Course Curricula

for

Undergraduate Programme

in

Biotechnology

UG-Certificate in Biotechnology

UG-Diploma in Biotechnology

B. Tech. Biotechnology

CONTENTS

INTRODUCTION

Biotechnology encompasses a range of tools and techniques aimed at comprehending the molecular biology of plants and animals to facilitate precise enhancements. Recent advancements in these methodologies have enabled remarkable progress in manipulating macromolecules such as DNA, RNA, and proteins, ultimately benefiting both plants and animals. It is crucial to equip undergraduates with skills in Biotechnology to address the increasing global demand. Recognizing this need, the VI Deans' Committee has undertaken the task of restructuring the Biotechnology course curriculum. The core tenets of the National Education Policy (NEP) have been integrated into the curriculum. Alongside fundamental coursework, students now have access to Skill Enhancement Courses (SECs) which are meticulously crafted to instill proficiency in various facets of Biotechnology. Furthermore, a "Deeksharambh (Foundation Course)" along with the Multi-Disciplinary Courses (MDCs), Value Added Courses (VAC), Ability Enhancement Courses (AECs) and internships have been included. During their final year (first semester of fourth year), students will have the flexibility to select elective courses. These elective courses are structured around four primary themes: Plant Biotechnology, Animal Biotechnology, Microbial and Environmental Biotechnology, and Bioinformatics.

This report reflects the outcomes of extensive consultations and discussions with Deans and educators from diverse Universities across the country. It is my earnest belief that students will immensely benefit from the amalgamation of theoretical knowledge and practical skills embedded within these restructured programmes.

HIGHLIGHTS

- The B.Tech. (Biotechnology) program is designed over 4 years, covering 167 credit hours of coursework. Additionally, students engage in 4 credit hours of non-gradial courses and 10 credit hours of MOOCs/Online Courses.

- The coursework consists of 112 credit hours, comprising 80 credits in major courses (including 20 credit hours of elective courses) and 32 credits in minor courses, 9 credit hours of MDC, 6 credit hours of VAC, 8 credit hours of AEC, 12 credit hours of SEC, and 20 credit hours of student READY activities. Two credit hours of non-gradial courses and 10 credit hours of (massive open online courses) MOOCs/Online Courses.

- Upon completing the first year and undertaking a 10-credit (10-week) industry/institute training or internship, students qualify for the first-level exit with a UG-Certificate in Biotechnology. However, students advancing to the second year of the program will not participate in this industry or institute training/internship.

- Upon completing the first and second years and undertaking a 10-credit (10-week) industry/institute training or internship, students are eligible for the second level exit with a UG-Diploma in Biotechnology. However, students progressing to the third year of the program will not participate in this industry or institute training/internship.

- During the fifth and sixth semesters in the third year, the students will be offered with specialized and advanced courses in Biotechnology and related disciplines. In the fifth semester, students participate in an Educational Tour spanning two weeks (10-14 days), designated as a non-gradial course.

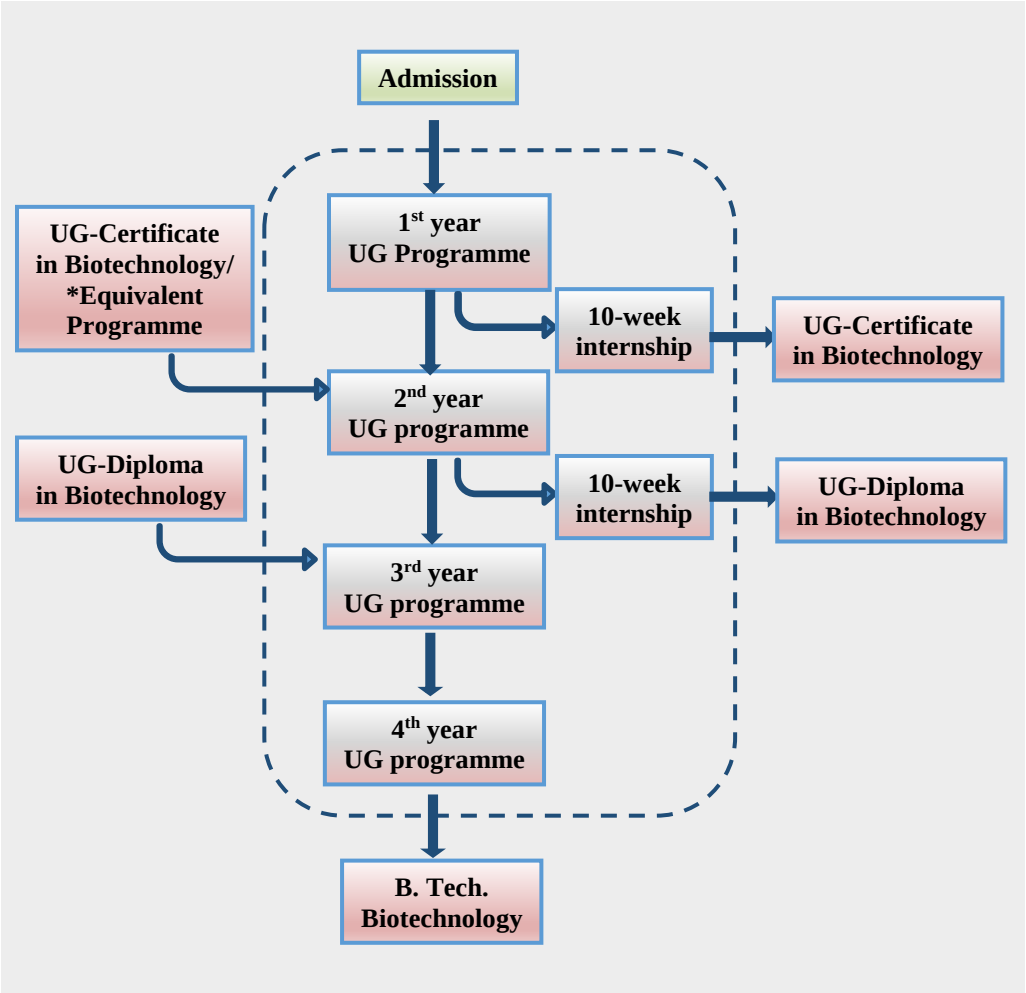
- A selection of courses categorized under four elective themes is proposed to provide a total of 20 credits in the seventh semester. Institutes may choose to adjust this selection to include additional specialized and advanced courses in areas such as Plant Biotechnology, Animal Biotechnology, Microbial and Environmental Biotechnology, and Bioinformatics.

- In the eighth semester, the student READY including in-plant training (RAWE/industry attachment/experiential learning/hands on training/project work/internship) will be taken up by the students.

- Students will enroll MOOCs/Online Courses totaling 10 credit hours during the four years (preferably during the third and fourth years) through approved portals with prior notification to the Head of the Institution.

Entry and Exit Options

The entry and exit options for the UG programmes in Biotechnology are shown in the Figure 1.



*Equivalent programme as decided as per the norms of University /UGC

Figure 1. Entry and exit options for the UG programmes in Biotechnology

Exit options

1. **UG-Certificate in Biotechnology:** Exit after the first year and completion of a 10-week internship.
2. **UG-Diploma in Biotechnology**: Exit after the second year and completion of a 10-week internship.
3. **B. Tech. Biotechnology:** On successful completion of four-year degree requirements.

Eligibility Criteria: 10+2 or intermediate with Physics, Chemistry, Mathematics, Biology from a recognized Board/University or as per the criteria decided by the ICAR/ SAU.

ACADEMIC PROGRAMMES

Four-Year B. Tech. Biotechnology

Semester-Wise Course Distribution

Semester I

Sl.No.	Course Title	Credit Hours	Total Credit hours
First Year			
Semester I			
1.	Molecular Biology	3(3+0)	**21(14+7) +2 Non-gradial**
2.	Introductory Cell Biology	3(3+0)	
3.	Fundamentals of Genetics	3(3+0)	
4.	Basic Mathematics/Basic Botany/Basic Zoology	2(2+0)	
5.	Farming Based Livelihood Systems	3(2+1)	
6.	National Cadet Corps I/ National Service Scheme I	1(0+1)	
7.	Communication Skill	2(1+1)	
8.	SEC 1: Practices in Plant Tissue Culture/ Practices in Animal Cell Culture	2(0+2)	
9.	SEC 2: Laboratory Management and Instrumentation	2(0+2)	
10.	Deeksharambh (Foundation Course)	2(0+2) NG	
Semester II			
1.	Introduction to Biotechnology	3(3+0)	**21(11+10)**
2.	Introduction to Plant Breeding	3(2+1)	
3.	Elementary Microbiology	2(1+1)	
4.	Entrepreneurship Development and Business Management	3(2+1)	
5.	Environmental Studies and Disaster Management	3(2+1)	
6.	National Cadet Corps II/ National Service Scheme II	1(0+1)	
7.	Personality Development	2(1+1)	
8.	SEC 3: Basic Techniques of Molecular Biology and Biotechnology	2(0+2)	
9.	SEC 4: Bioinformatics and Biocomputation	2(0+2)	
Second Year			
Semester III			
1.	Livestock Production and Management	3(2+1)	
2.	Recombinant DNA Technology	2(2+0)	

3.	Classical and Molecular Cytogenetics	3(2+1)	**20(12+8)**
4.	Plant Physiology/Anatomy and Physiology of Livestock	3(2+1)	
5.	Fundamentals of Crop Protection/ Livestock Product Technology	3(2+1)	
6.	Biomathematics	2(2+0)	
7.	Physical Education, First Aid and Yoga Practice	2(0+2)	
8.	SEC 5: Methods in Recombinant DNA Technology	2(0+2)	
Semester IV			
1.	Introductory Bioinformatics	4(3+1)	**21(15+6)**
2.	Molecular Marker Technology	2(2+0)	
3.	Biodiversity and Its Conservation	2(2+0)	
4.	Basic Biochemistry	4(3+1)	
5.	Human Ethics	1(1+0)	
6.	Agriculture Marketing and Trade	3(2+1)	
7.	Agriculture Informatics	3(2+1)	
8.	SEC 6: Practices in Molecular Marker Technology	2(0+2)	
Third Year			
Semester V			
1.	Microbial Genetics	4(3+1)	**23(18+5) +2(Non-gradial)**
2.	Molecular Genetics	3(3+0)	
3.	Nanobiotechnology	4(3+1)	
4.	Animal Biotechnology	3(2+1)	
5.	Genomics and Proteomics	3(3+0)	
6.	Enzymology and Enzyme Technologies	3(2+1)	
7.	Immunology	3(2+1)	
8.	Educational Tour	2(0+2) NG	
Semester VI			
1.	Molecular Diagnostics	3(2+1)	**20 (15+5)**
2.	Industrial Biotechnology	3(3+0)	
3.	Epigenetics and Gene Regulation	2(2+0)	
4.	IPR, Biosafety and Bioethics	2(2+0)	
5.	Computational Biology	3(2+1)	
6.	Introduction to Animal Breeding	3(2+1)	
7.	Biostatistics	2(1+1)	
8.	Food Science and Processing	3(2+1)	
Fourth Year			
Semester VII			

	Elective I. Plant Biotechnology		
1.	Applications of Genomics and Proteomics	4(3+1)	**20(14+6)**
2.	Principles of Molecular Breeding	4(3+1)	
3.	Molecular Breeding of Horticultural Crops and Forest Trees	3(2+1)	
4.	Molecular Breeding in Field Crops	3(2+1)	
5.	Seed Biology, Production and Management	3(2+1)	
6.	Plant Genetic Transformation	3(2+1)	
	Elective II. Animal Biotechnology		
1.	Principles and Procedures of Animal Cell Culture	4(3+1)	**20(15+5)**
2.	Animal Genomics	4(3+1)	
3.	Transgenic Animal Production	3(3+0)	
4.	Molecular Virology and Vaccine Production	3(2+1)	
5.	Embryo Transfer Technologies	3(2+1)	
6.	Animal Reproductive Biotechnology	3(2+1)	
	Elective III. Microbial and Environmental Biotechnology		
1.	Fundamentals of Molecular Pharming and Biopharmaceuticals	4(3+1)	**20(16+4)**
2.	Microbial Biotechnology	4(3+1)	
3.	Bioprospecting of Genes and Molecules	3(3+0)	
4.	Molecular Ecology and Evolution	3(3+0)	
5.	Food Biotechnology	3(2+1)	
6.	Green Biotechnology	3(2+1)	
	Elective IV. Bioinformatics		
1.	Programming in Bioinformatics	4(2+2)	**20(13+7)**
2.	Bioinformatics Tools and Biological Databases	3(2+1)	
3.	Structural Bioinformatics	3(2+1)	
4.	Pharmacogenomics	3(2+1)	
5.	Metabolomics and Systems Biology	4(3+1)	
6.	Computational Methods for Data Analysis	3(2+1)	
Semester VIII			
1.	Student READY (RAWE/industry attachment/experiential learning/hands on training/project work/internship) in the area of Plant Biotechnology, Animal Biotechnology, Microbial and Environmental Biotechnology and Bioinformatics	20(0+20)	**20(0+20)**

Department-Wise Course Breakup

Sl.No	Department-wise Courses	Credit Hours
Agriculture Courses		
1.	Farming Based Livelihood Systems	3(2+1)
2.	Introduction to Plant Breeding	3(2+1)
3.	Fundamentals of Crop Protection	3(2+1)
4.	Agriculture Marketing and Trade	3(2+1)
Animal Science Courses		
1.	Livestock Production and Management	3(2+1)
2.	Anatomy and Physiology of Livestock	3(2+1)
3.	Livestock Product Technology	3(2+1)
4.	Introduction to Animal Breeding	3(2+1)
Basic Science Courses		
1.	Plant Physiology	3(2+1)
2.	Biomathematics	2(2+0)
3.	Basic Biochemistry	4(3+1)
4.	Enzymology and Enzyme Technologies	3(2+1)
5.	Immunology	3(2+1)
6.	Biostatistics	2(1+1)
Biotechnology Core Courses		
1.	Molecular Biology	3(3+0)
2.	Introductory Cell Biology	3(3+0)
3.	Fundamentals of Genetics	3(3+0)
4.	Practices in Plant Tissue Culture	2(0+2)
5.	Practices in Animal cell Culture	2(0+2)
6.	Laboratory Management and Instrumentation	2(0+2)
7.	Introduction to Biotechnology	3(3+0)
8.	Elementary Microbiology	2(1+1)
9.	Basic Techniques of Molecular Biology and Biotechnology	2(0+2)
10.	Bioinformatics and Biocomputation	2(0+2)
11.	Recombinant DNA Technology	2(2+0)
12.	Classical and Molecular Cytogenetics	3(2+1)
13.	Methods in Recombinant DNA Technology	2(0+2)
14.	Introductory Bioinformatics	4(3+1)
15.	Molecular Marker Technology	2(2+0)
16.	Biodiversity and Its Conservation	2(2+0)

