Syllabus

Five-Year Integrated M.Sc. Major in Biological Sciences

Cochin University of Science and Technology (CUSAT)

w.e.f. June 2024

Program Outcomes: Integrated M.Sc.

PO1: Demonstrate a comprehensive understanding of fundamental principles and concepts in basic sciences.

PO2: Analyse, evaluate, and synthesize complex scientific information and data using appropriate methods and techniques.

PO3: Apply scientific reasoning and critical thinking adeptly to recognize, assess, and resolve problems encountered in various scientific contexts.

PO4: Utilize computational power, programming languages, and modern technologies proficiently to address scientific challenges, effectively integrating technological solutions into problem-solving processes.

PO5: Communicate scientific information effectively and demonstrate proficiency in the use of modern scientific tools and technologies for experimentation, data collection, analysis, and interpretation.

PO6: Adhere to ethical principles and practices in the conduct of scientific research and professional activities, and work collaboratively with others.

PO7: Engage in lifelong learning and professional development to enhance the knowledge and skills in basic sciences.

Program-Specific Outcomes (PSOs)

After the successful completion of the Biology program, the students are expected to

PSO1. Demonstrate an in-depth understanding of fundamental principles that underlie the field of Biology (Animal Science, Plant Science, Microbiology, Biochemistry, Molecular and Cell Biology, Genetics and Genetic Engineering, Immunology, Biotechnology, Computational Biology and Research Methodology).

PSO2. Implement the concept of science and technology to foster the traditional and modern techniques for solving the complex problems in any branches of biology.

PSO3.Show proficiency in performing various basic and advanced laboratory techniques employed in Biology in academia and industries.

PSO4. Design and conduct biological experiments, analyse and interpret experimental data and perform troubleshooting if necessary.

PSO5. Identify a research problem using literature survey, formulate hypothesis, develop a research plan, execute the research plan, write the project report and communicate effectively through written, oral and visual methods.

PSO6. Develop analytical thinking and problem-solving abilities, enabling them to gain skilful jobs in industries and research labs.

PSO7. Develop high thinking and entrepreneurship skills of various ventures in Biology using plant /animal/microbial resources, biological techniques and marketing of bioproducts.

PSO8. Communicate effectively, work in teams and lead in academic and non-academic institutions.

Integrated MSc Biological Sciences Scheme (2024 Admission onwards)

Semester	Number of courses offered by the department						
	Major 4 credits	**Minor 4 credits**	**MDC 3 credits**	**AEC 3 credits**	**SEC 3 credits**	**VAC 3 credits**	**Total credits**
I	1	2	1	2*			21
II	1	2	1	2*			21
III	1	2	1			2*	21
IV	4				1	1*	22
V	5				1		23
VI	5 Courses. Instead of one course with 4 credits, a student may do one/two online courses to acquire 4 credits				1		23
		Internship**					2
Total credits/courses	68 (17) DSC 60 (15) DSE 08 (04)	24 (6)	9 (3)	12 (4)	9 (3)	9 (3)	133
*Courses offered by the Centre for Integrated Studies, CUSAT **Not counted as a course Exit with BSc in Biological Sciences (Total credits = 133)							
VII	5 Courses + seminar/open ended labs/online course (2 credits)						22

VIII	2 Courses + seminar/open ended labs/online (2 credits) + Project (12 credits) Or 4 Major Courses + Mini project (4 credits) + seminar/open ended labs/online course (2 credits)						22
Total credits/courses	Hon. (Research): 112 (26 + Project) Hon. : 112 (28 + Mini Project)	24 (6)	9 (3)	12 (4)	9 (3)	9 (3)	177
Exit with BSc (Honours with Research) in Biological Sciences (Total credits = 177) Exit with BSc (Honours) in Biological Sciences (Total credits = 177)							
IX	5 Courses + online (2 credit**)						20-24
X	Major project + online (2 credit**)						20-24
Total credits	156	24 (6)	9 (3)	12 (4)	9 (3)	9 (3)	221
** Instead of taking two online courses worth 2 credits each, a student can opt for one online course worth 4 credits in the ninth/tenth semester. In such cases, the credits earned in that semester will be 24, and in the other semester, they will be 20. Exit with MSc in Biological Sciences (Total credits = 221)							

MDC: Multi-Disciplinary Courses
AEC: Ability Enhancement Courses
SEC: Skill enhancement Courses
VAC: Value Added Courses

Academic pathways offered by the Department of Biotechnology

Biological Sciences- Major:

3-year UG Program: To earn a Major in Biological Sciences, a 3-year UG Program, a student must complete a minimum of 68 credits in Biological Sciences, out of which 60 credits shall be from DSC courses and 8 credits from DSE courses.

4-year UG Program (Honours): To earn a Biological Sciences Major in a 4-year UG Program (Honours), a student must complete a minimum of 112 credits in Biological Sciences, out of which 96 credits shall be from DSC courses and 16 credits from DSE courses.

4-year UG Program (Honours with Research): To earn a Biological Sciences Major in a 4-year UG Program (Honours with Research), a student must complete a minimum of 112 credits in Biological Sciences, out of which 92 credits shall be from DSC courses and 8 credits from DSE courses and 12 credits from a research project.

Biological Sciences Minor:

3-year UG Program: To earn a Minor in Biological Sciences in a 3-year UG Program, a student must complete a minimum of 27 credits in Biological Sciences, out of which 24 credits shall be from DSC courses and 03 credits from an SEC elective.

4-year UG Program: To earn a Minor in Biological Sciences in a 4-year UG Program, a student must complete a minimum of 35 credits in Biological Sciences, out of which 24 credits shall be from DSC courses and 3 credits from an SEC elective 8 credits from DSE courses.

Discipline mention in Biological Sciences:

To earn a Discipline mention in Biological Sciences in a UG Program (3 or 4 years), a student must complete a minimum of 12 credits in Biological Sciences from DSC courses.

Structure and Scheme of the Course

SEMESTER I

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	ESE	Total	Credit
24-811-0101	Fundamentals of Life	100	Biological Sciences Major -DSC, Biological Sciences Minor-DSC, Biological Sciences Disci-DSE	3-0-2	50	50	100	4
24-811-0102	Introduction to Animal & Plant Biology	100	Biological Sciences Minor-DSC, Biological Sciences Disci-DSE	4-0-0	50	50	100	4
24-811- 0103	Mysteries of Biology	100	MDC	3-0-0	50	50	100	3
Semester credits	**21 (AEC:6; MDC:3; MAJOR PATHWAY: 4; MINOR PATHWAY: 8)**							**Cumulative credits- 21**

L: Lecture, T: Tutorial, P: Practicum

Biological Sciences Major-DSC: Core course for students Majoring in Biological Sciences.

Biological Sciences Minor-DSC: Core course for students Minoring in Biological Sciences.

Biological Sciences Disc-DSC: Core course for students who choose discipline mention in Biological Sciences.

Biological Sciences -MDC: Multidisciplinary elective course offered to students whose Major or Minor pathways are different from Biological Sciences.

AEC: Ability Enhancement Course (Languages).

MDC: Multidisciplinary Course

CE: Continuous Evaluation

ESE: End Semester Examination

SEMESTER II

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	ESE	Total	Credit
24-811-0201	Biomolecules	100	Biological Sciences Major - DSC, Biological Sciences Minor- DSC, Biological Sciences Disci- DSE	3-0-2	50	50	100	4
24-811-0202	General Microbiology	100	Biological Sciences Minor- DSC, Biological Sciences Disci- DSE	4-0-0	50	50	100	4
24-811-0203	Biophysical Chemistry	100	MDC	3-0-0	50	50	100	3
Semester credits	**21 (AEC:6; MDC:3; MAJOR PATHWAY: 4; MINOR PATHWAY: 8)**							**Cumulative credits- 42**

SEMESTER III

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	ESE	Total	Credit
24-811-0301	Genetics & Molecular Biology	200	Biological Sciences Major - DSC, Biological Sciences Minor- DSC, Biological Sciences Disci- DSE	3-0-2	50	50	100	4
24-811-0302	Ecology & Environmental Sciences	200	Biological Sciences Minor- DSC, Biological Sciences Disci- DSE	4-0-0	50	50	100	4
24-811-0303	Human Diseases & Healthcare management	200	MDC	3-0-0	50	50	100	3
Semester credits	**21 (VAC:6; MDC:3; MAJOR PATHWAY: 4; MINOR PATHWAY: 8)**							**Cumulative credits- 63**

SEMESTER IV

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	ESE	Total	Credit
24-811-0401	Introduction to Biotechnology	200	Biological Sciences Major -DSC	4-0-0	50	50	100	4
24-811-0402	Basic principles of metabolism	200	Biological Sciences Major -DSC	4-0-0	50	50	100	4
24-811-0403	Essential Cell Biology	200	Biological Sciences Major -DSC	4-0-0	50	50	100	4
24-811-0404	Cell Biology & Metabolism Lab	200	Biological Sciences Major -DSC	0-0-8	100	-	100	4
24-811-0405	Scientific Writing and Communication in Biology	200	Biological Sciences Major SEC, Biological Sciences Minor-DSC	3-0-0	50	50	100	3
Semester credits	**22 (VAC:3; SEC:3; MAJOR PATHWAY: 16)**							**Cumulative credits- 85**

SEMESTER V

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	ESE	Total	Credit
24-811- 0501	Plant Diversity-I	300	Biological Sciences Major -DSC	4-0-0	50	50	100	4
24-811- 0502	Plant Diversity-II	300	Biological Sciences -DSC	4-0-0	50	50	100	4
24-811- 0503	Non-chordates	300	Biological Sciences Major -DSC	4-0-0	50	50	100	4
24-811- 0504	Chordates	300	Biological Sciences Major -DSC	4-0-0	50	50	100	4
24-811- 0505	Animal & Plant Lab	300	Biological Sciences Major -DSC	0-0-8	100	-	100	4
24-811- 0506	Introduction to Cell culture techniques	200	Biological Sciences Major -SEC, Biological Sciences Minor-DSC	3-0-0	50	50	100	3
Semester credits	**23 (SEC:3; MAJOR PATHWAY: 20)**							**Cumulative credits- 108**

SEMESTER VI

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	**ESE**	**Total**	**Credit**
24-811- 0601	Evolution & Developmental Biology	300	Biological Sciences Major -DSC	4-0-0	50	50	100	4
24-811- 0602	Parasitology & Immunology	300	Biological Sciences -DSC	4-0-0	50	50	100	4
24-811- 0603	Parasitology & Immunology Lab	300	Biological Sciences Major -DSC	0-0-8	100	-	100	4
24-811-060X	Elective I	300	Biological Sciences Major -DSE Biological Sciences Minor -DSC Biological Sciences Disci-DSC	4-0-0	50	50	100	4
24-811-060X	Elective II	300	Biological Sciences Major -DSE Biological Sciences Minor -DSC Biological Sciences Disci-DSC	4-0-0	50	50	100	4
24-811-0604	Basics skills of Computational Biology	200	Biological Sciences Major -SEC, Biological Sciences Minor-DSC	3-0-0	50	50	100	3
24-811-0605	Internship*							2
Semester credits		**23 (SEC:3; MAJOR PATHWAY: 20)**						**Cumulative credits-133**

List of Electives I

24-811-0605 Plant Physiology and Biochemistry
24-811-0606 Economic Botany
24-811-0607 Medicinal Botany

List of Electives II

24-811-0608 Human Physiology and Endocrinology
24-811-0609 Economic Zoology
24-811-0610 Animal Forms and Functions

Internship

Students have to complete an internship of 2 credits (60 Hours of work) before the beginning of Semester VII
*internship should be pre-acquired in the 5th Semester
Exit with 3-year UG Degree OR continue to the 4th year.

Semester VII

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	ESE	Total	Credit
24-811-0701	Biochemistry	300	Biological Sciences Major -DSC/ Biological Sciences Minor- DSE	4-0-0	50	50	100	4
24-811-0702	Cell Signalling and Communication	400	Biological Sciences -DSC	4-0-0	50	50	100	4
24-811-0703	Advanced Microbiology	400	Biological Sciences Major -DSC	4-0-0	100	-	100	4
24-811-0704	Molecular Biology	400	Biological Sciences Major -DSC	4-0-0	50	50	100	4
24-811-0705	Advanced Biology Lab	400	Biological Sciences Major -DSC	0-0-8	50	50	100	4
24-811-0706	Open-ended Lab	400	Biological Sciences Major -SEC	0-0-4	100	-	100	2
Semester credits	**22 (Major Pathway: 22)**							**Cumulative credits- 155**

SEMESTER VIII
HONS WITH RESEARCH

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	ESE	Total	Credit
24-811-0801	MOOC1	300	Biological Sciences Major/Minor -DSE	4-0-0	-	100	100	4
24-811-0802	MOOC2	400	Biological Sciences Major -DSE	4-0-0	-	100	100	4
24-811-0803	Project	400	Biological Sciences Major -DSC	0-0-24	200	200	400	12
24-811-0804	Review Writing and Seminar	400	Biological Sciences Major -DSC	0-2-0	100	-	100	2
Semester credits	**22 (Major Pathway: 22)**							**Cumulative credits- 177**

SEMESTER VIII
HONS

Course Code	Course Name	Level	The course can be taken towards obtaining credits for:	L-T-P	Marks Distribution			
					CE	**ESE**	**Total**	**Credit**
24-811-0801	Cellular Metabolism	300	Biological Sciences Major -DSC/ Biological Sciences Minor- DSE	3-0-2	50	50	100	4
24-811-0802	Biostatistics & Bioinformatics	400	Biological Sciences Major -DSC	3-0-2	50	50	100	4
24-811-0803	Mini Project	400	Biological Sciences Major -DSC	0-0-8	100	-	100	4
24-811-080X	Elective III	400	Biological Sciences Major -DSE Biological Sciences Minor -DSC Biological Sciences Disci-DSC	4-0-0	50	50	100	4
24-811-080X	Elective IV	400	Biological Sciences Major -DSE Biological Sciences Minor -DSC Biological Sciences Disci-DSC	4-0-0	50	50	100	4
24-811-0804	Critical Analysis of Classical Papers	400	Biological Sciences Major -DSC, Biological Sciences Minor DSC	2-0-0	100	-	100	2
Semester credits	**22 (Major Pathway: 22)**							**Cumulative credits- 177**

List of Electives III

24-811-0805- Analytical Techniques
24-811-0806- Cancer Biology
24-811-0807- Neurobiology

List of Electives IV

24-811-0808- Plant Microbe Interactions
24-811-0809-Biofuels and Bioenergy
24-811-0810- Bioprocessing Methods and Techniques

Exit with 4-year UG Degree OR continue to the 5th year.

SEMESTER IX

Course Code	Course Name	Level	The course can be taken towards obtaining credits for	L-T-P	Marks Distribution			
					CE	ESE	Total	Credit
24-811-0901	Immunology	500	Biological Sciences Major - DSC	4-0-0	50	50	100	4
24-811-0902	Genetic Engineering	500	Biological Sciences Major - DSC	4-0-0	50	50	100	4
24-811-090X	Elective V	500	Biological Sciences Major - DSE Biological Sciences Minor - DSC Biological Sciences Disci-DSC	4-0-0	50	50	100	4
24-811-090X	Elective VI	500	Biological Sciences Major - DSE Biological Sciences Minor - DSC Biological Sciences Disci-DSC	4-0-0	50	50	100	4
24-811-0903	Immunology & Genetic Engineering lab	500	Biological Sciences Major - DSC	0-0-8	100	-	100	4
24-811-0904	Online course	500	Biological Sciences Major - DSC, Biological Sciences Minor-DSC	2-0-0 OR 4-0-0	-	100	100	2 or 4
Semester credits	**20-24 (Core: 12; Elective 10)**							**Cumulative credits-199**

List of Electives V

24-811-0905- NGS and Data Analysis
24-811-0906- Environmental Microbiology
24-811-0907- Microbiome
24-811-0908- Molecular Virology

List of Electives VI

24-811-0909- Environmental Biotechnology
24-811-0910- Plant Biotechnology
24-811-0911- Stem Cell and Regenerative Medicine
24-811-0912- Biopharmaceuticals
24-811-0913- Gene Silencing and Genome Editing

SEMESTER X

Course Code	Course Name	Level	The course can be taken towards obtaining credits for	L-T-P	Marks Distribution			
					CE	**ESE**	**Total**	**Credit**
24-811-1001	Major Project	600	Biological Sciences Major-DSC	0-0-40	600	-	600	20
24-811-1002	Online course** (if taken in IX for 4C then No need to take here)	500	Biological Sciences Major-DSE	2-0-0	-	100	100	2
Semester credits	**20-24 (Core: 20; Elective:2)**							**Cumulative credits-221**

**Instead of taking the online course worth 2 credits, a student has the option to select one online course worth 4 credits in the ninth/tenth semester. In such cases, the credits earned in that semester will total 24. Consequently, they won't need to enroll in the MOOC course in the other semester, and the maximum credits for that semester will be 20.

SEMESTER I

24-811-0101. FUNDAMENTALS OF LIFE (4C; 3L+0T+2P) (Academic Level 100)

Course description: The course covers the studies of living creatures, from the tiny and simple through to the complexities of plants and animals, ending with a basic understanding of ecology and the study of population dynamism. Different scopes of biology will also be conveyed to the students.

Course outcomes: After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain the biological processes common to life	Understand
C.O. 2: Compare fundamental differences in the forms and how they may differ	Analyse
C.O. 3: Comprehend and explain how present-day organisms may have arisen	Understand
C.O. 4: Interpret how different life forms, including humans, interact with each other and with the physical, chemical and biological world around them.	Analyse
C.O. 5: Use the knowledge gained through scopes of biology for higher studies and furthering careers in biology.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	-	2	-				
CO2	2	-	-	-				
CO3	3	-	-	-		2		
CO4	2	-	2	-				
CO5	2	-	-	-			1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to cell: Cell theory, Cell and its components: nucleus, mitochondria, chloroplast, Golgi apparatus, ribosomes, vacuoles; types of cells, the concept of tissues

MODULE II: Biomolecules of life: Water as a biological solvent, carbohydrate, nucleic acid, amino acids, proteins, lipids, enzymes, vitamins, and minerals.

MODULE III: Biodiversity: concept, values and types of biodiversity. Analysing and documenting biodiversity. Maintenance of ecological diversity, Biodiversity hotspots in India.

MODULE IV: Ecology and Conservation: Concepts and elements of Biotic and Abiotic environment; Interaction between biotic and abiotic environment; Ecosystem- concept and components, Community-structure and dynamics; Biome- grassland, tundra, forest, deserts, salt

& freshwater ecosystem; Biodiversity and Conservation; Impact of climate change on biodiversity.

MODULE V: Principles of Developmental Biology & Evolution: Basic concepts in developmental biology regarding plants and animals, and their biological significance Introduction to evolution: History, Types, Theories, and evidence of Evolution.

Suggested Practical

1. Familiarizing with microscopes and their application.
2. Microscopic examination and identification of unicellular and multicellular life forms: Monerans: Euglena, Paramecium, Amoebae, Chlamydomonas, Chlorella, Diatoms.
3. Microscopic observation of bacteria and fungi
4. Volvox as a model of evolution- (Cellular level- single cell to the multicellular organization)

REFERENCES

1. Reece, J. B., & Campbell, N. A. (2011). Campbell Biology. Boston, Benjamin Cummings / Pearson.
2. Manuel C Molles, Ecology: Concepts and Applications McGraw Hill 7th Edition 2014
3. Douglas J Futuyma, Evolution Oxford University Press 3rd Edition 2013
4. Barton et al., Evolution Cold Spring Harbor Laboratory Press 1st Edition 2007
5. Stephen C. Stearns and Rolf F. Hoekstra, Evolution: An Introduction Oxford University Press 1st Edition 2000
6. Nicholas J. Gotelli, A primer of Ecology Oxford University Press, 4th Edition 20086. Begon et al., Ecology: From Individuals to Ecosystem Wiley-Blackwell, 4th Edition 2005
7. Instant notes on ecology by A. Mackenzie, A.S. Ball, S.R. Virdee, 2nd edition- 2020

24-811-0102 INTRODUCTION TO ANIMAL & PLANT BIOLOGY (4C; 4L+0T+0P) (Academic Level 100)

Course description: This course provides a foundation for understanding the fundamental principles of life focusing on plants and animals. Through lectures, discussions, and laboratory exercises, we will explore the diversity, structure, function, and inter-dependence of these two kingdoms within the biological world.

Course Outcomes: After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understand the vast diversity of plants and animals	Understand
C.O. 2: Comprehend the basic structure and function of animal plant cells and reproduction	Understand
C.O. 3: Comprehend the basic structure and function of animal cells and tissues	Understand
C.O. 4: Understand the basic concepts of nutrition	Understand

C.O.5: Analyse the inter-relationships between plants and animals within ecosystems.	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2							
CO3	2							
CO4	2							
CO5	2					2		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I-Introduction: Characteristics of life, The scientific method and biological inquiry, Classification of living organisms (including major plant and animal groups)

MODULE II- Plant cell structure and function (including photosynthesis); Plant tissues, organs, and organ systems, Transport in plants (water and nutrients), Plant reproduction (sexual and asexual)

MODULE III- Animal structure and function: Animal cell structure and function, Animal tissues, organs, and organ systems (digestive, respiratory, circulatory, excretory, nervous, endocrine, reproductive), Animal movement and behaviour, Sensory reception

MODULE IV- Nutrition and Gas Exchange: Autotrophs vs. heterotrophs, Types of nutrition in plants and animals, Digestion and absorption in animals, Respiration in plants and animals

MODULE V- Interdependence and the Environment: Symbiotic relationships between plants and animals, Importance of plants and animals in ecosystems, Threats to biodiversity and conservation efforts

REFERENCES

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3. Agarwal, V. K. (2022). Zoology for Degree Students (For B.Sc. Hons. 4th Semester, As per CBCS). India: S Chand & Company Limited.
4. Campbell, P. N. (2013). The Structure and Function of Animal Cell Components: An Introductory Text. United Kingdom: Elsevier Science.
5. Yadav, P. R. (2006). Biotechnology of Animal Tissues. India: Discovery Publishing House Pvt. Limited.
6. Schulze, E., Beck, E., Müller-Hohenstein, K. (2005). Plant ecology. Germany: Springer.
7. Jain, V. K. (2000). Fundamental Of Plant Physiology. India: S. Chand Limited.
8. Animal Physiology. (2000). India: S. Chand, Limited.

24-811-0103 MYSTERIES OF BIOLOGY (3C; 3L+0T+0P) (Academic Level 100)

Course Description:
This course delves into captivating and intriguing aspects of the biological sciences, exploring fascinating phenomena, extraordinary adaptations, and curious behaviours exhibited by organisms across various taxa. Through a combination of lectures, discussions, readings, and hands-on activities, students will develop a deeper appreciation for the wonders of the natural world and gain insight into the scientific processes that unravel its mysteries.

Course Outcomes: After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explore the captivating topics in biology that ignite curiosity and inspire further study.	Apply
C.O. 2: Develop critical thinking skills through the analysis of complex biological phenomena.	Analyse
C.O. 3: Appreciate the diversity of life and the interconnectedness of biological systems.	Analyse
C.O. 4: Develop independent inquiry and research interest in fascinating biological topics.	Analyse
C.O. 5: Apply the knowledge gained for higher studies and furthering careering in biology and biological research.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2							2	
CO3	2							
CO4	2				1			
CO5	2						1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Module I- Introduction to Fascinations of Biology-Overview of the course objectives and structure**;** Importance of curiosity and wonder in biological sciences**;** Bioluminescence: Mechanisms and ecological significance of bioluminescence**;** Case studies of bioluminescent organisms

Module II- Extreme Environments- Adaptations of extremophiles to extreme conditions; Exploration of extreme environments on Earth and beyond; Cryptic Coloration and Mimicry: Camouflage, cryptic coloration, and mimicry in the animal kingdom; Examples of mimicry in insects, amphibians, and other organisms

Module III- Behavioural Ecology: Evolutionary drivers of animal behaviour; Case studies of complex behaviours in various species; Plant Communication: Signalling and communication mechanisms in plants; Inter-plant communication and defence strategies; **Unusual Reproductive Strategies**: Unique reproductive strategies in plants and animals; Ecological and evolutionary implications of different reproductive strategies

Module IV- Genetic Engineering and Synthetic Biology: Applications and ethical considerations of genetic engineering; Cutting-edge developments in synthetic biology

Neuroscience Mysteries: Fascinating phenomena in neuroscience; Current research and theories addressing neuroscientific mysteries

Module V- Evolutionary Arms Race: Coevolutionary interactions between species; Evolutionary adaptations driven by competition and conflict; Biodiversity Hotspots: Importance of biodiversity hotspots for conservation; Threats to biodiversity and efforts to preserve it; **Emerging Infectious Diseases**: Impact of emerging infectious diseases on human health and ecosystems; Factors contributing to disease emergence and spread

REFERENCES

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2. Yadav, P. R. (2006). Biotechnology of Animal Tissues. India: Discovery Publishing House Pvt. Limited.
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4. Jain, V. K. (2000). Fundamental Of Plant Physiology. India: S. Chand Limited.
5. Animal Physiology. (2000). India: S. Chand, Limited.
6. Smith and Smith (2014) Ecology 9th edition. Pearson Education
7. Desmond S. T. Nicholl (2023) An Introduction to Genetic Engineering

SEMESTER II

SEMESTER II

24-811-0201- BIOMOLECULES (4C; 3L+0T+2P) (Academic Level 100)

Course description: The program is designed to enable a student to acquire sound knowledge of biochemistry and its practical applicability. The course will encourage the students to join the industry or to prepare them for higher studies including research. The syllabus is based on a basic and applied approach to ensure that students develop problem-solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe the significance of biomolecules	Understand
C.O. 2: Differentiate the biomolecules (proteins, lipids, nucleic acids, and carbohydrates) based on their structural basis	Analyse
C.O. 3: Quantify various biomolecules.	Analyse
C.O. 4: Employ chromatographic techniques to separate various biomolecules.	Apply
C.O. 5: Apply proper procedures and regulations in handling and disposal of chemicals.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	2	1					
CO3	2	2	2					
CO4	2	2	1	1				
CO5	2		1	1				

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: A brief history of biochemistry, Basic chemistry- Elements, Functional groups, pH, Mole concept, Bonding and chirality, non-covalent interactions, Water, interactions in aqueous systems, Molarity, normality, Ionization state of biomolecules, Laws of thermodynamics, Gibbs free energy, and maintenance of equilibrium.

