2007) Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. Horwood Publishing Ltd., United Kingdom.

COURSE OUTCOME:

CO1: The student will develop understanding of the basic concepts of enzymology through enzyme kinetics, inhibition, mechanism of action,

CO2: The student will develop understanding the mechanisms of enzyme action and their regulation.

CO3: The student will be able to plan and execute isolation of novel enzymes, determine their kinetic properties, identify inhibition types.

CO4: The student will be able to contribute towards the creation of novel products as biosensors or bioreactors using enzyme immobilization technique towards meeting the challenges of sustainable development goals.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	++	+
CO2	+++	+++	++	+
CO3	++	++	+++	++
CO4	++	++	+++	+++

BCMB 434 – MOLECULAR BIOLOGY

3 Credits

COURSE OBJECTIVES: *To demonstrate knowledge and understanding of the molecular machinery of living cells. This course will introduce the principles that govern the synthesis of macromolecules: DNA, RNA and protein and chromatin organization.*

Prerequisite: Bachelor's level course in Life Sciences.

UNIT- I - Introduction

8h

Discovery of DNA - The genomes of bacteria, viruses, plasmids, mitochondria and chloroplast- Gene transfer in microorganisms- conjugation- transformation, transduction.

UNIT- II – Organization of genome

9h

Prokaryotic and eukaryotic genome - chromatin and chromosome structure- DNA-supercoiling -linking number- Cot curve, C-value paradox - satellite DNA - possible functions - repetitive sequences – transposons and transposition.

UNIT- III – DNA replication

9h

Prokaryotic and eukaryotic DNA replication – mechanism of replication, enzymes and necessary proteins in DNA replication, telomeres, telomerase and end replication, role of telomerase in aging and cancer. DNA Mutation and Repair - mutation subtypes, mismatch, base-excision, nucleotide-excision, and direct repair. DNA recombination - homologous, non - homologous.

UNIT- IV – Transcription

6h

Prokaryotic and eukaryotic transcription - RNA polymerases - general and specific transcription factors- regulatory elements. Mechanism of transcription regulation and transcription termination. Post-transcriptional modification - 5' cap formation- 3'end processing and polyadenylation- splicing- editing- nuclear export of mRNA, transcriptional Regulation-Inhibitors of transcription

UNIT- V – Translation

8h

Genetic code - Prokaryotic and eukaryotic translation - translational machinery. Mechanism of initiation - elongation and termination. Regulation of translation. Inhibitors of translation, post translational modifications.

Text Books

1. Berg, J.M., J, Jr.G.G., Hines, J.K., Tymoczko, J.L., Stryer, L (2023) Biochemistry (International Edition). New York, NY: W. H. Freeman and Co

- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2014) Molecular Biology of Gene. Cold Spring harbour, New York.

Suggested Reading

- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K.C. (2016) Molecular Cell Biology. W.H. Freeman, New York.
- Nelson, D.L. and Cox, M.M. (2012) Lehninger's Principle of Biochemistry. W.H. Freeman, New York.

COURSE OUTCOME:

CO1: Students will be able to understand the central dogma of biology.

CO2: Students will have an understanding of the central dogma of biology at a molecular level.

CO3: Student will be able to identify and apply the fundamental concepts of molecular biology to functioning of biological systems.

CO4: Students get equipped to apply the molecular biology knowledge to understand other advance subjects at a deeper level and to solve biological challenges.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	
CO2	+++	++	+	
CO3	+++	+++	+	
CO4		++	++	+

BMB 480 - ANALYTICAL BIOCHEMISTRY LAB**1 credit**

- 1. Buffers:** Basic principles, Concept of pH, buffering capacity and pKa, Preparation of different biological buffers in the laboratory, Calculations based on Henderson- Hassel Balch equation Use of pH meters. Handling of buffers and storage concerns.
- 2. UV- Visible Spectroscopy:** Basic Principles, Concept of extinction co efficient, absorption spectra of nucleic acids, amino acids, and proteins.
- 3.** Separation of biomolecules by precipitation techniques.
- 4.** Separation of biomolecules by extraction techniques - Partition chromatography, adsorption chromatography.
- 5.** Biomolecule separation by ion exchange chromatography.
- 6.** Separation of Biomolecules by Size exclusion chromatography.
- 7.** Determination isoelectric point of proteins.
- 8.** Electrophoretic separation of proteins.
- 9.** Subcellular fractionation by centrifugation.

Reference:

Hofman A. and Clokle S. (2018) Wilson and Walker's Principle and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge.

COURSE OUTCOME:

CO1: Students will be able to understand and apply the principles of buffer preparation, pH measurement, and use of spectrophotometry for analysing biomolecules.

CO2: Students will gain hands-on experience in separating biomolecules using precipitation, extraction, and chromatographic techniques.

CO3: Students will perform and interpret biomolecule separation using electrophoresis and subcellular fractionation through centrifugation.

CO4: Students will analyse experimental data, calculate key parameters (e.g., pKa, isoelectric point), and troubleshoot laboratory procedures.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	+
CO2	++	+++	++	++

CO3	++	+++	++	+
CO4	++	++	+++	++

BCMB 481- BIOMOLECULES LAB

1 Credit

1. Comparative estimation of reducing sugar by Benedict's & dinitro salicylic acid (DNSA) method – sensitivity & specificity.
2. Comparative of protein quantification methods – Biuret & Lowry – sensitivity, specificity, and interference
3. Estimation of DNA by diphenylamine method (DPA) – significance of deoxyribose.
4. Estimation of RNA by orcinol method – significance of ribose.
5. Estimation of cholesterol.
6. Estimation of inorganic phosphate.
7. Estimation of free proline.
8. Isolation and estimation of casein in milk.
9. Isolation of cholesterol and lecithin from egg.

Reference:

Hofman A. and Clokle S. (2010) Wilson and Walker Principle and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge.

COURSE OUTCOME:

CO1: Students can apply biochemical techniques to compare and select appropriate methods for estimating reducing sugars and proteins in food, clinical, or research samples based on sensitivity and specificity.

CO2: Students will able to utilize nucleic acid quantification methods for accurate assessment of DNA and RNA in biological samples, aiding in genetic and molecular biology applications.

CO3: Students can estimate and interpret levels of biologically important molecules (cholesterol, inorganic phosphate, and free proline) in physiological and diagnostic contexts.

CO4: Students will able to isolate and analyse biomolecules such as casein, cholesterol, and lecithin from natural sources, demonstrating skills applicable in dairy, nutritional, and pharmaceutical industries.

	PSO1	PSO2	PSO3	PSO4
CO1	++	++	++	++
CO2	++	+++	+++	+++
CO3	++	++	++	+++
CO4	++	+++	+++	+++

BCMB 482 - CELL BIOLOGY LAB

1 Credit

1. Observation of eukaryotic cells with the help of light microscope.
2. Permanent slide preparation and preparation of slide for dicot leaf section.
3. Cell counting and viability (yeast/bacteria).
4. Mitosis and the cell cycle in onion root-tip cell.
5. Isolation of mitochondria and assay for function.
6. Isolation of peroxisomes and assay for function.
7. Determination of osmotic fragility of cell (goat erythrocyte).
8. Isolation of goat erythrocyte plasma membrane and estimation of Na^+/K^+ ATPase.
9. Karyotyping
10. Mammalian Cell culture (demonstration and report only)

Reference:

Hardin, J. and Bertoni, G. P. (2022) The World of the Cell, Tenth Edition Pearson, Madison.

COURSE OUTCOME:

CO1: Students will acquire practical skills in microscopic techniques and histological analysis for studying cellular structures.

CO2: Students will be able to demonstrate competency in subcellular fractionation and associated biochemical assays.

CO3: Students will gain proficiency to interpret cell division stages and chromosomal organization using cytogenetic techniques

CO4: Students will be able to apply foundational techniques in cell culture and assess cellular integrity and viability under varying conditions.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	+
CO2	+++	+++	++	++
CO3	++	++	++	+
CO4	++	+++	++	++

BCMB 483 - ENZYMOLOGY LAB

1 Credit

COURSE OBJECTIVES: *To impart knowledge of the principles and protocols of enzyme assays, inhibition studies and to train the students to apply these principles and protocols through hands on experience of performing experiments, recording observation, processing the data generated to reach a conclusion.*

Pre-requisite: Bachelor's level course in Life Sciences.

1. Estimation of enzyme activity (serum alkaline phosphatase) by endpoint assay.
2. Estimation of enzyme activity (serum alkaline phosphatase/lactate dehydrogenase/horse radish peroxidase) by continuous monitoring assay.
3. Estimation of enzyme (serum aspartate transaminase) activity by coupled assay.
4. Effect of pH on enzyme (horse gram urease/ alkaline phosphatase) activity.
5. Effect of Temperature on enzyme (horse gram urease/alkaline phosphatase) activity.
6. Effect of substrate concentration on enzyme (serum alkaline phosphatase/urease) activity.
7. Determination of K_m & V_{max} of an enzyme (horse gram urease/alkaline phosphatase).
8. Partial purification of enzyme and determination of specific activity.
9. Determination of catalytic efficiency.
10. Enzyme inhibition study (cadmium chloride on alkaline phosphatase).
11. Determination of K_i (cadmium chloride on alkaline phosphatase).
12. Enzyme immobilization (yeast invertase on alginate)

Reference:

Bisswanger, H. (2011) Practical Enzymology. John Wiley & Sons, New Jersey.

COURSE OUTCOME:

CO1: The student will develop understanding of the basic principles and protocols of enzyme assay, inhibition studies, isolation, and immobilization.

CO2: The student will develop the ability to apply these principles and protocols to plan and execute experiments on enzyme studies.

CO3: The lab experiments will further enable the student to plan their own studies on enzymes applying these principles and protocols.

CO4: The student will be able to contribute towards identification of novel enzymes, their isolation, kinetic studies, and applications of the same.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	++	++
CO2	+++	+++	++	++
CO3	+++	+++	+++	+++
CO4	++	+++	+++	+++

CMB 484 - MOLECULAR BIOLOGY LAB**1 Credit**

1. Extraction of genomic DNA
2. Extraction of plasmid DNA
3. Spectrophotometric analysis of purity of isolated DNA
4. Agarose gel electrophoresis of genomic and plasmid DNA
5. Restriction digestion of chromosomal DNA
6. Restriction digestion of plasmid DNA
7. Isolation of DNA fragment from agarose gel
8. Isolation of RNA
9. Analysis of RNA by formaldehyde – agarose electrophoresis.

Reference:

Sambrook, J. and Russell, D.W. (2001). Molecular Cloning: A Laboratory Manual Vol 1, 2 & 3, CSHL Press. New York.

COURSE OUTCOMES:

CO1: Student learn the principles utilized in isolation, separation, and visualization of nucleic acids.

CO2: Student learn basic laboratory techniques and good laboratory practices.

CO3: Students get hands on training in isolating, separating, and visualizing nucleic acids.