17.	Practices in Molecular Marker Technology	2(0+2)
18.	Microbial Genetics	4(3+1)
19.	Molecular Genetics	3(3+0)
20.	Nanobiotechnology	4(3+1)
21.	Animal Biotechnology	3(2+1)
22.	Genomics and Proteomics	3(3+0)
23.	Molecular Diagnostics	3(2+1)
24.	Industrial Biotechnology	3(3+0)
25.	Epigenetics and Gene Regulation	2(2+0)
26.	IPR, Biosafety and Bioethics	2(2+0)
27.	Applications of Genomics and Proteomics	4(3+1)
28.	Principles of Molecular Breeding	4(3+1)
29.	Molecular Breeding of Horticultural Crops and Forest Trees	3(2+1)
30.	Molecular Breeding in Field Crops	3(2+1)
31.	Seed Biology, Production and Management	3(2+1)
32.	Plant Genetic Transformation	3(2+1)
33.	Principles and Procedures of Animal Cell Culture	4(3+1)
34.	Animal Genomics	4(3+1)
35.	Transgenic Animal Production	3(3+0)
36.	Molecular Virology and Vaccine Production	3(2+1)
37.	Embryo Transfer Technologies	3(2+1)
38.	Animal Reproductive Biotechnology	3(2+1)
39.	Fundamentals of Molecular Pharming and Biopharmaceuticals	4(3+1)
40.	Microbial Biotechnology	4(3+1)
41.	Bioprospecting of Genes and Molecules	3(3+0)
42.	Molecular Ecology and Evolution	3(3+0)
43.	Food Biotechnology	3(2+1)
44.	Green Biotechnology	3(2+1)
45.	Programming in Bioinformatics	4(2+2)
46.	Bioinformatics Tools and Biological Databases	3(2+1)
47.	Structural Bioinformatics	3(2+1)
48.	Pharmacogenomics	3(2+1)
49.	Metabolomics and Systems Biology	4(3+1)
50.	Computational Methods for Data Analysis	3(2+1)
Deficiency/Remedial Courses		
1.	Basic Mathematics	2(2+0)
2.	Basic Botany	2(2+0)
3.	Basic Zoology	2(2+0)
General Courses		
1.	National Cadet Corps I/ National Service Scheme I	1(0+1)
2.	Communication Skill	2(1+1)
3.	Entrepreneurship Development and Business Management	3(2+1)
4.	Environmental Studies and Disaster Management	3(2+1)

5.	National Cadet Corps II/ National Service Scheme II	1(0+1)
6.	Personality Development	2(1+1)
7.	Physical Education, First Aid and Yoga Practice	2(0+2)
8.	Human Ethics	1(1+0)
9.	Agriculture Informatics	3(2+1)
10.	Computational Biology	3(2+1)
11.	Food Science and Processing	3(2+1)
Student READY		**20(0+20)**
Non-gradial Courses		
1.	Deeksharambh (Foundation Course)	2(0+2)
2.	Educational Tour	2(0+2)
MOOCs/Online Courses		**10(0+10)**

Summary of Credit Hours for Different Categories of Courses

Sl. No.	Major Courses	Credit Hours	Total Credit Hours
1	Molecular Biology	3(3+0)	**60(51+9)**
2	Introductory Cell Biology	3(3+0)	
3	Fundamentals of Genetics	3(3+0)	
4	Introduction to Biotechnology	3(3+0)	
5	Introduction to Plant Breeding	3(2+1)	
6	Elementary Microbiology	2(1+1)	
7	Livestock Production and Management	3(2+1)	
8	Recombinant DNA Technology	2(2+0)	
9	Classical and Molecular Cytogenetics	3(2+1)	
10	Introductory Bioinformatics	4(3+1)	
11	Molecular Marker Technology	2(2+0)	
12	Biodiversity and Its Conservation	2(2+0)	
13	Microbial Genetics	4(3+1)	
14	Molecular Genetics	3(3+0)	
15	Nanobiotechnology	4(3+1)	
16	Animal Biotechnology	3(2+1)	
17	Genomics and Proteomics	3(3+0)	
18	Molecular Diagnostics	3(2+1)	
19	Industrial Biotechnology	3(3+0)	
20	Epigenetics and Gene Regulation	2(2+0)	
21	IPR, Biosafety and Bioethics	2(2+0)	
Minor Courses			
1	Basic Mathematics/Basic Botany/Basic Zoology	2(2+0)	
2	Plant Physiology/Anatomy and Physiology of Livestock	3(2+1)	

3	Fundamentals of Crop Protection/Livestock Product Technology	3(2+1)	
4	Biomathematics	2(2+0)	
5	Basic Biochemistry	4(3+1)	
6	Human Ethics	1(1+0)	**32(23+9)**
7	Enzymology and Enzyme Technologies	3(2+1)	
8	Immunology	3(2+1)	
9	Computational Biology	3(2+1)	
10	Introduction to Animal Breeding	3(2+1)	
11	Biostatistics	2(1+1)	
12	Food Science and Processing	3(2+1)	
Multi-Disciplinary Courses			
1	Farming Based Livelihood Systems	3(2+1)	**9 (6+3)**
2	Entrepreneurship Development and Business Management	3(2+1)	
3	Agriculture Marketing and Trade	3(2+1)	
Value Added Courses			
1	Environmental Studies and Disaster Management	3(2+1)	**6 (4+2)**
2	Agriculture Informatics	3(2+1)	
Ability Enhancement Courses			
1	National Cadet Corps I/ National Service Scheme I	1(0+1)	**8 (2+6)**
2	Communication Skill	2(1+1)	
3	National Cadet Corps II/ National Service Scheme II	1(0+1)	
4	Personality Development	2(1+1)	
5	Physical Education, First Aid and Yoga Practice	2(0+2)	
Skill Enhancement Courses (SEC)			
1	SEC 1: Practices in Plant Tissue Culture/ Practices in Animal Cell Culture	2(0+2)	**12 (0+12)**
2	SEC 2: Laboratory Management and Instrumentation	2(0+2)	
3	SEC 3: Basic Techniques of Molecular Biology and Biotechnology	2(0+2)	
4	SEC 4: Bioinformatics and Biocomputation	2(0+2)	
5	SEC 5: Practices in Recombinant DNA Technology	2(0+2)	
6	SEC 6: Practices in Molecular Marker Technology	2(0+2)	
Elective Courses in Plant Biotechnology			
1	Applications of Genomics and Proteomics	4(3+1)	**20 (14+6)**
2	Principles of Molecular Breeding	4(3+1)	
3	Molecular Breeding of Horticultural Crops and Forest Trees	3(2+1)	
4	Molecular Breeding in Field Crops	3(2+1)	
5	Seed Biology, Production and Management	3(2+1)	
6	Plant Genetic Transformation	3(2+1)	

Elective Courses in Animal Biotechnology			
1	Principles and Procedures of Animal Cell Culture	4(3+1)	**20 (15+5)**
2	Animal Genomics	4(3+1)	
3	Transgenic Animal Production	3(3+0)	
4	Molecular Virology and Vaccine Production	3(2+1)	
5	Embryo Transfer Technologies	3(2+1)	
6	Animal Reproductive Biotechnology	3(2+1)	
Elective Courses in Microbial and Environmental Biotechnology			
1	Fundamentals of Molecular Pharming and Biopharmaceuticals	4(3+1)	**20 (16+4)**
2	Microbial Biotechnology	4(3+1)	
3	Bioprospecting of Molecules and Genes	3(3+0)	
4	Molecular Ecology and Evolution	3(3+0)	
5	Food Biotechnology	3(2+1)	
6	Green Biotechnology	3(2+1)	
Elective Courses in Bioinformatics			
1	Programming in Bioinformatics	4(2+2)	**20 (13+7)**
2	Bioinformatics Tools and Biological Databases	3(2+1)	
3	Structural Bioinformatics	3(2+1)	
4	Pharmacogenomics	3(2+1)	
5	Metabolomics and Systems Biology	4(3+1)	
6	Computational Methods for Data Analysis	3(2+1)	
Student READY			**20**
Non-gradial Courses			
1	Deeksharambh (Foundation Course)	2(0+2)	**4 (0+4)**
2	Educational Tour	2(0+2)	
MOOCs/Online Courses			**10**

Abstract of Credit Hour Allocation over the Semesters

Semester	Core Courses (Major+ Minor)	Multi-Disciplinary Courses (MDC)	Value Added Courses (VAC)	Ability Enhancement Courses (AEC)	Skill Enhancement Courses (SEC)	Internship/ Project/ Student READY	Total Credit Hours	Non-gradial	MOOCs/ Online Courses
I	11	3[1]		1[2] + 2[3]	4[4,5]	-	21	2[6]	10
II	8	3[7]	3[8]	1[9] + 2[10]	4[11,12]	-	21	-	
Post-II	-	-	-	-	-	10[13]	-	-	
III	16	-	-	2[14]	2[15]	-	20	-	
IV	13	3[16]	3[17]	-	2[18]	-	21	-	
Post-IV	-	-	-	-	-	10[19]	-	-	
V	23	-	-	-	-	-	23	2[20]	
VI	21	-	-	-	-	-	21	-	
VII	20	-	-	-	-	-	20	-	
VIII	-	-	-	-	-	20	20	-	
Total	**112**	**9**	**6**	**8**	**12**	**20**	**167**	**4**	**10**

Note: The credit hours indicated represent the combined total of theory and practical components.

(1) Farming Based Livelihood Systems
(2) National Cadet Corps I/ National Service Scheme I
(3) Communication Skill
(4) Practices in Plant Tissue Culture/ Practices in Animal Cell Culture
(5) Laboratory Management and Instrumentation
(6) Deeksharambh (Foundation Course)
(7) Entrepreneurship Development and Business Management
(8) Environmental Studies and Disaster Management
(9) National Cadet Corps II/ National Service Scheme II
(10) Personality Development
(11) Basic Techniques of Molecular Biology and Biotechnology
(12) Bioinformatics and Biocomputation
(13) Internship for those exiting with UG-Certificate in Biotechnology
(14) Physical Education, First Aid and Yoga Practice
(15) Practices in Recombinant DNA Technology

(16) Agriculture Marketing and Trade
(17) Agriculture Informatics
(18) Practices in Molecular Marker Technology
(19) Internship for those exiting with UG-Diploma in Biotechnology
(20) Educational Tour

Summary of Credit Distributions

Categories of Courses		**Credit Hours**
Core Courses (Major and Minor)	:	92
Common Courses (MDC+VAC+AEC)	:	23
Skill Enhancement Courses (SEC)	:	12
Elective Courses	:	20
Student READY	:	20
Non-gradial Courses	:	4*
MOOCs/Online Courses (Non-gradial)	:	10**
Grand Total	:	167+4*+10**

DETAILED SYLLABI

Semester I

Molecular Biology **3(3+0)**

Objectives

- To study the principles and techniques of molecular biology.
- To study the central dogma of life.
- To study the tools in molecular biology.

Theory

History of molecular biology. Central dogma of life. Structure of DNA and RNA. Gene structure and function. DNA replication and transcription. Genetic code and translation. Structure of prokaryotic and eukaryotic nuclear and organelle genomes. Gene regulation in prokaryotes. Lac operon concept and tryp operon concept.

Introduction to microbial genetics; conjugation, transformation and transduction. Tools in molecular biology. Role of enzymes in molecular biology. Principles of Polymerase Chain Reaction and electrophoresis.

Suggested Reading

1. Lewin B, 2017, Gene XII, Oxford University Press.
2. Cooper GM and Hausman RE, 2018, The Cell: A Molecular Approach. Sinauer Associates Inc, 8th Ed.
3. Nelson DL and Cox MM, 2017, Lehninger principles of biochemistry, 7th Ed, W. H. Freeman.
4. Satyanarayana U and Chakrapani U, 2021, Essentials of Biochemistry, Elsevier.

Introductory Cell Biology **3(3+0)**

Objectives

- Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
- Students will understand how these cellular components are used to generate and utilize energy in cells.
- Students will understand the cellular components underlying mitotic cell division.
- Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation.

Theory

Origin and evolution of cell. Introduction to microscopy. Sub-cellular structure of prokaryotic and eukaryotic cells. Membrane structure and function: plasma membrane, cell wall and extracellular

matrix. Structural organization and function of intracellular organelles and organelle biogenesis. Nucleus, mitochondria, endoplasmic reticulum, golgi apparatus, lysosomes, peroxisomes, plastids and vacuoles.

Structure and function of the cytoskeleton and its role in motility. Cell membrane transport. Introduction to cell signalling. Cell growth, cell cycle and its control. Cell death and cell renewal.

Suggested Reading

1. Verma PS and Agarwal VK, 2016, Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S Chand and Sons.
2. Cooper GM and Hausman RE, 2018, The Cell: A Molecular Approach. Sinauer Associates Inc.

Fundamentals of Genetics **3(3+0)**

Objectives

- To study the history of genetics.
- To study inheritance and variation.
- To study chromosomes and cell division.
- To study the genetic basis of traits.

Theory

History of Genetics. Mendel's principles and rediscovery. Cell division. Chromosome structure and function. Chromosome theory of inheritance. Sex-linked, sex-limited and sex-influenced inheritance. Sex determination and sex differentiation.

Multiple allelism. Linkage and crossing-over. Gene-gene interaction. Genetic analysis in prokaryotes and eukaryotes. Extra chromosomal inheritance. Mutations. Hardy-Weinberg law. Quantitative inheritance. Introduction to human genetics. Genetic basis of evolution.

Suggested Reading

1. Brah GS, 2014, Animal Genetics: Concepts and Implications, 2nd Ed, Kalyani Publishers.
2. Gardener EJ, Simmons MJ and Snustad DP, 1991, Principles of Genetics. John Wiley and Sons, Inc, New York, USA.