MODULE II: Carbohydrates: Structure, chemical & biological properties and functions. Monosaccharides- Ribose, Glucose and fructose. Oligosaccharides -Sucrose, maltose, lactose, Polysaccharides- Glycogen, cellulose and starch. Glycoproteins, proteoglycans and glycolipids. Hetero-polysaccharides, Carbohydrates as informational molecules- the sugar code.

MODULE III: Nucleic Acids: Nucleotides, Nucleic Acid composition, a historical perspective leading up to the proposition of DNA double-helical structure; the difference

in RNA and DNA structure and their importance in the evolution of DNA as the genetic material. Lipids & Fats: Storage lipids, Structural lipids in membranes, Lipoproteins. Lipids as signals, cofactors and pigment, biological functions of lipids. Vitamins and Minerals: General accounts and biological functions.

MODULE IV: Proteins: structural and functional group properties; pH and properties of amino acids, Peptides and covalent structure of proteins; peptide bond, polypeptide, protein structure- secondary, tertiary and quaternary, protein structure & function, Enzymes as Biological Catalysts: General principles of enzyme catalysis, Activation energy and stereospecificity, classification of enzymes; Types of enzymes and their specific functions. Enzyme characterization and Michaelis–Menten kinetics, Regulation and Inhibition of enzyme.

MODULE V: Methods in Biophysical and Biochemical Analysis: Buffers, pH meter, Calorimetry, Spectrophotometry, Centrifugation techniques, Mass spectrometry, Chromatographic techniques, Electrophoretic Techniques.

Suggested practical

1. Preparation of Normal and Molar solutions
2. Preparation of Buffers (Acidic, Neutral and Alkaline Buffers)
3. Verification of Beer Lambert's law
4. Estimation of biomolecules (glucose, protein, lipids and nucleic acid).
5. Separation of biomolecules using paper and TLC
6. Electrophoretic Techniques

REFERENCES

1. Rodney F Boyer, Concepts in Biochemistry. John Wiley & Sons; 3rd Ed (2 December 2005).
2. Thomas Millar, Biochemistry Explained: A Practical Guide to Learning Biochemistry CRC Press; 1 edition (30 May 2002)
3. Lubert Stryer et al., Biochemistry, W. H. Freeman; 6th Edition (14 July 2006)
4. David L Nelson, and Michael M Cox et al., Lehninger principles of biochemistry WH Freeman; 7th ed.2017 edition (1 January 2017)
5. Lehninger. Principles of Biochemistry, Macmillan, U.K.
6. Geoffrey Zubay. Biochemistry. Macmillan Publishing company, New York
7. Sadasivam and Manickam. Biochemical Methods. New Age International Publishers. NewDelhi.
8. David T. Plummer, An Introduction to Practical Biochemistry. Tata McGraw Hill.
9. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). Lehninger principles of biochemistry. Macmillan
10. Tymoczko, J. L., Berg, J. M., &Stryer, L. (2011). Biochemistry: a short course. Macmillan.
11. Voet, D., & Voet, J. G. (2016). Fundamentals of Biochemistry. 5th Edition. Wiley & Sons.

24-811-0202- GENERAL MICROBIOLOGY (4C; 4L+0T+0P) (Academic Level 100)

Course Description:

General Microbiology is an introductory course that explores the fundamental principles of microbiology, focusing on the morphology, physiology, genetics, ecology, and pathogenesis of microorganisms. Students will examine the diversity of microorganisms, including bacteria, viruses, fungi, and protozoa, and their roles in various environments, human health, and biotechnology. Laboratory exercises will complement theoretical concepts, providing hands-on experience in microbiological techniques and experimentation.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1 Understand the basic characteristics and classification of microorganisms and to explore the structure and function of microbial cells	Understand
C.O. 2: Examine microbial growth and metabolism	Analyse
C.O. 3: Investigate the genetics and molecular biology of microorganisms.	Analyse
C.O. 4: Analyse the interactions between microorganisms and their environments and to study the role of microorganisms in human health and disease.	Apply
C.O. 5: To develop proficiency in microbiological techniques and laboratory skills.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	2	1					
CO3	2	2			1			
CO4	2	1	1	1				
CO5	2	1	2	1	1			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I Introduction to Microbiology- Definition and scope of microbiology; Historical perspectives; Microbial diversity and classification. **Microbial Cell Structure and Function-** Prokaryotic and eukaryotic cell structure; Cell wall composition and function; Membrane structure and transport mechanisms; Microbial motility and appendages

MODULE II Microbial Growth and Metabolism-Growth requirements and factors affecting growth; Nutritional categories and metabolic pathways; Energy production and ATP synthesis; Microbial fermentation and respiration. **Microbial Genetics**- DNA structure and replication; Gene expression and regulation; Mutation and genetic variation; Horizontal gene transfer

MODULE III Microbial Ecology- Microbial interactions and symbiosis**;** Biogeochemical cycles and microbial roles**;** Microbial communities and ecosystems. **Environmental Microbiology**- Microbial adaptation to extreme environments; Bioremediation and microbial degradation; Microbial contributions to agriculture and industry

MODULE IV Microorganisms and Human Health- Host-microbe interactions**;** Infectious diseases and epidemiology; Immunology and host defence mechanisms**;** Microbial pathogenesis and virulence factors

MODULE V. **Microbiological Techniques**- Aseptic techniques and culture methods; Microscopic examination of microorganisms; Biochemical tests for microbial identification; Molecular techniques and genetic analysis

Suggested Practical

1. Sterile technique and media preparation
2. Microbial isolation and staining techniques
3. Microbial growth kinetics and quantification
4. Identification of unknown microorganisms
5. Molecular biology techniques (PCR, gel electrophoresis, etc.)

REFERENCES

1. Prescott's Microbiology, 10th Edition Authors: Joanne Willey, Linda Sherwood and Christopher J. Woolverton, 2016
2. Microbiology: An Introduction, 13th Edition Authors: Gerard J. Tortora, Berdell R. Funke and Christine L. Case, 2018
3. Microbiology Fundamentals: A Clinical Approach (3rd Edition) Marjorie Kelly Cowan, Heidi Smith, Jennifer Lusk, 2019
4. Ananthanarayan and Paniker's Textbook of Microbiology, (12th Edition) 2022

24-811-0203- BIOPHYSICAL CHEMISTRY (3C; 3L+0T+0P) (Academic Level 100)

Course Description: This course aims to provide an overview of some of the fundamentals of biophysics and biochemistry. The course will discuss advanced topics with an emphasis on structure, function relationships and techniques for probing the structure and dynamics of biological systems.

Course Outcome (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe the basic units in biological science	Understand
C.O.2: Discuss the laws of Thermodynamics and biomolecular interactions	Understand
C.O.3: Discuss the biomolecular kinetics and protein chemistry	Understand
C.O. 4: Differentiate the different types of microscopes and their working principles and elucidate different chromatographic techniques.	Analyse
C.O.5: Elucidate the mechanisms of various separation techniques in spectroscopy and their applications	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8

CO1	3							
CO2	2	2						
CO3	2	1						
CO4	2	1	1					
CO5	2	1	1					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Introduction to Biophysical Chemistry- Definition and scope of biophysical chemistry**;** Interdisciplinary nature of the field**;** Historical development and key concepts. Introduction to measurements, SI units-standard units for measurement, Basic units, Derived units-volume; Mole concept; Hydrogen ion concentration. -pH. Determination of pH. Dissociation of weak acids (pKa), Buffers of blood plasma, red blood cells and tissue fluids.

MODULE II- Thermodynamics of Biomolecular Systems- Laws of thermodynamics and their application to biological systems; Thermodynamic properties of biomolecules; Gibbs free energy and its role in biochemical reactions. **Biomolecular Interactions-** Properties of covalent molecules- bond length, energy and bond angle. Hydrogen bond, inter-and intra-bio-molecular interactions.

MODULE III- Kinetics of Biomolecular Reactions-Rate laws and reaction mechanisms**;** Enzyme kinetics and catalysis**;** Transition state theory and reaction mechanisms. **Protein Folding and Stability**- Protein folding pathways and energy landscapes; Factors influencing protein stability; Chaperones and protein folding diseases

MODULE IV- Basics of microscopy: principle, working, types (light, electron microscopy) and application of microscopy in life science research; Separation techniques: **Chromatography**- basic principles, types and application; Centrifuge- Basic principle, types and applications.

MODULE V- Electrophoresis- Basic principle, types and applications; Biopolymers-Classification. polymerization process. **Spectroscopy**: Basic principles, Beer-Lamberts law, types and applications, X-ray crystallography and NMR spectroscopy, Radioisotopes-applications in life science

REFERENCE

1. Rodney F Boyer, Concepts in Biochemistry. John Wiley & Sons; 3rd Ed (2 December 2005)
2. Single Molecule Biology. (2009). Netherlands: Elsevier Science
3. McMurry, J. (2013). Fundamentals of General, Organic, and Biological Chemistry. United Kingdom: Pearson.
4. Springer Handbook of Microscopy. (2019). Germany: Springer International Publishing.
5. Roberson, R. W., Chandler, D. E. (2009). Bioimaging: current concepts in light and electron microscopy. United Kingdom: Jones and Bartlett Publishers.
6. Gel Electrophoresis. (1964). United States: Academy.
7. Pavia, D. L., Vyvyan, J. A., Lampman, G. M., Kriz, G. S. (2014). Introduction to Spectroscopy. United States: Cengage Learning.

SEMESTER III

SEMESTER III

24-811-0301- GENETICS AND MOLECULAR BIOLOGY (4C; 3L+0T+2P) (Academic Level 200)

Course Description: This course aims to provide an overview of genetics starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutations. The course will help in building sound fundamental knowledge of the principles of genetics, to be used as a stepping stone for higher studies and research in this field. The course also aims to provide students with an introduction of the underlying molecular mechanisms of various biological processes in cells and organisms. The study primarily involves learning about the structure and synthesis of deoxyribose and ribose nucleic acids, the formation of proteins, and the regulation of gene expression. The course aims to develop a basic understanding of molecular biology techniques and their applications.

Course Outcomes: After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe the basic principles of inheritance with examples	Understand
C.O.2: Predict the inheritance pattern of heredity based on classical genetics and gene interaction analysis	Analyse
C.O. 3: Differentiate the basic structures of DNA and RNA Discuss the DNA replication machinery in prokaryotes and eukaryotes.	Understand
C.O. 4: Explain the mechanism of the flow of genetic information in prokaryotes and eukaryotes	Analyse
C.O.5: Discuss and apply the knowledge of gene regulation in Molecular biology studies in lab	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1	1					
CO3	2	1	1	1	1			
CO4	2			1	1			
CO5	2	1	1	1	1			1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I-Mendelian Genetics- Mendelian principles, the concept of traits & alleles, monohybrid and dihybrid crosses, back cross and test cross and Mendel's success, Modified Mendelian ratios; Incomplete dominance, Recessive and Dominant epistasis, Complementary genes, Duplicate gene, Duplicate dominant genes and Inhibitory factor. Multiple Alleles-General accounts. ABO blood group in man. Rh factor. Quantitative characters- quantitative inheritance, polygenic inheritance, cytoplasmic inheritance.

MODULE II -Linkage and crossing over- Linkage and its importance, linkage and independent assortment. Complete and incomplete linkage. Crossing over – a general account, two-point and three-point test crosses. Determination of gene sequence. Interference and coincidence. Mapping of chromosomes (recombination mapping) and complementation

analysis. Conjugation, transduction and transformation. Sex determination- Sex chromosomes, the chromosomal basis of sex determination in Drosophila and humans. Pedigree analysis.

MODULE III- Introduction: history, development and scope of molecular biology. DNA as the genetic material, Griffith's experiment, Avery, Mac Leod and Mc Carty, experiment, Hershey & Chase's experiment. Structure of nucleic acids - Watson - Crick model of DNA, DNA replication in prokaryotes and eukaryotes. Semi-conservative method. Replication machinery and mechanism, enzymes involved in DNA replication. Arrangement of DNA in a chromosome- Nucleosome structure. Modification and repair of DNA. Different types of DNA and RNA.

MODULE IV- Gene Expression: One gene-one enzyme hypothesis, one gene-one polypeptide hypothesis, central dogma hypothesis, colinearity of genes and gene products. RNA: structure & types, Genetic code - features and wobble hypothesis. Contributions of Nirenberg and his associates, Khorana and his associates. Transcription of RNAs and post-transcriptional modifications & reverse transcription and PCR. Translation and post-translational modification of proteins

MODULE V- Gene regulation in prokaryotes; operon concept - Lac operon and Trp operon. Regulation of eukaryotic gene expression. Level of control of gene expression, transcriptional factors, regulation of RNA processing, mRNA translation, mRNA degradation & protein degradation control, epigenetics.

Suggested Practical

Genetics

1. Monohybrid cross and Dihybrid cross using Pea plant & Drosophila.
2. Gene interactions
3. Barr body staining from cheek cells
4. Preparation of human karyotype and study of chromosomal aberrations with respect to number, translocation, deletion, etc. from the pictures provided.

Molecular Biology

1. Genomic DNA isolation
2. PCR amplification of DNA (Demo)
3. Electrophoretic separation of Nucleic Acid/Proteins
4. Scoring of bands on RAPD Agarose gel
5. Use of restriction enzymes- Single and double digestion

REFERENCES

1. Alberts, B., Johnson, A., Walter, P., Lewis, J., Raff, M., & Roberts, K. (2008). Molecular cell biology. New York: Garland Science.
2. Lodish, H., Berk, A., Darnell, J. E., Kaiser, C. A., Krieger, M., Scott, M. P. & Matsudaira, P. (2008). Molecular cell biology. Macmillan.
3. Lewin, B., Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2014). Lewin's Genes XI. Jones & Bartlett Publishers.
5. Hardin, J., Bertoni, G. P., & Kleinsmith, L. J. (2017). Becker's World of the Cell. Pearson Higher Ed.
6. Baker, T. A., Watson, J. D., & Bell, S. P. (2003). Molecular biology of the gene. Benjamin-Cummings Publishing Company.

24-811-0302 ECOLOGY AND ENVIRONMENTAL SCIENCES (4C; 4L+0T+0P) (Academic Level 200)

Course description: This course explores the interconnectedness of living organisms with their environment and the challenges we face in maintaining a healthy planet. Through lectures, discussions, labs, and field trips the students will have a classic experience on the various concepts of ecology and environmental science.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understanding the basic concepts of ecology and evolution	Understand
C.O. 2: Evaluate the basic components of the ecosystem	Analyse
C.O. 3: Understanding the concepts of population	Understand
C.O. 4: Analyse human impacts on the environment, including pollution, climate change, and habitat loss	Analyse
C.O. 5: Understanding the fundamentals of environmental policies and legislation	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2							
CO3	2							
CO4	2			2			1	
CO5	2				2		1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Introduction to Ecology and Environmental Science: The science of ecology and environmental science: history, key concepts, and interdisciplinary nature. Levels of ecological organization: populations, communities, ecosystems, biomes, the biosphere. Environmental ethics and sustainability principles.

MODULE II- Abiotic and biotic components of ecosystems, Energy flow through ecosystems: trophic levels, food webs, energy pyramids. Biogeochemical cycles: carbon, nitrogen, phosphorus, water. Ecological succession: primary and secondary succession.

MODULE III- Population characteristics: density, dispersion, growth patterns, Population regulation: density-dependent and density-independent factors. Life history strategies: r- and K-selection. Human population growth and its ecological consequences.

MODULE IV- Environmental pollution: types, sources, and impacts (air, water, soil), Climate change: causes, consequences, and mitigation strategies, Habitat loss and biodiversity decline, Impacts of Environmental pollution, Resource depletion and sustainable use practices.

MODULE V- Environmental policy and legislation, Renewable energy sources and energy conservation, Sustainable resource management practices, Individual actions and collective responsibility for environmental protection.

REFERENCES

1. Townsend, C. R., Begon, M., & Harper, J. L. (2008). *Essentials of ecology* (No. Ed. 3). Blackwell publishing.
2. Begon, M., Howarth, R. W., & Townsend, C. R. (2014). *Essentials of ecology*. John Wiley & Sons.
3. Rana, S. V. S. (2009). Essentials of Ecology and Environmental Science. India: Prentice-Hall Of India Pvt. Limited.
4. Hadjibiros, K. (2013). Ecology and Applied Environmental Science. United Kingdom: CRC Press.
5. Yadav, P. R., Mishra, S. R. (2004). Environmental Ecology. India: Discovery Publishing House.
6. Ecology, Environmental Science & Conservation. (2014). India: S. Chand Pvt. Limited.

24-811-0303- HUMAN DISEASES AND HEALTH CARE MANAGEMENT (3C; 3L+0T+0P) (Academic Level 200)

Course Description: This course will introduce the basic knowledge of various aspects of human diseases and the healthcare industry. It also aims to understand various factors that contribute to the occurrence of diseases and how those diseases may be treated by clinical professionals.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
C.O. 1: Demonstrate a basic understanding of the mechanism of diseases, diagnosis and treatment	Understand
C.O. 2: Discuss the understanding of the pathophysiology	Understand
C.O. 3: Demonstrate the knowledge of various diseases affecting the organs	Understand
C.O.4: Discuss the importance of genetic disorders and their possible cures	Apply
C.O.5: Discuss the various aspects of public health policy and health care management	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	2						
CO2	2	1						
CO3	2	2			1			
CO4	2	1			1		1	
CO5					1		1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Epidemiology and Infectious Diseases. Overview of epidemiology, epidemiology tools, history of diseases, quantifying disease in a population, comparing disease rate, outbreaks of disease, epidemiological aspects of infections and chronic diseases of national importance.

MODULE II- Basics of Pathophysiology. Introduction to the basics of pathophysiology, altered cellular and tissue biology, cellular adaptation, atrophy, hypertrophy, hyperplasia, dysplasia, metaplasia, cell injury, immunological & inflammatory injury, manifestations of cellular injury, cell death: apoptosis, necrosis, and autophagy.

MODULE III- Pathophysiology of Organ Dysfunction and Disorders. Diseases of the nervous system, Diseases of the endocrine system, Diseases of the cardiovascular system, Diseases of the reproductive system and sexually transmitted diseases.

MODULE IV- Genetic Disorders: General introduction to human genetics and various genetic disorders, autosomal and X-linked disorders, gene mutation and chromosomal abnormalities, inborn errors of metabolism, pedigree analysis, introduction to cytogenetics and its applications.

MODULE V- Public Health Policy and Health care Management: Overview of public health policy, an overview of WHO and global health policies, an overview of Indian public health policies, Health Care Management Overview of public health care management in India and other countries.

REFERENCES

1. Pathophysiology of Disease: An Introduction to Clinical Medicine 8E. (2018). United Kingdom: McGraw-Hill Education.
2. Marya, R. K. (2006). Pathophysiology. India: CBS Publishers & Distributors.
3. Wright, A., Hastie, N. (2007). Genes and Common Diseases: Genetics in Modern Medicine. United Kingdom: Cambridge University Press.
4. Thompson, E. A. (1986). Pedigree Analysis in Human Genetics. United Kingdom: Johns Hopkins University Press.
5. Pal, G. P. (2009). Medical Genetics. India: A.I.T.B.S. Publishers.
6. Agarwal, V. K. (2009). Genetics. India: S. Chand Limited.
7. Introduction to Health Care Management. (2016). United States: Jones & Bartlett Learning.

SEMESTER IV

SEMESTER IV

24-811-0401- INTRODUCTION TO BIOTECHNOLOGY (4C; 4L+0T+0P) (Academic Level 200)

Course Description: This course is designed to give students both a theoretic background and a working knowledge of instrumentation and techniques employed in a biotechnology lab. Emphasis will be placed on the introduction of foreign DNA into bacterial cells as well as the analysis of nucleic acids and proteins.

Course Outcome (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain the different frontiers in Biotechnology	Understand
C.O. 2: Explain the mechanisms of molecular cloning	Understand
C.O. 3: Discuss various transformation techniques and generation of genetically modified organisms	Apply
C.O. 4: Elucidate the mechanism of data mining and data processing	Apply
C.O.5: : Learn and apply the knowledge of IPR and patenting in Biotechnology	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							2
CO2	1	1	1	1				
CO3	2	2	1	1				
CO4	2			1	1			
CO5	2				1		1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Introduction-Major areas of Biotechnology, revolutionary discoveries and their applications: blue biotechnology (marine) White biotechnology (industry), yellow biotechnology (food production), grey biotechnology (bioremediation and environmental improvement), brown biotechnology (desert), gold biotechnology (bioinformatics, nanotechnology and computer science), violet biotechnology (legal, ethical and philosophical issues), dark biotechnology (bioweapons and warfare).

MODULE II- Molecular techniques in gene manipulation: Restriction enzymes, cloning vectors and expression vectors, steps involved in cloning, transformation techniques. Cloning and expression vectors. Restriction enzymes- nomenclature, types and mechanisms.

MODULE III- Transformation techniques- gene gun, calcium chloride method and electroporation. Genomic and cDNA library construction and their applications **Genetically modified organisms**: Applications and status, Production of genetically modified plants and animals with examples. Selection of transgenics using various techniques

MODULE IV- General bioinformatics: Different types of file formats, biological data, and databases- general classification. Text-based and sequence-based search engines, Sequence alignment techniques. Introduction to different operating systems.

MODULE V- Intellectual property rights: Introduction, commercialisation, patent laws, copyrights, royalty, plagiarisms, citations, acknowledgements. Geographical indications, protection of plant varieties.

REFERENCES

1. Basic Biotechnology. (2006). United Kingdom: Cambridge University Press.
2. Dubey, R. C. (1993). A Textbook of Biotechnology. India: S. Chand Limited.
3. Loroch, V., Renneberg, R. (2016). Biotechnology for Beginners. Germany: Elsevier Science.
4. Pazdernik, N., Clark, D. P. (2012). Molecular Biology. Netherlands: Elsevier Science.
5. Ploegh, H., Amon, A., Berk, A., Kaiser, C. A., Bretscher, A., Krieger, M., Lodish, H., Martin, K. C. (2016). Molecular Cell Biology. United Kingdom: W. H. Freeman.
6. Parashar, S., Goel, D. (2013). IPR, Biosafety and Bioethics. India: Pearson Education India.
7. The Role of Intellectual Property Rights in Agriculture and Allied Sciences. (2018). Canada: Apple Academic Press.
8. Xiong, J. (2006). Essential bioinformatics. Spain: Cambridge University Press.
9. Dubey, R. C. (2014). Advanced Biotechnology. India: S. Chand Limited.

24-811-0402- BASIC PRINCIPLES OF METABOLISM (4C; 4L+0T+0P) (Academic Level 200)

Course Description: This course will provide a basic understanding of metabolism by studying its major pathways, regulation, and molecular components. It will cover the various aspects of metabolism and biochemistry. This course is designed to teach students with basics of the metabolism of various biomolecules.

Course Outcome (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain the different aspects of thermodynamics and bioenergetics and explain why ATP is the energy currency of the cell	Apply
C.O. 2: Explain the mechanisms of metabolism of carbohydrates	Understand
C.O. 3: Explain the mechanisms of metabolism of lipids	Understand
C.O. 4: Explain the mechanisms of metabolism of amino acids	Understand
C.O.5: Explain the mechanisms of metabolism of nucleic acids	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	1						
CO2	2					1		
CO3	2					1		
CO4	2					1		
CO5	2					1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Overview of thermodynamics and bioenergetics: ATP as energy molecules, Role of mitochondria in ATP synthesis, other important high energy compounds and their significance; Laws of thermodynamics, Oxidation-reduction reactions.

MODULE II- Carbohydrate metabolism: Carbohydrate metabolism and energetics: glycolysis, gluconeogenesis and TCA cycle and their significance

MODULE III- Lipid metabolism: Lipid metabolism overview and their significance. Biosynthesis of lipid and beta-oxidation and their relevance

MODULE IV- Amino acid metabolism: Amino acid biosynthesis and catabolism and their significance, Urea cycle and its significance.

MODULE V- Nucleic acid metabolism: Biosynthesis (*de novo* and salvage pathways) and catabolism of nucleic acids and their significance

REFERENCES

1. Nelson, D. L., Cox, M. (2017). Lehninger Principles of Biochemistry: International Edition. United Kingdom: Macmillan Learning.
2. Rodwell, V. W., Weil, P. A., Kennelly, P. J., Bender, D., Botham, K. M. (2018). Harper's Illustrated Biochemistry Thirty-First Edition. United States: McGraw Hill LLC.
3. Voet, D., Voet, J. G. (2021). Biochemistry. Singapore: John Wiley & Sons, Limited.
4. Holtzhauer, M. (2006). Basic methods for the biochemical lab. Germany: Springer.
5. Satyanarayana, U. (2017). Biochemistry - E-book. India: Elsevier Health Sciences.

24-811-0403- ESSENTIAL CELL BIOLOGY (4C; 4L+0T+0P) (Academic Level 200)

Course description: The objective of the course is to help the students to learn and develop an understanding of a cell as a basic unit of life. This course is designed to enable them to understand the functions of cellular organelles and how a cell carries out and regulates cellular functions. The course will also provide an overview of classical and modern cell biology-based techniques.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain the fundamental principles of cell biology.	Understand
C.O. 2: Identify and differentiate the cellular organelles using microscopy.	Analyse
C.O. 3: Identify and differentiate plant, animal and microbial cells based on morphological features and size.	Analyse
C.O. 4: Describe the process of cell signalling and its role in cellular functions	Understand
C.O. 5: Discuss various techniques in cell biology and list the advances made in the field of cell biology and their applications.	Remember

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	2	2					
CO3	2	2	2	2				
CO4	2	1						
CO5	2	1	1					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- History, development and scope of cell biology; discovery of cells; cell theory and its modern version. Cell and its components: basic types of cells- prokaryotic and eukaryotic, nature and comparison. Ultra-structural organization and functions: Plasma membrane- ultrastructure- fluid mosaic model, functions of the plasma membrane.

MODULE II - Cellular Organelles and their functions: Mitochondria, Endoplasmic reticulum, Golgi bodies, Lysosomes, Microbodies, Ribosomes, Proteasomes, Centrioles, Cytoskeleton, Nucleus-nuclear envelope and Nucleolus, chromosomes, Nucleoproteins, Nucleosome model of DNA organization, structural and numerical variations of chromosomes, Polytene, Lamp brush and B chromosomes.

MODULE III- Histology-Animal histology: Tissues: Epithelial tissue; types, characteristics and functions, Blood, Bone, Cartilage and Adipose tissues, Muscle tissue; Cellular and molecular mechanism of muscle contraction, Nervous tissue. Plant histology- Plant tissues; meristematic & permanent (simple complex tissues), tissue systems.