CO4: Students develop the ability to critically think to overcoming experimental failures.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	+++	+	
CO2	+++	++	+	
CO3		++	+++	
CO4		+++	+++	

BCMB 435 - BIOSTATISTICS AND SCIENTIFIC WRITING

3 Credits

COURSE OBJECTIVES: *The objective of the course is to learn basic statistics and scientific communication.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I – Central Tendency and Dispersion of Data 12h

Introduction- definition of statistics-population and universe- the sample and population- statistical inference- parameter and statistics. Handling of bulky data- construction of a histogram- interpretation of histogram- the normal distribution- the mean-mode-and standard deviation- uncertainties in estimating a mean.

UNIT- II – Chi Square and Poisson's Distribution 8h

Proportion data- Examples of Proportion data- MPM- sterility testing of medicines- animal toxicity- infection and immunization studies e.g., LD50, ED50, PD50 statistical treatment to proportion data- Chi-square test- goodness of fit to normal distribution. Count data- Examples of count data (bacterial cell count, radioactivity count, colony, and plaque count, etc.). Statistical treatment to count data- Poisson's distribution- standard error- confidence limits of counts.

UNIT- III - Test of significance 7h

Analysis of variance- Introduction –procedure-F and t test. Basic information on statistical softwares such as SPSS, GraphPad prism.

UNIT- IV – Correlation and Regression 10h

Correlation regression and line fitting through graph points- standard curves- correlation- linear regression (fitting the best straight line through series of points)- standards curves and interpolations of unknown y-values thereon.

UNIT- V – Scientific Writing & Communication 8h

Methodology for writing science report and oral presentation- compilation of experimental record- program of writing- use of vocabulary- use of good English-art of illustration- report writing- editing and correcting- technique of oral presentation.

Text Book:

1. Glover. T. and Mitchell, K. (2015) Introduction to Biostatistics. McGraw –Hill Science.
2. Zar. J.H. (2010) Biostatistical Analysis, Pearson Education, New Jersey.

Suggested Reading:

1. Green, R. H. (1979) Sampling Design and Statistical Methods for Environmental Biologists, John Wiley & Sons, New Jersey.
2. Snedecor, G. W. and Cochran, W. G. (1989). Statistical methods. Iowa State Press, Iowa.
3. Matthews, J.R. and Matthews, R.W. (2007) Successful Scientific writing: A step-by-step Guide for Biomedical Scientists, Cambridge University Press, Cambridge.

COURSE OUTCOME:

CO1: Students will gain an understanding of key statistical concepts such as central tendency, dispersion, and data distribution.

CO2: Students will develop the ability to apply statistical tools including chi-square tests, Poisson distribution, t-tests, and ANOVA in biological data analysis.

CO3: Students will acquire skills to interpret experimental data through correlation analysis, regression, and use of standard curves.

CO4: Students will build competence in scientific communication, focusing on clear and effective report writing and oral presentations.

	PSO1	PSO2	PSO3	PSO4
CO1	++	+++	+	+
CO2	++	+++	++	+
CO3	+	++	++	+
CO4	+	+	++	+++

BCMB 436 - GENOMICS**3 Credits**

COURSE OBJECTIVES: *To get an overview of genomics, its functional aspects and understanding of genome analysis.*

Pre-requisite – Master's level course in Molecular Biology.

UNIT- I - Overview of Genomics 8h

Introduction to Genomics, number of genes and complexity of genomes, Structural genomics, Comparative genomics, Organelle genome: nuclear genome, mitochondria and chloroplast, Concepts of Metagenomics, Conservation, and diversity of genomes.

UNIT- II – The Genome Project 11h

History, organization and goals of human genome project, Strategies for sequencing genomes, genome mapping, DNA segment nomenclature, Organization of human genome: Mitochondrial genome, Gene density, CpG islands, RNA-encoding genes, functionally identical/similar genes, Diversity in size and organization of genes, Annotation. Human genome diversity, Human Microbiome Project, 16S rRNA analysis.

UNIT- III – Functional genomics 10h

Functional genomics of microbes, plants and animals; transcriptome analysis methods, microarrays, and serial analysis of gene expression. Basic concepts of identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling, identification of SNPs.

UNIT- IV – Molecular markers in genome analysis 8h

Tools for genome analysis- RFLP, RAPD, AFLP, SSLPs, STR, EST and SNPs, Disease monitoring, Linkage and Pedigree, disease prognosis, genetic counselling.

UNIT- V – Pharmacogenomics 8h

Pharmacogenetics, cancer genomics, immunogenomics, somatic cell Genomics, biochemical genomics, single cell analysis, Genetics of globin triplet repeat Disorders, polygenic inheritance, Effects of drugs in individual and susceptibility, Personalized medicine, Synthetic Genomes. Ethics and issues of synthetic.

Text Books

1. Ronald Cohn, Stephen W. Scherer, and Ada Hamosh (2023). Genetics and Genomics in Medicine (9th Eds). Elsevier,
2. Zdanowicz, M.M. (2010) Concepts in Pharmacogenomics, American Society of Health-System Pharmacists, Bethesda.

3. Arthur Lesk (2017). Introduction to Genomics (3rd Eds). Oxford University press, New York.

Suggested reading

1. Dale, J.W., Schantz, M.V., Plant, N. (2012) Concepts and Applications of DNA Technology. John Wiley & Sons, Ltd, Chichester.
2. Pevsner, J. (2015) Bioinformatics and Functional Genomics, John Wiley and Sons, Inc., Hoboken

COURSE OUTCOME:

CO1: Students will have a fundamental concept and current knowledge on genomics science and genome projects.

CO2: Students will understand the structure and function of the genome in eukaryotes, prokaryotes, and organelles

CO3: Students will be capable of understanding various experimental methods used to identify and analyse the transcribed parts of a genome.

CO4: Students will be able to illustrate the fundamentals of genomics and apply the knowledge to various biomedical applications.

	PSO1	PSO2	PSO3	PSO4
CO1	++	+++	++	+
CO2	++	+++	++	
CO3		+++	+++	+
CO4		++	++	+++

BCMB 437 - METABOLISM AND REGULATION**3 Credits**

COURSE OBJECTIVES: *To provide an overview of cellular metabolism, organization of metabolic networks and regulatory mechanisms.*

Pre-requisite – Master's level course in Biomolecules and Enzymology.

UNIT- I - General Introduction 10h

Metabolism – Anabolism – Catabolism - Xenobiotic metabolism. Metabolism of carbohydrates: glycolytic pathway, gluconeogenesis pathway, reciprocal regulation of gluconeogenesis and glycolysis. Pentose phosphate pathway - Citric acid cycle and its regulation - Glycogen synthesis and degradation - Regulation of glycogen metabolism - Cori's cycle.

UNIT- II - Metabolism of Lipids 10h

Oxidation of fatty acids - beta oxidation, alpha oxidation and omega oxidation, oxidation of fatty acids with odd number of carbon atoms. Ketone bodies formation and utilization. Biosynthesis of saturated fatty acids and unsaturated fatty acids, regulation of fatty acid biosynthesis. Biosynthesis of tri-acylglycerol and phospholipids. Cholesterol biosynthesis, regulation of cholesterol biosynthesis-transcription factor SREBP2. Bile acid biosynthesis and its regulation.

UNIT- III - Metabolism of Amino acids 8h

Overview of biosynthesis of non-essential amino acids from amphibolic intermediates – α - ketoglutarate, oxaloacetate, 3-phosphoglycerate. Glucose - alanine cycle, Urea cycle and its regulation. Outline of glutathione synthesis.

UNIT-IV -Metabolism of Purines and Pyrimidines 9h

De Novo synthesis of purine and pyrimidine nucleotides, regulation of purine and pyrimidine biosynthesis, catabolism of purines and pyrimidines, Salvage of bases. Purine and Pyrimidine Antimetabolites- clofarabine 6-thioguanine, 5-fluorouracil, 6-mercaptopurine.

UNIT- V - Dietary Minerals 8h

Biosynthesis of heme, Catabolism of heme, Metabolism of iron: absorption, storage, transport and excretion, iron deficiency and overload., Cellular energy sensor -AMP-activated protein kinase (AMPK), Genetic errors of metabolism: representative examples– galactosemia, phenylketonuria, alkaptonuria, Lesch-Nyhan syndrome.

Text Books

1. Nelson, D.L. and Cox, M.M. (2013) Lehninger's Principle of Biochemistry, Macmillan, London.
2. Murray, R.K., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2006) Harper's Biochemistry, McGraw Hill, New York.

Suggested Reading

1. Voet, D., Voet, J.G., Pratt, C.W (2016) Fundamentals of Biochemistry. Life at the molecular level, Wiley-VCH, New Jersey.
2. Berg, J.M., Tymoczko, J.L, Stryer, L. (2012) Biochemistry, H. Freeman and Company, Canada.

COURSE OUTCOMES:

CO1: Students will be able to understand the biochemical steps involved in the metabolic pathways of carbohydrate, lipid, amino acids, nucleic acids, heme metabolism and its regulation.

CO2: Students will be able to comprehend the concept of metabolism and deliberate the importance of the hormone insulin, a master regulator of energy metabolism and understand AMPK as a metabolic sensor to the cellular energy needs.

CO3: Students will be able to understand the cause of major inborn errors of metabolism, use of antimetabolites in therapeutics and the importance of xenobiotic metabolism.

CO4: After the completion of the course, students will get equipped to apply the metabolic pathway knowledge at a deeper level and use it in biomedical research.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	+++	+	
CO2	+++	++	+	
CO3	+++	+++	+	
CO4		++	++	+

BCMB 438 - MOLECULAR ENDOCRINOLOGY**3 Credits****COURSE OBJECTIVES:**

To provide basic understanding of organization, physiology, and regulation of endocrine glands along with biological functions and control mechanisms.

Pre-requisite – Bachelor's level course in Life Sciences.

UNIT-I- Introduction to Endocrinology**8h**

Definition and scope of Endocrinology – historical and anatomical aspects of the mammalian endocrine system. Definition of a hormone – chemical nature of mammalian hormones – types of hormone receptors. Secondary messenger systems – General mechanism of signalling by G-protein coupled receptors, receptor tyrosine kinase and ion channels. General mechanism of peptide and non-peptide hormone action. Axis and feed-back regulation of the endocrine system.

UNIT - II – Brain and gut hormones**8h**

Brain as endocrine organ – Hypo-physio tropic hormones – significance of hypophyseal portal system. Pituitary gland and its hormones – chemistry and biochemical functions. Concentric and peripheral regulation of appetite, ions & fluid - Neuro-hormones & Neuropeptides – Gut hormones and brain axis – Neuropeptides – roles in obesity – Peripheral & brain - renin angiotensin. Pineal gland hormones – chemistry – mechanism of action. Melatonin and circadian rhythm.

UNIT- III – Thyroid and Parathyroid gland hormones**8h**

Thyroid gland hormones chemistry – biochemical functions – mechanism of action. Regulation of thyroid function. Disorders of thyroid hormone – Concept and etiology of primary, secondary, tertiary hypothyroidism, and peripheral resistance – Hashimoto's thyroiditis – thyrotoxicosis – Graves' disease. Thyroid function test. Parathyroid glands – biochemical functions. Hormones involved in calcium metabolism – chemistry – molecular mechanism of action.