Basic Mathematics **2(2+0)**

Objectives

- To study the basic principles and functions in mathematics like limits and continuity.
- To study differentiation and integration.
- To study matrices and determinants.

Theory

Functions; Limit: Introduction, left-handed and right-handed limits, general rules for the calculation of limits Standard limits. Continuity: Definition of continuity, continuity of algebraic functions. Continuity of trigonometric and exponential functions.

Differentiation: Differentiation by the first principle, sum, difference, product and quotient formulae, differentiation using the chain rule, differentiation of functions in parametric and implicit form, logarithmic differentiation, geometrical interpretation of derivative. Successive differentiation, geometrical interpretation of derivative, maxima and minima, tangent and normal.

Integration: Integration by substitution, integration by partial fractions, integration by parts, integration by trigonometric substitution.

Matrices and Determinants: Definition of matrix, addition, subtraction and multiplication, inverse of matrix. Solution of linear equations; by Crammer's rule and inverse of matrix.

Suggested Reading

1. NCERT, 2012, Mathematics of Class XII, NCERT, India.
2. Sharma RD, 2014, Mathematics of Class XII, Dhanpat Rai Publisher.

Basic Botany **2(2+0)**

Objectives

- To study the basic taxonomy and classification of plants.
- To study the features of plant kingdom and morphology.
- To study the internal structure of plants.

Theory

Plant kingdom and features of each group. Morphology, modifications and functions of root, stem, leaf, flower and inflorescence. Pollination and fertilization. Fruit types. Structure of dicot and monocot seed, and seed germination.

Cell structure. DNA, chromosome and genes. Cell and tissue types. Internal structure of root, stem and leaf.

Plant taxonomy, systems of classification. Characteristics and economic importance of Poaceae, Brassicaceae, Fabaceae, Malvaceae, Rutaceae, Rosaceae, Asteraceae and Solanaceae families.

Suggested Reading

1. Pande PC and Jain DK, 2022, A textbook of Botany Angiosperm. S. Chand publications.
2. NCERT 2021. Biology of Class XI. NCERT, India.
3. David M Hillis; H Craig Heller; Sally D Hacker; David W Hall; David E Sadava. 2020. Life: the science of biology 12th Ed, Sunderland publication. eBook
4. Bhatia K.N. and Tyagi M.P. 2020 Elementary Biology. A truemen publication

5. Bendre AM and Kumar A, 1999, Textbook of Practical Botany. Vol. 2, 7th Ed, Rastogi Publications.
6. Bendre AM and Pande PC, 2009, Introduction to Botany, Rastogi publications.
7. Dutta AC, 1995, A Class Book of Botany, 16th Ed, Oxford University Press.

Basic Zoology **2(2+0)**

Objectives

- To study cells and biomolecules.
- To study animal kingdom and nomenclature.
- To study the organization of mammalian systems.

Theory

Introduction to Zoology. Structure and functions of cell and cell organelles. Difference between prokaryotic and eukaryotic cell. Structure and function of biomolecules. Types of simple and compound tissues.

Binomial nomenclature. Classification and general survey of the animal kingdom. Functional organization of various systems of a mammal; digestive, circulatory, respiratory, excretory, nervous and reproductive. Laws of inheritance. Multipleallelism - blood groups. Genetic disorders in human and their inheritance.

Suggested Reading

1. Chopra G and Dhami PS, 2021, A Text Book of Biology, Pradeep Publications.
2. NCERT, 2022, Biology of Class XI, 2022-23. NCERT, India.
3. David MH, Craig HH, Sally DH, David WH and David ES, 2020, Life: the science of biology, 12th Ed, Sunderland Publication.
4. Bhatia KN and Tyagi MP, 2020, Elementary Biology, A Truemen Publication.

Farming Based Livelihood Systems **3(2+1)**

Objectives

- To make the students aware about farming based livelihood systems in agriculture
- To disseminate the knowledge and skill how farming based systems can be a source of livelihood

Theory

Status of agriculture in India and different states. Income of farmers and rural people in India. Livelihood-definition, concept and livelihood pattern in urban and rural areas. Different indicators to study livelihood systems. Agricultural livelihood systems (ALS); meaning, approach, approaches and framework. Definition of farming systems and farming based livelihood systems prevalent farming systems in India contributing to livelihood. Types of traditional and modern farming systems. Components of farming system/ farming-based livelihood systems- crops and

cropping systems, livestock, (dairy, piggery, goatry, poultry, duckry etc.). Horticultural crops, agroforestry systems, aquaculture, duck/poultry cum fish, dairy cum fish, piggery cum fish etc. Small, medium and large enterprises including value chains and secondary enterprises as livelihood components for farmers. Factors affecting integration of various enterprises of farming for livelihood. Feasibility of different farming systems for different agro-climatic zones. Commercial farming-based livelihood models by NABARD, ICAR and other organizations across the country. Case studies on different livelihood enterprises associated with the farming. Risk and success factors in farming-based livelihood systems. Schemes and programmes by central and state government, public and private organizations involved in promotion of farming-based livelihood opportunities. Role of farming-based livelihood enterprises in 21st century in view of circular economy, green economy, climate change, digitalization and changing life style.

Practical

Survey of farming systems and agriculture-based livelihood enterprises. Study of components of important farming-based livelihood models/ systems in different agro-climatic zones. Study of production and profitability of crop based, livestock based, processing based and integrated farming-based livelihood models. Field visit of innovative farming system models. Visit of agri-based enterprises and their functional aspects for integration of production, processing and distribution sectors and study of agri-enterprises involved in industry and service sectors (value chain models). Learning about concept of project formulation on farming-based livelihood systems along with cost and profit analysis. Case study of start-ups in agri-sectors.

Suggested Reading

1. Dixon J, Gulliver A and Gibbon D, 2001, Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World, FAO & World Bank, Rome, Italy & Washington, DC, USA.
2. Ashley C and Carney D, 1999, Sustainable Livelihoods: Lessons from Early Experience; Department for International Development: London, UK, Volume 7.
3. Reddy SR, 2016, Farming System and Sustainable Agriculture, Kalyani Publishers, New Delhi.
4. Panwar AS, Ravisankar N, Prusty AK, Shamim M, Singh R, Bhaskar S, Malik SK, Tomar RK, Arunachalam A and Alagusundaram K, 2019, Integrated Farming System models for Agricultural Diversification, Enhanced Income and employment, Indian Council of Agricultural Research, New Delhi.
5. Singh JP, Ravisankar N, Prusty AK, Sikka AK and Gangwar B, 2016, Region Specific Synthesized Integrated Farming System Models for Improved Production, Profitability and Nutrition (Series 1). IIFSR Bulletin No. 2016-1, AICRP on Integrated Farming Systems, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut, pp. 1-88.
6. Walia SS and Walia US, 2020, Farming System and Sustainable Agriculture, Scientific Publishers, Jodhpur, Rajasthan.
7. Bhatt BP, Abhay Kumar, Thakur PK, RS, Amitava Dey UK, Sanjeev Kumar BK, Jha, LK, Pathak KN, Hassan A, Singh SK, Singh KK and Singh KM, 2014, Livelihood Improvement of Underprivileged Farming Community: Some Experiences from Vaishali, Samastipur, Darbhanga and Munger Districts of Bihar by ICAR Research Complex for Eastern Region

ICAR Parisar, P.O. Bihar Veterinary College, Patna - 800 014, Bihar.
8. Carloni A, 2001, Global Farming Systems Study: Challenges and Priorities to 2030 – Regional Analysis: Sub-Saharan Africa, Consultation Document, FAO, Rome, Italy.
9. Evenson RE, 2000, Agricultural Productivity and Production in Developing Countries', In FAO, The State of Food and Agriculture, FAO, Rome, Italy.
10. Agarwal A and Narain S, 1989, Towards Green Villages: A strategy for Environmentally, Sound and Participatory Rural Development, Center for Science and Environment, New Delhi.

National Cadet Corps I **1(0+1)**

Objectives

- To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen.
- To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation.

Practical

Aims, objectives, organization of National Cadet Corps (NCC) and NCC song. DG's cardinals of discipline. Drill- aim, general words of command, attention, stands at ease, stand easy and turning. Sizing, numbering, forming in three ranks, open and close order march, and dressing. Saluting at the halt, getting on parade, dismissing, and falling out. Marching, length of pace, and time of marching in quick/slow time and halt. Side pace, pace forward and to the rear. Turning on the march and wheeling. Saluting on the march. Marking time, forward march, and halt. Changing step, formation of squad and squad drill. Command and control, organization, badges of rank, honours, and awards.

Nation Building- cultural heritage, religions, traditions, and customs of India. National integration. Values and ethics, perception, communication, motivation, decision making, discipline and duties of good citizens. Leadership traits, types of leadership. Character/personality development. Civil defense organization, types of emergencies, firefighting, protection. Maintenance of essential services, disaster management, aid during development projects. Basics of social service, weaker sections of society and their needs, NGO's and their contribution, contribution of youth towards social welfare and family planning. Structure and function of human body, diet and exercise, hygiene and sanitation. Preventable diseases including AIDS, safe blood donation, first aid, physical and mental health. Adventure activities. Basic principles of ecology, environmental conservation, pollution and its control.

National Service Scheme I **1(0+1)**

Objectives

- Evoking social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic

leadership, developing skill in programme, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

Practical

Orientation: history, objectives, principles, symbol, badge; regular programs under National Service Scheme (NSS). Organizational structure of NSS, Code of conduct for NSS volunteers, points to be considered by NSS volunteers' awareness about health. NSS program activities. Concept of regular activities, special camping, day camps, basis of adoption of village/slums, conducting survey, analyzing guiding financial patterns of scheme, youth program/ schemes of GOI, coordination with different agencies and maintenance of diary. Understanding youth. Definition, profile, categories, issues and challenges of youth; and opportunities for youth who is agent of the social change. Community mobilization. Mapping of community stakeholders, designing the message as per problems and their culture; identifying methods of mobilization involving youth-adult partnership. Social harmony and national integration. Indian history and culture, role of youth in nation building, conflict resolution and peace- building. Volunteerism and *shramdaan.* Indian tradition of volunteerism, its need, importance, motivation, and constraints; shaman as part of volunteerism. Citizenship, constitution, and human rights. Basic features of constitution of India, fundamental rights and duties, human rights, consumer awareness and rights and rights to information. Family and society. Concept of family, community (PRIs and other community-based organizations) and society.

Communication Skills **2(1+1)**

Objectives

To acquire competence in oral, written and non-verbal communication, develop strong personal and professional communication and demonstrate positive group communication

Theory

Communication process: the magic of effective communication. Building self-esteem and overcoming fears. Concept, nature and significance of communication process. Meaning, types and models of communication. Verbal and non-verbal communication. Linguistic and non-linguistic barriers to communication and reasons behind communication gap/ miscommunication.

Basic communication skills. Listening, speaking, reading and writing skills. Precise writing/abstracting/summarizing. Style of technical communication. Curriculum vitae/resume writing. Innovative methods to enhance vocabulary, analogy questions.

Structural and functional grammar. Sentence structure, modifiers, connecting words and verbals. Phrases and clauses. Case: subjective case, possessive case, objective case. Correct usage of nouns, pronouns and antecedents, adjectives, adverbs and articles. Agreement of verb with the subject: tense, mood, voice. Writing effective sentences. Basic sentence faults.

Practical

Listening and note taking. Writing skills; precise writing, summarizing and abstracting. Reading and comprehension (written and oral) of general and technical articles. Micro-presentations and impromptu presentations. Feedback on presentations. Stage manners; grooming, body language, voice modulation, speed. Group discussions. Public speaking exercises; vocabulary building exercises. Interview techniques. Organization of events.

Suggested Reading

1. Allport, GW, 1937, Personality: A Psychological Interpretation. Holt, New York.
2. Brown M and Gyles B, 1994, How to Interview and be Interviewed, Sheldon Press, London.
3. Carnegie D, 1997, The Quick and Easy Way to Effective Speaking, Pocket Books, New York.
4. Francis Peter SJ, 2012, Soft Skills and Professional Communication, Tata McGraw Hill, New Delhi.
5. Kumar S and Pushpa Lata, 2011, Communication Skills, Oxford University Press.
6. Neuliep JW, 2003, Intercultural Communication A Contextual Approach. Houghton Mifflin Co Boston.
7. Pease, A, 1998, Body Language, Sudha Publications, Delhi.
8. Raman M and Singh P, 2000, Business Communication, Oxford University Press.
9. Seely J, 2013, Oxford Guide to Effective Writing and Speaking, Oxford University Press.
10. Thomson AJ and Martinet AV, 1977, A Practical English Grammar, Oxford University.

Practices in Plant Tissue Culture **2(0+2)**

Objectives

- This course aims at imparting hands-on training on the calculation of per cent solutions, molarity, molality, normality; and preparation of buffers.
- To study basic equipments used in plant molecular biology and cell culture laboratories; washing, packing and sterilization of glass and plastic wares for cell culture.
- To study preparation of media and reagents for cell culture, primary culture technique, culture and sub-culturing of continuous cell lines, viability assay by trypan blue dye exclusion method, micropropagation, haploid production, embryo rescue, cryopreservation of primary cultures and cell lines.
- Preparation of phytohormones and sterilization.
- To study tissue culture laboratory management.

Practical

Laboratory safety and aseptic techniques, sterilization methods for equipment and media, media preparation, preparation of solid and liquid media, pH adjustment and sterilization of media. Culture initiation and explant selection. Selection of explants: meristem, node, leaf, embryo etc. Surface sterilization of plant material. Techniques for explant preparation and inoculation on to culture media. Callus induction and subculture. Subculture techniques: transfer of cultures to fresh media, monitoring and maintenance of cultures, organogenesis and embryogenesis.

Micropropagation. Genetic transformation. Cryopreservation and conservation. Project Work: students design and conduct a small-scale tissue culture project. They will choose a plant species, select appropriate explants, culture them in vitro, and document the progress and results.

Suggested Reading

1. Bhojwani SS and Razdan MK, 1996, Plant Tissue Culture: Theory and Practice, Elsevier.
2. Reinert J and Bajaj YPS (Ed), 1989, Applied and Fundamental Aspects of Plant Cell, Tissue, and Organ Culture, Springer-Verlag.