MODULE IV-Overview of cell signalling, communication between cells, plasma membrane and nuclear receptors; hormones; ion channels; secondary messengers; Cell Division: cell cycle- G1, S, G2, and M phases, amitosis. Mitosis & Meiosis; Cell cycle and Regulation, cancer cells, and cell death.

MODULE V- Cell Biology Techniques: **Cell Isolation** (plants and Animals), Microscopy and Micrometry: Fixed and live-cell imaging, Radioisotopes, Fluorescent Probes/Dyes as tools to study cellular functions, basics of FACS.

REFERENCES:

1. Campbell Biology, 10th Edition. Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson
2. Biology: A Global Approach (Paperback) by Jane B. Reece, Steven A. Wasserman 3) Molecular Biology of Gene: Watson et al.,
3. Molecular Cell Biology: By Darnell, Lodish, Baltimore
4. Concepts of Genetics William S Klug and M. R. Cummings, Gerald Karp, Cell Biology
5. Wayne M. Becker et al., World of the Cell
6. Bruce Alberts et al., Essential Cell Biology 4th Edition
7. Richard Goldsby and Thomas J Kindt, Kuby Immunology
8. Cooper, Geoffrey M., and Robert E. Hausman. 2009. *The cell: a molecular approach*. Washington, D.C.: ASM Press.
9. De Robertis & De Robertis: Cell & Molecular Biology, Lea & Febiger, 1987

24-811-0404- CELL BIOLOGY AND BIOCHEMISTRY LAB (4C; 0L+0T+8P) (Academic Level 200)

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Manipulating DNA molecule with restriction enzymes	Apply
C.O. 2: Demonstrate the steps involved in molecular cloning and transformation	Analyse
C.O. 3: Apply various staining techniques to visualize animal and plant cells	Analyse
C.O. 4: Determine the enzyme activity	Apply
C.O.5: Perform the qualitative and quantitative analysis of biomolecules	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1			2	2				
CO2			2					
CO3			2	1	1			
CO4			2	1				
CO5			2	1	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

LIST OF PRACTICAL

1. Quantitative analysis of biomolecules
2. Determination of enzyme activity using spectrophotometric assays.
3. Analysis of amino acid metabolism using chromatographic techniques (e.g., HPLC or TLC).
4. Staining and observation of various organelles under the microscope
5. Stages of Mitosis (Onion tip)
6. Blood smear preparation and its analysis.
7. Imaging of various murine cell types: Epithelial cells, endothelial cells, neuronal cells, immune cells.
8. Identifying permanent tissues from plant sections (parenchyma, collenchyma, sclerenchyma, xylem vessels)
9. Identifying apoptotic and necrotic cells by the cell staining procedure

24-811-0405 SCIENTIFIC WRITING AND COMMUNICATION IN BIOLOGY (3C; 3L+0T+0P) (Academic Level 200)

Course Description

This course is designed to equip students with the skills necessary to effectively communicate scientific concepts, research findings, and ideas within the field of biology. Through a combination of lectures, workshops, and practical exercises, students will learn how to write

scientific papers, reports, and proposals, as well as how to deliver clear and engaging presentations. Emphasis will be placed on critical thinking, clarity, accuracy, and ethical considerations in scientific communication.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understand the principles of scientific writing and communication.	Understand
C.O.2: Develop proficiency in writing various scientific documents, including research papers, lab reports, and grant proposals.	Analyse
C.O. 3: Learn how to organize and present scientific information in a clear, concise, and logical manner.	Analyse
C.O. 4: Enhance critical thinking skills through the evaluation and analysis of scientific literature.	Apply
C.O.5: Practice effective communication strategies for oral presentations and scientific discussions.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2						2	
CO3					2	2	2	2
CO4						2	1	
CO5						2	1	2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Module I: Introduction to Scientific Writing and Communication- Overview of scientific communication; Importance of effective communication in biology; Understanding the target audience; Ethical considerations in scientific writing

Module II: **Writing Scientific Papers**- Structure and organization of scientific papers; Writing abstracts, introductions, methods, results, and discussions; Citation and referencing styles (e.g., APA, MLA); Peer review process and responding to reviewer comments

Module III: Lab Reports and Technical Writing- Guidelines for writing lab reports and technical documents**;** Writing clear and concise methods sections**;** Data presentation and interpretation**;** Incorporating figures, tables, and graphs

Module IV: Research Proposals and Grant Writing-Components of research proposals**;** Grant writing strategies and techniques**;** Understanding funding agencies and grant applications**;** Budgeting and resource allocation

Module V: Oral Presentations and Scientific Talks- Planning and organizing oral presentations**;** Effective delivery techniques and public speaking skills**;** Visual aids and slide design**;** Handling questions and engaging with the audience **Communication in the Digital Age-** Writing for online platforms and social media**;** Blogging, science communication, and outreach**;** Using multimedia tools for scientific communication**;** Digital ethics and online presence

Suggested readings

1. R. Barrass 1978. Scientists Must Write. John Wiley and Sons, New York.
2. C. S. Loban and M. Schefter 1992. Successful Lab Reports: A Manual for Science Students. Cambridge University Press.
3. V. E. McMillan 1988. Writing Papers in the Biological Sciences. St Martin's Press, NewYork.
4. J. A. Pechenik 1997. A Short Guide to Writing About Biology. Addison-Wesley Pub Co.
5. "Writing for Science: A Practical Handbook for Science, Engineering, and Technology Students" by Heather Silyn-Roberts
6. Scientific journals and articles
7. Online writing guides and resources
8. Writing workshops and tutorials

SEMESTER V

SEMESTER V

24-811-0501- PLANT DIVERSITY I
(Algae/Fungi/Bryophytes/Pteridophytes/Palaeobotany) (4C; 4L+0T+0P)
(Academic Level 300)

Course description: The course will cover the diversity, life forms, life cycles, morphology and importance of algae and various fungal groups and their association (lichens). The concepts of phytopathology, plant diseases, causal organisms and their control will also be covered. This course aims at making familiarity with special groups of plants-Bryophytes and pteridophytes, joined together by a common feature of sexual reproduction involving antheridia and archegonia. As these groups are primitive, the palaeobotany fossil forms are also included to have an evolutionary outlook. Study of morphology, anatomy, reproduction and developmental changes therein through typological study should create a knowledge base for understanding plant diversity, economic values, and the taxonomy of lower groups of plants.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain why fungi are treated as a separate kingdom and not included in the plant and animal kingdom	Understand
C.O. 2: Classify algae, fungi, bryophytes, pteridophytes	Understand
C.O. 3: Differentiate fungi, lichens, bryophytes and pteridophytes based on morphology	Analyse
C.O. 4: Identify various plants and their organization in nature through field trips and the collection and conservation of plant samples	Remember
C.O. 5: Discuss the significance of palaeobotany in terms of understanding the evolution and emergence of plant diversity	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	3							
CO3	2							
CO4	3							
CO5	2	1						

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I-Algae: Classification (F.E Fritsch), Principles and modern trends in the taxonomy of algae. Morphology, anatomy, life cycle and reproductive biology of a) Cyanophyceae- Nostoc b) Chlorophyceae-Chlorella, Volvox, Oedogonium and Chara c) Xanthophyceae-Vaucheria d) Bacillariophyceae-Pinnularia e) Phaeophyceae-Sargassum f) Rhodophyceae- Polysiphonia. Contributions of Indian Algologists. Economic importance of algae. Applied aspects: Biofuel production, food supplements, pharmaceutical industries, algal blooms, commercial cultivation of algae.

MODULE II- Fungi: Eukaryotic, heterotrophic organisms, chitinous cell walls, multicellular (hyphae/mycelium) or unicellular (yeasts), Reproduction sexually and asexually via spores. Classification: Major classes: Zygomycetes, Ascomycetes, Basidiomycetes, Deuteromycetes,

Based on reproductive structures and life cycles. Morphology and Ultrastructure: Hyphae: Thread-like structures forming mycelium, Spores: Reproductive cells produced for dispersal. Growth and Reproduction: Asexual: Budding, fragmentation, or asexual spores, Sexual: Fusion of specialized cells to form spores, Characteristics of Mushrooms and Cultivation: Fruiting bodies of Basidiomycetes with caps, stalks, and gills, cultivated commercially using substrates and controlled environments.

MODULE III- Bryophytes: classification- general account, Study of habit, thallus organization, vegetative and sexual reproduction, and alternation of generation of the following types (Developmental details are not required), Type study: *Riccia, Marchantia, Anthoceros and Funaria*. Economic importance of Bryophytes

MODULE IV- Pteridophytes: Classification, General characters, morphological and anatomical features, life cycle and reproductive biology, Type study: *Psilotum*, *Selaginella*, *Pteris* and *Marsilea*, Stelar evolution in Pteridophytes, Economic importance of Pteridophytes.

MODULE V- Palaeobotany: Geological time scale, Fossil and fossil formation, types of fossils, fossil age calculation methods, the importance of fossils, Fossil Pteridophytes- *Rhynia,* Lepidodendron, Lepidocarpon. Fossil gymnosperms-*Lygnopteris.*

REFERENCES

1. Chopra RN and P. K. – Biology of Bryophytes - Wiley Eastern Ltd. New Delhi
2. Parihar N.S. – An introduction to Bryophyta - Central Book Depot. Allahabad
3. Vasishta B. R. - Bryophyta - S. Chand and Co. New Delhi
4. Coulter. J. M. - and Chamberlain C. J. (1958) – Morphology of Gymnosperms - Central Book Depot, Allahabad
5. Gupta V.K. and Varshneya U. D (1967) – An Introduction to Gymnosperms – Kedarnath, Ramnath – Meerut.
6. Smith G.M. (1955) - Cryptogamic Botany – Vol.II – Mc Graw Hill Co. New Delhi
7. Sporne K. R. (1967) - Morphology of Gymnosperms - Hutchin University Library, London
8. Vashista B. R. (1993) - Pteridophyta – S. Chand and co. New Delhi
9. Vashista B. R. (1993) Gymnosperms - S. Chand and co. New Delhi
10. Andrews H.N. (1967) - Studies on Palaeobotany – C. J. Felix.
11. Arnold C. A (1947) - Introduction to Palaeobotany - McGraw Hill Co. New Delhi.

24-811-0502- PLANT DIVERSITY II (Gymnosperms and Angiosperms)
(4C; 4L+0T+0P) (Academic Level 300)

Course Description: The course aims to provide knowledge of gymnosperms and angiosperms. The economic importance of diverse plants that offer resources to human life will be covered. The course also aims to provide knowledge of the plants used by the local communities, tribal, and ethnic groups, and their nutritive and medicinal value.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
C.O. 1: Explain the general characteristics of gymnosperm and angiosperm.	Understand

C.O. 2: Differentiate between gymnosperms and angiosperms based on morphological character	Analyse
C.O. 3: Compare the diversity among plants based on morphology, anatomy, life cycle.	Analyse
C.O. 4: Identify the local flora having economic and ethnobotanical importance for exploring the natural products with potential medicinal implications	Remember
C.O. 5: Classify various plants based on pollen architecture	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	3		2					
CO3	2		1					
CO4	3	2	2					
CO5	2		2					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I-Gymnosperms: Classification, general features, morphology, anatomy, life cycle and reproductive biology of Cycadopsida-*Cycas,* Coniferopsida-*Pinus* and Gnetopsida-*Gnetum*. Evolutionary trends in gymnosperms and their economic importance.

MODULE II-Angiosperms: Principles and importance of taxonomy, Herbarium technique, BSI and ICBN. Systems of classification. Outline classification of Bentham & Hooker and Cronquist. APG systems of classification. The concept of taxon and Taxonomic hierarchy, plant nomenclature. A brief reference to the citation of the author. Chemotaxonomy.

MODULE III-Morphology: Morphology of root, stem, leaves and inflorescence. Floral morphology and structure, the symmetry of flower, aestivation, placentation; floral diagram and floral formula, Fruit types: simple, aggregate, and multiple. Seeds: albuminous and exalbuminous. Palynology: Pollen architecture, Pollen transfer, Pollen–pistil interaction. Pollination and its types. Pollen allergy, palynological calendars and pollen analysis of honey.

MODULE IV-Economic botany: Binomial, family and morphology of useful parts of Maize, soya bean, sugarcane, cocoa, tea, pepper, cardamom, potato, banana, mango, cashew nut, tomato, vinca, opium, teakwood.

MODULE V-Ethnobotany: Ethnobotany and Folk medicines. Ethnobotany in India, Methods to study ethnobotany -Fieldwork, Herbarium, Ancient Literature, Archaeological findings, temples and sacred places. Applications of Ethnobotany: Medicinal plants of tribals with reference to Thuthi, Kadukkai, Perandai, Avarai, Kandankathari, Oomathai, Veliparuthi, Asparagus and Boerhaavia. Legal aspects-biopiracy, IPR & traditional knowledge,

REFERENCES

1. Sivarajan, V.V. Introduction to the principle of plant taxonomy, Oxford and IBH Publishing Company
2. Pandey SN and Misra SP, 2008 Taxonomy of Angiospenus; Ane Books Pvt. Ltd.
3. Verma V, 2009 Textbook of Economic Botany; Ane Books Pvt. Ltd.

4. Kapoor LD, 2001 Handbook of Ayurvedic Medicinal Plants, CRC Press New York, Ane Books Pvt. Ltd
5. Jones, S.B. Jr. and Luchsinger, A.E. 1986. Plant Systematics (2nd edition). McGraw-Hill Book Co., New York.
6. Lawrence. G.H.M. 1951. Taxonomy of Vascular Plants. Macmillan, New York.
7. Naik, V.N. 1984. Taxonomy of Angiosperms. Tata McGraw Hill, New York.
8. Singh. G. 1999. Plant Systematics: Theory and practice Oxford & IBH Pvt, Ltd.New Delhi.
9. Nordenstam. B.., El-Gazaly, G. and Kassas. M. 2000. Plant Systematics for 21st Century
10. S.K. Jain. Glimpses of Ethnobotany. Oxford and IBH Publishing Company, New Delhi.

24-811-0503- NON-CHORDATES (4C; 4L+0T+0P) (Academic Level 300)

Course description: The course will help the students to understand the features of the Kingdom Animalia and the systematic organization of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware of the characteristic morphological and anatomical features of diverse animals; the economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
C.O. 1: Discuss the importance of systematics and taxonomy of animals.	Understand
C.O. 2: Compare the adaptive features of non-chordates living in varied habits and habitats.	Analyse
C.O. 3: Classify non-chordates as per their distinguishing features.	Understand
C.O. 4: Examine the anatomy of different classes of non-chordates that enables survival advantages in their habitat	Analyse
C.O. 5: Identify various non-chordates based on systematics	Remember

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	1						
CO3	2	2	1					
CO4	2		2	1				
CO5	3	2	2					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Basis of classification of multicellular animals: Cleavage; Germ layers; Symmetry; Body cavity; Concept of Protostomia *vs.* Deuterostomia.

MODULE II- General characteristics and classification (up to Class/subclass level) of Major Phyla: Protozoa; Porifera; Cnidaria; Ctenophora; Platyhelminthes, Annelida, Arthropoda; Mollusca, Echinodermata.

MODULE III-A general account of structure and reproduction of *Paramecium*; *Sycon*; *Obelia*; *Aurelia*; Planaria (*Dugesia*); *Fasciola*; *Hirudinaria*; *Pila*; Prawn; Starfish: *Peripatus*; *Limulus*; *Balanoglossus*.

MODULE IV- Concept of Minor Phylum and their importance in the study of non-chordate evolution; General characteristics of Aschelminthes (Rotifera, Acanthocephala, Nematoda, Nematomorpha, Priapulida, Kinorhyncha, Gastrotricha), Ectoprocta; Chaetognatha; Echiura, Sipunculida, Pogonophora; Lophophorata (Phoronida, Brachiopoda, Bryozoa); Hemichordata

MODULE V- Reproduction in Protozoans; Theories on the origin of Metazoan; Canal system in sponges; Metagenesis in cnidarians; Coral and coral reefs; Nephridial system in annelids; Trochophore larva and its evolutionary significance; Shell in molluscs; Water vascular system in echinoderms; Larval forms of Echinoderms and their significance.

REFERENCES

1. Barnes: The invertebrates (3rd ed. 2001, Blackwell)
2. Moore: An introduction to the invertebrates (2001Cambridge)
3. Ekambaranath Ayar: A manual of Zoology, Part I – Invertebrata, (1973, S. Vishwanathan)
4. Kotpal, Agarwal and Khetrapal: Modern Textbook of Zoology: Invertebrate, (1976, Rastogi)
5. Marshall: Parker and Haswell Textbook of Zoology, Vol. I (7th ed. 1972, Macmillan)
6. Nigam: Biology of Non-chordates (1985, S. Chand)
7. Jordon and Verma: Invertebrate Zoology (1995, S. Chand)
8. Millar and Harley: Zoology (6th ed. 2005, Brown)

24-811-0504- CHORDATES (4C; 4L+0T+0P) (Academic Level 300)

Course description: The course is designed to provide the scope and historical background of chordates. It will impart knowledge regarding basic concepts of the origin of chordates and make the students understand the characteristics and classification of animals with notochords. An adequate explanation to the students regarding various mechanisms involved in the thriving survival of the animals within their geographic realms will create interest among students.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes.	Understand
C.O. 2: Differentiate the members of each class based on morphology, anatomy, life cycle and other distinguishing features.	Analyse
C.O. 3: Identify the similarities and differences in life functions among various groups of animals in Phylum Chordata.	Remember
C.O. 4: Compare the members based on anatomical features concerning function (circulatory, nervous and skeletal system of chordates).	Analyse
C.O. 5: Discuss the pattern of vertebrate evolution, organization and functions of various systems.	Remember

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	2						
CO3		3	2					
CO4		2	2	1				
CO5	2	2						

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- General characteristics, classification of the following up to sub-classes/ orders with examples and affinities of the following: Protochordata (Urochordata, Cephalochordata); Cyclostomata; Pisces; Amphibia; Reptilia; Aves; Mammalia; Origin of vertebrates, lungfishes; Amphibians, birds and mammals.

MODULE II- Functional morphology of *Branchiostoma*, *Petromyzon*; Mullet, Frog; *Calotes*, fowl and rabbit.

MODULE III-Adaptive radiation in vertebrates: Aquatic; Terrestrial; Aerial; Arboreal; Fossorial.

MODULE IV- Evolution of aortic arches; jaw suspension; respiratory organs (gills, skin, lungs, air sacs, accessory respiratory organs), kidney, skull in reptiles; brain (cerebral hemisphere, cerebellum).

MODULE V- General considerations of integumental derivatives Scales, feathers, hair, claws, nails, hoofs, horns, antlers, glands), stomach in ruminants, Parental care in amphibians; snake venom; bird migration; flightless birds; dentition in mammals.

REFERENCES

1. Aiyar. A Manual of Zoology, Vol.2.
2. Kotpal: Modern Textbook of Zoology Vertebrates (2003, Rastogi)
3. Nigam: Biology of Chordates (1983, S Chand)
4. Harvey *et.al*: The Vertebrate Life (2006)
5. Colbert *et.al*: Colbert's Evolution of the Vertebrates: A History of the Backboned Animals through time (5th ed, 2002, Willey-Liss)
6. Hildebrand: Analysis of Vertebrate Structure (4th ed, 1995, John Willey)
7. Jordan &Verma: Chordate Zoology (1998, S.Chand)
8. McFarland *et.al*: Vertebrate Life (1979, Macmillan Publishing)
9. Parker & Haswell: Textbook of Zoology, Vol. II (1978, ELBS)
10. Romer & Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
11. Sinha, Adhikari & Ganguli: Biology of Animals Vol.II (1988, New Central Book Agency)

24-811-0505- ANIMAL AND PLANT LAB (4C; 0L+0T+8P) (Academic Level 300)

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Identify and Evaluate the vegetative and reproductive structures of fungi, Algae, Bryophytes, and Pteridophytes	Analyse

C.O. 2: Apply taxonomic protocols and Classify algae, fungi, bryophytes, pteridophytes	Apply
C.O. 3: Differentiate fungi, lichens, bryophytes and pteridophytes based on morphology	Analyse
C.O. 4: Identify various plants and their organization in nature through field trips	Remember
C.O. 5: Collection and conservation of plant samples	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3		2					
CO2	2	2	2					
CO3	2	2	2	1				
CO4	2	2	2	1	2			
CO5	3		2				2	2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

LIST OF PRACTICAL

Plant Diversity

1. Study of vegetative and reproductive structures of Nostoc, *Chlamydomonas* (electron micrographs), *Oedogonium*, *Vaucheria*, and *Polysiphonia* through permanent slides.
2. Fungal staining by Lactophenol cotton blue
3. *Phytophthora*: Specimens/photographs
4. *Agaricus*: Specimens of button stage and full-grown mushroom; LS of gills.
5. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
6. *Riccia*- Habit- V.S of the thallus, VS through archegonia, antheridia and sporophyte
7. *Marchantia*- Habit, thallus VS, male receptacle and female receptacle- entire and VS, thallus gemma-entire and VS, Sporophyte VS
8. *Cycas*- T.S of leaf, T.S. of the coralloid root, Male and female cone, ovule (LS)
9. *Pinus*- T.S. of the stem, T.S. of the needle, male and female cone VS
10. Students must submit practical records, Herbarium sheets (15 No's) and Field books at the time of the practical examination.
11. Identify the economic products obtained from the plants mentioned under Economic Botany
12. Critical notes on plants of ethnobotanical relevance as mentioned in the syllabus.

Non-Chordates

1. Nereis - parapodium
2. Earthworm – body setae, nervous system
3. Scales of butterfly wing
3. Cockroach – mouth parts /salivary gland/nervous system
4. Honeybee – mouthparts/mosquito - mouthparts
5. Prawn – appendages (Any Three- Maxillipeds1,2,3, Chelate leg, First abdominal appendage) nervous system
6. Spot Identification: Taxonomy Identification, Classification up to class and a brief note of the following specimens.

I. Protista – Actinophrys, Noctiluca, Paramecium, Opalina – any 2
II. Phylum Porifera – Euplectella, Spongilla- any 1

III. Phylum Cnidaria – Hydra, Obelia, Physalia, Aurelia, Sea anemone, Madrepora – any 3
IV. Phylum Nematoda – Ascaris- male and female (entire)
V. Phylum Platyhelminthes – *Bipalium*, *Fasciola*, *Taenia solium* – any 1
VI. Phylum Annelida – Earthworm, Nereis, Leech, Aphrodite, Arenicola – any 1
VII. Phylum Onychophora – Peripatus
VIII. Phylum Arthropoda – Cockroach, Limulus, Eupagurus, Sacculina, Honeybee, Lepisma, Scorpion – any 3
IX. Phylum Mollusca – Chiton, Pila, Xancus, Dentalium, Perna, Mytilus, Teredo, Sepia, Octopus. – any 2
X. Phylum Echinodermata – Starfish, Brittle star, Sea urchin, Sea cucumber, Sea lily – any 2

Chordates

1. *Branchiostoma*- External features; Mounting of the oral hood, velum and pharyngeal wall Study of the following slides: T.S. through the oral hood, midgut diverticulum, pharyngeal region, gonads and post-oral region of the intestine; study of *Pyrosoma, Salpa, Doliolum*
2. Mounting of the cycloid and ctenoid scales; mounting of chromatophores of fish; study of different types of feathers: Contour, filoplume and down feathers
3. Vascular system- Heart and afferent and efferent branchial vessels of Mystus/ *Cirrhinus sp.;* Arterial and venous systems of rat
4. Respiratory system: Accessory respiratory organs of *Heteropneustes, Channa, Clarias*
5. Nervous system of a fish
6. Histology of tooth, tongue, oesophagus, stomach, intestine, pancreas, liver, spleen, kidney cartilage, bone of mammals
7. Study of the following museum specimens/animals from the Zoo or field
    1. Cyclostomata: *Petromyzon*
    2. Chondrichthyes: *Scoliodon*
    3. Osteichthyes
    4. Amphibia
    5. Reptilia
    6. Aves
    7. Mammalia

24-811-0506 INTRODUCTION TO CELL CULTURE TECHNIQUES
(3C; 3L+0T+0P) (Academic Level 200)

Course Description: The Plant and Animal Cell Culture Techniques course provides students with a comprehensive understanding of the principles, methodologies, and applications of cell culture techniques in both plant and animal systems. Through lectures, laboratory demonstrations, and hands-on training, students will learn the fundamentals of establishing and maintaining plant and animal cell cultures, as well as techniques for genetic transformation, propagation, and characterization. Emphasis will be placed on mastering sterile technique, media preparation, and experimental design relevant to both plant and animal cell culture research.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcomes	Cognitive Level
C.O. 1: Understand the principles and importance of cell culture in plant and animal research.	Understand

C.O. 2: Gain proficiency in sterile technique and aseptic practices specific to plant and animal cell culture.	Apply
C.O. 3: Learn methods for establishing, maintaining, and characterizing plant and animal cell cultures.	Analyse
C.O. 4: Develop skills in genetic transformation techniques applicable to both plant and animal cells.	Analyse
C.O. 5: Explore advanced applications and recent advancements in plant and animal cell culture research.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2		1					
CO3		2	2	2				
CO4			2		1			
CO5				2	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I. Introduction to Plant and Animal Cell Culture- Definition and historical context; Importance of cell culture in plant and animal research; Types of cells used in culture: Protoplasts, cell lines, primary cultures

MODULE II. **Laboratory Safety and Aseptic Technique**- Biosafety levels and laboratory regulations specific to plant and animal cultures; Sterile technique: Proper handling of plant tissues, animal cells, and culture media; Prevention and management of contamination in plant and animal cultures

MODULE III. Culture Media and Growth Conditions- Plant cell culture media: MS, B5, Woody Plant Medium; Animal cell culture media: DMEM, RPMI, MEM; Growth regulators and supplements for plant and animal cultures

MODULE IV. Plant Cell Culture Techniques-Isolation and culture of plant tissues and organs; Callus induction, organogenesis, and somatic embryogenesis; Regeneration of whole plants from cultured cells or tissues. **Animal Cell Culture Techniques-**Isolation and culture of animal cell lines and primary cultures; Sub-culturing and passaging animal cells; Cryopreservation and storage of animal cell cultures

MODULE V. Applications of Plant and Animal Cell Culture-Production of secondary metabolites in plant cultures; Recombinant protein expression in animal cell cultures; Disease modelling, drug screening, and biopharmaceutical production. **Ethical Considerations and Regulatory Compliance**-Ethical guidelines for plant and animal cell culture research; Compliance with regulations: Institutional policies, animal welfare; Case studies and discussion of ethical dilemmas

References

1. "Plant Tissue Culture: Techniques and Experiments" by Roberta H. Smith
2. "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications" by R. Ian Freshney
3. "Plant Cell Culture Protocols" edited by Robert J. Nicklin and John M. Carter
4. "Animal Cell Culture: Essential Methods" edited by John M. Davis and Jeanne L. Becker

SEMESTER VI

SEMESTER VI

24-811-0601- EVOLUTION AND DEVELOPMENTAL BIOLOGY (4C; 4L+0T+0P) (Academic Level 300)

Course description: This course offers a chance for students to learn about deciphering evidence ranging from fossil records to molecular data and arranges them to establish phylogenetic relationships of species and provides a platform to understand various forces which bring about variations among populations of a species and cause them to diversify into new species. The course also focuses on Developmental Biology to provide four-dimensional thinking for students to truly understand the patterns and process of embryonic development, body plan, fate map, induction, competence, regulative and mosaic development, molecular and genetic approach for the study of developing embryo which is not necessarily shared with any other disciplines in the biological sciences.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe the relationship of the evolution of various species and the environment they live in	Understand
C.O. 2: Explain the molecular events associated with the developmental process of living forms from a single fertilized egg, the zygote.	Understand
C.O. 3: Discuss the stages of developmental processes that lead to the establishment of the body structure of multicellular organisms	Understand
C.O. 4: State the importance of stem cell therapy, in vitro fertilization and amniocentesis etc.	Remember
C.O. 5: Describe the evolution of man, speech, language and culture,	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	3	2						
CO3	2							
CO4	2							
CO5	2						1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I

Biochemical and genomic evolution: The evolutionary history of proteins, Evolution of gene, gene families, molecular drive, Amino acid sequence divergence in proteins, Nucleotide sequence divergence in DNA noncoding RNA, micro RNAs, the phylogenetic utility of RNA structures, Hitchhiker's Guide to evolving networks, protein-protein interaction network, the evolution of metabolic networks, and concept of molecular clock, Outline of origin of prokaryotic and eukaryotic genomes

MODULE II

Origin of Higher Categories, Origin of Metazoa, theories of origin, Origin and evolution of Trilobites, vertebrate groups- Pisces, Amphibia, Reptilia, Aves and Mammals. The evolutionary history of neural integration, endocrine systems, Hormones Phylogenetic gradualism, and punctuated equilibrium, Micro and Macroevolution. Stages in Primate

Evolution- Prosimii, Anthropoidea and Hominids. Factors in human origin-Hominid fossils, Cytogenetic and Molecular basis of the origin of the man-African origin of modern man-Mitochondrial Eve, Y chromosomal Adam, - early migration, hunter-gatherer societies.