UNIT - IV– Adrenal, Pancreatic, and Adipose tissue hormones**8h**

Adrenal gland – hormones of adrenal cortex and medulla – chemical nature, functions, and regulation of secretions of the adrenal cortical hormones. Cushing's syndromes and Addison's disease. Biosynthesis and catabolism of catecholamines – biochemical functions. Pheochromocytoma. Pancreatic hormones – Insulin and glucagon chemistry, biochemical functions, mechanism of action. Diabetes mellitus. Somatostatin. Hormones of the adipose tissue – Leptin and adiponectin biological functions.

UNIT- V– Reproductive Endocrinology**8h**

Hormones of testes and ovary – Ovarian steroid hormones chemistry, biosynthesis, and transport. Endocrine functions of testis – synthesis, chemistry, and metabolism of androgens. Dynamics of sex hormone production and mechanisms of action. Testicular and ovarian determining genes – Mullerian inhibiting substance genes. Molecular basis of male and female contraception.

Text Books:

1. Rodwell, V., Bender, D., Weil, P.A., Kennelly, P., Botham, K. (2022) Harpers Illustrated Biochemistry, McGraw-Hill Education / Medical, New York.
2. Melmed, S., Polonsky, K.S., Larsen, P.R., Kronenberg, H.M. (2024) Williams Textbook of Endocrinology, Elsevier, New York.

Suggested Reading:

1. Hadely, M.E. and Levine, J.E. (2009) Endocrinology, Sixth Edition, Benjamin Cummings, San Francisco.
2. Wass, J.A.H., Stewart, P.M., Amiel, S.A., Davies, M.J. (2022) Oxford Textbook of Endocrinology and Diabetes, OUP, Oxford.

COURSE OUTCOME:

CO1: The student will develop understanding of organization, physiology, and function of the endocrine glands.

CO2: The student will be able to appreciate the complexity of regulation and crosstalk within the endocrine system.

CO3: The student will be able to analyse the clinical reports related to endocrine function to assess the health status of self and others in context of their endocrine function.

CO4: The student will be able to easily participate in molecular research towards the deeper understanding of the endocrine functions and their intervention to contribute towards a healthier society.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	+++	++	++
CO2	+++	+++	++	++
CO3	++	++	+++	++
CO4	++	++	++	+++

BCMB 439 – MOLECULAR GENETICS**3 Credits**

COURSE OBJECTIVES: *The course will focus on the fundamental concepts in genetics and techniques used to predict genetic outcomes.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Introduction to Genetics**10h**

Molecular Evolution: History of Genetics and Evolutionary biology, Neutral evolution, molecular divergence, and molecular clocks; Molecular tools in phylogeny, classification, and identification Mendelian and non-Mendelian principles: Laws of Inheritance, autosomal inheritance, Chi square analysis, Phenocopy, Inheritance of mitochondrial and chloroplast genes - Sex influenced and sex determined traits.

UNIT- II – Genome Mapping**7h**

Mapping in Bacteria, bacteriophages, and yeast: - Mapping genes by interrupted mating, deletion mapping. Chromosomal Mapping in Eukaryotes: Linkage maps, - Physical Mapping- restriction mapping, mapping with molecular markers, somatic cell hybrids. Linkage mapping in haploid organisms - tetrad analysis

UNIT- III – Developmental Genetics**8h**

Genetics of drosophila embryo development, axes and pattern formation in drosophila, Homeotic induction, Sex determination, Dosage compensation and X-inactivation in human female, Genomic imprinting. Technological Advances in Developmental Genetics (CRISPR-Cas9 and genome editing for studying developmental genes, Single-cell transcriptomics in developmental biology, Organoids, and stem cell-based models of development)

UNIT- IV – Human Genetics**9h**

Human genetics: Genetic disorders- Autosomal Dominant, Recessive and X- Linked and other Maternally inherited Diseases- Pedigree analysis- Genetic testing –Direct testing, – Karyotyping, Prenatal diagnosis - Gene tracking, Haplotype and Linkage Equilibrium, Quantitative genetics: QTL mapping, LOD score for Linkage testing. Population Genetics: Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Human Impact in Genetic Variation, Co-evolution.

UNIT- V – Mutations and Genetics of Cancer**6h**

Mutations - molecular & phenotypic perspective. Chromosomal mutations- deletion, duplication, inversion, translocation, ploidy and their genetic implications-origin of new genes and proteins; Gene duplication and divergence. Genetics of Cancer: Defects in DNA repair, oncogenes and proto-oncogenes, viral oncogenes, tumour suppressor genes.

Text Books

1. Klug, W.S., Cummings, M.R., Spencer, C.A. (2021) – *Concepts of Genetics* (13th Edition), Pearson.
2. Hartwell, L.H., Goldberg, M.L., Fischer, J.A., Hood, L. (2017) *Genetics: From Genes to Genomes*. (6th Edition) New York, NY: McGraw Hill
3. Gilbert, S. F., & Barresi, M. J. F. (2023). *Developmental Biology* (13th ed.). Oxford University Press.

Suggested Reading

1. Lodish, H., Berk, A., Kaiser, C.A., et al. (2021) – *Molecular Cell Biology* (9th Edition), W.H. Freeman
2. Brown, T.A. (2017) – *Genomes 4*, Garland Science

COURSE OUTCOME:

CO1: Students will have a deep understanding of basic, advanced, and molecular genetics concepts.

CO2: Students will be capable of applying the principles of molecular genetics to understand evolution at molecular level.

CO3: Students will be capable of applying concepts of molecular genetics to decipher genetic disorders, their transmission, understand developmental biology and stay updated with recent trends.

CO4: Students will skilled to design experiment and interpret results to solve biological research questions.

	PSO1	PSO2	PSO3	PSO4
CO1	++	+++	+	
CO2	++	+++	++	
CO3		++	+++	
CO4		++	+++	+

BCMB 485 - GENERAL MICROBIOLOGY LAB**1 Credit**

1. Introduction to sterilization techniques- sterilization of glass wares, autoclaving.
2. Preparation of liquid and solid media.
3. Isolation of Bacteria and fungi from soil samples – serial dilution technique.
4. Measurement of bacterial population
5. Pure culture techniques: spread plate, streak plate technique, and pour plate
6. Determination of Bacterial growth curve
7. Identification of bacteria by morphological and Biochemical characteristics
8. Smear preparation and staining of bacteria: simple staining, Gram's staining, and spore staining
9. In vitro antibiotic sensitivity tests for selected bacterial cultures
10. Methods for preserving microbial cultures: slant, glycerol stock and lyophilization

Reference:

1. Sherman, N. and Cappuccino, J.G. (2004) Microbiology A Laboratory Manual, Benjamin-Cummings Publishing Company, San Francisco.

COURSE OUTCOMES:

CO1: The course will impart knowledge and hands on training on various sterilization techniques

CO2: Students will get hands on experience in the preparation of different media for culturing of bacteria.

CO3: Student will attain skills to perform different culture techniques and preservation methods

CO4: Students can use the knowledge obtained to test the efficacy of different drugs to control microbial growth

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	
CO2	+++	++	++	
CO3	+++	+++	+++	
CO4	+	++	++	+++

BCMB 486 - METABOLISM AND REGULATION LAB**1 Credit**

1. Estimation of urea
2. Estimation of uric acid
3. Estimation of creatinine
4. Determination of bilirubin
5. Estimation of pyruvate
6. Precipitation of calcium and estimation of calcium
7. Assay of acid phosphatase enzyme activity
8. Determination of catalase activity from liver/serum
9. Assay of alcohol dehydrogenase/ glutamate dehydrogenase enzyme activity in liver/ serum
10. Determination of alanine transaminase enzyme activity

Reference:

1. Hofman A. and Clokle S. (2010) Wilson and Walker's Principle and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge.
2. Bisswanger, H. (2011) Practical Enzymology. John Wiley and Sons, New Jersey.

Course Outcomes:

CO1: Estimate urea, uric acid, creatinine, bilirubin, glucose, pyruvate and calcium in a given unknown sample using standard methods and procedures.

CO2: Assay of enzyme activities such as catalase.

CO3: Develop skills and procedural acumen using the instrument spectrophotometer. Plot a standard calibration curve and hence calculate the concentration of X in the unknown.

CO4: Learn the principle of the experiments, working principle of spectrophotometer, prepare the reagents, carry out accurate pipetting necessary to obtain consistent results within a time period.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	+++	+	
CO2	+++	+++	+	
CO3	+++	+++	+	
CO4		++	++	+

BCMB 536 - GENETIC ENGINEERING**3 Credits**

COURSE OBJECTIVES: *To provide understanding of genetic manipulation and gene transfer in addition to providing insights into its success in living systems.*

Pre-requisite: Master's level course in Molecular Biology.

UNIT- I - Introduction to Genetic Engineering 8h

Enzymes used in rDNA technology (Restriction enzymes, nucleases, RNA polymerases, DNA polymerases, PNK, alkaline phosphatases, DNA ligases). Cloning Vectors for *E. coli*: Plasmids, Bacteriophage λ , Filamentous phage, Cosmids, Phagemids and other advanced vectors: BAC, YAC, P1-derived Artificial Chromosome, Shuttle vectors, Expression vectors.

UNIT- II – Gene Transfer Techniques 7h

Cloning Vectors for Eukaryotes: Vectors for cloning in yeast, Vectors for cloning in animal cells– adenoviral vector, adeno-associated viral vectors, retroviral vectors, baculovirus vectors for cloning in insect cells. Ligation of DNA fragments– using DNA ligases, homopolymer tailing, linkers and adaptors. Introduction of foreign DNA into prokaryotes - Natural gene transfer methods, calcium chloride mediated transformation, transfection with phage vectors. Introduction of foreign DNA into animal cells - lipofection, electroporation, microinjection, microprojectile.

UNIT- III - Gene Cloning Strategies 8h

Construction of genomic and cDNA libraries. Selection and screening of recombinant clones: Methods based on nucleic acid hybridization, finding specific clones by functional complementation. Reporter genes. Studying protein-protein interactions-Phage display libraries, yeast two hybrid systems.

UNIT- IV – Gene Manipulation Techniques 8h

DNA sequencing methods –Sanger's sequencing method, Next generation sequencing methods– pyrosequencing, Polony sequencing. Polymerase chain reaction and its applications, altering genes- Site-directed mutagenesis. DNA microarrays. Dot Blot and Slot Blot Hybridization, Fluorescence *in-situ* hybridization. Analysis of DNA protein interactions- Electrophoretic mobility shift assay, Filter-binding assay, Chromatin Immunoprecipitation (ChIP) assay, Methylation Interference assay.

UNIT- V – Expression of Engineered Proteins 8h

Expression systems: Overview of bacterial expression systems for heterologous protein production, Overview of Eukaryotic expression systems. Concepts of gene knock out technique. Retroviral, DNA microinjection and engineered stem cells methods for producing transgenic mice, production of recombinant insulin, Gene Therapy: Gene silencing by RNA

interference technology, Uses of TALEN, ZFN and CRISPR-CAS in genome editing. Necessity of bioethics in rDNA technology.