Practices in Animal Cell Culture **2(0+2)**

Objectives

- To learn washing of glasswares, packing and sterilization of glass and plasticware for cell culture
- Preparation of media and reagents for cell culture.
- Primary culture technique. Culture and sub-culturing of continuous cell lines. Viability assay by trypan blue dye exclusion method. Cryopreservation of primary cultures and cell lines.
- To study tissue culture laboratory management.

Practical

Laboratory safety and aseptic techniques. Cell culture media and supplements. Composition of cell culture media: DMEM, RPMI, MEM, etc. Serum and serum-free media formulations. Preparation and sterilization of media supplements. Cell culture initiation and maintenance. Cell line authentication and characterization, Thawing and subculturing of cells. Monitoring cell growth and viability. Cell passaging and cryopreservation. Cell line development and authentication. Methods for establishing new cell lines. Authentication techniques: STR profiling, isoenzyme analysis, quality control measures in cell culture. Cell-based assays. Principles of cell-based assays: viability, proliferation, apoptosis, techniques for measuring cell responses: MTT assay, flow cytometry, ELISA. Application of cell-based assays in drug screening and toxicity testing. Transfection (lipofection, electroporation) and gene expression, 3D cell culture and tissue engineering, cell culture project. Students design and conduct a small-scale cell culture project. They will choose a specific cell line or assay, culture cells accordingly, perform experiments, analyze data, and present their findings.

Suggested Reading

1. Michael B, 2003, Animal Cell Culture and Technology, THE BASICS (Garland Science).
2. Bhatia S, Naved T and Sardana S, 2019, Introduction to animal tissue culture science, IOP Publishing Ltd.
3. Al-Rubeai M (Ed), 2015, Animal cell culture. Springer International Publishing, ISBN: 978-3-319-10319-8, 978-3-319-10320-4.
4. Davis JM (Ed), 2011, Animal cell culture: essential methods. John Wiley and Sons, ISBN: 0470666587, 9780470666586.

5. Butler M, 2004, Animal cell culture and technology, Taylor and Francis, ISBN: 9781859960493,1859960499.

Laboratory Management and Instrumentation **2(0+2)**

Objectives

- To study the establishment and management of different molecular biology laboratories.
- To impart hands-on training on good laboratory practices, calculation of per cent solutions, molarity, molality, normality; and preparation of buffers.
- To study basic equipments used in animal molecular biology and cell culture laboratories, record keeping, teamwork, and SOP of different instruments of the labs.
- Safe disposal of laboratory chemiclas and reagents as per the biosafety guidelines.

Practical

Importance of laboratory safety and regulatory compliance. Quality management systems: ISO 9001, GLP, GMP, laboratory safety and regulatory compliance. Risk assessment and hazard identification. Inventory management and equipment maintenance. Principles of laboratory inventory management. Equipment calibration and preventive maintenance. Documentation and record-keeping for regulatory compliance. Quality assurance and control. Introduction to quality assurance (QA) and quality control (QC). Quality control checks for laboratory reagents and instruments, Troubleshooting common laboratory errors and deviations. Spectroscopy and spectrophotometry, applications in quantitative analysis and molecular biology. Chromatography techniques, microscopy and imaging. Molecular biology techniques. Instrumentation project: students design and conduct a small-scale project using one of the laboratory instruments covered in the course. They will collect data, analyze results, and present their findings.

Suggested Reading

1. Gakhar SK, Miglani M and Ashwani K, 2013, Molecular Biology: A Laboratory Manual, ISBN: 9789382332305.
2. Fulekar MH and Pandey B, 2013, Bioinstrumentation, ISBN: 9789382332398.
3. Green MR and Sambrook J, 2012, Molecular cloning: A Laboratory Manual 4th Ed, Cold Spring Harbor.
4. Rapley R and Whitehouse D, (Eds), 2015, Molecular biology and biotechnology, Royal Society of Chemistry.
5. Kreuzer H and Massey A, 2008, Molecular biology and biotechnology: a guide for students 3rd Ed, ASM Press.

Deeksharambh (Foundation Course) **2(0+2)**

Objectives

- Aims at creating a platform for students to help for cultural Integration of students from different backgrounds, know about the operational framework of academic process in university, instil life and social skills, social awareness, ethics and values, team work,

leadership, creativity, etc. and identify the traditional values and indigenous cultures along with diverse potentialities both in indigenous and developed scenario.

The details of activities will be decided by the parent universities. The structure shall include, but not restricted to:

- Discussions on operational framework of academic process in University, as well as interactions with academic and research managers of the University.
- Interaction with alumni, business leaders, perspective employers, outstanding achievers in related fields, and people with inspiring life experiences.
- Group activities to identify the strength and weakness of students (with expert advice for their improvement) as well as to create a platform for students to learn from each other's life experiences.
- Activities to enhance cultural Integration of students from different backgrounds.
- Field visits to related fields/ establishments.
- Sessions on personality development (instilling life and social skills, social awareness, ethics and values, team work, leadership, etc.) and communication skills.

Semester II

Introduction to Biotechnology **3(3+0)**

Objectives

- To understand the basic concepts of molecular biology and methods used in the manipulation of nucleic acids to isolate and characterize genes.
- To understand how molecular tools are used to modify an organism. To study the history, concepts and scope of biotechnology.
- To study the applications of biotechnology

Theory

Introduction to genetic material, history of genetic material, physical and chemical basis of genetic material. Structure of DNA and RNA, scope and importance of Biotechnology. Plant, microbial, animal, medical, environmental, industrial. Marine, agricultural and food biotechnology. Nanobiotechnology.

Introduction to recombinant DNA technology. Vectors, DNA manipulating and modifying enzymes, gene cloning. Introduction to genomics and proteomics. Molecular markers, DNA sequencing. Genetic transformation and transgenic organisms. Bioinformatics. Biosafety guidelines.

Suggested Reading

1. Singh B, Gautam SK, Chauhan MS and Singla SK, 2015, Textbook of Animal Biotechnology, The Energy and Resources Institute, TERI.
2. Singh BD, 2020, Biotechnology Expanding Horizons, Kalyani publishers.

3. Thieman W and Palladino M, 2018, Introduction to Biotechnology (What's New in Biology), 4th Ed, Pearson ISBN 0134650190, 9780134650197
4. Chawla HS, 2024, Introduction to Plant Biotechnology, 4th Ed., CBS Publishers and Distributors Pvt. Ltd.

Introduction to Plant Breeding **3(2+1)**

Objectives

- To study the development and goals of plant breeding.
- To study modes of reproduction.
- To study the methods of plant breeding

Theory

History, aims and objectives of plant breeding. Role of related sciences in plant breeding. Modes of reproduction - sexual, asexual, apomixes and significance in plant breeding. Modes of pollination, genetic consequences, differences between self- and cross-pollinated crops. Germplasm resources and their utilization.

Methods of breeding: introduction and acclimatization. Selection: mass selection, Johannesen's pureline theory, genetic basis, pure-line selection. Hybridization: aims and objectives, types of hybridization. Methods of handling segregating generations. Pedigree method, bulk method, back cross method. Heterosis, inbreeding depression, various theories of heterosis, exploitation of hybrid vigour. Hardy Weinberg law, selection in cross-pollinated crops. Population improvement programmes. Synthetics and composites. Methods of breeding vegetatively propagated crops.

Incompatibility and male sterility and their utilization in crop improvement. Mutation breeding. Ploidy breeding. Wide hybridization and its significance in crop improvement. Procedure for release of new varieties.

Practical

Classification of plants. Botanical description and floral biology of field crops: rice, sorghum, maize, wheat, bajra, sugarcane, brassicas, groundnut, sunflower, sesamum, red gram, bengal gram, green gram, soybean, black gram, cotton. Study of megasporogenesis and microsporogenesis. Fertilization and life cycle of an angiosperm plant. Hybridization techniques and precautions to be taken. Selfing, emasculation and crossing techniques. Study of male sterility and incompatibility.

Suggested Reading

1. Allard RW. 1960. Principles of Plant Breeding, John Wiley and Sons.
2. Chahal GS and Gosal SS, 2002, Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches, Narosa Publishers.
3. Singh P, 2014, Essentials of Plant Breeding, Kalyani Publishers.
4. Singh BD, 2009, Plant Breeding: Principles and Methods, Kalyani Publishers.

Elementary Microbiology **2(1+1)**

Objectives

- To study the history of microbiology and major groups of eukaryotes and prokaryotes.
- To study the preservation methods and repositories.
- To study bacterial growth and metabolism.
- To study the applications of microbes.

Theory

History of Microbiology and its applied areas. Microorganisms and their role in health and environment. Control and prevention measures against microorganisms/diseases. Introduction to eukaryotic and prokaryotic cells. Major groups of eukaryotes; fungi, algae and protozoa. Major groups of prokaryotes; bacteria, archaebacteria, rickettsia and chlamydia. Preservation of microorganisms, microbial repositories at national and international level.

Bacterial growth. Metabolism in bacteria, ATP generation, chemoautotrophy, photoautotrophy, respiration, fermentation. Viruses and Bacteriophages, structure and properties, lytic and lysogenic cycles, viroids, prions.

Beneficial microorganisms in agriculture, biofertilizers, microbial pesticides. Microbes in composting and biodegradation. Microbiology of water and food.

Practical

Microscope and other instruments in a microbiological laboratory. Media preparation, sterilization and aseptic methods for isolation, identification, preservation and storage. Identification of bacteria by staining methods. Enumeration of bacteria by pour plate and spread plate methods. Micrometery.

Suggested Reading

1. Woolverton CJ, Sherwood LM, and Willey JM, 2016, Presscotts Microbiology, McGraw-Hill Education.

Entrepreneurship Development and Business Management **3(2+1)**

Objectives

- To provide student an insight into the concept and scope of entrepreneurship.
- To expose the student to various aspects of establishment and management of a small business unit.
- To enable the student to develop financially viable agribusiness proposal.

Theory

Development of entrepreneurship, motivational factors, social factors, environmental factors, characteristics of entrepreneurs, entrepreneurial attributes/competencies. Concept, need for and importance of entrepreneurial development. Evolution of entrepreneurship, objectives of

entrepreneurial activities, types of entrepreneurs, functions of entrepreneurs, importance of entrepreneurial development, and process of entrepreneurship development. Environment scanning and opportunity identification need for scanning–spotting of opportunity-scanning of environment– identification of product / service – starting a project; factors influencing sensing the opportunities. Infrastructure and support systems- good policies, schemes for entrepreneurship development; role of financial institutions, and other agencies in entrepreneurship development. Steps involved in functioning of an enterprise. Selection of the product / services, selection of form of ownership; registration, selection of site, capital sources, acquisition of manufacturing know how, packaging and distribution. Planning of an enterprise, project identification, selection, and formulation of project; project report preparation, Enterprise Management. Production management – product, levels of products, product mix, quality control, cost of production, production controls, Material management. Production management – raw material costing, inventory control. Personal management – manpower planning, labour turn over, wages / salaries. Financial management /accounting – funds, fixed capital and working capital, costing and pricing, long term planning and short-term planning, book keeping, journal, ledger, subsidiary books, annual financial statement, taxation. Marketing management- market, types, marketing assistance, market strategies. Crisis management- raw material, production, leadership, market, finance, natural etc.

Practical

Visit to small scale industries/agro-industries, Interaction with successful entrepreneurs/ agric-entrepreneurs. Visit to financial institutions and support agencies. Preparation of project proposal for funding by different agencies.

Suggested Reading

1. Charantimath PM, 2009, Entrepreneurship Development and Small Business Enterprises. Pearson Publications, New Delhi.
2. Desai V, 2015, Entrepreneurship: Development and Management, Himalaya Publishing House.
3. Gupta CB, 2001, Management Theory and Practice. Sultan Chand & Sons.
4. Grover I, 2008, Handbook on Empowerment and Entrepreneurship. Agrotech Public Academy.
5. Khanka SS, 1999, Entrepreneurial Development. S. Chand & Co.
6. Mehra P, 2016, Business Communication for Managers. Pearson India, New Delhi.
7. Pandey M and Tewari D, 2010, The Agribusiness Book. IBDC Publishers, Lucknow.
8. Singh D, 1995, Effective Managerial Leadership. Deep & Deep Publications.
9. Singhal RK, 2013, Entrepreneurship Development & Management, Katson Books.
10. Tripathi PC and Reddy PN, 1991, Principles of Management. Tata McGraw Hill.
11. Desai V, 1997, Small Scale Industries and Entrepreneurship. Himalaya Publication House.

Environmental Studies and Disaster Management **3(2+1)**

Objectives

- To expose and acquire knowledge on the environment and to gain the state-of-the-art - skill and expertise on management of disasters.

Theory

Introduction to environment; environmental studies. Definition, scope and importance, multidisciplinary nature of environmental studies. Segments of environment, spheres of earth; lithosphere, hydrosphere, atmosphere. Different layers of atmosphere. Natural resources; classification. Forest resources. Water resources. Mineral resources. Food resources. Energy resources. Land resources. Soil resources. Ecosystems. Concept of an ecosystem; structure and function of an ecosystem. Energy flow in the ecosystem. Types of ecosystems. Biodiversity and its conservation: Introduction, definition, types. Biogeographical classification of India. Importance and value of biodiversity. Biodiversity hot spots. Threats and conservation of biodiversity.

Environmental pollution. Definition, cause, effects and control measures of air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, light pollution. Solid waste management; classification of solid wastes and management methods, composting, incineration, pyrolysis, biogas production, causes, effects and control measures of urban and industrial wastes. Social issues and the environment. Urban problems related to energy. Water conservation, rain water harvesting, watershed management. Environmental ethics; issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment protection act. Air (prevention and control of pollution) act. Water (prevention and control of pollution) act. Wildlife Protection Act. Forest Conservation act. Human population and the environment; environment and human health. Human rights, value education. Women and child welfare. Role of information technology in environment and human health.

Disaster management; disaster definition, types, natural disasters, floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, heat and cold waves. Man-made disasters, nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, road accidents, rail accidents, air accidents, sea accidents. International and national strategy for disaster reduction. Concept of disaster management, national disaster management framework, financial arrangements, role of NGOs, community-based organizations and media in disaster management. Central, state, district and local administration in disaster control. Armed forces in disaster response. Police and other organizations in disaster management.