MODULE III

Developmental Biology: Introduction theories- Preformation, Epigenesis, Recapitulation and Germplasm. Subdivisions of Developmental biology. Spermatogenesis and oogenesis, the structure of Graafian follicle, typical egg and sperm, Polarity of egg, egg envelops; classification of eggs based on different criteria. Fertilization: Agglutination, sperm penetration, activation of egg, amphimixis; physiological and biochemical changes during and after fertilization. Parthenogenesis, Cleavage, Morula formation, blastulation and blastocyst.

MODULE IV

Cell differentiation: totipotency, pluripotency and unipotency of embryonic cells. Determination and differentiation in embryonic development. Gene action, Drosophila as a model organism (a brief account only), Homeotic genes and Hox genes, Presumptive organ forming areas and fate maps, Gastrulation, morphogenetic movements, epiboly and emboly, the concept of germ layers, derivatives of germ layers.

MODULE V

Human - implantation, pregnancy, parturition. Placentation in mammals - different types of the placenta, functions, Teratology. Experimental embryology, developmental disorders. In vitro fertilization and embryo transfer experiments in mammals and test-tube babies, prenatal diagnosis, and sex determination methods – amniocentesis chorionic villus sampling, ultrasound scanning. Embryonic and adult stem cell research and stem cell therapy.

REFERENCES

1. Dobzhansky Th. et al. (1976): Evolution. Surjeet Publ.
2. Freeman S. and Jon C. Herron (1998): Evolutionary Analysis. Prentice-Hall
3. Futuyma D. J. (1998): Evolutionary Biology. Sinauer
4. Hartl D. L. and A. G. Clark (1989 & 1997): Principles of Population Genetics. Sinauer
5. Li Wen-Hsiung and Dan Graur (1991): Fundamentals of Molecular Evolution. Sinauer
6. Strickberger M. W. (2000): Evolution. Jones and Bartlett
7. White M. J. D. (1978): Modes of Speciation. Freeman
8. P.C. Jain. (2007). Elements of Developmental Biology, 6th Edn. Rastogi Publications
9. Begley, D.J., Firth, J.A. and Houtt, J.R.S. (1980). Human Reproduction and Developmental Biology, MacMillan Press Ltd.
10. Gilbert. S.F. (2000). Developmental Biology. Sinauer Associates, Inc. Publishers.
11. Huettner, A.F. (1959). Comparative Vertebrate Embryology. MacMillan.
12. Nelson. (1960). Comparative Embryology of Vertebrates. MacMillan.

24-811-0602- PARASITOLOGY AND IMMUNOLOGY (4C; 4L+0T+0P) (Academic Level 300)

Course description: Parasitology will enable us to diagnose parasites correctly, understand their life cycle and control them effectively and use some of them as biocontrol agents. Parasitology; especially the study of the life cycles of parasites; has helped in defying the stigmas and religious taboos for many societies freeing many of the people from superstition

and ill health. The course shall surely skill the students to see, appreciate and understand the diversity of parasites in the whole spectrum of the study of life. Also, provide an overview on the immune system and its function. The course shall also make the students aware of the possible scopes of the subject which include research and applied aspects including entrepreneurial works.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain the fundamentals of parasitology, parasitic invasion in both plants and animals; applicable to medical and agriculture aspects.	Understand
C.O. 2: Describe the measures to prevent a parasitic attack, Diagnosis, Prophylaxis and Treatment of parasitic infections.	Understand
C.O. 3: Discuss the basics of immunology and list immunological components	Understand
C.O. 4: Differentiate various blood cells by microscopy	Analyse
C.O. 5: Differentiate various parasites as per morphology	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	3						2	
CO3	2							
CO4	2	1	1					
CO5	2		1			1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I

Introduction to Parasitology Brief introduction of Parasitism, Parasite, Parasitoid and Vectors, Host-parasite relationship, Ecology of parasites, Population dynamics of parasite and establishment of the parasite population in the host body, the evolution of parasitism, evolution and coevolution of parasite with respect to host strategy, Important case studies in the field of Parasitology including some historical events such as the role of the mosquito control and the successful completion of the construction of the Panama canal.

MODULE II

Parasitic Protists Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Entamoeba histolytica*, *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani*, *Plasmodium vivax*. Parasitic Platyhelminthes Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Fasciolopsis buski, Schistosoma haematobium, Taenia solium* and *Hymenolepis nana*.

MODULE III

Parasitic Nematodes Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis*. Study of the structure, lifecycle and importance of *Meloidogyne* (Root-knot nematode), Pratylencus (Lesionnematode), Parasitic Arthropoda Biology, importance and control of ticks, mites, *Pediculus humanus, Xenopsylla*

cheopis and *Cimex lectularius*. Crustacean parasites. Parasitic Vertebrates A brief account of parasitic vertebrates; Cookiecutter Shark, Candiru, Hood Mockingbird and Vampire bat.

MODULE IV

Introduction, history, development and scope, Immunity: definition, classification of immunity. Innate and adaptive, Components of the Immune system: organs and tissues of the immune system. Antigens and Antibody, epitopes, antibodies (Immunoglobulins) - definition, the general structure of Ig, Ig determinants, precipitation reactions, agglutination reactions, complement fixation, neutralization, opsonization, complement system, major histocompatibility complex (MHC), types of immune responses- humoral immune response, cellular immune response, mention cytokines, define immunological memory, immunological tolerance, and immune suppression.

MODULE V

Hypersensitivity/allergy and Autoimmunity: definitions, classification- types I, II, and III, immunodeficiency diseases, Acquired Immune Deficiency Syndrome (AIDS); Auto immunity- definition, mechanism, mention AI diseases; transplantation immunity, graft versus host reactions, Immunization, and vaccination.

REFERENCES

1. Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA.
2. Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwell, U. K.
3. Parasitology: A Conceptual Approach, Eric S. Loker, Bruce V. Hofkin
4. Kuby Immunology, Richard, Thomas, Barbara, Janis, W. H. Freeman and Company [Latest edition].
5. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, Garland Science Publishing [Latest edition].
6. Essentials of Immunology, David, Brostoff and Roitt, Mosby & Elsevier Publishing
7. Fundamentals of Immunology by William E. Paul, Lippincott Williams & Wilkins Publishing
8. Cellular and Molecular Immunology by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai, Elsevier Publishing

24-811-0603- PARASITOLOGY AND IMMUNOLOGY LAB (4C; 0L+0T+8L)
(Academic Level 300)

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Identify and Analyse different fossils and differentiate between analogous and homologous structures	Analyse
C.O. 2: Differentiate between various developmental stages of frog and chick embryo development	Analyse
C.O. 3: Identify the life stages of important parasites and differentiate between their life stages	Remember and Analyse
C.O. 4: Compare various lymphoid organs and identify different types of blood cells	Analyse

C.O. 5: Apply the techniques of ELISA and immunoelectrophoresis for the identification of various proteins and peptides	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3		1					
CO2	3	2						
CO3	2	2	1		1			
CO4	2	1	1			1		
CO5	2	2	1				1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

LIST OF PRACTICAL

1. Study of life stages of *Entamoeba histolytica, Giardia intestinalis, Trypanosoma gambiense, Leishmania donovani* and *Plasmodium vivax* through permanent slides/microphotographs.
2. Study of adult and life stages of *Fasciolopsis buski, Schistosoma haematobium, Taenia solium* and *Hymenolepis nana* through permanent slides/microphotographs.
3. Study of adult and life stages of *Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti* and *Trichinella spiralis* through permanent slides/microphotographs.
5. Study of *Pediculus humanus* (Head louse and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.
6. Demonstration of lymphoid organs.
7. Histological study of the spleen, thymus and lymph nodes through slides/photographs.
8. Preparation of stained blood film to study various types of blood cells.
9. Basic patterns of precipitation by Ouchterlony's double immuno-diffusion method.
10. ABO Blood group antigen determination by haemagglutination.
11. Cell counting and viability test from splenocytes of farm-bred animals/cell lines.
12. Demonstration of (a) ELISA (b) Immunoelectrophoresis
13. Detection of complement activity using haemolysis of antibody-coated SRBC and standard serum

24-811-0604 BASIC SKILLS OF COMPUTATIONAL BIOLOGY (3C; 3L+0T+0P) (Academic Level 200)

Course description: This course introduces the fundamental concepts and practical skills required to utilize computational tools for analysing biological data. Through lectures, discussions, coding exercises, and tutorials, the students will explore how computational biology bridges the gap between biology and computer science. The course introduces students to the power of molecular visualization tools and their applications in various biological disciplines.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understand the vast amount and diverse nature of biological data generated by high-throughput sequencing	Understand

C.O. 2: Develop basic programming skills using a scripting language	Apply
C.O. 3: Develop a problem-solving approach to analyse biological data using computational methods.	Understand
C.O. 4: Explore the role of computational tools in analysing biological structures	Analyse
C.O. 5: Interpret and visualize biological data using computational tools.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	2	2					
CO2	2			2	1			
CO3	2				2	2		
CO4					2	2	2	
CO5						2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to computational biology: Big data in biology: Genomics, Transcriptomics, Proteomics, etc. Basic principles of computer science relevant to biology: Algorithms, data structures, data types, programming concepts. Overview of major bioinformatics databases and online resources.

MODULE II: Introduction to programming: Programming languages and types, Learning the basics of a scripting language like Python (syntax, data types, loops, functions). Working with biological data in Python: reading, manipulating, and visualizing data. Automating common tasks in data analysis using scripts.

MODULE III: Sequence analysis techniques: Introduction to the world of biological sequences, Sequence similarity searches and interpreting the data, Introduction to sequence alignments and standalone packages for sequence alignments. Sequence submission portals, gene ontology and annotations

MODULE IV: Structural proteomics: Protein folding problems, methods of sequence-based protein structure predictions, understanding protein function using sequence and structure analysis, Protein-protein interaction prediction tools and their applications

MODULE V: Data Visualization and Communication: Understand the importance of molecular visualization in biological research, Introduction to molecular visualization tools, Visualizing protein structure and function prediction methods, Online modelling servers and applications.

REFERENCES

- Harisha, S. (2013). Fundamentals of Bioinformatics. India: I.K. International Publishing House Pvt. Limited.
- Sequence Alignment: Methods, Models, Concepts, and Strategies. (2009). United Kingdom: University of California Press.
- Lesk, A. (2014). Introduction to Bioinformatics. United Kingdom: OUP Oxford.
- Hagen, H. (2007). Visualization in Medicine and Life Sciences. Germany: Springer Berlin Heidelberg.

- Introduction to Biological Data Analysis in Python. (2023). (n.p.): Stilianos Louca.
- Via, A., Rother, K., Tramontano, A. (2014). Managing Your Biological Data with Python. United Kingdom: Taylor & Francis.
- Bioinformatics, Fifth edition: Methods and Applications - Genomics, Proteomics and Drug Discovery. (2022). (n.p.): PHI Learning Pvt. Ltd.
- Tramontano, A. (2018). Introduction to Bioinformatics. United Kingdom: CRC Press.

24-811-0605- PLANT PHYSIOLOGY AND BIOCHEMISTRY (4C; 4L+0T+0P) (Academic Level 300)

Course description: The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology. The course also highlights the importance of secondary metabolites and nitrogen fixation.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1: Describe the importance of physical theories for maintaining the physiology	Understand
C.O.2: Differentiate biodiversity based on morphology, anatomy, cell structure and biochemistry with plant functioning.	Analyse
C.O.3: Explain the significance and transportation of mineral nutrition with respect to plants.	Understand
C.O. 4: Apply the knowledge of plant hormones for crop improvement in plant biotechnology	Apply
C.O. 5: Discuss the process of photosynthesis and the rate-limiting steps	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	2						
CO3	2							
CO4	2		2	2	2			
CO5				1	2			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Physiology: General Introduction on physiological processes, their significance and applications, Water relations of plants, physical aspects of absorption-imbibition, diffusion and osmosis. Water potential and osmotic potential, Plasmolysis and its significance, Mechanism of water absorption-active and passive absorption, root pressure, aquaporins. Pathway of water across root cells, Ascent of sap-vital and physical theories. Transpiration-cuticular, lenticular and stomatal. Mechanism-theories -starch sugar hypothesis, potassium - ion theory. Significance of transpiration, anti-transpirants, Guttation and its significance.

MODULE II-Mineral nutrition: Gross chemical analysis of the plant body, ash analysis, criteria for the essentiality of elements, macro and microelements, the role of essential elements

and their deficiency symptoms. Culture methods-sand culture, hydroponics and aeroponics. Mechanism of mineral absorption (a) passive absorption-ion exchange and Donnan equilibrium (b) active absorption -carrier concept, Lundegardh hypothesis, Translocation of solutes: Pathway of movement, phloem transport, mechanism of transport-Munch hypothesis, protoplasmic streaming theory-activated diffusion hypothesis, electro-osmotic theory.

MODULE III- Plant movements: Tropic and nastic movements. Circadian rhythm and biological clock. Stress Physiology: Types of stress- water, temperature, salt, stresses caused by pests and pathogens and pollutants, Plant defense systems and mechanisms. Growth regulators-Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid-synthetic plant hormones-practical applications. Senescence and abscission. Photoperiodism. Vernalization, Dormancy.

MODULE IV- Photosynthesis, structure and function of the chloroplast, Fluorescence and phosphorescence, Red drop, Emersion effect; Two pigment systems; Mechanism of photosynthesis-Light reaction, Calvin cycle; comparative study of C3, C4 and CAM plants; photorespiration, Factors affecting photosynthesis-Law of limiting factor, Respiration Energy relation of respiration-RQ and its significance-Factors affecting respiration.

MODULE V-Secondary Metabolites and Nitrogen Fixation: Types, structure, functions, Biosynthesis of Secondary metabolites, economic importance. Plants and Nitrogen: The nitrogen cycle, Nitrogen metabolism: Source of nitrogen, Biological nitrogen fixation-symbiotic and asymbiotic. Nitrogen fixation by blue-green algae-rotation of crops. Genetics of N fixation - Nif genes and Leghaemoglobin. Biosynthesis of amino acids- reductive amination and transamination. GDH and GS/ GOGAT pathway.

REFERENCES

1. Dayananda B, 1999. Experiments in Plant Physiology. Narosa Publishing House, New Delhi.
2. Taiz L, Zeiger E, 2023. Plant Physiology and Development (7th Edn). Panima publishing Corporation, New Delhi.
3. Hopkins W G, Norman P A Huner, 2008. Introduction to plant physiology. John Wiley and sons. New York.
4. Jain J L, Sanjay Jain, Nitin Jain, 2005. Fundamentals of Biochemistry. S Chand, New Delhi.
5. Lehninger A L, 1975. Biochemistry. Lalyan publishers, Ludhiana.
6. Nelson D L, Cox M M, 1993. Principles of Biochemistry. MacMillan Publications.
7. Pandey S N, Sinha B K, 2006. Plant Physiology. Vikas Publishing House Pvt. Ltd.
8. Srivastava H S, 2005. Plant Physiology. Rastogi publications, Meerut.
9. Verma V, 2007. Textbook of Plant Physiology. Ane Books India, New Delhi.

24-811-0606 ECONOMIC BOTANY (4C, 4L+0T+0P) (Academic Level 300)

Course Description: This course explores the economic significance of plants, focusing on their uses, cultivation, conservation, and commercial applications. Through theoretical knowledge and practical examples, students will gain insights into the historical, cultural, and contemporary aspects of economic botany, with an emphasis on sustainable utilization and management of plant resources.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1: Understand the historical development and theoretical foundations of economic botany.	Understand
C.O.2: Identify and classify economically important plant species and their products and explore the cultural, social, and economic significance of plants in human societies.	Analyse
C.O.3: Examine the principles and practices of plant cultivation, breeding, and domestication for economic purposes and analyse the impact of human activities on plant biodiversity and conservation strategies.	Analyse
C.O. 4: Evaluate the role of plants in providing food, medicine, fibres, dyes, and other commercial products.	Apply
C.O. 5: Develop an understanding of sustainable practices in plant resource management and utilization and apply economic botany principles to real-world scenarios and case studies.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2							
CO3	2							
CO4		2	1					
CO5							1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Origin of Cultivated Plants**-Concept of Centres of Origin, their importance with reference to Vavilov's work examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

MODULE II: **Cereals-** Wheat and Rice (origin, morphology, processing & uses), a brief account of millets. **Legumes-** General account, importance to man and ecosystem. **Sugars & Starches**- Morphology and processing of sugarcane, products and by-products of the sugarcane industry. Potato – morphology, propagation & uses.

MODULE III- Spices- Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper. **Beverages**- Tea, Coffee (morphology, processing & uses). **Oils & Fats**- General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and Brassica and Coconut (Botanical name, family & uses)

MODULE IV- Essential Oils- General account, extraction methods, comparison with fatty oils & their uses. **Natural Rubber-** Para-rubber: tapping, processing and uses. **Drug-yielding plants**- Therapeutic and habit-forming drugs with special reference to Cinchona, Digitalis, Papaver and Cannabis.

MODULE V- Tobacco- Tobacco (Morphology, processing, uses and health hazards). **Timber plants**- General account with special reference to teak and pine. **Fibres** Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses)

REFERENCES

1. Economic Botany- A comprehensive study by S L Kochhar, Fifth Edition(2016), Cambridge University Press, UK
2. A Text Book of Economic Botany by V Verma, (2009)Anne Books Pvt Ltd, New Delhi
3. Economic Botany: Principles and Practices by G.E. Wickens (2012) Kluwer Academic Publishers, New York

24-811-0607 MEDICINAL BOTANY (4C, 4L+0T+0P) (Academic Level 300)

Course Description: This course explores the medicinal properties of plants, focusing on their botanical sources, active constituents, pharmacological actions, and therapeutic applications. Through lectures, laboratory demonstrations, and fieldwork, students will gain insights into the diverse range of medicinal plants, their traditional uses, modern pharmacology, and implications for healthcare and drug discovery.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1: Understand the chemical composition and pharmacological properties of medicinal plants.	Understand
C.O.2: Explore traditional and contemporary uses of medicinal plants in healthcare systems worldwide.	Understand
C.O.3: Analyse the role of medicinal botany in drug discovery, pharmaceutical industry, and alternative medicine.	Analyse
C.O. 4: Develop practical skills in the collection, identification, processing, and preparation of medicinal plants.	Apply
C.O. 5: Appreciate the cultural, historical, and ethical dimensions of medicinal botany and herbal medicine.	Understand/Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	3							
CO3	2	2		1				
CO4			2	1	1			
CO5					2	2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Introduction to Medicinal Botany**- Definition and scope of medicinal botany. Historical perspectives on medicinal plants and herbal medicine. Importance of medicinal plants in traditional and modern healthcare systems

MODULE II: **Botanical Sources of Medicinal Plants**- Classification and identification of medicinal plant families and species. Plant parts used in herbal medicine: roots, leaves, flowers, seeds, and fruits. Botanical gardens and herbaria: resources for studying medicinal plants

MODULE III: **Phytochemistry of Medicinal Plants**- Secondary metabolites in plants: alkaloids, glycosides, terpenoids, and phenolics. Chemical composition and bioactive compounds in medicinal plants. Methods of extraction, isolation, and characterization of plant

constituents**. Pharmacology of Medicinal Plants-** Pharmacokinetics and pharmacodynamics of herbal remedies**.** Mechanisms of action and therapeutic effects of medicinal plants**.** Safety, toxicity, and adverse effects of herbal products

MODULE IV: **Traditional Medicine Systems**- Traditional healing practices and indigenous medicine systems. Ayurveda, Traditional Chinese Medicine (TCM), Unani, and other traditional systems. Ethnobotanical studies and documentation of traditional knowledge. **Plant Conservation and Sustainable Harvesting-** Conservation status of medicinal plants: threats and conservation strategies**.** Sustainable harvesting practices and cultivation of medicinal crops**.** Certification schemes and ethical sourcing of medicinal plants

MODULE V: **Therapeutic Applications of Medicinal Plants**. Herbal remedies for common ailments: digestive disorders, respiratory infections, skin conditions, etc. Phyto-therapy in chronic diseases: cardiovascular disorders, diabetes, cancer, etc. Herbal preparations: decoctions, infusions, tinctures, extracts, and essential oils. **Modern Applications and Research in Medicinal Botany.** Role of medicinal plants in drug discovery and development Pharmaceutical industry and herbal medicine: challenges and opportunities Clinical trials and evidence-based medicine in herbal therapeutics

REFERENCES

1. Medicinal Plants: Properties, Uses and Production (2021) D. K. Semwal
2. Medical Botany: Plants Affecting Human Health by Memory P. F. Elvin-Lewis; Walter H. Lewis.
3. A Handbook of MEDICINAL PLANTS - A Complete Source Book (2012) edited by Prajapati, Sharma, Kumar, Purohit
4. Relevant research and review articles

24-811-0608- HUMAN PHYSIOLOGY AND ENDOCRINOLOGY (4C; 4L+0T+0P) (Academic Level 300)

Course description: The students will be introduced to the principles of normal biological function in the human body. Basic human physiology will be outlined and correlated with histological structures. The course also provides students with a basic understanding of human endocrine glands, neuro-endocrine glands and their structure, function and signalling pathways. Students will also study the influence of biological rhythm on hormone secretion.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1. Explain the principles of normal biological function in the human body.	Understand
C.O.2. Compare histological structures with their function	Analyze
C.O.3. Discuss how animals maintain an internal homeostatic state in response to changes in their external environment.	Understand
C.O. 4. Describe the endocrine system and the basic properties of hormones.	Understand
C.O. 5. Gain insight into the molecular mechanism of hormone action and its regulation.	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	3	2						
CO3	2							
CO4	2							
CO5	2							

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Nutritional physiology: Structure and digestive system: General introduction, types of nutrition, mechanical and chemical changes of food in the alimentary canal, balanced diet, nutritional disorders-PEM, vitamin and mineral deficiency, hormonal control of digestion Circulatory physiology: Structure of heart, Blood composition and functions of blood plasma and formed elements, blood groups, mechanism of blood clotting, intrinsic and extrinsic pathways, disorders of blood clotting, anticoagulants, heartbeat, conducting system and pacemaker, pulse and blood pressure, clinical significance, control of cardiac activity, common cardiovascular diseases-arteriosclerosis, atherosclerosis, myocardial infarction, electrocardiogram, angiogram, angioplasty, Lymph and lymphatic system.

MODULE II- Respiratory physiology: Structure of lungs. Gas exchange, respiratory pigments-structure of haemoglobin, transport of oxygen-Oxyhaemoglobin curve, Bohn effect, transport of CO_2-carbonic acid, carbamino haemoglobin, bicarbonate and chloride shift, carbon monoxide poisoning, bronchitis, asthma, physiological effects of smoking, fibrosis
Renal Physiology: Structure of kidney. Nephron-structure, urine formation, counter current multiplier system, the role of the kidney in osmoregulation, renal disorders-nephritis, haematuria, renal calculi, acidosis, and alkalosis-, fibrosis, Dialysis and kidney transplantation

MODULE III- Muscle Physiology: Brief account of types of muscles, fast and slow twitch muscles, red and white muscles, the ultrastructure of striated muscle fibre, muscle proteins, simple muscle twitch, summation, tetanus, tonus, ALL or None Law, fatigue, oxygen belt, rigor mortis, physiological and biochemical events in muscle contraction.
Sensory physiology: Structure of eye and ear. Physiology of vision, visual elements and pigments, photochemistry of vision. Eye defects-myopia, hyperopia, presbyopia, astigmatism, cataract. Structure of ear and mechanism of hearing, hearing impairments-deafness, labyrinthine disease. olfactory, gustatory and tactile sense organs.