Text Books

1. Primrose, S.B. and Twyman, R. (2006) Principles of Gene Manipulation and Genomics, Wiley-Blackwell Publishers, New Jersey.
2. Brown, T.A. (2016) Gene Cloning and DNA Analysis, Wiley-Blackwell Publishers, New Jersey.

Suggested Reading

1. Nicholl, D.S.T. (2010) An Introduction to Genetic Engineering, Cambridge University Press, United Kingdom.
2. Glick, B.R., Pasternak, J.J., Patten, C.L., (2012) Molecular Biotechnology: Principles and Applications of recombinant DNA, ASM Press, Washington DC.
3. Sambrook, J. and Russell, D.W. (2012) Molecular Cloning: A Laboratory Manual –a set of 3 volumes, CSHL Press, New York.

COURSE OUTCOME:

CO1: Understand the basic steps of gene cloning and the role of enzymes and vectors responsible for gene manipulation.

CO2: Gain knowledge on the construction of cDNA libraries and understand the principle of various techniques such as Next generation sequencing techniques, site directed mutagenesis, DNA protein interaction and protein - protein interactions.

CO3: Acquire detailed knowledge of gene transfer methods and use suitable hosts for gene cloning and gene expression.

CO4: After completion of the course the students will gain basic knowledge on applications of genetic engineering techniques such as creation of transgenic mice and gene therapy, which prepares them for further trainings in the area of genetic engineering.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	+++	+	
CO2	+++	+++	+	
CO3	+++	+++	+	
CO4		++	+	+

BCMB 537 - IMMUNOLOGY**3 Credits**

Course Objectives: *To understand the basic concepts in Immunology and techniques used in Immunology research*

Pre-requisite: Master's level course in Cell Biology and Molecular Biology.

UNIT- I - Introduction to immunology 8h

History and scope of immunology; Types of Immunity-Innate/basic immunity, Acquired immunity-natural, artificial, active and passive immunity; chemical nature of antigens – complete antigens, haptens, immunogenicity, antigenicity, epitopes; PAMPs, DAMPs; PRRs-Toll like receptors, acute phase proteins; Types and functions of immune cells – cells of myeloid and lymphoid lineage- granulocytes, dendritic cells, macrophages, T and B lymphocytes; Primary and Secondary immune response; Inflammation- stages of inflammatory response-; Pathways of complement activation – Classical, Properdin and Lectin pathways; Regulation of complement system

UNIT- II -Functions of Lymphoid organs- 6h

Primary and Secondary lymphoid organs; stages in the development of T and B lymphocytes in the Thymus and Bone marrow-positive and negative selection; MHC molecules - types and significance of MHC molecules; antigen processing and presentation to T cells- endogenous and exogenous pathways; Role of secondary lymphoid organs in the production of effector T and B Lymphocytes-Mechanism of activation of T cells and B cells in the lymph nodes and spleen; Lymphocyte recirculation.

UNIT- III – Humoral Immunity and Immunological Techniques- 8h

Immunoglobulins-structure, types and biological functions; Primary and Secondary immune response; Molecular basis of antibody diversity-multiple germ-line gene segments, somatic gene recombination, N and P nucleotide addition and somatic hypermutation; Mechanism of antigen-antibody interaction; principle and applications of precipitation, agglutination reactions, ELISA, RIA, Western Blotting, FACS and immunofluorescence techniques; Hybridoma technique- principle and methodology for production of monoclonal antibodies; Biomedical applications of murine and humanized monoclonal antibodies. Vaccines: conventional vaccines-attenuated, killed and subunit vaccines; Modern vaccines- recombinant vaccines, DNA vaccines and Edible vaccines

UNIT- IV – Cell Mediated Immunity- 8h

Functions of T cell subsets-Th1, Th2, Treg, CTLs, and NK cells; Mechanism of activation of T cells; Tolerance mechanisms-central and peripheral tolerance-clonal deletion, clonal anergy; Role of cytokines in immune regulation; T cell-B cell interaction-immunoglobulin class switching; Mechanism of target cell killing by CTLs and NK cells-death signalling-induction of apoptosis-intrinsic and extrinsic pathways

UNIT- V – Immunopathology-**10h**

Types, causes and immune mechanisms involved in hypersensitivity reactions; Autoimmune diseases – causes of autoimmunity; types - systemic and organ specific autoimmune diseases- systemic lupus erythematosus, rheumatoid arthritis, haemolytic anaemia, IDDM, Grave's disease, Myasthenia gravis; Immune deficiency disorders-types-Primary and secondary immune deficiency diseases – XLA, CVID, Wiscott-Aldrich syndrome, DiGeorge syndrome, SCID, AIDS; Transplantation immunity -types of grafts; immune mechanisms associated with allograft rejection; Applications of physical, chemical and biological immunosuppressive agents

Text Books:

1. Punt, J., Stranford, S., Jones, P., Owen, J. (2019) Kuby's Immunology, 8th edition. W. H. Freeman, New York.
2. Murphy, Kenneth., Weaver, Casey and Leslie Berg. (2022) Janeway's Immunobiology, 10th edition, Garland Science, New York.

Suggested Reading:

1. Delves, P.J., Martin, S.J., Burton, D.R., Roitt, I.M. (2017) Roitt's Essential Immunology, 13th edition Wiley-Blackwell Publishers, New Jersey

COURSE OUTCOMES:

CO1: The students will be able to understand the concept of immune-surveillance mechanisms in human body against pathogens;

CO2: develop abilities to differentiate the functioning of cells of humoral immunity and cell mediated immunity;

CO3: get insights on the mode of action of immune cells at cellular and molecular level;

CO4: be able to grasp the principle and applications of different immunological techniques, concepts of development of vaccines and immunosuppressant drugs

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++		
CO2	+++	++	+	
CO3	+++	++	++	
CO4	++	++	++	+++

BCMB 538 - PROTEOMICS**3 Credits**

COURSE OBJECTIVES: *The course focuses on the detailed study of proteins which represent the cell's major proportion of functional molecules. The course will familiarize students on the application of technologies for the analysis and quantification of proteins.*

Pre-requisite: Master's Level Course in Genetic Engineering.

UNIT- I – Introduction to Proteomics**10h**

Human genome - Genomes to Proteomes - HUPO –Human Proteome Project, Branches of proteomics - Protein extraction Methods: Subcellular fractionation, Density gradients, Ultrafiltration, - Protein fractionation - Affinity purification –Removal of interfering compounds, salts, DNA, lipids, Protein solubilization methods, chaotropes, detergents, etc - Sample handling and storage

UNIT- II – Structural Proteomics**8h**

Protein structure-function relationship – Disulfide bonds, Post translational modifications, Glycosylation, Phosphorylation, other modifications, Applications - methods for detection of protein-protein interactions - Yeast 2 hybrid systems – Phage display – Surface Plasmon Resonance (SPR) - Fluorescence Resonance Energy Transfer (FRET).

UNIT- III – Proteomic Techniques for Analysis**10h**

Gel based and Gel free proteomics - 1D and 2-D gel electrophoresis, Stable Isotope Labelling with Amino acids in Culture (SILAC).– Mass Spectrometry – Principles - MALDITOF - RP chromatography /Tandem mass spectrometry – Protein sequence analysis -Peptide mass finger printing- N-terminal determination methods- Protein modification – Protein microarrays – Tissue microarray – Infra red Protein array with Quantitative Readout (IPAQ) -- Algorithms for proteomics –OMSSA - SEQUEST - MASCOT.

UNIT- IV – Protein expression**8h**

Expression Systems – *E. coli*, Yeast, *Pichia pastoris*, Baculovirus - introduction, detection and purification of expressed transgenes - antibody generation antibody capture and antibody Engineering – Protein/peptide chemical synthesis — Protein-polynucleotide interactions Reconstitution of proteins in lipid vesicles, - Liposomes-Peptide and protein drugs. Protein-based vaccine.

UNIT- V – Proteomic approach for Clinical studies**9h**

Protein Biomarker Discovery and Validation - low abundance and hydrophobic proteins. High throughput techniques ITRAQ and ICAT to identify protein molecules in sample Body fluid profiles, blood disease profiles, diabetes profiles stroke and myocardial infarction, Alzheimer, Proteomics in Biotechnology.

Text Books

1. Twyman, R.M. (2014) Principles of Proteomics, Taylor & Francis group, New York USA.
2. Comai, L, Katz, J., Mallick, P. (2017) Proteomics: Methods and Protocols. Humana Press Inc., New York.

Suggested Reading

1. Cathy H. Wu. C.H, Cecilia N. Arighi. C.N. and Karen E. Ross. K.E. (2017) Protein Bioinformatics, Humana Press Inc., New York.
2. Sanjeeva Srivastava (2022). From proteins to proteomics: Basic concepts. Techniques and application. CRC Press.

COURSE OUTCOME:

CO1: Students will understand the basics of the evolution of proteomics as an area and procedures to characterize proteins in a complex biological sample.

CO2: Students will be able to know the experimental aspects and techniques in addressing systems-level applications.

CO3: It will provide information to understand the current trends in proteome science and the use of advanced bioinformatics tools for protein functional and structural attributes.

CO4: Students should be able to utilize proteomics and its potential to understand biochemical processes, regardless of the type of organism, and problems in the biotechnology industry.

	PSO1	PSO2	PSO3	PSO4
CO1	++	+++	++	+
CO2	++	+++	++	+
CO3		+++	+++	++
CO4		++	++	+++

BCMB 560 - GENETIC ENGINEERING LAB**1 Credit**

1. Culture of *E. coli* cells & plasmid isolation
2. Preparation of competent cells
3. Calcium chloride mediated transformation
4. Ligation of DNA
5. Polymerase chain reaction
6. Restriction fragment length polymorphism
7. Random amplified polymorphic DNA
8. Sub-cloning of GFP protein

Reference:

Sambrook, J. and Russell, D.W. (2012) Molecular Cloning: A Laboratory Manual –a set of 3 volumes, CSHL Press, New York.

Course Outcomes:

CO1: Isolate plasmid DNA and carry out electrophoresis techniques to separate DNA.

CO2: Develop skills and procedural acumen in recombinant DNA techniques such as transformation, ligation of DNA, RFLP and RAPD,

CO3: Carry out PCR experiment.

CO4: Students get hands on training and develop the ability to critically think to overcoming experimental failures.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	+++	+	
CO2	+++	++	+	
CO3		++	+++	
CO4		+++	++	

BCMB 561 - IMMUNOLOGY LAB**1 Credit**

1. Agglutination reactions- Active agglutination- Widal Test, Blood group analysis
2. Passive agglutination reactions -Latex agglutination Test
3. Precipitation reactions on gel-double immunodiffusion
4. Single radial immunodiffusion (SRID)
5. Immunoelectrophoresis (IEP)
6. ELISA technique
7. SDS-PAGE analysis
8. Immunoblotting technique

Reference:

Gordon, J.R. (2004) A Practical Guide to cellular and Molecular Research Methods in Immunology, Saskatchewan.