Practical

Visit to a local area to document environmental assets river/forest/grassland/hill/mountain. Energy; biogas production from organic wastes. Visit to wind mill / hydro power / solar power generation units. Biodiversity assessment in farming system. Floral and faunal diversity assessment in polluted and un polluted system. Visit to local polluted site urban/rural/industrial/agricultural to study of common plants, insects and birds. Environmental sampling and preservation. Water quality analysis; pH, EC and TDS. Estimation of Acidity, alkalinity. Estimation of water hardness. Estimation of DO and BOD in water samples. Estimation of COD in water samples. Enumeration

of *E. coli* in water sample. Assessment of suspended particulate matter (SPM). Study of simple ecosystem, visit to pond/river/hills. Visit to areas affected by natural disaster.

Suggested Reading

1. De AK, 2010, Environmental chemistry, New Age International Publishers, New Delhi. ISBN:13–978 81 224 2617 5. 384 pp
2. Dhar Chakrabarti PG, 2011, Disaster management - India's risk management policy frameworks and key challenges. Centre for Social Markets (India), Bangalore. 36 pp.
3. Barucha E, 2004, Text book for Environmental studies, University Grants Commission, New Delhi.
4. Parthiban KT, Vennila S, Prasanthrajan M, Umesh Kanna S, 2023, Forest, Environment, Biodiversity and Sustainable development. Narendra Publishing House, New Delhi.
5. Prasanthrajan M, and Mahendran PP, 2008. A text book on Ecology and Environmental Science, ISBN 81-8321-104-6. Agrotech Publishing Academy, Udaipur.
6. Prasanthrajan M, 2018, Objective environmental studies and disaster management, ISBN 9789387893825, Scientific publishers, Jodhpur.
7. Sharma PD, 2009, Ecology and Environment, Rastogi Publications, Meerat.
8. Tyler M and Scot S, 2009, Living in the Environment (Concepts, Connections, and Solutions), Cengage Learning Publication, Belmont, USA.

National Cadet Corps II **1(0+1)**

Objectives

- To develop qualities of character, courage, comradeship, discipline, leadership, secular outlook, spirit of adventure and sportsmanship and the ideals of selfless service among the youth to make them useful citizen.
- To create a human resource of organized trained and motivated youth to provide leadership in all walks of life including the Armed Forces and be always available for the service of the nation.

Practical

Arms Drill- Attention, stand at ease, stand easy. Getting on parade. Dismissing and falling out. Ground/take up arms, examine arms. Shoulder from the order and vice-versa, present from the order and vice-versa. Saluting at the shoulder at the halt and on the march. Short/long trail from the order and vice- versa. Guard mounting, guard of honour, Platoon/Coy Drill. Characteristics of rifle (.22/.303/SLR), ammunition, fire power, stripping, assembling, care, cleaning, and sight setting. Loading, cocking, and unloading. The lying position and holding. Trigger control and firing a shot. Range Procedure and safety precautions. Aiming and alteration of sight. Theory of groups and snap shooting. Firing at moving targets. Miniature range firing. Characteristics of Carbine and LMG. Introduction to map, scales, and conventional signs. Topographical forms and technical terms. The grid system. Relief, contours, and gradients. Cardinal points and finding north. Types of bearings and use of service protractor. Prismatic compass and its use. Setting a map, finding north and own position. Map to ground and ground to map. Knots and lashings,

Camouflage and concealment, Explosives and IEDs. Field defenses obstacles, mines and mine lying. Bridging, waterman ship. Field water supplies, tracks and their construction. Judging distance. Description of ground and indication of landmarks. Recognition and description of target. Observation and concealment. Field signals. Section formations. Fire control orders. Fire and movement. Movement with/without arms. Section battle drill. Types of communication, media, latest trends and developments.

National Service Scheme II **1(0+1)**

Objectives

- To evoke social consciousness among students through various activities viz., working together, constructive, and creative social work, to be skilful in executing democratic leadership, developing skill in programme, to be able to seek self-employment, reducing gap between educated and uneducated, increasing awareness and desire to help sections of society.

Practical

Importance and role of youth leadership. Meaning, types and traits of leadership, qualities of good leaders; importance and roles of youth leadership, Life competencies. Definition and importance of life competencies, problem-solving and decision-making, interpersonal communication. Youth development programs. Development of youth programs and policy at the national level, state level and voluntary sector; youth-focused and youth-led organizations. Health, hygiene and sanitation. Definition needs and scope of health education; role of food, nutrition, safe drinking water, water borne diseases and sanitation (Swachh Bharat Abhiyan) for health; national health programs and reproductive health. Youth health, lifestyle, HIV AIDS and first aid. Healthy lifestyles, HIV AIDS, drugs and substance abuse, home nursing and first aid. Youth and yoga. History, philosophy, concept, myths, and misconceptions about yoga; yoga traditions and its impacts, yoga as a tool for healthy lifestyle, preventive and curative method

Personality Development **2(1+1)**

Objectives

- To make students realize their potential strengths, cultivate their inter-personal skills and improve employability.

Theory

Personality Definition, nature of personality, theories of personality and its types. The humanistic approach, Maslow's self-actualization theory, shaping of personality, determinants of personality, Myers-Briggs typology indicator. Locus of control and performance. Type A and Type B behaviours, personality and organizational behaviour.

Foundations of individual behaviour and factors influencing individual behaviour. Models of individual behaviour. Perception and attributes and factors affecting perception. Attribution theory and case studies on perception and attribution. Learning; meaning and definition, theories and

principles of learning. Learning and organizational behaviour. Learning and training, learning feedback. Attitude and values. Intelligence; types of intelligence, theories of intelligence, measurements of intelligence, factors influencing intelligence, intelligence and organizational behaviour, emotional intelligence. Motivation; theories and principles. Teamwork and group dynamics.

Practical

MBTI personality analysis. Learning styles and strategies. Motivational needs. Firo-B, Interpersonal Communication. Teamwork and team building. Group Dynamics. Win-win game. Conflict Management. Leadership styles. Case studies on Personality and Organizational Behaviour.

Suggested Reading

1. Andrews S, 1988, How to Succeed at Interviews, 21st (rep.), Tata McGraw-Hill, New Delhi.
2. Heller R, 2002, Effective Leadership, Essential Manager series, DK Publishing.
3. Hindle T, 2003, Reducing Stress, Essential Manager series, DK Publishing.
4. Lucas S, 2001, Art of Public Speaking, Tata McGraw-Hill, New Delhi.
5. Mile DJ, 2004, Power of Positive Thinking, Rohan Book Company, New Delhi.
6. Pravesh Kumar, 2005, All about Self- Motivation, Goodwill Publishing House, New Delhi.
7. Smith B, 2004, Body Language, Rohan Book Company, New Delhi.
8. Shaffer DR, 2009, Social and Personality Development, 6th Ed, Wadswor, Belmont, CA.

Basic Techniques of Molecular Biology and Biotechnology 2(0+2)

Objectives

- To provide hands-on training on isolation and purification of DNA. Measurement of nucleic acid concentration using spectrophotometer and gel electrophoresis. Designing of PCR primers, DNA amplification using PCR, elution of PCR products, SDS PAGE, staining and de-staining of proteins, Western blot.
- To study bacteriological media, preparation of media for bacterial culture, preparation of competent cells and transformation, isolation of plasmids from bacteria, and preservation of bacterial clones.
- To study basic computing. Introduction to UNIX, LINUX. Nucleotide information resource: EMBL, GenBank, DDBJ, unigene, protein information resource: SwissProt, TrEMBL, Uniprot; structure databases: PDB, MMDB. Search engines: Entrez, ARSA, SRS. Similarity searching: BLAST and interpreting results. Multiple sequence alignment: ClustalW; structure visualization of DNA and proteins using Rasmol.

Practical

Overview of molecular biology: DNA, RNA, proteins. Laboratory safety and basic techniques. Nucleic acid extraction. Principles of DNA and RNA extraction from various sources. Extraction methods: Phenol-chloroform, silica-based columns, quality assessment and quantification of nucleic acids. Polymerase Chain Reaction (PCR), Optimization of PCR conditions and

troubleshooting, gel electrophoresis, analysis of PCR products, restriction digests, and DNA/RNA samples. Molecular cloning, DNA sequencing. Principles of DNA sequencing: Sanger sequencing, DNA sequencing reaction setup and analysis, interpretation of sequencing data and sequence alignment. Protein analysis techniques. Gene expression analysis. Practical project: students design and conduct a small-scale molecular biology project. They will choose a specific technique or experiment, perform the necessary procedures, analyze data, and present their findings.

Suggested Reading

1. Green MR and Sambrook J, 2012, Molecular cloning: A Laboratory Manual, 4th Ed, Cold Spring Harbor.
2. Rapley R and Whitehouse D, (Eds), 2015, Molecular biology and biotechnology, Royal Society of Chemistry.
3. Kreuzer H and Massey A, 2008, Molecular biology and biotechnology: a guide for students 3rd Ed, ASM Press.

Bioinformatics and Biocomputation **2(0+2)**

Objectives

- To expose the students to the construction and use of computers, special algorithms, new complexity theories, computing science and related mathematics.
- To understand the scientific and economic impact of bioinformatics.
- To have a better understanding of organisms, their metabolism and their evolution.
- To study their applications in health care and drug design, new (bio)materials and their engineering, food (engineering) and food production.

Practical

Information search and data retrieval, genome analysis and gene mapping, alignment of pairs of sequences, alignment of multiple sequences and phylogenetic analysis, tools for similarity search and sequence alignment, profiles and hidden Markov models, gene identification and prediction, gene expression analyses, protein classification and structure analysis and visualization, protein structure prediction, computational methods for pathway and systems biology, technologies and strategies for drug discovery, biomarkers in drug development, computer-aided drug design.

Suggested Reading

1. Laplante PA (Ed), 2004, Biocomputing, ova Biomedical.
2. Altman RB, Dunker AK, Hunter L, Ritchie MD, Murray TA and Klein TE, 2017, Biocomputing, https://doi.org/10.1142/10388.

Semester III

Livestock Production and Management **3(2+1)**

Objectives

- To study the history of livestock in India, animal husbandry and breeds of livestock.
- To study the management of livestock in terms of the housing system, health, and diseases.
- To study the economic importance of livestock.

Theory

Livestock history in India: Vedic, medieval and modern era. Demographic distribution of livestock and role in economy. Introductory animal husbandry. Breeds of livestock, cattle, buffalo, sheep, goat and pig. Important traits of livestock. General management and feeding practices of animals. Handling and restraining of animals. Housing systems. Importance of grasslands and fodders in livestock production. Common farm management practices including disinfection, isolation, quarantine and disposal of carcass. Common vices of animals and their prevention. Diseases and parasite control and hygiene care.

History and economic importance of poultry. Poultry breeds. Reproductive system of male and female birds. Formation and structure of eggs. Important economic traits of poultry. Egg production, egg weight, egg quality. Fertility and hatchability, plumage characteristics and comb types. Care and management of chicks, grower and layers/broiler. Brooding management. Hatchery practices. Poultry Diseases, control and hygiene care.

Practical

Visit to livestock farms/demonstration centres. Breeds of cattle, buffalo, sheep, goat and pigs. Familiarization with body parts of animals. Handling and restraining of cattle, buffalo, sheep, goat and swine. Male and female reproductive system and artificial Insemination. Feeding of livestock. Methods of identification: marking, tattooing, branding, tagging. Milking methods. Record Keeping. Visit to the poultry farm, poultry breeds, body parts of chicken, duck, quail and turkey. Housing, equipment, nesting and brooding requirements. Male and female reproductive system. Methods of identification and sexing. Hatchery layout and equipment. Identification of diseases and control of parasites. Vaccination and maintenance of farm records.

Suggested Reading

1. Banerjee GC, 2020, A Textbook of Animal Husbandry, Oxford and IBH Publication.
2. Thomas CK and Sastry NSR, 2020, Livestock Production Management, Kalyani Publishers.
3. Sastry NSR and Thomas CK, 2020, Dairy Bovine Production, Kalyani Publishers.

Recombinant DNA Technology **2(2+0)**

Objectives

- The students will be trained on the principles of genetic engineering.
- To study the components like vectors, enzymes, and host cells.
- To study methods used for confirming cloning and expression.

Theory

Recombinant DNA technology. Restriction endonucleases: types and uses. DNA manipulating enzymes, DNA ligases. Vectors: properties of an ideal vector, structure of vector, cloning vectors

and expression vectors; plasmids, cosmids, phagemids, BACs, PACs, YACs, transposon vectors, shuttle vectors, co-integrating vectors. Competent cells. Gene isolation and cloning; Genetic transformation of *E. coli*, gel electrophoresis, preparation of probes, Southern blotting; Northern blotting; Western blotting, PCR and PCR based methods in recombinant DNA technology.

Suggested Reading

1. Singh BD, 2021, Biotechnology Expanding Horizons, Kalyani Publishers.

Classical and Molecular Cytogenetics **3(2+1)**

Objectives

- This course aims at studying the basics of chromatin.
- To study the chromosome, banding and chromosome variations.
- To study genome analysis through chromosome variations.

Theory

Introduction and history. Structure of chromatin. Chromosome structure and chromosome landmarks. Specialized chromosomes. Differential staining of the chromosomes - Q-banding, G banding, C banding, R banding. In situ hybridization-FISH, GISH.

Changes in chromosome number: aneuploidy - monosomy, trisomy and tetrasomy, haploidy and polyploidy- autopolyploidy and allopolyploidy. Methods of doubled haploid production. Structural aberrations of chromosomes: deletions, duplications, inversions and translocations. Locating genes on chromosomes. Genome analysis.

Practical

Lymphocyte culture from blood for karyotyping. Fibroblast cultures from eggs for karyotyping. Preparation of metaphase chromosome spread. Staining techniques of chromosome spreads. Karyotyping and ideogram preparation, chromosome banding techniques: Q-banding, G banding, C banding, R banding

Suggested Reading

1. Becker K and Hardin, 2004, The World of Cell. 5th Ed, Pearson Edu.
2. Carroll M, 1989, Organelles, The Guilford Press.
3. Charles B, 1993, Discussions in cytogenetics, Prentice Hall.
4. Gupta PK, 2007, Cytogenetics, Rastogi publications.
5. Popescu P, Hayes H and Dutrillaux B, 2000, Techniques in animal cytogenetics, Springer Science and Business Media.
6. Mahabal R, 2010, Fundamentals of Cytogenetics and Genetics, PHI Learning Pvt. Ltd.
7. Fan YS, 2002, Molecular Cytogenetics: Protocols and applications. Humana Press.