MODULE IV-Nerve Physiology: Structure of brain, Neurons-structure, types of neuron. Synapse and types of synapse, nerve impulse propagation, synaptic transmission. Reflex action, refractory period, neurotransmitters, electro encephalogram. Nerve disorders- epilepsy, Alzheimer's disease, Parkinson's disease

MODULE V- Endocrinology: Definition, classification and characteristics of chemical messengers (hormones, neurohormones, neurotransmitters, cytokines, pheromones), Hormone delivery: Endocrine, paracrine and autocrine modes, Hormone feedback mechanisms, Structure and functions of: Pituitary, Thyroid, Parathyroid, Adrenal, Endocrine pancreas, Testis, Ovary, Endocrine glands in insects, Pars Intercerebralis-corpus cardiacum-corpus allatum complex, Prothoracic glands, endocrine disorders.

REFERENCES

1. Best and Taylor. (1990). Physiological basis of Medical Practice. Wilkins Co.

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3. Ganong, W.F. (2003), Review of Medical Physiology, McGraw Hill, New Delhi.
4. Guyton, A.C. (1981). Textbook of Medical Physiology, W.B. Saunders Co.
5. Hoar, W.S.(1975). General and Comparative Physiology, Prentice-Hall.
6. Mac. Eleroy, W.D. (1971). Cell Physiology and Biochemistry. Prentice-Hall of India Ltd.
7. Nagabhushanan, R., Kaobarkar M.S. and Sarojini, R. (1983). A textbook of animal physiology, Oxford IBH Publishing Co., New Delhi.
8. Prosser, C.L. (1978). Comparative animal physiology. W.B. Saunders Co.
9. Rama Rao, V., First aid in accidents, Srikrishnan Brothers, Thambuchetty Street, Madras.
10. Schmidt-Nielson K. (2002). Animal Physiology, Prentice Hall India Ltd.
11. Sebastian, M.M. Animal Physiology. Dona Publications, Changanacherry.
12. Norris: Vertebrate Endocrinology, Fourth Edition, 2007, Academic Press

24-811-0609- ECONOMIC ZOOLOGY (4C; 4L+0T+0P) (Academic Level 300)

Course Description: This course explores the economic significance of animals in various aspects of human life, including agriculture, medicine, industry, and conservation. Students will examine the role of animals in providing food, fibre, and other resources, as well as their impact on human health, the economy, and the environment.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1. Understand the economic importance of animals in agriculture, medicine, industry, and conservation.	Understand
C.O.2. Identify different animal species and their contributions to human society.	Apply
C.O.3. Analyze the impact of human activities on animal populations and ecosystems.	Analyze
C.O. 4. Explore strategies for sustainable management and conservation of economically valuable species, especially by addressing the local needs	Apply
C.O. 5. Ability for self-employment through pisciculture, diary, silk worm and poultry	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2							
CO3	2						1	
CO4							1	1
CO5						2	1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Insect pests and their economic importance: Common Pests of paddy, Sugarcane, Tea, vegetables and Fruits (Distribution, food plants, life-history, damage caused, prevention and control measures of the Insect pests to be dealt with)

MODULE II: Apiculture: Introduction, species of honey bees, social organisation and life history of honey bees; selection of bees for apiculture, methods of bee keeping (indigenous and modern methods), products of bee keeping (honey and bee wax), bee keeping as an industry.

MODULE III: **Fish and Fisheries**: Culture fisheries: - Introduction to fish culture, types of cultivable species. Freshwater fish culture technique and management of fish culture farm, harvesting and marketing. Capture fisheries: - Commercially important fisheries of Kerala. Fishing tools-crafts and gears. Preservation and processing of fish and fisheries.

MODULE IV: **Poultry**: Introduction, habitat of fowl: food and feeding of fowls- breeds of fowls (indigenous and exotic breeds); eggs and hatching, rearing of chickens; poultry products (eggs and meat); by-products of poultry. **Dairy industry**: Introduction- breeds of dairy animals (cow, buffalo, goat); Milk: processing of milk, marketing and distribution of milk, milk products (Curd, cream, Butter, Ghee, khoya, cheese).

MODULE V: **Sericulture**: Origin and history of the Sericulture Industry in India with special reference to Kerala. Introduction to different silkworms with special reference to Kerala and a brief account of their food plants. Different species of silkworm, their habit and habitat. Types of Cocoon and silk produced by them.

REFERENCES

1. Yadav Manju (2003). Economic Zoology, Discovery Publishing House.
2. Shukla and Upadhyaya (2014). Applied And Economic Zoology, Rastogi Publishers
3. Jabde Pradip V (2005). Textbook of applied Zoology, Discovery Publishing House, New Delhi. Suggested Readings
4. Ahsan Jawaid, Sinha Prasad S. (2000). A handbook on Economic Zoology. S. Chand and Co.

24-811-0610 ANIMAL FORMS AND FUNCTIONS (4C; 4L+0T+0P)
(Academic Level 300)

Course Description: This course aims to provide a thorough knowledge of structural details and a comparative account of the different organ systems of the body from lower to higher vertebrates, and proto-chordate, thus enabling them to appreciate the incredible vertebrate diversity. It helps students propose possible homology between structures and understand how they evolved as the vertebrates dwelled in different habitats. The structural modifications of the digestive, circulatory, respiratory, and skeletal systems relate to the distribution of animals in their different comfort zones of habitat and ecological niches.

Course outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Explain a comparative account of the different vertebrate systems	Understand

C.O. 2: Discuss the structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and the digestive system and its anatomical specializations concerning different diets and feeding habits.	Understand
C.O.3: Describe the evolution of the heart, modification in aortic arches	Understand
C.O. 4: Discuss the evolution of the brain, sense organs and excretory organs to a complex, highly evolved form in mammals	Understand
C.O.5: Analyse the structure and functions relationship of animals which furnish with survival advantages in a habitat	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2							
CO3	2							
CO4	2							
CO5	2							

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I

Modes of Feeding and Digestion: Feeding mechanisms: suspension, deposit, cropping and sucking (herbivorous) and raptorial (carnivorous), Intracellular and extracellular digestion: food vacuole and gastrovascular cavity, Types of excretion and Mode of Excretion Open tubular: metanephridia, Closed saccular: protonephridia, Malpighian tubules and kidney.

MODULE II

Respiratory Organs, Structure and function of gills, trachea, book lungs and vertebrate lungs.

MODULE III

Circulatory systems: Pattern of circulation in non-chordates and chordates, hemocoel, open and closed circulatory systems, the difference in chambers, evolutionary significance.

MODULE IV

Nervous system: Patterns of the nervous system in non-chordates, Organization of the nervous system in vertebrates: central and autonomic system, Receptors and sense organs, Phonoreception in fish and mammals, Photoreception in insects and mammals

MODULE V

Reproduction Types of asexual reproduction: fission, regeneration and parthenogenesis, Sexual reproduction: primary and accessory sex organs and their function

REFERENCES

1. Miller and Harley: Zoology (6th ed. 2005, W.C. Brown)
2. Nigam: Biology of Non-chordates (1997, S Chand)
3. Nigam: Biology of Chordates (1997, S Chand)
4. Parker and Haswell: Textbook of Zoology, Vol. II (2005, Macmillan)
7. Purves et al: Life-the Science of Biology, (7th ed. 2004, Sinauer)
8. Tortora and Anagnostakos: Principles of Anatomy and Physiology (6th ed. 1986, Harper and Row).
9. Schmidt Nielson: Animal Physiology (5th ed. 2005, Cambridge)

SEMESTER VII

SEMESTER VII

24-811-0701- BIOCHEMISTRY (4C; 4L+0T+0P) (Academic Level 300)

Course Description: This course aims to enrich the understanding of the fundamental principles and properties, classification, structure and function significance of biomolecules with a special focus given to enzyme catalysis, kinetics and applications. The course provides application-oriented insights on biochemical techniques involved in characterization, activity studies, structure prediction, and validation of physical, chemical and biological properties of biomolecules. The course covers the methodology and instrumentation aspects of a clinical biochemistry lab. Also introduces the concepts of glycobiology, proteomics and the emerging fields of glycomics and lipidomics.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understanding the fundamentals of biochemistry	Analyse
C.O. 2: Examine the chemistry of various biomolecules and apply the techniques to identify/purify/predict the structure/synthesise carbohydrates, lipids and their derivatives	Analyse
C.O. 3: Examine the chemical properties and interpret the quantity of various biomolecules and apply the techniques to identify/purify/predict the structure/synthesise proteins and nucleic acids	Analyse
C.O. 4: Investigate the general properties of enzymes using various methods, apply enzyme kinetics to study the nature of enzymes and inhibitors in terms of Km and Vmax Compare the affinity of Enzymes to substrates in terms of Km	Analyse
C.O. 5: Apply the techniques and handle the equipment used in the clinical diagnosis of diseases, Based on theoretical knowledge, set up the working model of a clinical biochemistry lab by a flow chart	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1						
CO3	2	2	1					
CO4			2	1	1			
CO5				1	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Chemical foundations of life: Overview of weak interactions in aqueous systems, Organic reaction mechanisms (Group-transfer reactions, oxidation and reductions, coupled reactions, Elimination, Isomerization and rearrangements), Thermodynamics of phosphate compounds (Phosphoryl-transfer reactions, High energy compounds and Biological energy transducers (ATP, NADH, NADPH, FADH, CoASH), ATP cycle, structural basis of free energy change during hydrolysis of ATP, High Energy phosphate compounds, Nernst equation and Redox-potentials. Thermodynamics principles in biology and energetics.

MODULE II: Glycobiology and Lipid Biology: Basic structure and reactions and classifications of carbohydrates and lipids, Carbohydrates and lipids as an energy sources, matter and information molecules. Glycoconjugates and their significance, Glycolipids, Carbohydrate based biomaterials and their applications. Techniques of extraction, separation and structure prediction, applications in biomedical sciences, glycomics and lipidomics.

MODULE III: Proteins and Nucleic acids: Chemical, Biological and Physical properties of Protein and nucleotides and types and classification, Structural organization of proteins, Ramachandran Plot, Globular and fibrous proteins, techniques involved in separation, purification, and sequencing and synthesis of peptides/proteins and techniques involved in structure prediction, Proteomics, Protein-ligand interactions and applications in drug development, Structure-activity relationships, and nucleotides as energy and information molecules.

MODULE IV: Enzymes: Examples of Enzymatic reactions, chymotrypsin, hexokinase, enolase etc. Reaction rates and Equilibria, Reaction coordinate diagram, Enzyme substrate complex, mechanisms of catalysis. Enzyme kinetics, Michaelis-Menton Equation, Line weaver burk plots and other representations, enzyme inhibition and allosteric enzymes and bisubstrate reactions. Applications of enzymes, enzyme significance of isozymes in disease diagnosis, enzymes as therapeutic targets and the scope of enzyme engineering.

MODULE V: Clinical Biochemistry- Definition and scope of clinical biochemistry in diagnosis, analyses, collection and preservation of biological fluids (blood, urine & CSF), normal values, reagents for analysis, Requirements of setting up of clinical laboratory, collection preparation, preservation, and handling of clinical samples, quality control, Safety measures in clinical laboratory and practices, common techniques and equipment used in clinical diagnosis of communicable and non-communicable diseases.

REFERENCES

1. Lehninger, A. L., Nelson, David L., Cox, Michael M. (2013).Principles of Biochemistry.6th revised edition
2. Biocatalysis: Biochemical Fundamentals and Applications .2nd reprint Edition. Imperial College Press.
3. Combs Jr, G. F., & McClung, J. P. (2016). The vitamins: fundamental aspects in nutrition and health. Academic press.
4. Lurton, R. (2010).Clinical Biochemistry.2nd Edition. Viva books.
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6. Cooper T.G. (2015). Tools of Biochemistry.2nd edition, Wiley-Interscience 11. Sadasivam S. and Manickam A.(2009).
7. Biochemical Methods, 2ndedn.New Age International Ltd Publishers.
8. Mu, P., & Plummer, D. T. (1988). Introduction to practical biochemistry. Tata McGraw-Hill Education.
9. Jayaraman J.(1992).Laboratory manual in Biochemistry.John Wiley
10. Enzymes: biochemistry, biotechnology, clinical chemistry. Elsevier. 5. Chaplin, M.F. Buke, C.(1990). Enzyme technology.Cambridge University Press. 6. Grundwald, D. Peter. (2016).
11. Biocatalysis: Biochemical Fundamental and Applications.2nd reprint Edition. Imperial College Press 7. Grunwald, P. (2009).
12. Biocatalysis: biochemical fundamentals and applications. Imperial College Press.

24-811-0702- CELL SIGNALLING AND COMMUNICATION (4C; 4L+0T+0P) (Academic Level 400)

Course Description: Cell Signalling and Communication is a comprehensive course that explores the mechanisms by which cells communicate with each other to coordinate various physiological processes. Students will study the molecular pathways involved in signal transduction, intercellular communication, and the regulation of cellular responses. Emphasis will be placed on understanding the relevance of cell signalling in health and disease.

Prerequisites: Basic knowledge of cell biology and biochemistry.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Understand the fundamental principles of cell signalling and communication	Understand
C.O. 2: Identify and describe the key components involved in signal transduction pathways.	Understand
C.O. 3: Analyse the mechanisms of intercellular communication, including direct and indirect signalling.	Analyze
C.O. 4: Explore the role of cell signalling in development, homeostasis, and disease.	Understand
C.O. 5: Develop critical thinking skills to evaluate experimental evidence and current research in cell signalling.	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2							
CO3	2	1						
CO4		2	1					
CO5		2	1			1	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Introduction to Cell Signalling**- Overview of cell signalling and its importance Types of signalling molecules: hormones, neurotransmitters, growth factors. Principles of signal reception, transduction, and cellular response. **Signalling Pathways**- Intracellular signalling cascades: cyclic AMP (cAMP), phosphoinositide signalling, kinase cascades G protein-coupled receptors (GPCRs) and their signalling mechanisms Receptor tyrosine kinases (RTKs) and their role in cell growth and differentiation

MODULE II Cell Signalling in Development- Signalling pathways in embryonic development and tissue patterning**.** Role of morphogens and growth factors in cell fate determination**.** Cell signalling in stem cell maintenance and differentiation

MODULE III: Intercellular Communication- Gap junctions and direct cell-cell communication**.** Paracrine and autocrine signalling**.** Synaptic transmission and neurotransmitter signalling**. Signalling and Disease-**Aberrant signalling in cancer: oncogenes,

tumour suppressors, and apoptotic pathways**.** Signalling pathways in metabolic diseases: insulin resistance, diabetes Neurodegenerative disorders and synaptic dysfunction

MODULE IV: Signalling in Immune Response-Role of cytokines and chemokines in immune cell communication**.** Signalling pathways in inflammation and immune cell activation**.** Immunotherapy and modulation of immune signalling in disease treatment**. Cellular Communication in the Microenvironment-**Cell-matrix interactions and extracellular matrix signalling**.** Cell adhesion molecules and their role in cell-cell communication**.** Signalling in wound healing and tissue regeneration

MODULE V: **Emerging Topics in Cell Signalling-** Signalling in aging and longevity**.** Computational modelling of signalling networks**.** Single-cell signalling analysis techniques. Advanced Microscopic and flow cytometry techniques, FRET-based assessment of cell signalling, Immune cell sorting and analysis, FISH. Determination of calcium flux, localization and translocation of proteins during various cellular events, tracking of cellular events like apoptosis and autophagy.

REFERENCES

1. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter, Molecular Biology of the Cell (6th Edition) by Garland Science; 2014
2. Chris A. Kaiser, Kelsey C. Martin, Harvey Lodish, Arnold Berk, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Matthew P. Scott Molecular Cell Biology (8th Edition) by, Published by W H. Freeman; 2016
3. Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander D. Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter; Essential Cell Biology (4th Edition) by Garland Science; 2013
4. Gerald Karp, Janet Iwasa, Wallace Marshall; Cell Biology (8th Edition); by Wiley; 2018
5. David E. Sadava; Jones & Bartlett Learning, Cell Biology: Organelle Structure and Function; 1993
6. Harvey Lodish; Arnold Berk; Chris A. Kaiser; Monty Krieger; Anthony Bretscher; Hidde Ploegh; Angelika Amon; Kelsey C. Martin; W.H. Freeman; Molecular Cell Biology (8th Edition), 2016
7. Geoffrey M. Cooper, Robert E. Hausman; The Cell: A Molecular Approach (8th Edition) by Sinauer Associates; 2014
8. Jeff Hardin Gregory Paul Bertoni; Becker's World of the Cell, (9th Edition) by Pearson; 2015

24-811-0703- ADVANCED MICROBIOLOGY (4C; 4L+0T+0P) (Academic Level 400)

Course description: The course aims to understand the advanced biology of bacteria, viruses, fungi and associated pathogenesis in plants and animals. The course also helps gain in-depth knowledge of the microflora in various habitats and environmental conditions and their plausible industrial applications.

Prerequisites: General Microbiology

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1: Application of specific molecular markers like 16S rDNA/ 18S rDNA /COXa sequence amplification and analysis for molecular classification of microorganisms	Apply
C.O.2: Construction of phylogenetic tree to understand the relatedness	Analyse
C.O.3: Construct Antibiogram for analysis of the antibiotic profile of given pathogens-Disk diffusion method	Analyse
C.O.4: Quantify the antibiotic sensitivity using liquid assay-MIC	Apply
C.O.5: Amplify the R-gene using PCR techniques, confirm its presence by electrophoresis and analyse the sequence data	Apply & Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	2	2					
CO2				1	2	2		
CO3				1	1	2		
CO4			2	1	1			
CO5			2	1	1			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Bacteriology: Classification, virulence factors, microbial communication system; bacterial quorum sensing; toxin genes, virulence, Biofilms in disease; Pathogenic bacteria and viruses, AMR genes in pathogenesis, plant diseases, microbial diseases in animals, Human Bacterial diseases-Tuberculosis, leprosy, Cholera, Typhoid, Human microbiota and their role in human health, Drug-resistant bacteria, antibiotics and antimicrobial agents.

MODULE II- Virology: Virus and bacteriophages, Viruses and bacteriophages, general properties of viruses, Viral structure, genetic materials, virulence factors, viral metabolism, reproduction, phages, viral structure, the taxonomy of viruses, viral replication, cultivation and identification of viruses; sub-viral particles–viroids and prions. Viruses, bacteriophages and their applications, Viral diseases: Polio, HIV, Hepatitis, Rabies, Influenza, H1N1, SARS, COVID-19

MODULE III- Mycology: Fungal diseases in plants and animals pathobiology, beneficial fungi, Antibiotic production, antibiotic resistance mechanisms and alternative measures.

MODULE IV- Microbial genetics: Organization of the bacterial chromosome, Regulation of gene expression, Induction, and repression- the lac operon, regulatory mutants of the lac operon. Quorum sensing and cross-talks. Importance and uses of mutation analysis. Isolation and identification of mutants. Extrachromosomal inheritance. Gene transfer and mapping by conjugation, Gene transfer by transformation and transduction, Transposons. Genetics of bacteriophages- lytic and lysogenic cycles

MODULE V- Genetic analysis of bacteria: Gene mapping, conjugational analysis, transformation and transduction, Molecular techniques in gene mapping-gene libraries, Restriction mapping and PFGE, Diagnosis and epidemiology-gene probes for detection of pathogens, Detection of virulence genes; diagnostic use of PCR, molecular epidemiology.

Genetic analysis of Phages – complementation and recombination tests with phages. Genetic experiments with the rII genes of phage T4. Deciphering the genetic code using rII mutants. Constructing phage genetic linkage maps using two-factor and three-factor crosses.
Assays to analyse transposition events – suicide vectors and mating out assays. Transposon mutagenesis, cloning genes by transposon mutagenesis, mini-Mu elements, and their use in *in vivo* cloning.

REFERENCES

1. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (2001). Textbook of microbiology. MC Graw-Hill publications, 5th edn, New York, 1193, 504-508.
2. Gibson, D. T. (1984). Microbial degradation of organic compounds. Marcel Dekker Inc.
3. Adams, M. R., & Moss, M. O. (2000). The microbiology of food preservation: In Food microbiology.
4. Davis B.D., Dulbecco R., Eisen H N and Ginsberg H S.(1990). Microbiology.4th edition, J. B. Lippincott Company, Newyork.
5. Frazier, W. C., & Westhoff, D. C. (1988). Food microbiology 4th ed. Tata McGraw-Hill Publishing Co. Ltd. New Delhi.
6. Stanier, R.Y. (1987). General Microbiology, 5th Edition, Prentice Hall Macmillan Education Ltd.
7. White, D. (1996). The physiology and biochemistry of prokaryotes: General Pharmacology.
8. Ananthanarayan, R. (2005). Ananthanarayan and Paniker's textbook of microbiology. Orient Blackswan.
9. Marjorie Kelly Cowan (2015). Microbiology: A Systems Approach,3rd edition, McGraw-Hill Higher Education.
10. Booth S J. (2010). Microbiology: Pearls of Wisdom, 2nd edition, Scientific book center.
11. Sherwood, L., Willey, J. M., &Woolverton, C. (2011). Prescott's Microbiology. McGraw-Hill.

24-811-0704- MOLECULAR BIOLOGY (4C; 4L+0T+0P) (Academic Level 400)

Course description: This course is intended to be an advanced course in molecular biology that builds on the basic undergraduate Molecular Biology course. The course is intended to focus more on the fundamental principles of Molecular Biology than the vast information that is there in the field. At the end of the course, students will be able to explain the principles underlying life at a cellular level. They will also be able to design appropriate experiments to test hypotheses regarding the inner workings of a cell. This course will also introduce students to the latest discoveries in the field by way of analysis of original journal articles and presentations by the students.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Describe the fundamental principles of replication and maintenance and gene expression and regulation. in cells	Understand
C.O. 2: Design experimental strategies for testing molecular biological	Analyse

hypothesis	
C.O. 3: Analyse experimental data to explain the reasons for observed changes in gene expression and activity in cells	Analyse
C.O. 4: Select appropriate model systems for studying different molecular biological processes	Analyse
C.O. 5: Analyse and understand journal articles containing original research	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	1	2					
CO3		2	2			1	1	
CO4					1	1	2	
CO5							1	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I

Structure of Macromolecules: Bonds and interactions in Biology; Central Dogma; Structure of DNA and RNA; Denaturation & renaturation of DNA, unique and repetitive DNA sequences (LINEs, SINEs), the 3D structure of proteins, protein folding, Dynamics (Haemoglobin, Myoglobin).

MODULE II

Maintenance of Genome: Genome structure, Chromatin and the Nucleosome; Replication of DNA, Extrachromosomal Replicons; Mutability and Repair of DNA, Homologous Recombination; Site-specific recombination, Transposition of DNA

MODULE III

Transcription and Translation of Genetic Information: Mechanism of Transcription; RNA polymerases in eukaryotes, general and specific transcription factors, assembly of pre-initiation complex, enhanceosomes, elongation factors and elongation; Types of introns and mechanism of splicing. Translation; The Genetic Code.

MODULE IV

Promoter analysis and characterization: Deletion mapping, Transient/stable expression system, S1/RNase mapping, EMSA, DNase I Foot-printing. RNA editing, catalytic RNA; Regulation of initiation of transcription. Control of gene expression: Transcriptional regulation in prokaryotes; Transcriptional Regulation in Eukaryotes. Post-transcriptional gene silencing, RNA Interference. Post-translational modifications

MODULE V

Regulatory RNAs; Gene Regulation in Development and Evolution; Systems Biology; Model Organisms in Molecular Biology (*Saccharomyces cerevisiae Arabidopsis thaliana*, *Drosophila melanogaster*, *Caenorhabditis elegans*, zebrafish, *Mus musculus*).

REFERENCES

1. Molecular Biology of the Gene,7th edition, Watson et al. 2013, CSHL Press (Primary Reference Book)
2. Genes XII, Lewin et. al., 2017, Jones and Bartlett Pub Inc.

3. Molecular Biology of the Cell, Alberts, Bruce, 6th edition, 2014, Garland Pub. Inc.
4. Biochemistry of Nucleic acids, -Roger L. P. Adams et al.,11th edition, 2007, Chapman & Hall
5. Molecular Cell Biology, Lodish, Baltimore, et al., 8th edition, 2016, W.H. Freeman and Co.
6. Molecular Biology and Biotechnology: A Comprehensive Desk Reference, Meyers, Robert A, 2011 ed. Wiley, New Delhi.
7. Molecular Biology –David Clark and Nanette K Pazdernik, 2nd edition,2013, Academic press
8. Selected research papers to be given

24-811-0705- ADVANCED BIOLOGY LAB (4C; 0L+0T+8P) (Academic Level 400)

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Evaluate and estimate various biomolecules using standard biochemical techniques	Analyse
C.O. 2: Analyze various organelles of cells using imaging	Analyse
C.O. 3: Identity carbohydrates (sugars), amino acids/proteins, cholesterol and triglycerides and nucleic acids	Analyse
C.O. 4: Apply recombinant DNA technology technique to demonstrate the bacterial transformation in *E. coli*	Apply
C.O. 5: Apply chromatographic and electrophoretic techniques for purification and molecular analysis of the proteins	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	2	2	1				
CO2		2	2	1	1			
CO3		2	2					
CO4				1	1	1		
CO5				1	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

LIST OF PRACTICAL

Biochemistry

1. Qualitative and Quantitative tests for carbohydrates/proteins/lipids and nucleic acids
2. Cholesterol profiling, Liver and kidney function test
3. Enzyme extraction /purification and Assay to determine activity and specific activity
4. Factors affecting enzyme activity/Fluorescence spectroscopy to study the effect of temperature and pH on protein structure
5. Effect on velocity: MM plot and Lineweaver -Burk Plot determination of Km and Vmax
6. Effect of inhibitors on enzyme activity

Cell Biology

1. Cell culture facilities in practice
2. Cell culture in vitro
3. Trypsinisation and methods for detachment of cells
4. Cell counting and reseeding.
5. Cell imaging analysis of marker proteins for visualizing; various organelles, proliferation, apoptosis, cell-matrix, differentiation and proteins involved in signal transduction.
6. Cell cycle stages by FACS analysis
7. Tissue sectioning using a cryostat.
8. Visualization of the processed tissue samples
9. Immunocytochemistry

Molecular Biology

1. DNA and RNA isolation
2. Primer designing
3. PCR and semi-quantitative RT PCR
4. Analysis of PCR products on an agarose gel.
5. Southern/Northern/Western hybridization techniques
6. Restriction digestion and analysis
7. Competent cell preparation and analysis of efficiency

Advanced Microbiology

1. Media preparation, microbial culture (bacterial and fungal).
2. Growth curves, preservation of the bacteria, plating, dilution plating.
3. Effect of temperature, pH, salts and other stress factors on bacterial growth.
4. Isolation of bacteria from various surroundings, Identification of bacteria by biochemical assays and Gram staining.
5. Antibiotic or drug inhibition assays.
6. Transformation and competent cell preparation studying *E. coli* as a model microorganism for R&D.