COURSE OUTCOMES:

CO1: Students will be able to differentiate the principle of precipitation and agglutination reactions by performing the reactions.

CO2: Students will get hands on experience in performing different immunodiffusion and immunoelectrophoretic techniques and know their applications.

CO3: Student will attain skills to perform ELISA techniques and immunoblotting techniques and know their biomedical applications.

CO4: Students can use the skills obtained in this program for various applications in health care management

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	
CO2	+++	++	++	
CO3	+++	+++	+++	
CO4	+	++	+++	+++

BCMB 441 - GENERAL MICROBIOLOGY**3 Credits**

Course Objectives: *To develop a lucid understanding of the microbial diversity, structural features of prokaryotes, culture conditions for bacteria and major microbial diseases*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I- Introduction to Microbiology**6h**

History and scope of Microbiology. Germ theory of disease, Koch's postulates. Sterilization methods-physical and chemical methods; use of disinfectants and antiseptic agents; Microscopy – principle and applications bright field, dark field, fluorescence, phase contrast and electron microscopes; Principle and uses of simple, differential, negative and spore staining techniques

UNIT- II -Microbial diversity and antimicrobial agents**10h**

Carl Woese's three domain system of classification. Major groups of bacteria- Archaeobacteria, Eubacteria- identification of bacteria based on phenetic, physiologic/metabolic characteristics and molecular phylogeny. General characteristics of major groups of Fungi, viruses and protozoa Life cycle of DNA and RNA viruses and bacteriophages; Mode of action of antimicrobial agents; antibacterial, antiviral, antifungal, anti-helminthic and anti-protozoan drugs; Mechanism of development of antibiotic resistance in microbes.

UNIT- III – Structural features of bacteria**6h**

Structure of Gram positive and Gram-negative bacterial cell walls, periplasm, flagella, pili, capsule, cell membrane, nucleoid, plasmids, inclusion bodies and endospores;

UNIT- IV – Culture techniques**6h**

Culture media - composition and uses of solid, liquid, simple, complex, differential and selective media; Culture methods- batch culture, continuous and synchronous culture techniques; bacterial growth kinetics; Effect of pH, temperature and radiation on growth.

UNIT- V – Microbial diseases**8h**

Respiratory diseases-diphtheria, tuberculosis, pneumonia and Influenza; Skin diseases-measles, chickenpox, human papilloma virus, and dermatophyte (tinea) infections; Diseases affecting GIT- Oral thrush, typhoid, cholera, pathogenic E. coli infections, amoebiasis, and hepatitis; Genitourinary infections –syphilis, candidiasis, HIV; Protozoan and helminthic diseases- malaria, trypanosomiasis, leishmaniasis, filariasis

Text Books:

1. Dorothy Wood, Joanne Willey, Kathleen Sandman (2022) Prescott, Microbiology, McGraw Hill Higher Education, New York.

2. Tortora, G.J., Funke, B.R., Case, C.L. (2023). Microbiology: An Introduction. Benjamin Cummings, San Francisco.

Suggested Reading:

1. Microbiology: Principles and Explorations, 10th Edition
2. Jacquelyn G. Black, Laura J. Black January 2018

COURSE OUTCOMES:

CO1: The course will impart knowledge on microbial diversity, basis of classification of microbes and the uses of different microscopes.

CO2: Students will be able to understand the distinguished structural features of various microorganisms and their growth characteristics.

CO3: Student will attain skills to optimise various media conditions for culturing microbes.

CO4: Students get to know the major microbial diseases, their control using antimicrobial agents and the basis of drug development

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	
CO2	+++	++	+	
CO3	+++	+++	++	
CO4	+	++	++	++

BCMB 442 – HUMAN PHYSIOLOGY**3 Credits**

COURSE OBJECTIVES: *This course aims to introduce the students to the Physiological concepts of homeostasis and control mechanisms and to study the functions of body systems- with emphasis on clinical relevance.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I – Introduction and the Digestive System**9h**

Homeostasis and Internal environment - Neural and hormonal regulation of body functions
Structure and function of the digestive system - Digestive processes in different regions - regulation of gastric secretion and motility- intestinal secretion and motility –Gastrointestinal hormones- Pathophysiology of digestive disorders.

UNIT- II – Cardio physiology**9h**

Functional anatomy of the heart - Electrical activity of the heart- cardiac cycle & cardiac output- heart sound-cardiovascular regulatory mechanisms - basic E.C.G. interpretation (Lead-II)- Pathophysiology of cardiovascular diseases.

UNIT- III – Respiratory physiology**9h**

Functional anatomy of the respiratory tract – Respiratory muscle and their role in breathing
Mechanism of respiration - lung volumes and capacities - gas exchange in the lungs- regulation of respiration- Disorders of respiration.

UNIT- IV – Renal physiology**9h**

Structure and function of kidney and nephron - glomerular filtration - tubular reabsorption and secretion. Urine formation - regulation of renal blood flow - counter current multiplier and exchanger systems - renal role in acid base balance. Renal disorders.

UNIT- V – Nerve and Muscle Physiology**9h**

Nerve physiology - structure and types of neurons- resting membrane potential and ionic basis -action potential - nerve impulse conduction -Synaptic transmission - neurotransmitter and neuromodulators- synaptic plasticity - Neuromuscular junction and synaptic plasticity. Disorders of nerve physiology. Muscle physiology- Types of muscle tissue – Mechanism of muscle contraction - Excitation-contraction coupling - Role of calcium and ATP in muscle contraction -types of muscle contraction- Disorders of nerve and muscle physiology.

Text Books

1. Preston, R.R. and Wilson, T.E. (2024) Lippincott® Illustrated Reviews: Physiology. 3rd Edition. Lippincott Williams & Wilkins, Philadelphia.

2. Barrett, K.E., Barman, S.M., Brooks, H.L., Yuan, J.X-J, (2019) Ganong's Review of Medical Physiology. 26th ed. New York: M

Suggested Reading

1. Hall, John E. (2021). Guyton and Hall textbook of medical physiology, 14th international edition, (14). Philadelphia: Elsevier

COURSE OUTCOME:

CO1: Students will understand the physiological concept of homeostasis and the regulatory mechanisms that maintain internal body balance.

CO2: Students will be able to explain the structure and function of major organ systems with emphasis on clinical relevance.

CO3: Students will be able to interpret physiological functions and clinical parameters to analyse and understand common disorders and diseases.

CO4: Students will be able to apply physiological knowledge to describe key processes such as nerve impulse conduction, gas exchange, urine formation, and muscle contraction.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	+
CO2	+++	++		++
CO3	++	+++	++	++
CO4	+++	++	++	+

BCMB 443 - PLANT BIOCHEMISTRY AND BIOTECHNOLOGY**3 Credits**

COURSE OBJECTIVES: *To learn basic metabolic processes plants in addition to theoretical knowledge of various applications like tissue culture, transgenic crops, and micro propagation.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Introduction to Plant cells**9h**

Photosynthesis: Chloroplast- structure and function, photosynthetic pigments and light harvesting complexes, photo-inhibition of photosynthesis, photosynthetic carbon reduction (PCR) cycle, C4 syndrome and Crassulacean acid metabolism. Oxidative respiration. Alternate electron pathways and Respiration rate.

UNIT- II- Nitrogen metabolism & Plant hormones**9h**

Physical and biological nitrogen fixation - ammonification, nitrification, denitrification. Biochemistry and genetics of nitrogen fixation and ammonium assimilation. Biosynthesis, physiological effects, and mechanism of action of auxins, gibberellic acids, cytokinin, abscisic acid, ethylene, brassinosteroids and polyamines. Photomorphogenesis – phytochrome, cryptochrome and photoperiodism.

UNIT- III - Plant Stress physiology & Secondary metabolites**7h**

Plant stress, plant responses to abiotic and biotic stresses, water deficit and drought resistance, flooding, temperature stress, salt stress, ion toxicity, pollution stress and potential biotic stress (insects and diseases). Functions of all secondary metabolites flavonoids, alkaloids, terpenoids, anthocyanins, tannins, steroids and lignin. Applications of secondary metabolites - drug development, biopesticides and biofertilizers.

UNIT- IV- Introduction to plant tissue culture**8h**

Media composition and preparation. Culture types - callus culture, cell suspension culture, protoplast culture. Somatic embryogenesis, organogenesis, embryo culture and embryo rescue. Micropropagation. Protoplast isolation, protoplast culture and fusion, selection of hybrid cells, cybrids, soma clonal variation. Germplasm storage and cryo- preservation.

UNIT- V- Application of Plant Biotechnology**7h**

Application of transgenesis in crop improvement – insect resistance, disease resistance, virus resistance, herbicide resistance and resistance to abiotic stress. Transgenics - Bt cotton, Bt brinjal and rice.

Text Book:

1. Taiz, L., Zeiger, E., Møller, I.M., & Murphy, A. (2023) – *Plant Physiology and Development* (7th Edition), Sinauer Associates

2. Heldt, H.-W. & Piechulla, B. (2021) – *Plant Biochemistry* (5th Edition), Academic Press
3. Nelson, D.L. and Cox, M.M. (2017) *Lehninger Principles of Biochemistry*, Macmillan Higher Education, Basingstoke.

Suggested Reading:

1. Slater, A., Scott, N.W., & Fowler, M.R. (2008) – *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd Edition), Oxford University Press
2. Reddy, S.M., Reddy, S.R., & Girisham, S. (2017) – *Plant Biotechnology*, Scientific Publishers

COURSE OUTCOME:

CO1: Students will obtain an overview of plant physiology, stress response, tissue culture and biotechnology.

CO2: Students will learn the working principles and procedure of plant tissue culture and biotechnology.

CO3: The student will learn the significance plant physiology, hormones, secondary metabolites, tissues culture and biotechnology.

CO4: Students will be in position to apply these concepts to solve agricultural and environment problems through plant biotechnology.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	+++	+	
CO2	+++	+++	++	
CO3	++	+++	+++	+
CO4		++	+++	++

BCMB 541 - CANCER BIOLOGY**3 Credits****COURSE OBJECTIVES:**

To understand cancer and the complex mechanisms that underlie its development and progression and thus to identify ways to treat the disease.

Pre-requisite: Master's level course in Cell Biology and Molecular Biology.

UNIT-I- Introduction to Cancer**8h**

Growth characteristics of cancer cells. Morphological and ultra structural properties of cancer cells. Types of growth -hyperplasia, dysplasia, anaplasia, and neoplasia. Nomenclature of neoplasms. Differences between benign and malignant tumours. Hallmarks of cancer. Epidemiology of cancer.

UNIT-II- Cancer cell biology and biochemistry**9h**

Aberrant metabolism during cancer development. Warburg effect. Paraneoplastic syndromes. Tumour markers. Cellular proto-oncogenes-oncogenes activation. Growth factors- EGF, TNF- α and TGF- β and growth factor receptors–Signal transduction in cancer –transcription factors- NFAT, NF-kB, SMAD, and STAT in cancer. RAS signalling in cancer.