Plant Physiology **3(2+1)**

Objectives

- This course aims at introducing concepts of plant physiology and their importance in agriculture.
- To study the plant growth and metabolism.
- To study plant's response to stresses.

Theory
Plant physiology, its scope in agriculture. Osmosis, imbibition, water absorption, water translocation and transpiration. Stomatal mechanisms. Physiological role and deficiency symptoms of major and minor elements. Absorption and translocation of minerals.

Concepts of photosynthesis, photorespiration, respiration and translocation of photoassimilates. Dynamics of growth. Stress physiology. Nitrogen and sulphur metabolism. Plant growth regulators. Their biosynthesis and physiological roles, seed germination and seed dormancy, senescence, vernalization.

Practical
Demonstration of processes of diffusion, osmosis, imbibition and plasmolysis. Ascent of sap, transpiration. Deficiency symptoms of nutrients in crop plants. Plant growth analysis. Quantitative and qualitative estimation of plant pigments. Experiments on photosynthesis and respiration. Effects of plant growth regulators on plant growth and seed germination. Experiments on seed dormancy. Relative water content and plant water potential. Proline estimation.

Suggested Reading
1. Bhatia KN and Prashar AN, 1990, Plant Physiology, Trueman Book Company.
2. Salisbury FB and Ross CW, 1992, Plant Physiology, Wordsworth Publishing Company.
3. Srivastava HN, 2000, Plant Physiology, Pradeep Publications.
4. Taiz L and Zeiger E, 2002, Plant Physiology, Sinauer Associates; 3 Edition.

Anatomy and Physiology of Livestock **3(2+1)**

Objectives
- This course introduces the basic concepts in the anatomy and physiology of livestock.
- To study the structure and function of various tissues and organs.
- To study the physiological aspects of tissues and organs.

Theory
Definition of terms used in veterinary anatomy, topography, contour, landmarks and functional anatomy of various organs in cow, buffalo, sheep and goat structural and functional classification of muscles.

Structure of animal cells and tissues: study of microscopic structure of organs from digestive, urinary, respiratory, reproductive, nervous, cardiovascular and endocrine systems. Gametogenesis, fertilization, cleavage, gastrulation and the development of fetal membranes in livestock, structure

and types of mammalian placenta. Development of the organs of digestive, urogenital, cardiovascular, nervous and endocrine glands.

Introduction to blood physiology. Genetic and endocrine control of the reproductive system; maternal recognition of pregnancy. Introduction to physiology of mammary glands: structure and development, hormonal control of mammary growth, lactogenesis and lactation cycle.

Practical
Hands-on training on the structure and function of the major body systems in livestock, including mammals such as cattle, sheep, goats, and pigs. Practical applications in livestock management and health.

Suggested Reading
1. Ghosh RK, 2020, Primary Veterinary Anatomy (Systemic and Regional), 8th Ed, Current Book International.
2. Dyce KM, Sack MO and Wensing CJS, 2016, Textbook of Veterinary Anatomy, 5th Ed, W. B. Saunders Co.
3. Ghosh RK, 2013, Essentials of Veterinary Histology and Embryology, 3rd Ed, Current Book International.
4. McGeady TA, 2017, Veterinary Embryology, 2nd Ed, Wiley Blackwell, Singapore.
5. Reece WO, (Ed), Dukes' Physiology of Domestic Animals Ninth Edition.
6. Hafez B and Hafez ESE (Eds), 2013, Reproduction in Farm Animals, 7th Ed.

Fundamentals of Crop Protection **3(2+1)**

Objectives
- To study insects, their classification, structure and incidences.
- To study pathogens, their classification, pathogenesis and disease development.
- To study the best practices of insect and disease management.

Theory
Insects – their general body structure. Importance of insects in agriculture. Life cycle of insects. Insects diversity. Feeding stages of insects and kinds (modifications) of mouthparts. Concepts in population build-up of insects – GEP, DB, EIL, ETH and pest status.

Causes of insect-pests outbreak. General symptoms of insect attack. Principles and methods of insect-pests management. Integrated Pest Management concept.

Importance and scope of plant pathology. Concept of disease in plants. Nature and classification of plant diseases. Importance and general characters of fungi, bacteria, fastidious bacteria, nematodes, phytoplasmas, spiroplasmas, viruses, viroids, algae, protozoa and phanerogamic parasites.

Pathogenesis due to obligate and facultative parasites. Variability in plant pathogens. Conditions necessary for the development of disease epidemics. Survival and dispersal of plant pathogens. Management of key diseases and nematodes of major crops.

Practical

Familiarization with generalized insect's body structure and appendages. Life stages. Acquaintance with insect diversity. Identification of important insect pests of cereals, cotton, oilseeds, pulses, sugarcane, fruit and vegetables crops and stored-grains, and their symptoms of damage. Acquaintance with useful insects: predators, parasitoids, pollinators, honey bees and silkworms. Acquaintance with various pesticidal formulations. Principles and working of common plant protection appliances. Calculation for preparing spray material.

Acquaintance with plant pathology laboratory equipment. Preparation of culture media for fungi and bacteria. Demonstration of Koch's postulates. Study of different groups of fungicides and antibiotics and methods of their evaluation. Diagnosis and identification of important diseases of cereals, cotton, oilseeds, pulses, sugarcane, fruit and vegetable crops and their characteristic symptoms.

Suggested Reading

1. Atwal AS and Dhaliwal GS, 2002, Agricultural Pests of South-Asia and Their Management, Kalyani Publishers.
2. Dhaliwal GS and Arora R, 1996, Principles of Insect Pest Management, National Agriculture Technology Information Centre.
3. Dhaliwal GS, Singh R and Chhillar BS, 2006, Essentials of Agricultural Entomology, Kalyani Publishers.
4. Singh H, 1984, Household and Kitchen Garden Pests – Principles and Practices, Kalyani Publishers.
5. Sehgal PK, 2017, Fundamentals of Agricultural Entomology Unknown Binding, Kalyani Publishers.
6. Agrios, GN, 2010, Plant Pathology. Acad. Press.
7. Mehrotra RS and Aggarwal A, 2007, Plant Pathology, 7th Ed, Tata Mc Graw Hill Publ. Co. Ltd.
8. Singh RS, 2008, Plant Diseases, 8th Ed, Oxford and IBH. Pub. Co.
9. Singh RS, 2013, Introduction to Principles of Plant Pathology, Oxford and IBH Pub. Co.
10. Stakman EC and Harrar JG, 1957, Principles of Plant Pathology, Ronald Press, USA.
11. Tarr SAJ, 1964, The Principles of Plant Pathology, McMillan, London.
12. Kumar S, 2021, Fundamentals of Plant Pathology, SBN9789390591206, NIPA.

Livestock Product Technology **3(2+1)**

Objectives

- To study the composition and value of milk.
- To study milk processing and milk standards.
- To study properties and values of the meet.

Theory
Composition and nutritive value of milk and factors affecting composition of milk; current status of dairy industry in India. Physiochemical properties of milk. Milk Processing: milk collection, chilling, transportation, standardization, homogenization, pasteurization and packaging. Toxins and pesticide residues in milk and milk products. Organic milk food products. Bureau of Indian standards for milk and milk products; FSSAI standards for milk and milk products. Sanitation in milk plant.

Retrospect and prospects of the meat industry in India. Structure and composition of muscle (including poultry). Conversion of muscle into meat; nutritive value of meat. Meat adulteration, preservation of meat, physicochemical and microbiological quality of meat and meat products. Laws governing national, and international trade in meat and meat products, organic meat food products, and food products of genetically modified animals.

Practical
Sampling of milk, estimation of fat, solids not fat (SNF) and total solids. Determination of specific gravity of milk. Platform tests, cream separation. Microbiological quality of milk, meat and meat products. Visit modern milk and meat processing units.

Suggested Reading
1. Sharma BD, 1999, Meat and Meat Products Technology: Including Poultry Products Technology, Jaypee Bros Medical Publishers.
2. Sukumar D, 2001, Outlines of Dairy Technology, Oxford University Press.

Biomathematics **2(2+0)**

Objectives
- This study the basic theories of mathematics.
- To study factor reduction and eigenvalues.
- To study the applications of biomathematics.

Theory
Rolle's theorem, Lagrange's theorem, Taylor's and Maclaurin's series. Partial differentiation, Euler's theorem on homogeneous function, change of variable. Jacobian, maxima and minima of two or more than two variables eigen values and eigen vectors of a matrix. Reduction formulae, definite integrals and its applications.

Solution of ordinary differential equation of first degree and first order and their application for determination of the volume of blood and drug distribution. Epidemic models, simultaneous differential equation of first order and their applications to predator models. Linear differential equations of higher order and their applications to the simple biological problem. Numerical methods for solving algebraic and transcendental equations.

Suggested Reading

1. Grewal BS, 2013, Higher Engineering Mathematics, Khanna Publishers.
2. Rastogi SK, 2008, Biomathematics, Krishna Prakashan Media Pvt. Ltd.
3. Srivastava AC and Srivastava PK, 2011, Engineering Mathematics, Vol. I, PHI Learning Pvt. Ltd.
4. Srivastava AC and Srivastava PK, 2011, Engineering Mathematics, Vol.III, PHI Learning Pvt. Ltd.

Physical Education, First Aid and Yoga Practices **2(0+2)**

Objectives

- To make the students aware about Physical Education, First Aid and Yoga Practices
- To disseminate the knowledge and skill how to perform physical training, perform first aid and increase stamina and general wellbeing through yoga.

Practical

Physical education. Training and Coaching, meaning and concept. Methods of training; aerobic and aerobic exercises. Calisthenics, weight training, circuit training, interval training, Fartlek training. Effects of exercise on muscular, respiratory, circulatory and digestive systems. Balanced diet and nutrition; effects of diet on performance. Physiological changes due to ageing and role of regular exercise on ageing process. Personality, its dimensions and types. Role of sports in personality development. Motivation and achievements in sports. Learning and theories of learning. Adolescent problems and its management. Posture, postural deformities. Exercises for good posture.

Yoga; history of yoga, types of yoga, introduction to yoga. Asanas, definition and importance, Padmasan, Gaumukhasan, Bhadrasan, Vajrajasan, Shashankasan, Pashchimotasan, Ushtrasan, Tadasan, Padhastasan, Ardhchandrasan, Bhujangasan, Utanpadasan, Sarvangasan, Parvatasan, Patangasan, Shishupalanasan – left leg-right leg, Pavanmuktasan, Halasan, Sarpasan, Ardhdhanurasan, Sawasan. Suryanamaskar, Pranayama (Definition and Importance), Omkar, Suryabhedan, Chandrabhedan, AnulomVilom, Shitali, Shitkari, Bhastrika, Bhramari. Meditation, definition and importance, Yogic Kriyas (Kapalbhati), Tratak, Jalneti and Tribandh. Mudras, definition and importance, Gyanmudra, Dhyanmudra, Vayumudra, Akashmudra, Pruthvimudra, Shunyamudra, Suryamudra, Varunmudra, Pranmudra, Apanmudra, Vyanmudra, Uddanmudra. Role of yoga in sports. Teaching of asanas, demonstration, practice, correction and practice.

History of sports and ancient games. Governance of sports in India. Important national sporting events. Awards in sports. History, latest rules, measurements of playfield, specifications of equipment, skill, technique, style and coaching of major games (Cricket, Football, Table Tennis, Badminton, Volleyball, Basketball, Kabaddi and Kho-Kho) and Athletics.

Need and requirement of first aid. First aid equipment and upkeep. First aid techniques. First aid related with respiratory system. First aid related with heart, blood and circulation. First aid related with wounds and injuries. First aid related with bones, joints, muscle related injuries. First aid

related with nervous system and unconsciousness. First aid related with gastrointestinal tract. First aid related with skin, burns. First aid related with poisoning. First aid related with bites and stings. First aid related with sense organs. Handling and transport of injured traumatized persons. Sports injuries and their treatments.

Methods in Recombinant DNA Technology **2(0+2)**

Objectives

- Hands on training on good laboratory practices, media and stock preparation.
- To enable skill development by providing hands-on training on methods in recombinant DNA technology.

Practical

Preparation of growth, madia, stock solutions and buffers. Plasmid DNA isolation. Quality and quantity assessmentof DNA. Restriction digestion of DNA. Agarose gel electrophoresis. Preparation of competent cells and genetic transformation of *E. coli*. Screening of recombinant DNA clones in *E. coli*. Confirmationof recombinant clones.

Suggested Reading

1. Green MR and Sambrook J, 2012, Molecular cloning: A Laboratory Manual, 4th Ed, Cold Spring Harbor.
2. Glick BR and Patten CL, 2022, Molecular biotechnology: principles and applications of recombinant DNA, John Wiley and Sons.
3. Carson S and Robertson D, 2005, Manipulation and Expression of Recombinant DNA, Elsevier.

Semester IV

Introductory Bioinformatics **4(3+1)**

Objectives

- To train the students on applications of computers on analyzing the biomolecules (DNA, RNA and protein).
- To study various types of databases.
- To study various operations and algorithms in bioinformatics.

Theory

Introduction to bioinformatics. Development and scope of bioinformatics. Applications of computers in bioinformatics. Operating systems, hardware, software, internet, www resources, FTP, application of bioinformatics in agriculture.

Primary databases: Nucleotide sequence databases (GenBank, EMBL), protein sequence databases; Secondary databases: SwissProt/TrEMBL, conserved domain database, Pfam; Structure

databases: Protein Data Bank (PDB), MMDB, SCOP, CATH; File formats: GenBank, EMBL, FASTA, PDB, Flat file, ASN.1, XML.

Introduction to sequence alignment and its applications. Pairwise and multiple sequence alignment, the concept of local and global alignment; Algorithms. Dot Matrix method, dynamic programming methods (Needleman–Wunsch and Smith–Waterman). Tools of MSA: ClustalW, TCoffee. Phylogeny. Introduction to BLAST and FASTA; MSA and phylogeny. Assembly and annotation.

Practical

Hands-on training on databases, database construction and management, algorithms and analysis of DNA, RNA and proteins.