24-811-10706 OPEN-ENDED LAB (2C; 0L+0T+4P) (Academic Level 400)

Course Description: The Open-Ended Laboratory Exploration course provides students with the opportunity to engage in hands-on scientific inquiry and experimentation. Through a series of open-ended laboratory activities, students will explore various concepts of Biological Sciences, develop experimental skills, and enhance their critical thinking abilities. The course emphasizes creativity, curiosity, and independent problem-solving.

SEMESTER VIII

SEMESTER VIII

BSc HONORS WITH RESEARCH

24-811-0801 MOOC1 (4C; 4L+0T+0P) (Academic Level 300)
24-811-0802 MOOC2 (4C; 4L+0T+0P) (Academic Level 400)
24-811-0803 Project (12C; 0L+0T+24P) (Academic Level 400)

24-811-0804 Review Writing and Seminar (2C; 0L+2T+0P) (Academic Level 400)

BSc HONORS

24-811-0801- CELLULAR METABOLISM (4C; 3L+0T+2P) (Academic Level 300)

Course Description: This advanced course in biochemistry includes the study of metabolic pathways, energetics, regulation of carbohydrates, amino acids, fatty acids, nucleic acids as well as Electron transport chain and Photosynthesis. In addition, the course offers a deep understanding of analysing the energetics of metabolic pathways, interpretation of metabolic syndromes and disorders at clinical point of view, basic concepts to develop diagnostic protocols and therapeutic strategies against metabolic errors. Also provides insights in to predicting metabolic pathways and hub proteins with respect to disease pathogenesis, identification and validation of metabolites as biomarkers.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O. 1: Compare and contrast biosynthetic and catabolic pathways of carbohydrates based on enzymes involved, intermediates and their regulation Interpret the energetics of carbohydrate metabolic pathways. Interpret the metabolic disorders of carbohydrates and examine how they can be diagnosed clinically	Apply
C.O. 2: Understanding basic metabolic pathways of Lipids and their conjugates Examine the energetics of lipid metabolic pathways. Develop the protocols to interpret the metabolic disorders of lipids and examine how they can be diagnosed clinically	Analyze
C.O. 3: Understanding basic metabolic pathways of Purine and Pyrimidines. Examine the energetics of purine and pyrimidine metabolic pathways. Develop the protocols to interpret the metabolic disorders of purine and pyrimidine and examine how they can be diagnosed clinically.	Analyse
C.O. 4: Understanding basic metabolic pathways of amino acids and proteins. Examine the energetics of protein metabolic pathways. Develop the protocols to Interpret the metabolic disorders of amino acids and proteins and examine how they can be diagnosed clinically.	Analyse

C.O. 5: Interpret metabolic pathways based on proteomics data, Design metabolomic models/protocols to explore novel biomarkers, therapeutic targets and development of therapeutics and diagnostics strategies	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	2						
CO2	2	1	2					
CO3		2	2	2				
CO4	2	1						
CO5		2	1			1	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Overview of carbohydrate metabolism, basic concepts, Glycolysis, Krebs cycle, Electron Transport chain, Photosynthesis, aerobic and anaerobic respiration, ATP synthesis, Energetics, Pentose phosphate pathway, Gluconeogenesis, Glycogenesis, Glycogenolysis, Regulation of carbohydrate metabolism. Inborn errors of carbohydrate metabolism and diagnosis, Galactosemia and Glycogen storage diseases, Metabolic syndrome and life style diseases, Diabetes and Lactose intolerance

MODULE II: Lipid metabolism: Biosynthesis and degradation and regulation fatty acids metabolic pathways, Ketone bodies: formation and utilization. Biosynthesis and degradation and regulation of cholesterol, Eicosanoids biosynthesis, Disorders of Lipids:Clinical features and laboratory findings in disorders of triglyceride, lipoprotein and cholesterol metabolism, lipoprotein and apolipoprotein metabolism; HDL, LDL, VLDL, apoA, apoB, apoC, apoE and their receptors. Fat absorption, transport, storage and metabolism, Investigation and principles of treatment of hyperlipidemia, Inbpre errors of lipid metabolism, lipid storage diseases and diagnosis.

MODULE III: Nucleic Acid metabolism: Biosynthesis and degradation of purines and pyrimidines, regulation of purines and pyrimidines biosynthesis. Biosynthesis of ribonucleotides and deoxyribonucleotides. Uric acid overproduction and underexcretion; pathology and differential diagnosis of gout, treatment of gout, Enzyme disorders of nucleotide metabolism (Lesh-Nyhan syndrome and Orotic acid urea, diagnosis and treatment

MODULE IV: Amino acid metabolism and disorders: Protein degradation and turn over, Amino acid synthesis, Catabolism of amino acid nitrogen - transamination, deamination, ammonia formation; urea cycle, regulation and disorders of amino acid metabolism. Clinical features and laboratory findings in disorders of amino acid protein metabolism, protein misfolding and associated clinical pathogenesis, prion proteins and relevance in neurodegenerative diseases.

MODULE V: Metabolomics and application: Pathway analysis and enrichment by *in-silico* prediction and experimental validation, Networks and interactions between metabolites, pharmaceuticals, SNPs and Proteins, techniques of Metabolic profiling and fingerprinting and their applications, diagnosis of metabolic genetic diseases and syndrome, metabolite target analysis, metabolic applications within animals, plants and microbes, transcriptomics and proteomics in system biology and synthetic biology.

Suggested Practical

1. Estimation of carbohydrates (Sugars), proteins, cholesterol and triglycerides and nucleic acids by spectroscopic analysis
2. Basic metabolic panel: Clinical biochemical tests for glucose, calcium, electrolytes and Liver function and Kidney function test
3. Chromatographic Techniques to study metabolic intermediates
4. Fluorescence spectroscopy to study ligand-protein interaction
5. Proteomics Data analysis, *In-silico* prediction of metabolic pathways, hub proteins,
6. In silico system biology model development, development of metabolic prediction models.

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3. Lehninger, A. L., Nelson, David L., Cox, Michael M. (2013).4.Principles of Biochemistry.6th revised edition. Freeman and Co.
4. Devlin, Thomas. M. (2010). Text book of Biochemistry with Clinical Correlations- 7th edition. John Wiley & Sons.
5. Harper's illustrated biochemistry (2015) Peter J. Kennelly, Kathleen M. Botham, Owen P. McGuinness, Victor W. Rodwell, P. Anthony Weil
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24-811-0802 BIOSTATISTICS AND BIOINFORMATICS (4C; 3L+0T+2P)
(Academic Level 400)

Course description: This course offers an overview of the fundamental concepts of Biostatistics and Bioinformatics. An interdisciplinary program, it emphasizes the integration of Computer Science with Biology and introduces the students to various computational methods and software tools based on biostatistics for understanding biological databases, gene sequence alignments, gene annotation, protein structure predictions, drug discovery, molecular phylogeny, metagenomics, etc.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	Cognitive Level
C.O.1: Understand and interpret commonly reported statistical measures in Biological science and perform basic statistical analyses such as hypothesis testing and estimation	Apply
C.o.2: Measure variability (standard deviation, standard error, co- efficient of variance) and hypothesis testing (Z-test, t-Test, chi-square test)	Apply
C.O. 3: Describe theoretical sources of biological data, and list various biological databases – nucleic acids, protein sequence, metabolic pathways and small molecule	Understand

C.O. 4: Identify various file formats of sequence data and tools for submission of data in databases as well as retrieval of gene and protein data from databases	Understand
C.O. 5: Apply various computational tools and methodologies and their application in structural bioinformatics, functional genomics and in silico drug discovery.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1	2					
CO3	2	2						
CO4		2	1	1				
CO5		1	2	1	1			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to Biostatistics: Variable and attribute; Population *vs.* Sample; Arrangement of data; Frequency distribution. Graphical presentation of data: Line diagram; Bar diagram; Pie chart; Histogram. Measures of central tendency: Arithmetic mean; Mode; Median.

MODULE II: Measures of dispersion: Variance; Standard deviation; Standard error of the mean; Testing of hypothesis and goodness of fit: Null hypothesis, Level of significance, Probability, Normal distribution, Error of inference, Student's t-test, Chi-square test.

MODULE III: Overview of Information Technology: features of the modern Personal Computer and Peripherals computer networks and Internet. Introduction to Operating System. DOS/Windows. Linux. Purchase of technology, license. guarantee. warranty. Definition, Nature & Scope of Bioinformatics.

MODULE IV: Computational Biology; Key Bio-sequences in Molecular Biology - DNA, RNA and Amino acid sequences. Popular Databases in Bioinformatics – NCBI, DDJB, PDB, OMIM; BLAST & FASTA sequence file formats.

MODULE V: Approach of Comparative Biology based on sequence comparison - The basic idea of sequence comparison (algorithms not required) - idea of scoring matrices. The BLAST search engine and types of BLAST- important features- Multiple sequence alignment and phylogenetic analysis). Basic concepts of computer aided drug discovery. Basic concepts of protein structure prediction. Introduction to Comparative Genomics.

Suggested Practical

1. To perform a “two-sample t- test” for a given set of data
2. To learn graphical representations of statistical data with the help of computers (e.g. MS Excel).
3. Accessing different biological databases
4. Retrieval of nucleotide and protein sequences from the databases.
5. To perform pair-wise alignment of sequences (BLAST) and interpret the output
6. Generation of a phylogenetic tree and its analysis
7. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences

8. Predict the structure of a protein from its amino acid sequence.
9. Homology-based protein structure prediction

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24-811-0803- MINI PROJECT (4C; 0L+0T+8P) (Academic Level 400)

24-811-0804- CRITICAL ANALYSIS OF CLASSICAL PAPERS (2C; 2L+0T+0P) (Academic Level 400)

Course Description:
This course aims to equip students with essential skills in effectively communicating scientific concepts and critically analysing research literature. Through interactive lectures and paper presentations, the students will learn how to articulate complex ideas with clarity and precision, while also improving their ability to evaluate the validity, reliability, and significance of research findings. Each week, two-hours will be dedicated to this course, during which each student is given the opportunity to present a research paper of their interest and follow it up with a group discussion with their classmates and teachers. By the end of the course, students will have developed the proficiency to craft well-structured scientific reports, deliver compelling presentations, and engage in insightful discussions on contemporary scientific issues, thus empowering them to excel in both academic and professional settings.

Course Outcomes (CO) After completing the course, the student will be able to:

Course Outcome		Cognitive Level
C.O.1.	Appreciate the path-breaking work published in research papers	Understand

C.O.2.	Apply data analysis tools and logical reasoning in the in-depth study and critical analysis of primary literature data	Apply
C.O.3.	Generate hypothesis from primary literature and anecdotal data	Analyse
C.O.4.	Ability to effectively summarize a compendium of research work or information	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1				1	1	
CO3				2	1			
CO4							1	2

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Source of Scientific Information: Journals (current and back volumes): Indexing journals, abstracting journals, research journals, review journals, e-journals; Impact factor; NCBI-Pub Med., Data Bank and Data Mining; INFLIBNET, INSDOC.

MODULE II: Scientific communication - Writing: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

MODULE III: Student presentations

Guidelines for selecting research papers for presentation:

1. Impact factor: Research papers selected for presentation should have an Impact Factor exceeding 5, ensuring the inclusion of high-quality, influential studies that have made significant contributions to their respective fields.
2. Citation metrics: Preference should be given to papers with a substantial number of citations, indicating widespread recognition and influence within the scientific community. Papers demonstrating robust citation metrics serve as reliable indicators of their importance and relevance in the field.
3. Relevance and timeliness: Papers should be selected based on their relevance to current research trends and emerging topics within the discipline. Emphasis should be placed on choosing papers that address timely issues and contribute to advancing knowledge in key areas of interest.
4. Rigorous peer review: Papers undergoing rigorous peer review processes, preferably from reputable publishers/journals (Springer, John Wiley & Sons, Taylor & Francis, Elsevier etc), with stringent editorial standards, should be prioritized. This ensures the integrity and reliability of the research findings presented, enhancing the credibility of the selected papers.
5. Contribution to advancing knowledge: Selected papers should represent significant advancements or breakthroughs in their respective fields, offering novel insights, innovative methodologies, or transformative outcomes that contribute to the advancement of scientific knowledge and understanding.

General guidelines for paper presentation:

1. A total duration of 40 minutes, with an additional 20 minutes designated for interactive discussion, is allocated for each student presentation.
2. Adherence to the assigned time limit is strongly encouraged to ensure effective time management during the presentation session.
3. The presenting student is required to submit a concise summary (1-2 pages) of the research paper of their choice one-day prior to their presentation.
4. Other students in the batch are required to submit their summaries within two days following the presentation.
5. Students are urged to utilize the subsequent assessment criteria as a reference while preparing for their presentations, as they will be evaluated based on the following marking pattern.

Criteria	**Maximum Marks**
The Standard and Quality of the paper selected	20
Presentation, Delivery, and Time management	30
Subject Knowledge/ Answering Questions	20
Summary writing	10
Overall quality	20
Total	100

24-811-0805- ANALYTICAL TECHNIQUES (4C; 4L+0T+0P) (Academic Level 400)

Course Description: Analytical Techniques in Biological Sciences is designed to provide students with a comprehensive understanding of the various analytical methods and instruments used in the field of biology. The course will cover theoretical principles, practical applications, and hands-on experience with a variety of techniques commonly employed in biological research. Emphasis will be placed on the critical evaluation of data and the selection of appropriate analytical methods for specific biological questions.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcome	**Cognitive Level**
C.O. 1: Introduce students to the fundamental principles underlying analytical techniques in biological sciences.	Understand
C.O. 2: Familiarize students with a range of analytical methods used for the study of biological systems.	Understand
C.O. 3: Provide students with practical skills in using laboratory instruments and equipment for biological analysis.	Remember and Apply
C.O. 4: Develop students' ability to interpret and critically evaluate data obtained from analytical techniques.	Apply
C.O. 5: Enable students to design experiments and select appropriate analytical methods for specific research questions in biology.	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2							
CO3	2	2	1					
CO4		2	1					
CO5			2	1	1	1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to Analytical Techniques in Biology- Overview of analytical methods. Importance of analytical techniques in biological research. **Spectroscopic Techniques**- UV-Visible Spectroscopy, Fluorescence Spectroscopy, Infrared Spectroscopy Nuclear Magnetic Resonance (NMR) Spectroscopy, FTIR, Raman Spectroscopy. Principles of Mass Spectrometry

MODULE II: Chromatographic Techniques- Planar chromatography: Paper and Thin-layer chromatography Gas Chromatography (GC), Liquid Chromatography (LC), High-Performance Liquid Chromatography (HPLC), Thin-Layer Chromatography (TLC). **Molecular Techniques**: Types of PCR: multiplex, nested; reverse-transcription PCR, real-time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, ARMS; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; microarray: 16S rRNA typing; EST; SAGE; Blotting techniques - Southern, Northern

MODULE III: Electrophoretic Techniques- General principles, electrophoresis of nucleic acids: Agarose, pulse-field and sequencing gels, Capillary electrophoresis, Single-molecule electrophoresis. Electrophoresis of proteins: SDS-PAGE, native gels, gradient gels, isoelectric focusing, two-dimensional gels, gel-free protein electrophoresis

MODULE IV: Microscopic Techniques-Light microscopy; lenses and microscopes, refractive index, magnification, resolution: Rayleigh's Approach, Dark-field; Phase Contrast, Differential Interference Contrast; Fluorescence microscopy; Confocal microscopy; Electron microscopy: TEM and SEM. Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM), Atomic Force Microscopy (AFM).

MODULE V: Centrifugation: Basic principles of sedimentation, Types of centrifuges: Micro centrifuge, High speed & Ultracentrifuges; Types of rotors, Preparative and analytical ultracentrifugation methods; preparative centrifugation; differential and density gradient centrifugation; analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

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24-811-0806- CANCER BIOLOGY (4C; 4L+0T+0P) (Academic Level 400)

Course Description: This course aims to provide an inclusive outline of the biology and pathology of cancer by exploring the role of mutations, and dysregulated signalling pathways in cell survival, apoptosis, cell cycle regulation, angiogenesis, metastasis and cancer stemness. The course enriches the basic principles of diagnostics and therapeutic strategies for cancers. In addition, it fosters a deeper insight into techniques to unravel the mechanisms of cancer evolution.

Course Outcomes (CO): After completing the course student will be able to

Course outcomes		**Cognitive level**
C.O.1	Understanding the fundamentals of carcinogenesis	Understand
C.O.2	Understand the basic principles of genetics and epigenetic changes associated with carcinogenesis and demonstrate the methods to identify genetic and epigenetic changes	Understand
C.O.3	Examine intricate signalling events associated with cancer to interpret receptors, oncogenes and enzymes for developing therapeutics.	Analyse
C.O.4	Investigate the role of various mutations/oncogenes/proteins in determining the angiogenic/metastatic and stemness potential of cancer	Analyse
C.O.5	Apply the techniques to evaluate and identify novel biomarkers and therapeutic targets	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	2							
CO3	2							
CO4	2		2	1	1			
CO5			2		1		1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to cancer, types, etiology and incidence; Causes of Cancer, Types of carcinogens: Chemical, Physical and Biological, cancer as a genetic disease, tumour viruses, Oncogenes and tumour suppressor genes, Oncogenesis, immune evasion mechanisms, Clonal evolution, Stages of carcinogenesis and signalling.

MODULE II: Genetics and Epigenetics aspects of Carcinogenesis - Defects in DNA repair and their link to cancer; Driver and passenger mutations, mutational analysis, genomic instability, heterogeneity, Epigenetic changes in cancer, methylation, Histone Acetylation, Non-coding RNAs, miRNAs in cancer, Cancer metabolism and Warburg effect, Techniques employed to identify non-coding RNA, microRNA and epigenetic changes.

MODULE III: Sustaining proliferative signalling: role of growth factors and receptors, complex signalling enabling enhanced survival, cell cycle deregulation, Major pathways in cancer: Ras, EGFR, Wnt, MAPK, AKT, mTOR, Jak-Stat, etc, anti-apoptotic pathways, Bcl2 family proteins, role of P53, events enabling replicative immortalization, role of telomere, Techniques employed in unravelling survival/ apoptosis/cell cycle machinery.

MODULE IV: Angiogenesis, **Metastasis and Cancer Stem cells**: factors aiding the mechanism of angiogenesis, hypoxia (vegf), metastasis (metalloproteinases, EMT), and cancer stem cell maintenances, side cell population, (stem cell markers and efflux pumps), mechanism of tumour aggression and relapse, Techniques employed to elucidate the mechanism of angiogenesis, metastasis and identification of stem cells.

MODULE V: Diagnosis and Therapeutics of Cancer: Diagnostic techniques and methods, biopsy, histopathology, cytology, FISH, FACS, PET, MRI, CT, mammogram and others; Endoscopy methods, Cancer predisposition, SNPs, RFLP, NGS, Single-cell RNA sequencing, exome sequencing, identification and validation of novel markers and therapeutic targets, cancer treatments, surgery, radiation, chemotherapy, immunotherapy, targeted therapy, and precision medicine.

REFERENCES

1. Robert A Weinberg, The Biology of Cancer, 2nd Edition, Garland Publishing (Primary reference)
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3. Peter J Selby Margaret A Knowles, An Introduction To Cellular And Molecular Biology of Cancer by 4th Edition, 2005, Oxford University Press.
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24-811-0807- MOLECULAR NEUROBIOLOGY (4C; 4L+0T+0P)
(Academic Level 400)

Course Description: The course structure is aimed at providing in-depth knowledge of molecular and cellular neurobiology by giving emphasis on human neurobiology. The course introduction focuses on neuroanatomy, neurodevelopment, cell types of the nervous system and mechanisms of neural communication. During the later stages of this course, students get a chance to learn about more integrated functions of the nervous system like sensory processing and the programming of motor functions. In addition, students will also get a basic understanding about how new memories are formed, stored, and retrieved in the brain. The course also focuses on the neuroscience of brain diseases and describes the current methods in neuroscience research.

Course Outcomes(CO): After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Demonstrate a solid understanding of basic neuroanatomy and nervous system function on a molecular, cellular and systems level.	Understand
C.O.2	Analyse how neurons are connected and how it communicates in neuronal circuits that control our behaviour.	Analyse
C.O.3	Analyse the functions of the nervous system such as the regulation of sensation, integration and response; with special emphasis on cognitive functions like learning and memory.	Analyse
C.O.4	Understand and Analyse the neurological disorders such as Alzheimer's disease, Parkinson's Disease, Amyotrophic lateral sclerosis (ALS), Huntington's disease, Schizophrenia, psychiatric disorders, Traumatic Brain Injury and Stroke.	Analyse
C.O.5	Analyse the neurobiological techniques, such as brain histology, optogenetics, electrophysiology, CLARITY, behavioural analyses and transgenics, also identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.	Analyse/ Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2		2	2					
CO3		2	2	1				
CO4	2	1						
CO5	2	2		1				

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Organization of the nervous system: Organization of nervous system; CNS, PNS, Neuroanatomy, Meninges, Cerebrospinal fluid, Blood Brain Barrier, Neuron structure and classification, Glial cells: Structure and function of glial cells, Glial – Neuronal interplay, Neurotrophic factors, Neurogenesis; Birth and migration of neurons, Neural stem cells, Brain changes across the lifespan.

MODULE II: Propagation of nerve impulses and molecular mechanisms of neurotransmission: Biological and electrical properties of neurons, Ionic Basis of the Resting Membrane Potential, Ionic Basis of the Action Potential, Molecular Mechanisms of Action Potential Generation, Propagation of Action Potentials, Synaptic Transmission, Neurotransmitters; chemistry, synthesis, storage, release and uptake, Ionotropic Neurotransmitters Receptors, Metabotropic Neurotransmitters Receptors and Postsynaptic Mechanisms, Synaptic Integration, Long-Term Potentiation and Depression, Spike-Timing Dependent synaptic Plasticity, Hebb's Postulate

MODULE III: Neural Control Systems: Sensory Systems; The Visual System, Audition, Vestibular Sensation and Chemical Senses, Movement and Motor Control, Neural control of; Immune, Cardiovascular, Endocrine and Enteric nervous systems

MODULE IV: Complex Brain Functions and Brain Disorders: Circadian Rhythms, Sleep; Brain Waves and Sleep Stages, Neurobiology of Emotion, Reward and Addiction, Learning and Memory; Cognitive development, Visual Recognition, Language, Short-term, long-term and Working Memory.
Neurodegenerative disorders; Alzheimer's, Parkinson's, Huntington's and Prion Diseases Amyotrophic Lateral Sclerosis, Epilepsy, Psychotic disorders, Schizophrenia, Bipolar disorder

MODULE V: Neurobiology Techniques: Neuronal cell culture, Animal behaviour analysis in Neuroscience, Electrophysiology**,** Whole Brain Imaging; fluorescence, functional magnetic resonance imaging (fMRI), positron emission tomography (PET), Electrochemical techniques; exocytosis measurements, fast-scan cyclic voltammetry, Calcium imaging, Optogenetics, CLARITY

REFERENCES

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2. Neuroscience (7th Edition) by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, Leonard E. White; 2023
3. Neuroscience: Exploring the brain (Enhanced Edition 4th Edition) by Mark F Bear, Barry W. Connors, Michael A. Paradiso; 2020
4. Basic Neurochemistry Principles of Molecular, Cellular, and Medical Neurobiology. (9th Edition) by Scott Brady, George Siegel; 2024
5. From Neuron to Brain (6th Edition) by John G. Nicholls, A. Robert Martin, David A. Brown, Mathew E. Diamond, David A. Weisblat, Paul A. Fuchs; 2020
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7. Basic Clinical Neuroscience (3rd Edition) by Paul A. young, Paul H. young and Daniel L. Tolbert; 2015
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9. Laboratory Press; 2014
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11. Molecular Neurobiology, A Practical Approach-1. Chad and H. Wheal; 1991

24-811-0808- PLANT MICROBE INTERACTIONS (4C; 4L+0T+0P)
(Academic Level 400)

Course Description: This advanced course in Plant-Microbe interactions includes the study of Plants as microbial habitat, cellular plant pathogens and the diseases they cause, Defence of plants and stress responses, Invasion of plant tissue-establishment of symbiotic relations; pathogen invasion strategies, Resistance mechanisms against attack by plant pathogens and plant immune system, Methods employed for disease diagnosis, Molecular Basis of Plant Disease Resistance, Plant defence responses against viruses, and Engineering pathogen resistance in crop plants

Course outcomes (CO): After completing the course the student will be able to

Course Outcome		**Cognitive Level**
C.O.1	Analyse the importance of plant-microbe interactions concerning plant diseases	Analyse
C.O.2	Understand and analyse the different plant defence mechanisms and discuss interactions between plants and non-pathogenic/symbiotic bacteria and fungi in agriculture, horticulture and forestry	Understand/Analyse
C.O.3	Apply the conventional and advanced methodology to study the plant-pathogen interaction	Apply
C.O.4	Apply the knowledge on the molecular plant disease resistance mechanisms	Apply
C.O.5	Discuss plant viral diseases and apply that knowledge to generate engineered disease-resistant plants	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	3							
CO2	2	2	2	1				
CO3	2		2	1				
CO4		2	2	1				
CO5			1				2	1

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Plants as microbial habitat; Introduction to plant-microbe interactions: importance, variety, and two examples (*Fusarium oxysporum* and *Xanthomonas campestris*), symbiotic relations (mycorrhiza, rhizobium), plant diseases cycle, control of plant diseases

MODULE II: Overview of plant defence mechanisms, Infection mechanisms; attachment; enzymes; the role of toxins and other compounds; secondary metabolites of commercial value

MODULE III: Methodology to study plant-microbe interaction- culture techniques, transcriptome profiling, metabolic profiling, proteomics, microscopy, and spectroscopic techniques

MODULE IV: Resistance mechanisms against insect attack; gene-for-gene interactions; The plant immune system- Connecting virulence & resistance; induced resistance

MODULE V: Plant defence responses against viruses, Plant virus transmission; Engineering pathogen resistance in crop plants

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2. Bhadauria, Vijai. "OMICS in plant disease resistance. "*Current Issues in Molecular Biology* 19.1 (2016): 1-2.
3. Bouarab, Kamal, Normand Brisson, and Fouad Daayf, eds. *Molecular plant-microbe interactions*. CABI, (2009).
4. Butter, Nachhattar Singh. *Insect Vectors and Plant Pathogens*. CRC Press, (2018).
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24-811-0809-BIOFUELS AND BIOENERGY (4C; 4L+0T+0P) (Academic Level 400)

Course Description:

This course focuses on bioenergy and the utilization of biomass and biomass waste for energy recovery. The conversion of waste to biofuels, bioenergy and bio-products has been included in the course. The course encompasses thermochemical energy processes (combustion, gasification, pyrolysis), mechanical and chemical processes (oil extraction and trans-esterification), finally biochemical processes (fermentation, anaerobic digestion and bio-electrochemical system). The emphasis is given to Bio-electrochemical systems. The Bio-electrochemical systems used for the conversion of waste to energy such as microbial fuel cells and microbial electrochemical cells has been detailed in this course.