UNIT-III- Carcinogenesis & Free radicals**9h**

Chemical carcinogenesis- stages in chemical carcinogenesis - Initiation, promotion, and progression. Ames test. Radiation and Viral carcinogenesis - DNA and RNA viruses in human cancer. Free radicals, antioxidants in cancer. Cancer endocrinology.

UNIT-IV - Cancer cell regulation**10h**

Cell Cycle Regulation-Tumour suppressor genes p53, p21, Rb, BRCA1 and BRCA2. Telomeres and Immortality; cell- cell interactions, cell adhesion-invasion and metastasis - VEGF signalling, angiogenesis. Hypoxia; Epigenetics-Role of DNA methylation in gene silencing- epigenetic silencing; Apoptosis in cancer-cell death by apoptosis–role of caspases; Death signalling pathways-mitochondrial and death receptor pathways. Autophagy in cancer.

UNIT-V - Diagnosis and Cancer treatment**9h**

Different types of diagnostic approaches to detect cancer. Strategies of cancer treatment–chemotherapy - gene therapy; Immunotherapy- Immune checkpoint therapy and CAR T-Cell therapy; Radiotherapy and Cancer vaccines. Resistance against anticancer drugs. Nutrition and cancer management. Phytomedicine in cancer. Cancer drug discovery: genomics and proteomics approach. Cancer stem cells.

Text Book:

1. Weinberg, R.A. (2013) The Biology of Cancer, Garland Science, New York.
2. McKinnell, R.G., Parchment, R.E., Perantoni, A.O., Pierce, G.B., Damjanov, I (2006). The Biological Basis of Cancer, Cambridge University Press, Cambridge.

Suggested Reading:

1. Pelengaris, S. and Khan, M. (2013). The Molecular Biology of Cancer. Wiley-Blackwell publication, New Jersey
2. Alison, M.R. (2007). The Cancer Hand Book. Nature Publishing Group.
3. Hanahan, D. and Weinberg, R.A. (2000) "Hallmarks of Cancer". Cell. 100: b57-70. doi:10.1016/s0092-8674(00)81683-9
4. Hanahan, D. and Weinberg R.A. (2011) Hallmarks of Cancer: The Next Generation. Cell.; 144(5):646-674. doi: 10.1016/j.cell.2011.02.013.
5. PDQ Cancer Information Summaries. Bethesda (MD): National Cancer Institute (US); 2002-NCBI Bookshelf ID: NBK82221.

COURSE OUTCOME:

CO1: Students will be able to explain the cellular, molecular, and biochemical basis of cancer initiation and progression.

CO2: Students will have the potency to interpret and analyze oncogenic signalling pathways and the role of key regulatory genes in cancer biology.

CO3: Students will be able to evaluate the mechanisms of carcinogenesis, cancer metabolism, metastasis, and immune evasion.

CO4: Students will have the ability to critically assess modern diagnostic tools and therapeutic strategies including targeted therapies and immunotherapy.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	+
CO2	+++	++	++	++
CO3	+++	++	++	++
CO4	+++	+++	++	++

BCMB 542 - CLINICAL BIOCHEMISTRY**3 Credits**

COURSE OBJECTIVES: *The course focuses on understanding the methodology and interpretation of biochemical tests performed on body fluids and tissues to support diagnosis, treatment, and monitoring disease.*

Pre-requisite: Master Level Course in Metabolism.

UNIT- I - Clinical biochemistry and quality assurance 8h

Clinical biochemistry: concept, definition, and scope; Biological samples: types, collection, processing, stability, and storage; Phlebotomy tubes; Chemical composition of biological fluids: blood, urine and cerebrospinal fluid; Reference range; Quality assurance; Accuracy, precision, and reliability; other factors in quality control Factors. Values in health and diseases.

UNIT- II – Kidney and Liver function test 10h

Kidney function tests: Assessment of renal function, creatinine clearance, GFR measurement. Laboratory investigation of kidney disorders: Acute and chronic renal failure, proteinuria, hematuria, nephrotic and nephritic syndromes. **Liver function tests:** Total protein, albumin/globulin ratio, bilirubin metabolism urobilinogen, bile acids. Jaundice; pre-hepatic, hepatic and post hepatic, plasma changes. Clinically important enzymes- alkaline phosphatase, AST, ALT, creatinine kinase enzymes, Prothrombin Time and Coagulation Markers, Liver Fibrosis and Cirrhosis, Hepatic Encephalopathy

UNIT- III – Disorders of carbohydrate and lipid metabolism 6h

Diabetes mellitus- types, pathophysiology, insulin receptors and resistance, diagnostic tests (C-peptide assay, HbA1c, OGTT, fructosamines, insulin tolerance test). Acute and Chronic Complications of Diabetes- Obesity and Metabolic Syndrome- Lipid and Carbohydrate Metabolism Disorders- Lysosomal Storage Disorders.

UNIT- IV – Prenatal Diagnosis 8h

Prenatal diagnosis of diseases, Amniocentesis, and chorionic villus sampling (CVS). amniotic fluid and foetal blood examination. Acetylcholinesterase and other tests on amniotic fluid. Karyotyping, Chromosomal abnormalities by cytogenetics. Newborn screening: PKU, cystic fibrosis and sweat tests.

UNIT- V – Molecular diagnosis of genetic defects 8h

DNA probes; restriction fragment length polymorphism (RFLP); polymerase chain reaction (PCR); amplification of mRNA. Diagnosis of genetic diseases by molecular biology techniques (cystic fibrosis, Hemochromatosis, thalassemia, sickle cell diseases), Clinical diagnosis of AIDS.

Text Books

1. Marshall, W.J., Bangert, S.K. (2020) Clinical Chemistry. Elsevier.
2. McPherson, R.A., Pincus, M.R. (2022) Henry's Clinical Diagnosis and Management by Laboratory Methods. Elsevier.
3. Vasudevan, D.M., Sreekumari, S., Vaidyanathan, K. (2019). Textbook of Biochemistry for Medical Students (9th ed.). Jaypee Brothers Medical Publishers.

Suggested Reading

1. Hofmann, A., & Clokie, S. (Eds.). (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (8th ed.). Cambridge University Press
2. Singh, S.P. (2019). Textbook of Biochemistry (8th ed.). CBS Publishers

COURSE OUTCOME:

CO1: Student will be able to clinically assess the laboratory indicators of diseases.

CO2: Students will be knowing the biochemical tools needed to accomplish diagnostic and management of diseases.

CO3: Students will be knowing the molecular biology techniques to diagnose hereditary and acquired disorders.

CO4: Students will be able to interpret the biochemical and molecular diagnosis data and report.

	PSO1	PSO2	PSO3	PSO4
CO1	+	+++	++	+
CO2	+	+++	+++	+
CO3		+++	+++	++
CO4		++	+++	+++

BCMB 543 – STEM CELL AND REGENERATIVE BIOLOGY**3 Credits**

COURSE OBJECTIVES: *The course will focus on the biology and mechanism involving stem cells, their applications in replacing, regenerating, and engineering human cells for translational regenerative medicine and ethical issues associated with the same.*

Pre-requisite: Master's level course in Cell Biology.

UNIT- I – Introduction to Stem Cells**6h**

Definition and Criteria for Stem Cells; Pluripotent, Multipotent and Totipotent Stem cells; Primordial germ cells, Embryonic stem cells; Amniotic fluid derived stem cells; Cord blood stem cells.

UNIT- II – Stem Cell Biology and Mechanisms**10h**

Molecular Basis of Pluripotency, Mechanisms of Self Renewal, Role of LIF/JAK/STAT, Nodal/Activin/TGF β , FGF/MAP kinase pathways, Chromatin signature of pluripotent cells, Cell cycle regulators in Stem cells; Stem cell niches, change of phenotype and differentiation, Senescence of Dividing somatic cells, aging and stem cell renewal, Quiescent Stem Cells.

UNIT- III –Tissue and Organ Development**10h**

Differentiation in early development, Potency, Commitment, Polarity and the specification of asymmetric divisions, induction, competence determination and differentiation, morphogenetic gradients, cell fate and cell lineages, Epigenetic silencing, and lineage commitment; Cellular differentiation of the nervous system, Progenitors in adult brain, Epithelial stem cells; Adult progenitor cells, Mesenchymal stem cells, Plasticity; Dedifferentiation, Cancer stem cells.

UNIT- IV – Stem Cell Technology**8h**

Characteristics and characterization of Human Pluripotent Cells; Fluorescence and Magnetic bead assisted cell sorting, Derivation, characterization, and maintenance of Murine and Human Embryonic Stem Cells, Differentiation of embryonic stem cells; Derivation of induced pluripotent stem cells; Derivation and differentiation of Human Embryonic Germ Cells; Genomic Reprogramming, Fate Mapping of Stem Cells.

UNIT- V – Stem Cells in Regenerative Therapeutics**6h**

Neural stem cells in neurodegenerative diseases; Hematopoietic stem cell transplantation; Epithelial stem cells and burns; Stem cells and heart disease; Pancreatic stem cells and diabetes; Liver stem cells and cell therapy for liver disease; Embryonic stem cells in tissue engineering, Organoids. Examples of stem cells in Clinical Trials and translational therapeutics, stem cell banking, Ethical concerns in stem cell research.

Text Books:

1. Celso, C. L., Red-Horse, K., Watt, F.M. Stem Cells: From Biological Principles to Regenerative Medicine (2020), Cold Spring Harbor Laboratory Press; 1st edition
2. Lanza, R. and Atala, A. (2025) Essentials of Stem Cell Biology, Academic Press, California.
3. Clarke, M. and Frampton, J (2020) Stem Cells: Biology and Application, 1st Edition, Garland Science.

Suggested Reading:

1. Slack, J.M.W. (2018) The Science of Stem Cells, Wiley-Blackwell; 1st edition

COURSE OUTCOME:

CO1: The student will develop understanding of stem cell biology and the molecular mechanisms behind their unique characteristics

CO2: The student will appreciate the technical rigor in stem cell isolation, making of iPSCs and their characterization and differentiation to various differentiated phenotype.

CO3: The student will explore the applications of stem cells in translational therapeutics in organ replacements and degenerative diseases.

CO4: The student will be ready for practical exposure to stem cell laboratory for practical training to become capable to join stem cell work force to contribute to healthier society.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	++	++
CO2	++	+++	++	++
CO3	++	++	+++	+++
CO4	++	++	+++	+++

BCMB 544 - CLINICAL RESEARCH AND REGULATIONS**3 Credits**

OBJECTIVES: *This is a job-oriented course which will introduce the basic principles of modern drug design, discovery, and regulations of drug development. The course will impart knowledge on clinical trials management, regulatory affairs, and patent rights.*

Pre-requisite: Master's Level Course in Genetic Engineering.

UNIT- I**8h**

General Introduction to public health, drug design and drug discovery, Sources of drugs – Plants, Microbial and Animal origin, Recombinant therapeutic proteins – Use of transgenic models for therapeutic purpose, Drug delivery systems, pre-clinical drug development strategies.