Suggested Reading

1. Baxevanis AD, Ouellette BFF, 2011, Bioinformatics: A practical guide to the analysis of genes and proteins, John Wiley and Sons.
2. Mount DW, 2001, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor.
3. Xiong J, 2012, Essential Bioinformatics, Cambridge University Press.

Molecular Marker Technology **2(2+0)**

Objectives

- To study the importance and types of molecular markers.
- To study the mapping populations; development and analysis.
- To study the applications of molecular markers in mapping and breeding.

Theory

Types of molecular markers - RFLP; PCR-based markers like RAPD, SCAR, SSR, STS, CAPS, AFLP, SNP and their variants. Uses of molecular markers. Application as a genetic tool for genotyping and gene mapping. Mapping populations: F_2, DH, RILs, NILs. Bulked segregant analysis, linkage maps, physical maps.

Application of molecular markers. Assessing genetic diversity, variety protection. Introduction to genomic selection, marker-assisted breeding for accelerated introgression of trait/transgene and quantitative traits. Human and animal health. Association with genetic-based diseases. Paternity determinations. Parentage using SNP data. Forensic studies. DNA Fingerprinting.

Suggested Reading

1. Verma PS, 2018, Cell Biology Genetics Molecular Biology Evolution and Ecology, Chaukhamba Auriyantaliya Publishers.
2. Manikanda Boopathi N, 2020, Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits, Springer.
3. Gupta PK, 2015, Molecular Biology and Genetic Engineering, Rastogi Publication.
4. Manikanda Boopathi N, 2013, Genetic mapping and marker-assisted selection, Springer.

5. Schook LB (ed), 2020, Gene-mapping techniques and applications, CRC Press.
6. Watson JD, Levine M, Baker TA, Gann A, Bell SP and Losick, R, 2014, Molecular Biology of the Gene, Pearson.

Biodiversity and Its Conservation **2(2+0)**

Objectives

- To study the concepts of biodiversity.
- To study the methods of protecting biodiversity.
- To study regulations on biodiversity conservation.

Theory

Concepts of biodiversity, bioresource and wildlife management, conservation strategies: in situ and ex-situ conservation. Wildlife conservation projects in India. Protection of biodiversity for its suitable utilization. Threats to biodiversity. WCU Red data book; Biodiversity hotspots in India. National bureaus of genetic resources. Biodiversity Mapping. Biogeographical regions.

Sustainable development. Diversification of cropping system. Diversity of indigenous livestock. Threats to biodiversity; WCU Red data book. Vulnerability and extinction of flora and fauna. Endangered species in various ecosystems. Germplasm banks. Environmental impact assessment. Bioremediation and biosafety. Introduction to regulatory agencies and legislation.

Suggested Reading

1. Gaston KJ and Spicer JI, 2004, Biodiversity An Introduction, Blackwell Publishers.
2. Das MK and Choudhury BP, 2008, A Textbook on Plant Nomenclature and Biodiversity Conservation, Kalyani Publishers.
3. Hopsetti BB. and Venketashwarlaru M, 2001, Trends in Wild Life Conservation and Management, Vol. 2, Daya Publishing House.
4. Singh MP and Singh BS, 2002, Plant Biodiversity and Taxonomy, Daya Publishing House.

Basic Biochemistry **4(3+1)**

Objectives

- To study the structure and functions of biomolecules of living organisms.
- To study metabolism and bioenergetics.
- To study secondary metabolites and their applications

Theory

Introduction and importance. Biomolecules: carbohydrates, lipids, proteins and nucleic acids – structure, functions and properties. Acids, bases and buffers of living systems. The pK of biomolecules. Vitamins and hormones.

Bioenergetics. Metabolism – basic concept: glycolysis, citric acid cycle, glycogenesis, glycogenolysis, oxidative phosphorylation, fatty acid oxidation; Ketone bodies' metabolism.

Secondary metabolites: alkaloids, phenolics and their applications in food and pharmaceutical industries.

Practical
Qualitative tests for carbohydrates, amino acids, proteins and lipids. Extraction and characterization of lipids by TLC. Determination of acid, iodine and saponification values of oil. Extraction, quantitative estimation and separation of sugars by paper chromatography.

Suggested Reading
1. Nelson DL and Cox MM, 2017, Lehninger principles of biochemistry, 7th Ed, W. H. Freeman.
2. Satyanarayana U and Chakrapani U, 2021, Essentials of Biochemistry, Elsevier.

Human Ethics **1(1+0)**

Objectives
- To study the meaning and concepts of human behaviour
- To study human ethical values.
- To study spirituality and attitude.
- To study the methods of stress management

Theory
Universal human aspirations. Happiness and prosperity. Human values and ethics. Concept, definition, significance and sources. Fundamental values. Right conduct, peace, truth, love and non-violence. Ethics: professional, environmental, ICT. Sensitization towards others particularly senior citizens, developmentally challenged and gender.

Spirituality, positive attitude and scientific temper. Teamwork and volunteering. Rights and responsibilities. Road safety. Human relations and family harmony. Modern challenges and value conflict. Sensitization against drug abuse and other social evils. Developing personal code of conduct (SWOT Analysis). Management of anger and stress.

Suggested Reading
1. Gaur RR, Sangal R and Bagaria GP, 2011, A Foundation Course in Human Values and Professional Ethics, Excel Books.
2. Mathur SS, 2010, Education for Values, Environment and Human Rights, RSA International.
3. Sharma RA, 2011, Human Values and Education -Axiology, Inculcation and Research, R. Lall Book Depot.
4. Sharma RP and Sharma M, 2011, Value Education and Professional Ethics, Kanishka Publishers.
5. Srivastava S, 2011, Human Values and Professional Ethics, S K Kataria and Sons.

6. Srivastava S, 2011, Environmental Science, S K Kataria and Sons.
7. Tripathi AN, 2009, Human Values, New Age International (P) Ltd Publishers.

Agricultural Marketing and Trade **3(2+1)**

Objectives

- To understand the fundamentals of agricultural marketing and trade.
- To analyze the factors influencing supply and demand in agricultural markets.
- To explore different marketing channels and strategies in agriculture.
- To examine the role of government policies and regulations in agricultural markets.

Theory

Agricultural Marketing: Concepts and definitions of market, marketing, agricultural marketing, market structure, marketing mix and market segmentation, classification and characteristics of agricultural markets; demand, supply and producer's surplus of agri commodities: nature and determinants of demand and supply of farm products, producer's surplus – meaning and its types, marketable and marketed surplus, factors affecting marketable surplus of agri-commodities; pricing and promotion strategies: pricing considerations and approaches – cost based and competition based pricing; market promotion – advertising, personal selling, sales promotion and publicity – meaning, merits and demerits; marketing process and functions: Marketing process concentration, dispersion and equalization; exchange functions – buying and selling; physical functions – storage, transport and processing; facilitating functions – packaging, branding, grading, quality control and labelling (Agmark); Market functionaries and marketing channels: Types and importance of agencies involved in agricultural marketing; meaning and definition of marketing channel; number of channel levels; marketing channels for different farm products; Integration, efficiency, costs and price spread: Meaning, definition and types of market integration; marketing efficiency; marketing costs, margins and price spread; factors affecting cost of marketing; reasons for higher marketing costs of farm commodities; ways of reducing marketing costs. Role of Govt. in agricultural marketing: Public sector institutions- CWC, SWC, FCI, CACP and DMI – their objectives and functions; cooperative marketing in India. Risk in marketing: Types of risk in marketing; speculation and hedging; an overview of futures trading. Agricultural prices and policy. Meaning and functions of price; administered prices; need for innovations in agricultural price policy. Trade: concept of international trade and its need, theories of absolute and comparative advantage. Present status and prospects of international trade in agri-commodities; WTO; Agreement on Agriculture (AoA) and its implications on Indian agriculture; IPR. Role of government in agricultural marketing. Role of APMC and its relevance in the present-day context.

Practical

Plotting and study of demand and supply curves and calculation of elasticities. Study of relationship between market arrivals and prices of some selected commodities. Computation of marketable and marketed surplus of important commodities; Study of price behaviour over time for some selected commodities. Construction of index numbers; Visit to a local market to study

various marketing functions performed by different agencies, identification of marketing channels for selected commodity, collection of data regarding marketing costs, margins and price spread and presentation of report in the class. Visit to market institutions – NAFED, SWC, CWC, cooperative marketing society, etc. to study their organization and functioning. Application of principles of comparative advantage of international trade.

Suggested Reading

1. Acharya, SS, and Agarwal NL, 2006, Agricultural Marketing in India, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Chinna SS, 2005, Agricultural Economics and Indian Agriculture. Kalyani Pub, N Delhi.
3. Salvator D, 2008, Microeconomics: Theory and Applications, New York: Oxford University Press.
4. Kohls RL, and Uhl JN, 2002, Marketing of Agricultural Products, Prentice-Hall of India Private Ltd., New Delhi.
5. Kotler and Armstrong, 2005, Principles of Marketing, Pearson Prentice-Hall.
6. Lekhi RK and Singh J, 2006, Agricultural Economics. Kalyani Publishers, Delhi.
7. Memoria CB, Joshi RL and Mulla NI, 2003, Principles and Practice of Marketing in India, Kitab Mahal, New Delhi.
8. Pandey M and Tewari, D, 2004, Rural and Agricultural Marketing, International Book Distributing Co. Ltd, New Delhi. Sharma, R., 2005, Export Management, Laxmi Narain Agarwal, Agra.

Agricultural Informatics **3(2+1)**

Objectives

- To acquaint students with the basics of computer applications in agriculture, multimedia, database management, application of mobile app and decision- making processes, etc.
- To provide basic knowledge of computer with applications in agriculture.
- To make the students familiar with Agricultural-Informatics, its components and applications in agriculture.

Theory

Introduction to computers, anatomy of computers, memory concepts, units of memory, operating system. Definition and types, applications of MS-Office for creating, editing and formatting a document, data presentation, tabulation and graph creation, statistical analysis, mathematical expressions, database, concepts and types, creating database. Uses of DBMS in agriculture, internet and World Wide Web (WWW); concepts and components.

Computer programming. General concepts, introduction to visual basic, Java, Fortran, C/ C++, etc. concepts and standard input/output operations.

e-Agriculture, Concepts, design and development, application of innovative ways to use information and communication technologies (IT) in agriculture, computer models in

agriculture. Statistical, weather analysis and crop simulation models, concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes, sensitivity, verification, calibration and validation, IT applications for computation of water and nutrient requirement of crops. Computer-controlled devices (automated systems) for agri-input management, smartphone mobile apps in agriculture for farm advice. Market price, postharvest management etc. Geospatial technology; concepts, techniques, components and uses for generating valuable agri-information. Decision support systems; concepts, components and applications in agriculture. Agriculture expert system, soil information systems etc. for supporting farm decisions. Preparation of contingent crop-planning and crop calendars using IT tools, Digital India and schemes to promote digitalization of agriculture in India.

Practical

Study of computer components, accessories, practice of important DoS Commands, Introduction of different operating systems such as Windows, Unix/ Linux, creating files and folders, File management. Use of MS-WORD and MS Power-point for creating, editing and presenting a scientific document, MS- EXCEL - Creating a spreadsheet. Use of statistical tools. Writing expressions, Creating graphs, Analysis of scientific data, Handling macros. MS-ACCESS, creating database, preparing queries and reports, demonstration of agri- information system, Introduction to World Wide Web (WWW) and its components, Introduction of programming languages such as Visual Basic, Java, Fortran, C, C++, Hands on practice on Crop Simulation Models (CSM), DSSAT/Crop-Info/Crop Syst/ Wofost, Preparation of inputs file for CSM and study of model outputs, computation of water and nutrient requirements of crop using CSM and IT tools, Use of smart phones and other devices in agro-advisory and dissemination of market information, Introduction of Geospatial Technology, Hands on practice on preparation of Decision Support System, Preparation of contingent crop planning, India Digital Ecosystem of Agriculture (IDEA).

Suggested Reading

1. Rajaroman V and Adabala N, 2015, Fundamentals of Computer, PHI Learning Private Ltd, New Delhi.
2. ITL Education Solutions Ltd, 2006, Introduction to Information Technology, PEARSON Education.
3. Date CJ, 2007, An introduction to Database Systems, Addison-Wesley.
4. Dhabal PS and Manoranjan P, 2017, Concepts and Techniques of Programming in C, I.K. International Publishing House Pvt. Limited.
5. Mahapatra SK, Mishra P and Pradhan J, 2022, Introductory Agri Informatics, Jain Brothers.

Practices in Molecular Marker Technology **2(0+2)**

Objectives

- This course aims at imparting skills through hands-on training in the area of molecular markers and their applications.

- To study the development of markers and marker systems, genotyping with various types of markers, mapping, diversity analysis, marker-assisted selection, DNA fingerprinting, diversity and cluster analysis, phylogenetic analysis

Practical

Overview of molecular markers: types, applications, significance. Principles of genetic variation and inheritance, DNA Extraction and quantification, PCR-Based molecular markers, RFLP (Restriction Fragment Length Polymorphism) analysis, AFLP (Amplified Fragment Length Polymorphism) analysis, SSR (Simple Sequence Repeat) analysis, SNP (Single Nucleotide Polymorphism) analysis. Principles of SNP detection, PCR-based SNP genotyping assays, SNP array and sequencing-based approaches. DNA sequencing and sequence analysis, interpretation of sequencing data and sequence alignment, Marker-Assisted Selection (MAS), genomic selection and marker discovery. Practical Project: students design and conduct a small-scale molecular marker project. They will choose a specific technique or experiment, perform the necessary procedures, analyze data, and present their findings.

Suggested Reading

1. Verma PS, 2018, Cell Biology Genetics Molecular Biology Evolution and Ecology, Chaukhamba Auriyantaliya Publishers.
2. Manikanda Boopathi N, 2020, Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits, Springer.
3. Gupta PK, 2015, Molecular Biology and Genetic Engineering, Rastogi Publication.
4. Manikanda Boopathi N, 2013, Genetic mapping and marker-assisted selection, Springer.
5. Schook LB (ed), 2020, Gene-mapping techniques and applications, CRC Press.
6. Watson JD, Levine M, Baker TA, Gann A, Bell SP and Losick, R, 2014, Molecular Biology of the Gene, Pearson.

Semester V

Microbial Genetics **4(3+1)**

Objectives

- To provide an understanding of using microorganisms for genetic analyses.
- To study genetic variability and recombination among microbes.
- To study plasmids, their types and use in recombinant DNA technology.