Course Outcomes (CO)

After completing the course the student will be able to:

Course Outcome		**Cognitive Level**
CO 1	Comprehend various technologies used for the synthesis of Biofuel and generation of energy	Understand
CO 2	Illustrate the detailed mechanism and technologies used for the conversion of waste to Bioenergy	Understand
CO 3	Learn the development of microbial fuel cell systems for bio-electricity production	Understand
CO 4	Learn the development of microbial electrochemical systems for bio-hydrogen production	Analyse
CO 5	Practical application of the Bio-electrochemical system	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3							
CO2	2	1						
CO3		1			1			
CO4			2	1		1		
CO5			2		1		1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

Module I: Fundamental concepts in understanding Biofuel/Bioenergy production, Renewable feedstock and their production, Biomass pre-processing: drying, size reduction, and densification, Various Biofuels/Bioenergy from biomass

Module II: Biomass conversion to heat and power: thermal gasification of biomass, anaerobic digestion, Biomass conversion to Biofuel: thermos-chemical conversion, syngas fermentation, Biochemical conversion to ethanol: biomass pre-treatment, Different enzymes, enzyme hydrolysis, and their applications in ethanol production. Biodiesel production from oil seeds, waste oils and algae

Module III: Conversion of waste to Biofuels, bio-products and Bioenergy, Types of waste and their distributions, Strategies for waste management, Waste preparation and Pre-treatment for conversion, Technologies for conversion of waste to energy and products.

Module IV: Bioenergy derived from Electro-chemically active biofilms**:** Bioelectricity production, Synthesis of metal Nano-particles, Bio-hydrogen production, Environmental remediation, Microbial fuel cell: Types of Reactors, Methodology**,** Polarization curve, Coulombic efficiency, cyclic voltammetry, Tafel Analysis and Microbial electrolysis cell.

Module V: Environmental impacts of Biofuel production, Energy balance and life-cycle analysis of Biofuel production, Value-added processing of Biofuel residues and co-products;

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24-811-0810- BIOPROCESSING METHODS AND TECHNIQUES (4C; 4L+0T+0P) (Academic Level 400)

Course Description: This course gives the student an insight into bioprocesses for industrial applications. Differences between bio- and chemical processes, types of bioprocesses, screening for industrially important organisms, strain improvement strategies are all part of

this course. In addition, the kinetics of fermentation in batch and continuous mode, the mass transport processes, reactor design, types of reactors, process control and downstream processing of biological are included.

Course Outcomes (CO): After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O. 1	Employ various methods of strain improvement of industrial organisms	Understand
C.O. 2	Employ batch processes, as well as sterilization processes for application	Understand
C.O. 3	Evaluate factors that contribute to the enhancement of cell and product formation during the fermentation process	Understand
C.O. 4	Analyse kinetics of cell and product formation in batch, continuous and fed-batch cultures	Analyse
C.O. 5	Differentiate the rheological changes during the fermentation process	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2	2	2					
CO2		2	2		1			
CO3			2		1			
CO4			2	1	1			
CO5					2		1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Range of fermentation technology and its chronological development. Basic principle component of fermentation technology. Types of microbial culture. Isolation and screening of industrially useful microorganisms, Primary and secondary screening. Strain improvement in industrial microbiology: mutation and genetic manipulations. Culture Preservation techniques. Screening, detection and assay of fermentation products (physical, chemical and biological assay).

MODULE II: Growth kinetics, primary and secondary metabolites. Feedback inhibition and repression. Types of fermentations: aerobic and anaerobic; submerged and Solid State; Importance of media in fermentation, media formulation and modification. Design of fermentation media Kinetics of growth in batch, continuous, fed- batch fermentation, Storage of cultures for repeated fermentations,

MODULE III: Design of bioprocess vessels: Significance of impeller, Baffles, Sparger, Types of culture/ production vessels: Air-lift, Cyclone column, Packed Tower and their application in production process, Principles of upstream processing. Sterilization: thermal death kinetics, batch & continuous sterilization systems, Sterilization of air, fibrous filters; sterile filtration of biological.

MODULE IV: Introduction to Oxygen requirement in Bioprocess. Energetics of microbial growth in fermenter: Reaction rates, Heat and Mass Transfer, Transport phenomenon in reactors, macroscopic balance of energy and energy flow. Design of a fermenter, instrumentation and process control; Types of fermenter Parts and their functions. Auxiliary instrumentation of bioreactors; Microprocessor controlled fermenters. online measurements;

Monitoring variables such as temperature, aeration, agitation, pressure, pH, foaming; Computers in bioprocess control systems; Economic aspects of bioprocess.

MODULE V: Introduction to Upstream and downstream processing of industrial fermentations: Cell disruptions, Flocculation, Filtrations, Ultra Filtration, Ultra centrifugation, Gel filtration, Chromatographic methods, two phase aqueous separations, Cell and Enzyme immobilization. Fermentation of Antibiotics (Penicillin, Streptomycin), Organic acids (Citric acid, Lactic acid), Enzymes (Penicillin G, Streptokinase), Ethanol and Recombinant Proteins (Insulin).

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SEMESTER IX

SEMESTER IX

24-811-0901- IMMUNOLOGY (4C; 4L+0T+0P) (Academic Level 500)

Course Description: This course is intended to provide a solid grounding in immunology, starting with the basic concepts and proceeding to a deeper understanding of the mechanisms of immune functioning. Special emphasis is given to the 'teamwork' in immune responses. The course also underscores how the system can go wrong, and how it can be corrected or managed using innovative technology. The recently enhanced appreciation of the pre-eminence of the innate immune system, the importance of the intestinal immune system, and the immunomodulatory potential of the gut microbiota are also highlighted. The course also points out the tremendous scope for basic and applied immunological research.

Course Outcomes (CO): After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
C.O.1.Define/recognize the fundamental organization and associations of the immune system.	Understand
C.O.2. Explain/describe/discuss how the immune system functions in a 'teamwork' fashion, and how it is regulated.	Understand
C.O.3. Explain/describe/discuss how the immune system can go wrong, and what types of immuno-pathologies result.	Understand
C.O. 4. Apply appropriate strategies, techniques, and technologies in the management of immune system disorders.	Apply
C.O. 5. Analyze the intricate regulatory mechanisms of the immune system in specific clinical conditions such as hypersensitivities, immunodeficiencies, and autoimmune diseases.	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	1							
CO2	1							
CO3	1		1					
CO4	1		1	2	1			
CO5	1		1		2			

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Introduction to the Immune System**: Historical landmarks, branches, broad divisions of the immune system, antigens vs. immunogens, haptens and carriers, epitopes and paratopes. Hematopoiesis, Theories on immune system functioning; Cells and molecules of the immune system, Inflammation: cellular and molecular events, acute and chronic inflammation, contribution to hypersensitivity and autoimmune reactions; Overview of comparative immunology; Overview of psycho-neuro-endocrine-immunology (PNEI); Overview of the circadian – immune connection; Overview of eco immunology.

MODULE II: **Humoral and Cell-mediated immune responses**: Structure and functions of primary and secondary lymphoid organs; Development, maturation, and functions of T- and B lymphocytes, molecular markers of T- and B- lymphocytes; structure and functions of

antibodies, monoclonal vs. polyclonal antibodies, primary and secondary immune responses, clonal selection and clonal expansion, effector cells of the immune system and their specific roles; Generation of receptor diversity (BCR and TCR), subsets of T- and B- cells; Complement: the 3 pathways, regulatory molecules, disorders of the complement system.

MODULE III: **Strategies of immune functioning**: MHC/HLA: its structure, functions, and role in antigen presentation, disorders of antigen processing and presentation, the relative risk associated with specific MHC haplotypes; Lymphocyte trafficking and interaction at the germinal centres, the role of HEV in lymphocyte trafficking; Immune responses against bacteria, fungi, parasites, viruses, and prions; Immune evasion strategies of pathogens.

MODULE IV: **Clinical immunology**: Immunodeficiencies; Hypersensitivity reactions; Autoimmune diseases; Transplantation immunology; Tumour immunology

MODULE V: **Immuno-prophylaxis and Immuno-technology**: Nanotechnology and its applications in immunology; Hybridoma technology and its applications in medicine; Vaccines: their development, and applications in medicine; Immune manipulation of the intestinal immune system, and the gut microbiota Consolidated immunotherapeutic strategies concerning hypersensitivity, autoimmunity, transplantation, immunodeficiencies, and tumour immunology.

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24-811-0902- GENETIC ENGINEERING (4C; 4L+0T+0P) (Academic Level 500)

Course Description: This is an advanced course dealing with the tools and techniques involved in manipulating DNA. The various modules elaborate the different enzymes, the types of vectors used, the expression systems, the heterologous host systems used as well as the various cloning strategies and the processes involved therein. In addition techniques such as

PCR, blotting, site-directed mutagenesis, gene transfer and various screening strategies are also included.

Course Outcomes (**CO**): After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
C.O.1: Elaborate the different enzymes, vectors, as well as cloning strategies	Understand
C.O.2: Apply the different enzymes used in genetic engineering.	Apply
C.O.3: Use different types of vectors for cloning	Apply
C.O. 4: Produce a genomic DNA library and screening for recombinants and construct a probe and do blotting techniques	Analyse
C.O. 5: Employ different types of PCR techniques for gene amplification and clone the amplicon	Analyse

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	1	2	1					
CO2	1		1					
CO3	1		2		1	1		
CO4	1	2				1		
CO5	1	1		1				

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Enzymes in rDNA technology: Restriction–modification systems, Deoxyribose nucleases: exonucleases and endonucleases, Restriction enzymes-type-I, II, and III. S1 Nucleases, DNA Ligases, Alkaline phosphatase, DNA polymerase.

MODULE II: Cloning strategies: Shotgun cloning, amplicon cloning, cDNA cloning and its advantages and disadvantages. Construction of genomic DNA and cDNA libraries: Cloning Vectors -plasmids, lambda phage, SV40, Phagemids; Construction of artificial chromosome vectors-BAC & YAC; Expression systems and their applications.

MODULE III: Recombinant DNA-tailing, cohesive ends: Use of linkers, blunt end methods; In vitro packaging, Host vector systems; Probe construction; recombinant selection and screening; Southern hybridization, Colony hybridization, Plaque hybridization.

MODULE IV: Applications: PCR: RT-PCR, Inverse PCR, Nested PCR, LAMP; Molecular Markers - RAPD, RFLP, DNA fingerprinting, microsatellites and mini-satellites, SNPs, ESTs, Barcoding; Site-directed mutagenesis; Gene transfer in animals and plants: direct gene transfer and molecular chimeras Microinjection, electroporation, biolistic, direct gene transfer using PEG, calcium chloride, calcium phosphate; Vector mediated gene transfer-Agrobacterium mediated transfer.

MODULE V: Heterologous protein expression in prokaryotes and Eukaryotes- Expression in *E. coli*, yeasts and mammalian cells; Advantages and disadvantages of the various expression systems; cloning of genes into vectors; production and subsequent characterization of the recombinant protein. Genome editing strategies: CRISPR-Cas, TALENS, ZFNs, engineered nucleases, mega-nucleases; MAGE and applications.

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24-811-0903 IMMUNOLOGY & GENETIC ENGINEERING LAB (4C; 0L+0T+8P) (Academic Level 500)

Course Outcomes (**CO**): After the completion of the course, the student will be able to

Course Outcomes	**Cognitive Level**
C.O. 1: Evaluating the blood cell indices using a haemocytometer	Analyse
C.O. 2: Define the basic principles of heaemagglutination and immunodiffusion	Remember
C.O. 3: Analyse antibodies or complement proteins attached to blood cells using diagnostic techniques	Analyse
C.O. 4: Describe the basic principles of immune electrophoresis and evaluate and quantify peptides, proteins, antibodies, and hormones using the ELISA technique	Analyse
C.O. 5: Apply knowledge of molecular biology, immunogenetics to detect specific proteins using western blotting techniques	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2		1	1				
CO2	2		1	1	1			
CO3	1		1	2				
CO4	1		1	1	1			
CO5	1		2			2		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

LIST OF PRACTICAL

<u>Immunology</u>

1. Differential white cell count
2. Haemagglutination (Direct and Indirect)

3. Immunodiffusion (Ouchterlony, Mancini)
4. Complement fixation test
5. Coombs' test
6. Basic immunoelectrophoresis
7. Rocket immunoelectrophoresis
8. Western blotting
9. ELISA
10. HLA typing (immunological and PCR-based)

Genetic Engineering

1. Isolation of genomic DNA
2. Isolation of plasmid DNA from transformed *E. coli*
3. Restriction digestion and analysis of DNA
4. Isolation of total RNA and cDNA library construction (Demo)
5. Preparation of competent cells and Transformation in *E. coli*
6. Construction of genomic DNA library
7. PCR Techniques
8. Real-time PCR (demonstration)
9. DNA sequencing (demo by industrial visit)

24-811-0904 ONLINE COURSE (2C; 2L+0T+0P) (Academic Level 500)

24-811-0905- NGS AND DATA ANALYSIS (4C; 4L+0T+0P) (Academic Level 500)

Course Description: This course provides a strong understanding of the different Next-generation sequencing platforms, which have become the premier tools in genetic and genomic analysis. The course will also provide a better overview of the different public datasets and different file formats in the NGS platforms. The course provides hands-on experience on the R and Linux platforms, which are the inevitable tools for NGS data processing. The course will also introduce the basics of structural biology and molecular docking. The course layout has adapted to the needs of beginners in the field of life science and allows students with no or little background in bioinformatics to get a first hands-on experience in this fast-evolving topic

Course Outcomes (CO): After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Explain the fundamentals of next-generation sequencing technologies	Understand
C.O.2	Explain the NGS workflow, data files and formats	Understand
C.O.3	Analyse and visualize data using R	Analyse
C.O.4	Effectively analyse and interpret RNA sequencing and genome data	Analyse
C.O.5	Effectively predict and analyse the structure of proteins	Analyse

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	1							
CO3	1			2				
CO4	1	1	1	2		2		
CO5	1	2						

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to Next Generation Sequencing (NGS): Principles of NGS technology, Major Applications of NGS, Different NGS Platforms: Illumina, Ion Torrent Semiconductor Sequencing, Pacific Biosciences SMRT, Oxford Nanopore Technologies. Data mining: Database for biological datasets, accessing information from public databases, Sequence storage and retrieval and various file formats

MODULE II: Operating Systems and Concepts: Basic introduction to different Operating systems. Linux: Introduction to Linux, basic commands used for Navigation and Directory controls. File Maintenance Commands, Display Commands and print commands, working with the files, file attributes, pipes, wildcards, working with processes working with basic editors. Basic regular expressions, string search applications using regular expressions. Spreadsheet applications: An introduction to the different spreadsheet applications

MODULE III: Introduction to R: Defining the R project, Obtaining R, Generating R codes, Scripts, Text editors for R, Graphical User Interfaces (GUIs) for R, R Studio, R Packages. R Objects and data structures: Variable classes, Vectors and matrices, data frames and lists, Data sets included in R packages, Summarizing and exploring data, Reading data from external files- tables, fasta files, Storing data to external files, creating basic plots like histograms, scatterplots and bar charts, Creating and storing R workspaces.

MODULE IV: RNA Seq and Genome sequencing: Principles of RNA Sequencing and experimental design, De novo and Resequencing approaches. File format and Quality control: Quality control of datasets obtained from public datasets, Filtering, adapter removal, Mapping, RNA-Seq Data Normalization, Identification of Differentially Expressed Genes, Functional Analysis of identified genes. Genome sequencing: Principles of Genome sequencing and experimental design, Sequencing Strategies for De novo Assembly: Assembly of Contigs, Assessment of Genome Characteristics, Contig Assembly Algorithms; Scaffolding, Assembly Quality Evaluation and Gap Closure. Comparative genomics: Tools and applications

MODULE V: Structural databases: Introduction to structural databases, Protein Data Bank, Molecular Modelling Data Bank, Protein structure prediction- homology modelling, fold recognition, template free modelling. Protein folding problems, Introduction to drug designing and docking methods to generate new structures, Tools for molecular docking.

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24-811-0906- ENVIRONMENTAL MICROBIOLOGY (4C; 4L+0T+0P)
(Academic Level 500)

Course description: This course gives the student an insight into environmental microbiology including a brief history and development of environmental microbiology; aerobiology, aquatic microbiology, microbial diversity insoil and in extreme environments; culture-dependent and culture-independent approaches for understanding microbial diversity in the environment; microbial interactions; microbes in biodegradation of organic compounds, microbes in waste management including liquid waste and solid waste, bioremediation of environmental pollutants

Course outcomes (CO) : After completing the course, the student will be able to

Course outcomes		**Cognitive level**
C.O.1	Discuss the significant contributions of microbiologists, the emergence of environmental microbiology, biogeochemical roles, and significant applications of microbes in solving environmental pollution problems	Understand
C.O.2	Discuss the diversity of microbes in the air, aquatic environments, and drinking water and apply the same for the conservation of the environment and sustainable utilization of environmental resources	Apply
C.O.3	Discuss the diversity of microbes in soil and in extreme environments for the conservation of the environment and apply the same for sustainable utilization of environmental microorganisms	Apply
C.O.4	Discuss about indicator organisms, municipal solid and liquid waste management and apply using waste management techniques	Apply
C.O.5	Discuss the bioremediation of environmental and metal pollutants and use microbes for bioremediation or organic and metal pollution	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1	1					
CO3	1							
CO4	2		1	1		2		
CO5	1					1		

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Brief history and development of environmental microbiology: History and development of microbial ecologyhighlighting significant contributions of microbiologists and emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution. Microbial biogeochemistry, C, N, S, P, Fe cycles. Role of microorganism in the maintenance of the fertility of soil and self-purification of rivers and aquatic bodies; Environmental Concerns in releasing genetically engineered microorganisms in environment; Microorganisms in biological warfare and bioterrorism. **Culture-dependent and culture-independent approaches** for Understanding microbial diversity in the environment.

MODULE II: Aerobiology- -Microbial contamination of air – Sources of contamination-Microbial indicators of air pollution. Enumeration of bacteria in air, Air sampling devices. Air sanitation. Effect of Air Pollution on Plants and Humans. **Aquatic microbiology:** Diversity of microbes in aquatic environments, Microbiology of drinking water, – Water pollution and water borne pathogens –Bacteriological examination of water – Indicator organisms. Purification and disinfection of water. Role of microbes in marine fouling and corrosion. Marine microbes and climate change.

MODULE III: Microbial diversity in soil: Diversity of microbes in terrestrial (agricultural and desert soils) environments, and animal (cattle, termites, pests such as cockroaches and nematodes, and human beings), plants and their role in the ecosystem. **Microbial diversity in extreme environments:** Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, barophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles.

MODULE IV: Indicator Microorganisms, Total Coliforms, Fecal Coliforms and *Escherichia coli*. Fecal Enterococci. *Clostridium perfringes*. Bacteroides and Bifidobacterium. Heterotrophic Plate Count, Bacteriophages. Municipal Wastewater Treatment, Drinking Water Treatment The Nature of Wastewater, Conventional Wastewater Treatment. Oxidation Pools. Septic Tanks. Wetlands Systems Sludge Processing. Treatment of Industrial effluents (distillery, textile, pulp and paper).. **Solid waste management:** composting, anaerobic digestion & biomethanation

MODULE V: Microorganisms and Organic Pollutants, The Overall Process of Biodegradation, Contaminant Structure, Toxicity, and Biodegradability. microbial degradation of cellulose, lignocellulose, paper, textiles, leather, rubber, emerging contaminants and xenobiotics. Environmental Factors Affecting Biodegradation, Biodegradation of Organic Pollutants. Bioremediation. Bioremediation of environmental

pollutants: Petroleum hydrocarbons **Genetically modified microorganisms and Biotechnology.**

Microorganisms and Metal Pollutants. Metals in the Environment. Metal Solubility, Bioavailability, and Speciation. Metal Effects on the Microbial Cell. Mechanisms of Microbial Metal Resistance and Detoxification, Microbial Metal Transformations, Microbial Approaches in the Remediation of Metal-Contaminated Environments.

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13. I.L.Pepper and C.P.Gerba, 2004, Environmental Microbiology-A Laboratory Manual. Elsevier, Academicpress

24-811-0907- MICROBIOME (4C; 4L+0T+0P) (Academic Level 500)

Course description: This course provides an overview of the role of microbiome in human health and disease. It focuses on conceptual frameworks and technologies for understanding how microbiomes, particularly gut microbiomes impact human health and well-being. This course will cover the various microbiomes such the gut, soil, plant, oral, skin etc. The course will also discuss the dysbiosis and rebalancing of the microbiome, The course will also cover various omics techniques used to study the microbiome and microbiome strategies for the treatment of diseases

Course outcomes (CO) After completing the course, the students will be able to:

Course outcomes		**Cognitive level**
C.O.1	Illustrate ecological principles of the human microbiomes, and the importance of conservation of the global microbiomes of peoples from different human populations to development and health	Understand
C.O.2	Discuss the growing importance of considering the human gut microbiome in the treatment and prevention of diseases and illness and to assess the potential of the microbiota (probiotics) and diet (prebiotics) to achieve and maintain health	Apply
C.O.3	Discuss the significance of the microbiome of the environment, soil, water, plant, skin, oral cavity etc and to apply the same for maintaining human health and ecological balance	Apply
C.O.4	Discuss and understand the current technologies in next-generation sequencing and metagenomics in interpreting the role of the human microbiome	Apply
C.O.5	Discuss the application of microbiome for therapeutic purposes	Apply

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	1	1	1					
CO3	2		1				1	
CO4	1	2						
CO5	1	1					1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to the human microbiome. Human microbiome at various taxonomic levels, from the domains of bacteria, fungi and viruses down to species and strain-level differences. Other microorganisms of the human microbiome, The mycome and virome in health and disease. Pathobionts and pathogens, Opportunistic infections, Spore-forming opportunists. Dynamics of microbiome from birth to adulthood. The importance of organismal microbiomes for immunity and metabolism.

MODULE II: The gut microbiome, Diet and the human microbiome, Microbial imbalances and perturbations: Dysbiosis and the gut microbiome, Antibiotics and the human microbiome, Drug metabolism by the microbiome, Behaviour and the microbiome (the gut-brain axis),

Rebalancing of the microbiome: Probiotics, prebiotics and the human microbiome, Current probiotics– from faecal transplants to yoghurts

MODULE III: The skin microbiome. Environmental Microbiome. (Soil, water). Plant microbiome, Animal microbiome. Oral Microbiome, The Microbiome of the Geno-urinary System Oncobiome. Specialised pathogens and their tricks, Food poisoning, enteropathogenic *E. coli* and *Salmonella* (type III secretion systems II), Yersinia and the black death (type III secretion systems I) STDs and *Neisseria gonorrhoeae* (genomic flexibility)

MODULE IV: Introduction to metagenomics and next generation sequencing. DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing and shotgun metagenomics sequencing methods. Functional analysis of the microbiome from DNA sequence functional analysis, meta-transcriptome, metabolome, proteome, and glycome.

MODULE V: Exchange between the human microbiome and the built environment. Comparative microbiomes from other animals. Next-generation therapies for microbial dysfunction and pathology Phage therapy. Microbiome engineering and its promises. Use of animals in microbiome research.

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1. The Gut Microbiome in Health and Disease (2018). Dirk Haller. The Gut Microbiome in Health and Disease. ISBN 978-3-31-990544-0, 978-3-31-990545-7
2. Fundamentals of Microbiome Science: How Microbes Shape Animal Biology. (2018). Angela e Douglas. ISBN. 978140088982
3. The Microbiomes of Humans, Animals, Plants, and the Environment. 2021. Andrés Moya. ISBN: 2662-6128, PRINT ISSN: 2662-611X
4. The Marine Microbiome. 2022. Lucas J. Sta, Mariana Silvia Cretoiu
5. Gut Microbiome-Related Diseases and Therapies. 2021. Maria Gazouli. George Theodoropoulos

24-811-0908 MOLECULAR VIROLOGY *(*4C, 4L+0T+0P) (Academic Level 500)

Course description- The aim of this course is to provide basic knowledge of viruses, viral diseases, and topics important to the control of viral infections including vaccines and antiviral therapy. Replication mechanisms, molecular pathogenesis, host-pathogen interactions, immune evasion strategies, development of antivirals and vaccines, and the relationship between viral evolution and emerging viruses will be taught using representative viruses from different viral families. Rather than covering most of the important microorganisms, select representative model organisms will be taught in detail with the goal that students will be able to apply knowledge and concepts in self-study moving forward in their education and careers. The course also covers currenttrends in emerging viral infections important to public health and biosafety practices in virology laboratories.

Course outcomes (CO) - After completing the course, the students will be able to

Course outcomes		Cognitive level
C.O.1	Understand the classification and nomenclature of viruses, nature of viruses and their structure	Understand
C.O.2	Describe molecular details of replication of viruses with different nucleic acid genomes	Analyse
C.O.3	Describe some of the major viral diseases, their pathogenic mechanisms, transmission and clinical symptoms. Describe how specific viruses evade and/or subvert host innate and adaptive immune functions	Analyse
C.O.4	Employ testing viral diseases by various techniques and conduct diagnostic tests for viral diseases and explain how specific antiviral therapies interfere with viral biology to treat infection	Apply
C.O.5	Employ biosafety practices for handling infectious viruses	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	1						
CO3	2		1	2		1		
CO4	2		2	1	1			
CO5	2		1					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I- Introduction to virology: History and principles of virology, Virus structure and morphology, Classification, and nomenclature of viruses, ICTV and Baltimore. Routes of entry and transmission, acute and persistent infections, tissue tropism

MODULE II- The viral replication cycle: Replication strategies for DNA and RNA genome viruses, Host-pathogen interactions, viral receptors, attachment and entry of enveloped and non-enveloped viruses, Viral entry pathways-fusion, endocytosis, uncoating, cytoplasmic trafficking, nuclear entry, replication, maturation, and release

MODULE III: Molecular Pathogenesis and Transmission of viral diseases:

(1) dsDNA Viruses: Herpesvirus (Adeno virus, Herpes simplex virus, Pox Virus),

(2) ssDNA Viruses : Parvovirus

(3) dsRNA viruses – reoviruses

(4)+ ssRNA Viruses: Picornavirus (Poliovirus), Coronavirus.