UNIT- II**6h**

Clinical Trials – Fundamentals of clinical operations, Study design and methodology in clinical trials, Inclusion and Exclusion criteria, Informed Consent process, Clinical Trials Phase- I, II, III, IV; Monitoring treatment outcome and Termination of a trial, Clinical data management, Quality control; Ethical, Legal and Regulatory aspects of clinical trials.

UNIT- III**6h**

Quality Assurance in Clinical studies- Brief Introduction to Pharmacodynamics, Pharmacokinetic (ADME) aspects, Pharmacoepidemiology. **Pharmacovigilance** – Introduction, Importance of safety monitoring, Identification, and reporting of Adverse Drug Reaction (ADR), WHO adverse reaction terminologies and CTCAE guidelines, Risk assessment and management, Pharmacovigilance in India and Global perspective – CDSCO (India), US FDA, EMEA (Europe), Japan and Canada.

UNIT- IV**9h**

Regulatory Affairs - Regulatory aspects for drug product design, Drug and Cosmetics Act, Schedule-Y, Regulatory bodies in India and regulations in developed countries, medical device registration; Preparation, review, and submission of drug master files to regulatory bodies, Final approval procedures. **Patent and Intellectual property rights** – Importance and overview of IPR, The Indian Patents Act, Type of patents, Provisional applications, and Patent infringement.

UNIT- V**7h**

Guidelines: Guides to Good Manufacturing Practice (GMP), Good Laboratory Practice (GLP), Good Clinical Practice (GCP), Central Drugs Standard Control Organization (CDSCO) guidelines, International Council for Harmonization of Technical Requirement for Pharmaceuticals for Human Use (**ICH**) **guidelines** – Quality, Safety, Efficacy and Multidisciplinary guidelines; WHO and FDA guidelines; NABL and NABH.

Text books:

1. Rick, N.G. (2015) Drugs: From Discovery to Approval, Wiley-Blackwell, Singapore.
2. Weinberg, S. (2009) Guidebook for Drug Regulatory Submissions, Wiley publishers, Hoboken, New Jersey.
3. Guarino, R.A. (2009) New Drug Approval Process: Global challenges and Solutions, Informa Healthcare, London.

Suggested Reading:

1. Preston, C.L. (2016) Stockley's drug Interactions, Pharmaceutical Press, London.
2. Kerns E.H. and Li Di. (2008) Drug-like Properties: Concepts, Structure Design and Methods: from ADME to Toxicity Optimization, Elsevier Inc, Academic Press, California.
3. Carson P.A. and Dent N. (2007) Good Clinical, Laboratory and Manufacturing Practices Techniques for the QA Professional, The Royal Society of Chemistry, Cambridge.

COURSE OUTCOME:

CO1: Students will be able to understand the fundamentals of public health, drug discovery, and preclinical development, including modern drug delivery systems and therapeutic use of transgenic models.

CO2: Students will be able to explain the design, phases, and ethical/regulatory framework of clinical trials, and demonstrate knowledge of data management, monitoring, and trial termination processes.

CO3: Students will be able to apply principles of pharmacokinetics, pharmacodynamics, and pharmacovigilance to ensure drug safety and effectiveness, and interpret adverse drug reaction (ADR) reporting mechanisms globally and in India.

CO4: Students will be able to evaluate national and international regulatory frameworks, including IPR, GMP, GLP, GCP, and guidelines from CDSCO, ICH, WHO, and FDA for pharmaceutical product development and approval.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+++	++
CO2	+++	++	++	+++
CO3	++	+++	+++	+++
CO4	++	+	+	+++

BCMB 545 - DEVELOPMENTAL BIOLOGY AND AGEING**3 Credits**

COURSE OBJECTIVES: *The course offers a detailed understanding of the intricacies of developmental biology and how each step of development, patterning and ageing process takes place and how it is regulated at the molecular and cellular level.*

Course Prerequisite: Master Level Course in Cell Biology and Molecular Biology.

UNIT – I – Introduction to Developmental Biology 9h

Basic concepts of development: Levels of commitment – differentiation, maturation, specification, determination, induction, competence, and imprinting. Morphogenetic gradients and their role in positional information, cell fate determination, and pattern formation. Stem cell biology – definition, characteristics, types of potency (totipotent, pluripotent, multipotent, unipotent), embryonic and adult stem cells, and induced pluripotent stem cells (iPSCs). Environmental & evolutionary influences – teratogens, evolutionary developmental biology.

UNIT - II– Early embryonic development 8h

Gametogenesis and fertilization – oogenesis, spermatogenesis, acrosome reaction, zona pellucida interactions, polyspermy prevention. Pre-implantation development – cleavage patterns, blastula formation, embryonic genome activation. Gastrulation – germ layer formation, fate mapping, signaling pathways. Neurulation – neural tube formation, neural crest differentiation and migration.

UNIT-III– Cell- cell communication and signalling in development 8h

Cell to cell communication and its mechanisms (Autocrine, paracrine, juxtacrine signalling). Role of Extracellular Matrix (ECM) in Development, Epithelial-mesenchymal interactions. Major developmental signalling pathways - FGF-RTK pathway, JAK-STAT, Hedgehog family, Wnt family, TGF- β superfamily and Notch pathway.

UNIT -IV– Model organisms, organogenesis, and Sex determination 9h

C. elegans- Cell lineage, mosaic development, apoptosis. *Drosophila*- axis and pattern formation, morphogen gradients, segmentation, HOX genes. Amphibians – Spemann organizer, neural induction. Organogenesis – ectoderm (vertebrate eye lens induction, neural crest derivatives), mesoderm (limb development, heart morphogenesis), endoderm (pancreatic and liver development). Sex determination – mammalian SRY pathway, *Drosophila* sex-lethal (Sxl) gene, dosage compensation (X-inactivation), environmental sex determination mechanisms.

UNIT - V– Postembryonic development and ageing 10h

Metamorphosis in amphibians – hormonal and molecular regulation. Regeneration – epimorphosis, morphallaxis, compensatory regeneration; salamander limb and liver regeneration as examples. Cellular ageing – replicative and chronological ageing, key

mechanisms (senescence, oxidative stress, autophagy), ageing markers (p16, p21, SA- β -gal), telomere–telomerase regulation, and major ageing theories. Regulation of ageing – genetic, epigenetic, and nutrient influences, programmed cell death. Age-related diseases – progeroid syndromes, neurodegenerative (Alzheimer’s, Parkinson’s), and metabolic disorders (diabetes, obesity). Anti-ageing approaches – stem cell-based and regenerative therapies.

Text Books:

1. Gilbert, S. F., & Barresi, M. J. F. (2023). Developmental Biology (13th ed.). Oxford University Press.
2. Slack, J.M.W. (2021). Essential Developmental Biology (3rd ed.). Wiley-Blackwell

Suggested reading:

1. Wolpert, L., Tickle, C., Arias, A.M. (2019). Principles of Development (6th ed.). Oxford University Press.
2. Carlson, B.M. (2019). Human Embryology and Developmental Biology (6th ed.). Elsevier.

COURSE OUTCOME:

CO1: Students will be able to understand the core concepts of developmental biology including stem cells, differentiation, and environmental influences on development.

CO2: Students will explain key stages of early embryonic development and body axis formation.

CO3: Students will be able to describe major cell signalling pathways and mechanisms of cell communication in development.

CO4: Students will be able to analyze model organism studies, organogenesis, sex determination, and ageing processes, including regeneration and related diseases.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	+
CO2	++	++	+	+
CO3	+++	++	++	+
CO4	++	+++	++	++

BCMB 546 – NEUROBIOLOGY**3 Credits**

COURSE OBJECTIVES: *The course focuses on the basic concepts Neurobiology and observing the interdisciplinary nature of the Neurosciences will encourage participation from students majoring in Physics, Chemistry, Psychology and Computer Science alongside the students of the School of Life Sciences.*

Pre-requisite: Bachelor's level course in Basic Biology.

UNIT I – Introduction to the Nervous System**9h**

Gross organization of the brain and spinal cord; central and peripheral nervous system; major sensory systems including vision, hearing, balance, smell, taste, touch, and pain; structure of neurons, ion channels, action potentials, synaptic transmission; glial cell types including astrocytes, oligodendrocytes, Schwann cells, and microglia, and neural representation of perception, movement, and cognition.

UNIT II – Development of the Nervous System**7h**

Neural induction and patterning; developmental signalling pathways including Shh, TGF- β , Wnt, and Notch; generation and differentiation of neurons and glia; synapse maturation and neural plasticity; regenerative capacity of CNS and PNS, and the role of neural stem cells in repair.

UNIT III – Neurotransmitters and Neural Communication**10h**

Neurotransmitter synthesis, storage, release, receptor activation and inactivation; major neurotransmitter systems including glutamate, GABA, glycine, acetylcholine, monoamines (dopamine, serotonin, norepinephrine, histamine), endocannabinoids and retrograde signalling; neuropeptides including endogenous opioids and their receptors.

UNIT IV – Brain and Neuroethology**7h**

Development of behaviors; neuroethology of natural behaviours including navigation, communication, predator avoidance, foraging, courtship, examples- echolocation, bird song, electric fish communication, insect navigation; social behaviours including dominance, mating systems, parental care; biological rhythms including circadian cycles and sleep; neural mechanisms of learning, memory, emotion, stress, and adaptation.

UNIT V – Neurodegeneration and Neurochemical Disorders**7h**

Ageing brain and major disorders including Alzheimer's disease, Parkinson's disease, ALS, epilepsy, autism spectrum conditions, multiple sclerosis; neurochemical disorders including anxiety, depression, bipolar disorder, schizophrenia, psychosis; basic pharmacology of antipsychotics, antidepressants, anxiolytics, and addictive substances.

Text Books

1. Brady, S.T., Siegel, G. J., Albers, R.W., Price, D.L. (2012) Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology. Academic Press, Cambridge.
2. Augustine, G.J., Groh, J.M., Huettel, S.A., LaMantia, A.S., White, L.E., Purves, D. (2023) Neuroscience, Oxford University Press, Oxford.

Suggested Reading

1. Hall, J.E. and Guyton, C. (2015) Textbook of Medical Physiology. 13th edition by Saunders, Elsevier Inc., Philadelphia.
2. Preston, R.R. and Wilson, T.E. (2024) Lippincott® Illustrated Reviews: Physiology. 3rd Edition Lippincott Williams & Wilkins, Philadelphia.
3. Barrett, K.E., Barman, S.M., Brooks, H.L., Yuan, J.X-J, (2019) Ganong's Review of Medical Physiology. 26th ed. New York: McGraw-Hill Education; 2019. Barrett, K.E., Barman, S.M., Brooks, H.L., Boitano, S. (2012) Ganong's Review of Medical Physiology. McGraw-Hill Medical, New York.
4. Crossman, A.R. and Neary, D. (2014) Neuroanatomy. Churchill Livingstone, London.

COURSE OUTCOME:

CO1: The student will develop understanding of anatomical organization of the central and peripheral nervous system and its development.

CO2: The student will be able to appreciate how communication in neural circuits leads to sensory perceptions, movement, behaviour, learning and memory.

CO3: The student will be able to evaluate how the failure in the cellular processes lead to neurodegenerative diseases and neurocognitive dysfunctions.

CO4: The student will be able to contribute towards the creation of novel therapeutics against neurological disorders and join the expanding neuroscience workforce towards a healthier society.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	++	++
CO2	++	+++	++	++
CO3	++	++	+++	+++
CO4	++	++	+++	+++

BCMB 547 - INDUSTRIAL CONVERGENCE IN LIFE SCIENCES**2 Credits****COURSE OBJECTIVES:**

- *Skill development geared towards trained manpower for employment & entrepreneurship*
- *Understand the present trends in life science industry*
- *Familiarization to role of microbiome & awareness*
- *Responsibility towards environment & climate change*
- *Initiate curiosity in entrepreneurship.*

Course Pre-requisite: Master's Level Course in Genetic Engineering.**UNIT-I-Introduction to bio foundries & bio factories****6h**

Introduction to synthetic biology. Production of artemisinin as case study. Building the new bio-economy. Introduction to Bio foundries & circuits. Role of automation and robotics in bio factories; use of plants for engineering biologics & small molecules. Biosurfactants as an example of microbial cell factory-based production.

UNIT-II- Contemporary techniques in industry**5h**

Gene shuffling for large scale pathway assembly and engineering; Choices for microbial hosts for industrial applications– bacteria, yeast, insect. Gene editing methods – CRISPR/ Cas; Gene sequencing – Pyro-sequencing, Nanopore sequencing.

UNIT-III-Microbiome Communities**5h**

Definition & role of microbiome on human health and wellbeing; Role of 16s rRNA based identification – metagenomics approaches for microbiome analysis; Human Microbiome project; Antimicrobial resistance and superbugs – methods to counter; specific case studies on its influence (positive & negative) on plants (soil microbiome), animals (poultry – minimize use of antibiotics) and aquaculture (viruses). Rapid responses to counter bio-terrorism.

UNIT-IV- Conservation Biology & Climate Change**5h**

Impact of climate change, Community response and Government policies, Ecological footprint, Clean Development Mechanism (CDM); Earth summit, Kyoto protocol, Framework convention on Climate change (UNFCCC); Genetic methods for conservation biology; Assessment of carbon and water footprint on processes. Biodiversity act & agencies regulating it (National & State biodiversity authorities). Potential biological methods to counter plastic & e-wastes.

UNIT-V-Introduction to Entrepreneurship in life sciences**5h**

Need for entrepreneurship in life-sciences, Types of life-science companies in India (biopharma, bio Agri, bioinformatics, bio services, biocatalysts, bio industrial) and their

growth; New startups & bio-medical device companies; Types of bio-incubators (Bioparks, Bioclusters, BioNests); Bio industry associations – BIO, ABLE, AIBA; Funding avenues in India for entrepreneurship development – Government initiatives (DBT - BIRAC), philanthropic (Gates, Wellcome, DNDi) & private funding; Types of companies and steps in company formation; Steps in compiling business plans. Introduction to regulatory agencies– DGCI, CIB, NBA, GEAC, FSSAI, CDSCO, ISO.

Text Books:

1. Clark, D. and Pazdernik, N. (2015) Biotechnology, Academic Cell Press, Cambridge.
2. De Martinis, D. et al., (2017) Engineering the plant factory to produce biologics and small molecule medicines, Edited by Frontiers Research topics.
3. Sharma, D. and Saharan, B.S. (2018) Microbial Cell Factories, CRC Press, Boca Raton, Florida.
4. Braman, J.C. (2018) Synthetic biology – methods and protocols, Humana Press, New York.
5. Kauffman, C.M. (2015) Our Changing Climate: Introduction to Climate Science, American Meteorological Society.
6. Sodhi, N.S. and Ehrlich, P.R. (2010) Conservation Biology for All, Oxford University Press, Oxford.
7. Douglas, A.E. (2018) Fundamentals of Microbiome Science: How Microbes Shape Animal Biology, Princeton University Press, Princeton.
8. Ivaturi, V.K., Ganesh, M., Mittal, A., Subramanya, S., Sadagopan (2017) The Manual for Indian Start-ups: Tools to Start and Scale-up your new venture, Penguin Random House India.
9. The Staff of Entrepreneur Media (2015) Start Your Own Business: The Only Startup Book You'll Ever Need, Entrepreneur Press.

Suggested Reading:

1. Gene editing
 - i. <https://www.neb.com/tools-and-resources/feature-articles/crispr-cas9-and-targeted-genome-editing-a-new-era-in-molecular-biology>
 - ii. <https://www.addgene.org/crispr/guide/> Pyro sequencing: <http://www.archivesofpathology.org/doi/pdf/10.5858/arpa.2012-0463-RA>
3. Nanopore sequencing: <https://nanoporetech.com/resource-centre/introduction-nanopore-sequencing>
4. Bio Foundry: <http://cnpg.comparenetworks.com/347117-A-Biofoundry-for-Next-Generation-Synthetic-Biology/>
5. Industrialization of Biology: A Roadmap to accelerate the Advanced manufacturing of chemicals, National Academy of Sciences, 2015.
6. Biotech Industry survey: <https://www.ibef.org/download/Biotechnology-March-2017>.
7. CII report on biotech startups in India, 2017.
8. BIRAC annual report, 2017.

COURSE OUTCOME:

CO1: Students will be able to understand the principles and applications of synthetic biology and bio-manufacturing systems in life sciences.

CO2: Students will have the ability to apply modern gene editing and sequencing techniques in industrial and research contexts.

CO3: Students will learn to assess the impact of microbiomes on ecosystems and health, including responses to microbial threats.

CO4: Students will be able to evaluate environmental sustainability strategies and the entrepreneurial ecosystem in life sciences.

	PSO1	PSO2	PSO3	PSO4
CO1	++	++	+	+++
CO2	+++	+++	++	++
CO3	++	++	+++	++
CO4	++	++	++	+++

BCMB 548 - NANOBIO TECHNOLOGY**3 Credits**

COURSE OBJECTIVES: *The aim of this course is to provide basic knowledge about applications of nanoscience in the field of Biotechnology and Medicine.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT-I-Introduction**9h**

Overview of Nanomaterials and nanoparticles in biological applications; Biomimetic nanostructures; Overview of DNA and protein-based nanostructures; Inorganic nanoparticles; Applications of nanotechnology in bio separations, enzymatic reactions, and tissue/cell culture.

UNIT- II- Biological synthesis and characterization of nanomaterials**9h**

Biosynthesis- microbial, plant mediated synthesis. biofunctionalization of nano surfaces with peptides and proteins. Bacteriorhodopsin: structure and its potential applications in nanobiotechnology; S-layers: structure and its applications; Cell-nanomaterial interactions; Monitoring nano-bio interactions: Cell targeting and cell penetrating peptides Atomic Force Microscopy.

UNIT -III -Implications of Nanobiotechnology**6h**

Nanotoxicity: Absorption and distribution of Nanoparticles *in vivo*; Toxicological effects of nanoparticles in various target organs *in vivo*.

UNIT- IV -Nanostructures for Analytics**8h**

Nanoparticles for electro biochemical assays; Quantum dots in biology; Nanoparticle based bio-sensors; Protein nanoarrays; DNA nanoarrays; Lab-on-a-chip; Microfluidics: Definition and history, Advantages of microfluidic devices and their potential for nanobiotechnology.

UNIT- V -Nanoparticles for Diagnostic and Therapeutic**13h**

Introduction to drug delivery; Drug delivery systems based on nanotechnology: PLGA, lipid-based nanoparticles, nanocrystals; Nanocarriers for applications in medicine; siRNA delivery using nanoparticles; Targeted drug delivery using nanocarriers; Nanoparticle contrast agents for magnetic resonance imaging; Nanodiamonds for bioimaging and therapeutic applications; Nanotherapeutics.

Text Books:

1. Auclair, C., Boisseau, P., Houdy, P., Lahmani, M. (2009) Nanoscience Nanobiotechnology and Nanobiology. Springer-Verlag Berlin Heidelberg.
2. Niemeyer, C.M. and Mirkin, C.A. (2004). Nanobiotechnology: Concepts, Applications and Perspectives. Wiley-VCH, Weinheim, Germany.

Suggested Reading:

1. Niemeyer, C.M. and Mirkin CA. (2007). Nanobiotechnology II: More Concepts and Applications. Wiley-VCH, Weinheim, Germany.

COURSE OUTCOME:

CO1: Student will have the proficiency to understand the foundational principles and biological applications of nanomaterials and nanostructures.

CO2: Students will be able to demonstrate knowledge of biological synthesis, functionalization, and characterization of nanomaterials for biomedical use.

CO3: Students will gain the ability to evaluate the interactions, potential toxicological impacts, and safety concerns of nanomaterials in biological systems.

CO4: Students will analyse the use of nanoscale tools and devices in diagnostics, analytics, and therapeutic delivery systems.

	PSO1	PSO2	PSO3	PSO4
CO1	+++	++	+	++
CO2	++	+++	++	++
CO3	++	++	+++	++
CO4	++	+++	++	+++

BCMB 580 – SEMINAR PRESENTATION**1 Credit**

COURSE OBJECTIVES: *To enable the students to, perform review of literature, reading a research article, identify a research problem and presenting the findings of the paper. To use research papers to plan a study to answer the research problem using experimental techniques.*

Course Pre-requisite: Master Level Course on Biostatistics and Scientific Writing.

Course Plan

This course will have the following components

1. Performing Review of Literature.
2. Reading research articles.
3. Understanding how to write a research article and how to interpret the findings of a research article.
4. Presentation the scientific work using a research article.

COURSE OUTCOMES:

CO1: *The students will be capable of doing a focused literature review.*

CO2: *The students will be able to understand how to read and interpret the research findings of a research paper and write a research article.*

CO3: *The students will be able to differentiate a good research article from bad research article.*

CO4: *The students will develop the skill of effectively presenting research data.*

	PSO1	PSO2	PSO3	PSO4
CO1	+	++	++	+
CO2	+	++	+++	+
CO3		+++	+++	++
CO4		++	+++	+++

BCMB 581 - DISSERTATION**4 Credits****COURSE OBJECTIVES:**

To enable the students to have hands-on research experience and write a comprehensive report, present, and defend the same.

Course Pre-requisite: BCMB 548: Pre-Project and Presentation

Course Plan

This course will have the following components

1. Executing the proposed Research Plan.
2. Designing and planning experiments.
3. Performing experiments or *in silico* studies based on the criteria.
4. Writing a Comprehensive Research Report.
5. Presentation and defence of the Dissertation.

COURSE OUTCOME:

CO1: *The students will learn to identify a research question, design hypothesis-based objectives and execute a Research Project.*

CO2: *The student will learn to apply the knowledge and techniques that they have learned.*

CO3: *The students will be able to write a Project Report and scientific documents.*

CO4: *The students will be able to prepare, present, and defend their research outcomes.*

	PSO1	PSO2	PSO3	PSO4
CO1		+	+++	+++
CO2		++	+++	+
CO3		++	+++	++
CO4		+	+++	+++