(5) -ssRNA Viruses: Orthomyxovirus (Influenza virus), paramyxoviruses, rhabdoviruses

(6) ssRNA viruses with Reverse Transcriptase – retroviruses.

(7) dsDNA viruses with Reverse Transcriptase – hepadnaviruses

Emerging and re-emerging viruses that infect humans and animals: Filovirus (Ebola virus), Nipah, SARS-CoV2, Togavirus (Chikungunya virus), Flavivirus (Dengue Virus), *etc.*

Viral oncogenesis. Immune response to viral infection, viral immune escape mechanism.

MODULE IV: Detection and prevention: Eradication of viral diseases. Diagnosis of viral diseases: microscopy, serological diagnosis-ELISA. PCR immunocytochemistry, immunohistochemistry, haemagglutination, Western blot. Cultivation and enumeration of animal viruses. Plaque assay, LD 50 and TCID 50. **Antiviral agents and vaccines**: Interferons - mode of action and importance in therapy. Antivirals and antiretrovirals-mechanism of action, HAART therapy. Viral vaccine- Different types and their production — Killed and attenuated vaccines, recombinant viral vaccine, subunit vaccines. Virus as vectors for vaccination. Adjuvants. Vaccine delivery. Anti-sense RNA, siRNA, ribozymes

MODULE V: Biosafety in virology laboratory: Classification of viruses into hazard groups. Bio-safety level and biosafety cabinets. Disinfection, decontamination, solid and liquid waste disposal in virology laboratory

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2. Knipe David N, Hawley Peter M Fields Virology Vol.II, , 6th ed. 2013, Lippincot Williams and Wilkins, A,Wolters, Kluwer Business, USA
3. Aseheson, Nicolas H, Fundamental of Molecular Virology2nd ed. 2011, Wiley, New Delhi.
4. D. R. Harper,1st Molecular Virology- edition, 1994, Bio Sci. Pub
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6. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka Principles of Virology: MolecularBiology, Pathogenesis, and Control of Animal Viruses. Latest edition. Publisher: American Society Microbiology.
7. R. Ian Freshney. Culture of Animal Cells: A Manual of Basic Technique. Wiley.
8. Brian WJ Mahy and Hillar O Kangro. Virology Methods Manual Elsevier
9. John R. Stephenson, Alan Warnes. Diagnostic Virology Protocols: Methods in Molecular Medicine. HumanaPress. Springer Link
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14. Editors: Nicholas Johnson,The Role of Animals in Emerging Viral Diseases Academic Press, 2014, Pages 365
15. Brenda S. P. Ang, Tchoyoson C. C. Lim, Linfa Wang. Nipah Virus Infection Journal of Clinical Microbiology,Volume 56 Issue 6 e01875-17, June 2018, Chapter 11 - Nipah Virus: A Virus with Multiple Pathways of Emergence. Pages 293-315 A Review Article:
16. Editors: Saxena, Shailendra K. (Ed.)2019 Coronavirus Disease 2019 (COVID-19) ,Epidemiology, Pathogenesis, Diagnosis, and Therapeutics
17. Marco Cascella; Michael Rajnik; Arturo Cuomo; Scott C. Dulebohn; Raffaela Di Napoli.2019Features, Evaluation and Treatment Coronavirus (COVID-19) - https://www.ncbi.nlm.nih.gov/books/NBK554776/

24-811-0909- ENVIRONMENTAL BIOTECHNOLOGY (4C; 4L+0T+0P)
(Academic Level 500)

Course Description: Environmental Biotechnology explores the application of biological principles and processes to address environmental challenges. This interdisciplinary field integrates concepts from microbiology, biochemistry, engineering, and environmental science to develop sustainable solutions for pollution control, waste management, and resource recovery. Students will gain an understanding of the role of microorganisms, plants, and biotechnological techniques in mitigating environmental pollution, enhancing ecosystem resilience, and promoting environmental sustainability.

Course outcomes (CO): After completing the course. the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Discuss the fundamental principles in the fields of Environmental biotechnology that uses biology to tackle environmental issues sustainably,	Understand
C.O.2	Discuss the vital role microorganisms play in environmental processes and develop skills to apply microbial-based solutions to address environmental challenges effectively.	Understand
C.O.3	Appreciate practical knowledge and skills in selecting, designing, and implementing bioremediation strategies for various environmental contaminants, contributing to the development of sustainable solutions for pollution remediation and environmental protection	Understand
C.O.4	Discuss about waste management principles and sustainability and device strategies for bioconversion of waste to value-added products, and circular economy	Apply
C.O.5	Explain the importance of environmental monitoring, techniques for assessing air, water, and soil quality,	Understand

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	1							
CO2	2	2						
CO3	2		2	2		1		
CO4	1		2	2	2			
CO5	1		1					

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to Environmental Biotechnology- Overview of environmental biotechnology, Importance and scope of environmental biotechnology in addressing environmental issues, Historical development and milestones in environmental biotechnology, Principles of sustainable development and their relevance to environmental biotechnology

MODULE II: Environmental Microbiology-Microbial ecology and diversity in natural environments, Microbial metabolism and interactions relevant to environmental processes, Biodegradation and bioremediation processes, Role of microorganisms in wastewater treatment, soil remediation, and pollution control

MODULE III: Bioremediation Techniques-Introduction to bioremediation techniques and strategies, Physicochemical methods vs. bioremediation approaches, Microbial degradation of organic pollutants, Phytoremediation and its applications in environmental clean-up, Case studies and real-world applications of bioremediation technologies

MODULE IV: Waste Management and Resource Recovery- Principles of waste management and environmental sustainability, Anaerobic digestion for organic waste treatment and energy recovery, Composting techniques and applications in organic waste management, Bioconversion of waste to value-added products (e.g., biofuels, bioplastics), Circular economy concepts and their integration into waste management strategies

MODULE V: Environmental Monitoring and Assessment- Importance of environmental monitoring and assessment, Techniques for monitoring air, water, and soil quality, Biomonitoring approaches using indicator species and bioindicators, Risk assessment methodologies for environmental contaminants**.** Remote sensing and GIS applications in environmental monitoring and management

REFERENCES

1. Environmental Biotechnology: Principles and Applications" by Bruce Rittmann and Perry McCarty (2019)
2. "Biotechnology for Environmental Management and Resource Recovery" by G. Sridevi and T. Satyanarayana (2017)
3. "Environmental Biotechnology: A Biosystems Approach" by Daniel Vallero and Chris Callahan (2010)
4. "Principles of Environmental Biotechnology" by T. K. Bhattacharya and S. A. Dhillon (2015)
5. "Bioremediation: Principles and Applications" by Ronald L. Crawford and Don L. Crawford (2017)
6. "Handbook of Environmental Engineering: Environmental Biotechnology and Biodegradation" edited by Myer Kutz (2019)
7. "Environmental Biotechnology: Basic Concepts and Applications" by Indu Shekhar Thakur (2016)
8. "Biotechnology for Environmental Protection in the Pulp and Paper Industry" edited by Pratima Bajpai (2018)

24-811-0910- PLANT BIOTECHNOLOGY (4C, 4L+0T+0P) (Academic Level 500)

Course Description: This course integrates plant physiology with plant tissue culture techniques, covering gene identification, transgenic plant creation, and advanced methods like Map-based cloning. It includes practical training in tissue culture and genetic transformation, alongside discussions on secondary metabolite production, genetic diversity preservation, and plant-based carbon sequestration for climate change mitigation.

Course outcomes (CO)
After completing the course the student will be able to:

Course outcomes		Cognitive level
C.O.1	Discuss the fundamental principles and techniques in the fields of plant physiology and practical skills and theoretical knowledge to create and manipulate plant tissues for various applications.	Understand
C.O.2	Device strategies to provides a solid introduction to plant genome analysis and gene identification techniques, essential for understanding plant genetics and improving crop traits	Analyse
C.O.3	Appreciate the latest techniques that provides a comprehensive overview of gene transfer methods used to produce transgenic plants with desired traits.	Understand
C.O.4	Formulate strategies of genetic engineering that offers powerful tools for enhancing agricultural productivity, improving crop quality, and addressing global food security challenges	Analyse
C.O.5	Explain the enhancing secondary metabolite production, preserving genetic diversity, and utilizing plant-based carbon sequestration for climate change mitigation.	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3		2					
CO2	2		2	1				
CO3	2	1	2					
CO4	2	2		1				
CO5	2					2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Overview of uniqueness of plants:** General Introduction on physiological processes of higher plants, water relations of plants-, Includes transpiration (water loss), guttation (water exudation), and plasmolysis (cellular water loss). Photosynthesis: Process converting light energy into chemical energy (glucose) in chloroplasts. Involves light reactions (ATP/NADPH production) and Calvin cycle (CO2 fixation).Different pathways (C3, C4, CAM) optimize photosynthesis under varying conditions.

Plant Tissue Culture: Basic concepts: Totipotency: Cells' ability to regenerate into whole plants. Organogenesis: Formation of organs from cultured tissues.Somatic Embryogenesis: Embryo formation from somatic cells. Techniques: Techniques:
Callus, cell suspension, anther, ovule, root, shoot tip, and meristem cultures.
Protoplast culture for genetic manipulation. Micropropagation for rapid, mass plant production. Medicinal and ornamental plant conservation and propagation. Somaclonal variations and their implications. Artificial seed development for plant propagation and storage.

MODULE II: **Plant Genome analysis**; Gene Isolation –Gene Tagging: Identifying genes

by linking them to visible markers. Insertional Mutagenesis: Introducing foreign DNA to disrupt gene function and create mutants. Molecular Markers:DNA sequences aiding genetic mapping and trait analysis (e.g.,RFLP, RAPD, AFLP SSRs, ESTsSNPs), Mapping Populations, Marker-Assisted Selection (MAS) / Genomic Selection: **Identification of Candidate Genes**: Genetic Information (Positional Cloning) Biochemical and Expression Analysis: Transformation: Mutant Populations and Knockout Systems: Heterologous Expression Systems: Protein Analysis

MODULE III: The Gene transfer Techniques for the production of Transgenic: Indirect Gene transfer Methods: **Structural Features of Ti Plasmid, Mechanism of Gene Transfer to Plants, Molecular Events in Agrobacterium-Mediated Gene Transfer.** Direct gene transfer methods: **Particle Bombardment (Biolistics), Silicon Carbide Fiber-Mediated Transformation, Electroporation, Microinjection, PEG-Mediated Transformation.** Reporter Genes: Genes encoding proteins with easily detectable phenotypes (e.g., β-glucuronidase, green fluorescent protein) Scorable and Selectable Markers: (e.g., antibiotic resistance agents (e.g., herbicides, antibiotics)for the identification and propagation of transgenic cells or plants.

MODULE IV: Applications of Genetic Engineering in Agriculture: **Golden Rice:** Engineered to produce beta-carotene, addressing vitamin A deficiency. **Bt Crops:** (Cotton, Brinjal, Mustard) Provide pest resistance via Bt toxin expression**. Crop Resistance Traits: Herbicide Resistance:** Enables weed control with specific herbicides. **Pathogen Resistance:** Protection against viruses, bacteria, and fungi. **Oil Modification:** Alters oil composition for improved nutrition or industrial use. **Current Status of Transgenic Plants:** Commercial adoption in India and globally, notably Bt cotton. **Abiotic Stress Resistance:** Developing crops resilient to drought, salinity, etc.

RNAi Applications: Antisense RNA: Targets specific mRNA for gene regulation. **Genome Editing Tools:** ZFNs, TALENs, CRISPR-Cas9 for precise modifications, **Control of Pollination:** Ensure genetic purity via male sterility or GURT, Production of Biopharmaceuticals: Use plants for antibody, vaccine production, with strict regulation.

MODULE V: Plant Metabolic Engineering; Secondary metabolite production: plant products of industrial importance, cell suspension culture, growth kinetics and cell viability, nutrient media optimization; Scale-up studies: elicitors and precursors; Modes of culture: batch, fed-batch and continuous cultures, cell immobilization, biotransformation; Principles, design and operation of bioreactors: instrumentation, agitation, aeration system, temperature, foam control; Downstream processing: extraction, cell disruption, chromatography and purification of metabolites.

Germplasm Conservation: Importance of genetic diversity in agriculture and biodiversity conservation, Overview of germplasm conservation techniques. Role of germplasm conservation in climate change resilience.

Carbon Sequestration in Plants: Strategies for enhancing carbon fixation, Biomass production and carbon storage in plant tissues, Soil carbon sequestration through plant-microbe interactions, Reforestation, afforestation, and carbon farming practices.

REFERENCES

1. Plant Biotechnology: Current and Future Applications of Genetically Modified Crops" by Nigel Halford and Angela Karp (2019).

2. "Plant Biotechnology and Agriculture: Prospects for the 21st Century" edited by Arie Altman (2021).
3. "Plant Biotechnology: Principles and Applications" by Satbir Singh Gosal and G. S. Chauhan (2020).
4. "Plant Biotechnology: The Genetic Manipulation of Plants" by Adrian Slater, Nigel W. Scott, and Mark R. Fowler (2010).
5. "Plant Biotechnology: Recent Advancements and Developments" edited by Sunil Kumar and Surajit Das (2021).
6. Chilton, M. D., & Tu, J. (2020). Plant Metabolic Engineering. Springer.
7. Tanksley, S. D., & McCouch, S. R. (Eds.). (2021). Plant Genetic Resources and Climate Change. John Wiley & Sons.
8. "Principles of Plant Biotechnology: An Introduction to Genetic Engineering in Plants" by H. S. Chawla (2011).
9. "Plant Biotechnology and Genetics: Principles, Techniques, and Applications" by C. Neal Stewart Jr. (2008).
10. "Introduction to Plant Biotechnology" by H. S. Chawla (2013).
11. "Plant Biotechnology: The Genetic Manipulation of Plants" by Adrian Slater, Nigel W. Scott, and Mark R. Fowler (2008).
12. "Plant Biotechnology: Techniques and Applications" by C. Neal Stewart Jr. (2010).

24-811-0911- STEM CELL AND REGENERATIVE MEDICINE (4C; 4L+0T+0P) (Academic Level 500)

Course description: Stem cell research and regenerative medicine are one of the fastest-growing areas of biomedical research worldwide. Stem cells are specialized cells, which are undifferentiated and capable of self-renewal and have the potential to develop into differentiated cell types. Stem cells act as organisms reserve cells that replace specialized cells that are damaged or lost during the development. During this course, we explore several aspects of stem cell biology like the microenvironments or the niches that are required to maintain stem cells, asymmetric cell division, the genes required for stem cell fate, and the use of stem cells for medical/therapeutic applications. In addition, students will also get an insight into stem cell transplantation and tissue engineering in regenerative medicine and the ethical issues involved in this field of research.

Course Outcomes (CO): After completing the course the student will be able to:

Course outcomes		Cognitive level
C.O.1	Describe different types of stem cells and their specific characteristics and how they differ from fully differentiated cells.	Understand
C.O.2	Analyse the role of various intrinsic and extrinsic factors important for stem cell renewal and differentiation.	Analyse
C.O.3	Analyse the validity of applications of stem cells for regenerative medicine and the possible problems that need to be overcome.	Analyse
C.O.4	Apply techniques based on the use of Embryonic/Fetal, Induced pluripotent and Adult stem cells for regenerative medicine applications to human diseases.	Apply
C.O.5	Analyse the ethical issues associated with Embryonic/Fetal, Induced pluripotent, Adult stem cells and stem cell therapy with a global bioethics perspective and identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.	Analyse& Apply

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	2	2					
CO3	2	1	1					
CO4	2		1	1				
CO5	1					1	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Origin of stem cells: Origin of stem cells in organogenesis, Properties of Stem cells, Cell fate determination, Cell potency, Embryonic stem cells, Adult/Tissue-specific stem cells, Induced pluripotent stem cells (iPSCs), Cord blood stem cells and amniotic fluid stem cells, Developmental plasticity, Dedifferentiation, Trans-differentiation, Somatic Cells by Nuclear Transfer

MODULE II: Tissue-specific/Adult stem cells: Hematopoietic Stem Cells, Mesenchymal Stem Cells, Neural Stem Cells, Epithelial Stem Cells, Skin Stem Cells, Other tissue-specific stem cells, Cancer stem cells, Adult stem cells in tissue homoeostasis.

MODULE III: Regulation of Stem Cell Fate and Function: Stem cell niche, Morphogens and growth factors, Control of gene expression, Epigenetic regulation, Positional identity and polarity in regeneration, Cellular differentiation and environmental insults/Stress, Morphallaxis, Epimorphosis

MODULE IV: Tissue Engineering and Regenerative Medicine: Three-dimensional cell culture, Organ culture, Organotypic culture, Animal models of stem cell research, Preclinical study design, engineered scaffolds and matrices, Bioprinting of organs and tissues, Artificial skin substitute, Assessing potential stem cell risks and complications, Stem cell therapeutic efficacy and stability, Tumorigenicity

MODULE V: Stem cells from the laboratory to the clinic: Modes of cell and tissue delivery, Biobanking of stem cells, *In vivo* regeneration of tissues by cell transplantation, Immuno-isolation techniques, Regulatory perspectives, good laboratory/manufacturing practice (GLP/GMP), Ethical considerations in regenerative medicine, Autologous stem cell therapy, Xenograft and Allograft.

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1. Principles of regenerative medicine (3rd Edition) by Robert Lanza, Tony Mikos, Robert Nerem; Elsevier Academic Press; 2019
2. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells (v. 1). Academic Press; 2013
3. Stem Cells: scientific facts and fiction by Christine Mummery; Ian Sir Wilmut; AnjaVan, De, Stolpe; Bernard Roelen; Elsevier Academic Press; 2011
4. Essentials of Stem Cell Biology. (3rd Edition) By Robert Lanza and Anthony Atala, Elsevier Academic Press; 2013
5. Imaging and Tracking Stem Cells: Methods and Protocols (1st Edition) by Kursad Turksen, Springer Science; 2013
6. Stem Cells & Regenerative Medicine (1st Edition), KrishnaraoAppasani and Raghu K. Appasani; Springer Science, 2011
7. Human Stem Cell Technology and Biology: A Research Guide and Laboratory Manual (1st Edition) by Gary S. Stein, Maria Borowski, Mai X. Luong, Meng-Jiao Shi, Kelly P. Smith, Priscilla Vazquez, Wiley-Blackwell; 2011
8. Stem Cells in Regenerative Medicine: Science, Regulation and Business Strategies; (1st Edition) Alain A. Vertes, NasibQureshi, Arnold I. Caplan, Lee E. Babiss; Wiley-Blackwell; 2015
9. Purifying and Culturing Neural Cells: A Laboratory Manual by Ben A. Barres, and Beth Stevens, 2014
10. Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells (v. 1). Academic Press; 2013

24-811-0912- BIOPHARMACEUTICALS (4C; 4L+0T+0P) (Academic Level 500)

Course Description: This course introduces the basic principles of drug action and the principles of pharmacokinetics and pharmacodynamics. Techniques for drug development: Drug design, targeting & delivery; Drug discovery and development: Lead development, Preclinical and clinical studies, Pharmaceuticals derived from plants, microorganisms, fungi and marine organisms; Production of recombinant products and Good manufacturing practices (GMP) are the other topics covered.

Course Outcomes (CO): After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Discuss the basic principles of drug action and the principles of pharmacodynamics and pharmacokinetics.	Understand
C.O.2	Explain the application of various techniques for drug development: Drug design, targeting & delivery	Understand
C.O.3	Devise strategies for drug discovery and development and to evaluate drugs derived from different sources.	Apply

C.O.4	Describe the production of recombinant biopharmaceutical products such as hormones, thrombolytic agents, antiviral agents and recombinant vaccines.	Understand
C.O.5	Explain Good manufacturing practices (GMP) and design standard operating procedures (SOPs) for the production of biopharmaceuticals.	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2							
CO2	2	3	3					
CO3	2							
CO4	2					2		
CO5	1					2	1	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: **Basic principles of drug action**: Drug administration: drug dose, basis of dose-response curves and its significance, therapeutic index, therapeutic window, dosage forms, routes of administration; Pharmacokinetics: absorption, distribution, metabolism and elimination of drugs; Pharmacodynamics: types and mechanism of drug action, receptor-mediated drug action, stimulation of second messenger system, drug-receptor interactions, agonists, partial agonists, reversible and irreversible antagonist; Pharmacogenetics.

MODULE II: **Techniques for drug development**: Drug design: ligand and receptor-based, Techniques for measuring receptor-drug binding and its uses in new drug development, Techniques used in assay of drugs, quantification of drugs in the body, Targeted drug delivery, Application of nanomaterials in targeted drug delivery, molecular medicine.

MODULE III: **Pharmacognosy:** Importance of natural drug substances, Drugs derived from natural sources such as plants, bacteria, fungi, marine organisms: antibiotics, antivirals and anticancer compounds. **Phases of Drug Development**: drug discovery, preclinical studies; Clinical studies; review by the regulatory authority, drug approval process and post-market drug safety monitoring.

MODULE IV: **Production of recombinant products**: Insulin, human growth hormone, erythropoietin, interferon, recombinant vaccines, Food vaccines, Pharming, Monoclonal antibody-based therapeutic agents.

MODULE V: **Quality and regulatory guidelines for biopharmaceutical production:** Good manufacturing practices (GMP) for the production of recombinant biopharmaceutical products and the establishment of standard operating procedures (SOPs) for a production process, certification of pharmaceutical products

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1. Calbreath, D. F., and Ciulla, A. P. (1992). Clinical chemistry: a fundamental textbook. WB Saunders Company.

2. Walsh, G. (2003). Biopharmaceuticals: biochemistry and biotechnology. John Wiley & Sons.
3. Walsh, G. (2007). Pharmaceutical Biotechnology: Concepts and applications. John Wiley & Sons.
4. Thompson, A. (1991). Bioactive compounds from Marine organisms. Aspect Publications Ltd.
5. Satoskar, R. S., Rege, N., & Bhandarkar, S. D. (2015). Pharmacology and Pharmacotherapeutics-E- Book. Elsevier Health Sciences.
6. Katzung, B. G., Masters, S. B., & Trevor, A. J. (2004). Basic & clinical pharmacology.
7. Purohit, S. S., Kakrani, H. N., & Saluja, A. K. (2003). Pharmaceutical biotechnology. Agrobios (India).

24-811-0913- GENE SILENCING AND GENOME EDITING (4C; 4L+0T+0P)
(Academic Level 500)

Course Description: The Gene Silencing and Genome Editing course explores the principles, techniques, and applications of RNA interference (RNAi) and genome editing technologies. This course provides students with a comprehensive understanding of the molecular mechanisms underlying RNAi and genome editing, as well as practical skills in designing and implementing experiments utilizing these techniques. Ethical considerations and current advancements in the field are also discussed.

Course Outcomes (CO)
After completing the course the student will be able to:

Course outcomes		**Cognitive level**
C.O.1	Understand the molecular mechanisms of RNA interference.	Understand
C.O.2	Explore the principles and applications of genome editing technologies.	Understand
C.O.3	Develop skills in designing and executing RNAi and genome editing experiments using computational approaches	Analyse
C.O.4	Analyse the ethical implications of RNAi and genome editing.	Analyse
C.O.5	Analyse case studies to comprehend real-world applications and challenges of RNAi and genome editing.	Analyse

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CO1	2							
CO2	1	2						
CO3	2			1				
CO4	1							
CO5	2			2		2	2	

1– Slightly/Low, 2 – Moderate/Medium, 3-Substantial/High

MODULE I: Introduction to RNA Interference (RNAi)- Definition and historical context; Mechanisms of RNAi: Small interfering RNA (siRNA) and microRNA (miRNA); Applications in gene regulation, functional genomics, and therapeutics. **RNAi Techniques**- Design and synthesis of siRNA and miRNA; Delivery methods for RNAi molecules; Assays for evaluating RNAi efficiency and specificity

MODULE II: Genome Editing Technologies- Overview of genome editing tools: CRISPR-Cas9, TALENs, ZFNs, etc.; Molecular mechanisms of genome editing; Applications in gene knockout, knock-in, and modulation

MODULE III: **CRISPR-Cas9 Technology**- CRISPR components: Guide RNA (gRNA), Cas9 protein; Designing gRNA for target specificity; Applications in genome editing and gene regulation. **Practical Applications of RNAi and Genome Editing**- Gene silencing in model organisms and cell lines; Genome editing for disease modelling and therapeutic development; RNAi and genome editing in agriculture and biotechnology

MODULE IV: Ethical Considerations in RNAi and Genome Editing- Ethical guidelines and regulatory frameworks; Germline editing vs. somatic cell editing; Case studies: Ethical dilemmas in RNAi and genome editing research and applications

MODULE V: Current Trends and Future Directions-Advances in RNAi and genome editing technologies; Emerging applications in medicine, agriculture, and biotechnology; Challenges and opportunities in the field. **Case Studies and Discussion**- Analysing landmark studies in RNAi and genome editing B. Debating ethical issues and societal implications

REFERENCES

1. "RNA Interference: Methods for Plants and Animals" (2008) edited by T. Doran and C. Helliwell, eISBN : 978-1-78064-365-6
2. Genome Editing-Current Technology Advances and Applications for Crop Improvement (2022) edited by: Shabir Hussain Wani and Goetz Hensel. Springer
3. "CRISPR-Cas: A Laboratory Manual"(2009) edited by Jennifer A. Doudna and Prashant Mali. CSH Press
4. "RNA Interference: Challenges and Therapeutic Opportunities" (2015) edited by Mouldy Sioud, Springer
5. "Ethics of Genome Editing" (2021) European Group on Ethics in Science and New Technologies

SEMESTER X

SEMESTER X

24-811-1001 MAJOR PROJECT (20C; 0L+0T+40P) (Academic Level 600)

24-811-1002 ONLINE COURSE (2C; 2L+0T+0P) (Academic Level 500)**
(if taken in IX for 4C then No need to take here)