Theory

Microorganisms as tools for genetic studies. Genetic variability in microorganisms. Genetic analysis of representative groups of bacteria, fungi and viruses. Random and tetrad spore analysis. Recombination and chromosomal mapping. Complementation - intergenic and intragenic.

Bacterial plasmids. Structure, life cycle, mode of infection and their role in genetic engineering. Transfer of genetic material in bacteria. Conjugation, transformation and transduction. Genetics of

bacteriophage: T4, lambda and M13, life cycle, mode of infection. Mutation: types, mutagens, DNA damage and repair. Transposable elements; Lac operon, yeast genetics.

Concept and application of recombinant DNA technology. Use of genetic tools to improve the microbial strains for industry, agriculture and health.

Practical
Conjugation and transformation in bacteria. Spontaneous and auxotrophic mutation. Chemical and UV mutagenesis in fungi and bacteria.Complementation in fungi. Identification of mutants using replica plating technique. Isolation of genomic DNA from *E. coli*. Isolation and curing of plasmid. Identification of plasmid by electrophoresis / antibiotic plates.

Suggested Reading
1. Reece RJ, 2013, Analysis of Genes and Genomes, Wiley.
2. Michael RG and Joseph S, 2012, Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press.

Molecular Genetics **3(3+0)**

Objectives
- This course introduces DNA structure and function.
- To study DNA functions like replication and gene expression.
- To provide an understanding of gene regulation in prokaryotes and eukaryotes.

Theory
Structures, properties and modification of DNA. Molecular mechanisms of DNA replication, repair. Types of mutation. Linkage and recombination. Molecular mechanisms of crossing over. Centromere and telomere sequences, and DNA packaging. Repetitive DNA sequences and transposable elements. Markers and QTL.Synthesis and processing of RNA and proteins. Regulation of gene expression.

Genetic code, properties of genetic code, structure of a gene, promoters and their isolation. Synthesis and processing of RNA.

Regulation of gene expression. Transcription factors – their classification and role in gene expression. Epigenetic control of gene expression. Analysis of gene expression. Small RNAs, RNA interference and its applications.

Suggested Reading
1. Lewin B, 2017, Gene XII, Oxford University Press.
2. Hartl DL, 2021, Essential genetics and genomics, 7th Ed, Jones and Bartlett Learning.
3. Allison LA, 2011, Fundamental Molecular Biology, Wiley Global Education.
4. Brown TA, 1998, Genetics: A Molecular Approach, 3rd Ed, Stanley Thornes.
5. Lewin B, 2009, Genes, Jones and Bartlett Learning.

6. Tropp BE, 2014, Principles of Molecular Biology, Jones and Bartlett Learning.
7. Tropp BE. 2012. Molecular Biology: Genes to Proteins, 4th Ed, Jones and Bartlett Learning.
8. Gardener EJ, Simmons MJ and Snustad DP, 1991, Principles of Genetics, John Wiley and Sons, Inc, New York, USA.

Nanobiotechnology **4(3+1)**

Objectives

- To provide an understanding of the concepts and terminologies related to nanobiotechnology.
- To study nanosystems, their synthesis and application.

Theory

Introduction to nanotechnology. Concepts and Terminology. Nano-Bio Interface. Biological-based nanosystems, molecular motors, biosensors and other devices.

Self-assembly of molecules for nanotechnology applications. Biomimetics, biotemplating and de novo designed nanostructures and materials. DNA-nanotechnology. Nanomanipulations, material design, synthesis and their applications.

Practical

Introduction to nanomaterials and their properties. Nanoscale characterization techniques. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Atomic force microscopy (AFM) for nanoscale imaging and manipulation. Spectroscopic techniques (UV-Vis, fluorescence, Raman) for nanoparticle analysis. Nanoparticle synthesis and functionalization, chemical synthesis methods for nanoparticles (top-down and bottom-up approaches), surface functionalization techniques for controlling nanoparticle properties. Biomolecular interactions at the nanoscale, nanotoxicology and safety assessment. Project and presentations.

Suggested Reading

1. Gabor L, Hornyak J, Moore J, Tibbals, HF and Joydeep D, 2009, Fundamentals of Nanotechnology, CRC Press.
2. Kumar U, 2008, Nanotechnology: A Fundamental Approach, Agrobios

Animal Biotechnology **3(2+1)**

Objectives

- To study historical developments in animal biotechnology.
- To study the biotechnological tools for improving animal health and products.
- To study the use of molecular markers for animal genome analysis.

Theory

History and development of animal biotechnology. Basic techniques in animal cell culture. Introduction to embryo biotechnology, oocyte collection and maturation. Sperm preparation. in vitro fertilization. Cryopreservation of oocyte, sperm and embryos. Embryo transfer technology.

Breeds of livestock and their characteristics. Marker-assisted breeding of livestock. Introduction to animal genomics: RFLP, RAPD, SSRs, QTL, SNP, STR, mitochondrial DNA polymorphism. Rumen and its environment. Rumen microbes - manipulation of rumen microbes for better utilization of feed. Introduction to nutrigenomics. Milk biome. Manipulation of lactation by biotechnological tools. Application of biotechnology in meat and meat products.

Genome and protein-based diagnostics of important animal diseases: FMD, brucellosis, PPR, mastitis, bluetongue, newcastle disease. Introduction to vaccinology, live attenuated vaccines, killed vaccines, cell culture-based vaccines, recombinant vaccines.

Practical

Basic cell culture techniques, oocyte aspiration from ovaries, sperm preparation, in vitro fertilization. PCR-based detection of animal pathogens. PCR-RFLP. Immunohistochemical localization of protein marker in tissues/cells – meat species identification by PCR.

Suggested Reading

1. Srivastava AK and Singh RK, 2018, Animal Biotechnology, CBS Publishers and Distributors, ISBN 9788120416482, 8120416481.
2. Singh B, Gautam SK, Chauhan MS and Singla SK, 2015, Textbook of Animal Biotechnology, The Energy and Resources Institute, TERI.

Genomics and Proteomics **3(3+0)**

Objectives

- To provide an understanding of genomics; structural and functional.
- To study comparative genomics and its applications
- To study proteomics and related tools.

Theory

Introduction to genomics. Functional genomics and proteomics. Structural genomics: classical ways of genome analysis. BAC and YAC libraries. Next generation sequencing. Genome analysis and gene annotation. Genome projects: *E. coli*, Arabidopsis, Bovine, Human. Comparative Genomics: orthologous and paralogous sequences. Synteny, gene order, phylogenetic footprinting.

Functional genomics: Differential gene expression techniques: ESTs, cDNA-AFLP, microarray, Differential display, SAGE, RNAseq, Real-time PCR

Introduction to proteomics. Analysis of proteome. Native PAGE, SDS PAGE, 2D PAGE. Edmann Degradation. Chromatographic techniques: HPLC, GC, Mass Spectrometry: MALDI-TOF, LC-MS, SWATH-MS. Post Translational modifications.

Suggested Reading

1. Saraswathy N, Ramalingam P, 2011, Concepts and Techniques in Genomics and Proteomics, Elsevier Science.
2. Andreas H and Samuel C, 2018, Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press.

Enzymology and Enzyme Technologies **3(2+1)**

Objectives

- To study the basic structure, function and types of enzymes.
- To study enzyme kinetics, regulation of enzyme activity and applications of enzymes.

Theory

Classification and nomenclature of enzymes. General characteristics of enzymes, active site, cofactors, prosthetic groups. Metalloenzymes; Isolation, purification, characterization and assays of enzyme and international units. Criteria for purity.

Enzyme kinetics, effect of pH, temperature, determination of Km and Vmax. Regulation of enzyme activity. Enzyme inhibition. competitive, non-competitive and uncompetitive. Isoenzymes, schizomers and isoschizomers. Ribozymes. Immobilization of enzymes. Applications of enzymes; biotechnology, industry, environment, agriculture, food and medicine.

Practical

Isolation, purification and assay of enzymes. Determination of optimum pH and optimum temperature of enzymes. Thermostability of enzymes. Activators and inhibitors of enzyme catalysis. Immobilization of enzymes. Isoenzymes analysis.

Suggested Reading

1. Nelson DL and Cox MM, 2017, Lehninger principles of biochemistry, 7th Ed, W. H. Freeman.
2. Satyanarayana U and Chakrapani U, 2021, Essentials of Biochemistry, Elsevier.

Immunology **3(2+1)**

Objectives

- To study the meaning and importance of immunology.
- To study the classes of antigens and antibodies.
- To study the immunological techniques and DNA vaccines.

Theory

History and scope of immunology. Components of the immune system: organs, tissues and cells. Immunoglobulin structure and functions. Molecular organization of immunoglobulins and classes

of antibodies. Antibody diversity; antigens, haptens, antigens antibody interactions. Immuno-regulation and tolerance.

Allergies and hypersensitive response. Immunodeficiency. Concept of Vaccines and Vaccinology. Conventional Vaccines. Recombinant subunit vaccines. DNA vaccines and vectored vaccines. Immunological techniques. Immunological application in animal science, monoclonal antibodies and their uses.

Practical

Preparation of buffers and reagents. Precipitation and agglutination test; HA, HI test; immunoblotting, immune electrophoresis and fluorescent antibody test; enzyme immunoassays including ELISA variants, Western blotting. Raising of antisera in laboratory animals. Collection and preservation of antisera – separation, filtration and aliquoting.

Suggested Reading

1. Judy O, Jenni P, Sharon S and Patricia J, 2018, Kuby Immunology.

Semester VI

Molecular Diagnostics **3(2+1)**

Objectives

- To understand the importance of molecular diagnostics.
- To acquaint with various methods of diagnostic methods.
- To compare the advantages of molecular diagnostic methods with those of conventional methods.

Theory

Principle and applications of molecular diagnostic tests. Nucleic acid-based diagnostics for detection of pathogenic organisms. Application of restriction endonuclease analysis for identification of pathogens. Polymerase chain reaction (PCR) and its variants. Reverse transcriptase polymerase chain reaction (RT-PCR); isothermal amplification (LAMP); LCR, nucleic acid sequence-based amplification (NASBA); Real-Time PCR; DNA Probes; Southern blotting; Northern blotting. Protein-based assays: SDS-PAGE, Western Blot, Dot-blot, ELISA and lateral flow device.

Advantages of molecular diagnostics over conventional diagnostics, serodiagnostic, DNA array technology, Protein array, tissue array. Biosensors and nanotechnology. Development and validation of diagnostic tests.

Practical

Preparations of buffers and reagents. Collection of clinical and environmental samples for molecular detection of pathogens (bacteria/virus). Extraction of nucleic acids (DNA and RNA) from the clinical specimens. Restriction endonuclease digestion and analysis using agarose gel

electrophoresis. Polymerase chain reaction for detection of pathogens in blood and animal tissues. RT-PCR for detection of RNA viruses. PCR based detection of meat adulteration in processed and unprocessed meats. PCR based detection of pathogens in milk, eggs and meat. Lateral flow assay, ELISA.

Suggested Reading

1. Singh BD, 2021, Biotechnology Expanding Horizons, Kalyani Publishers.
2. Lela B, 2019, Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, FA Davis Company.

Industrial Biotechnology 3(3+0)

Objectives

- To understand various industrial bioprocesses.
- To acquaint with the production of primary metabolites and secondary metabolites.
- To study the industrial production of bioproducts.

Theory

Introduction to industrial bioprocess. Fermentation- bacterial, fungal and yeast. Traditional and modern biotechnology- a brief survey of organisms, processes, and products. Basic concepts of upstream and downstream processing in bioprocess.

Production of primary metabolites. Primary metabolites- production of commercially important primary metabolites like organic acids, and alcohols.

Production of secondary metabolites. Secondary metabolites- production processes for various classes of secondary metabolites: antibiotics, vitamins and steroids.

Production of bioproducts. Production of biopesticides, biofertilizers, biopreservatives, biopolymers biodiesel. bheese, beer, and bushroom culture, bioremediation.

Suggested Reading

1. Kumar HD, 1998, A Textbook on Biotechnology, 2nd Ed, Affiliated East West Press Pvt.
2. Balasubramanian D, Bryce CFA, Dharmalingam K, Green J and Kunthala J, 2004, "Concepts in Biotechnology" Universities Press Pvt.Ltd.
3. Ratledge C, and Bjorn K, 2001, Basic Biotechnology, 2nd Ed, Cambridge University Press.
4. Dubey RC, 2006, A Textbook of Biotechnology, S. Chand and Sons.

Epigenetics and Gene Regulation 2(2+0)

Objectives

- To have an understanding the epigenetics; its manifestation and consequences.
- To study the forms of DNA and histone modifications and their role in gene regulation.
- To study the influence of epigenetics on the small RNAs.

Theory

DNA methylation and histone modifications. DNA methylases, methyl binding proteins and histone modifiers. Epigenetic changes in response to external stimuli leading to changes in gene regulation. Role of DNA methylation in plant development: mutant case studies.

Introduction to small RNAs. History, biogenesis. In silico predictions, target gene identification, methylation of heterochromatin by het associated siRNAs. Gene regulation by small RNA and other classes of siRNAs. Role in epigenetics. Jacob Monod model, RNA editing, genome imprinting.

Suggested Reading

1. Sambrook JF and Russell DW (Ed), 2001, Molecular Cloning: A Laboratory Manual, 3rd Ed, Vols 1, 2 and 3, Cold Spring Harbor Laboratory Press.
2. Mohanpuria P, Kumar V, Mahajan M, Mohammad H and Yadav SK, 2010, Gene Silencing: Theory, Techniques and Applications: Genetics-Research and Issues, Nova Science Publishers.

IPR, Biosafety and Bioethics 2(2+0)

Objectives

- To study the importance and forms of IPR.
- To study the role of IPR in connection with biodiversity and research outcomes.
- To study the biosafety guidelines for handling the GMOs.

Theory

Introduction to Intellectual Property, concepts and types. International treaties for the protection of Ips. Indian Legislations for the protection of various types of intellectual property. Patent search, filing process. Material transfer agreements.

Biodiversity definition, importance and geographical causes for diversity. Species and population biodiversity, maintenance of ecological biodiversity hot spots in India. Convention on biological diversity. Cartagena protocol of bio-safety, and risk management for GMO's. Bio-safety guidelines, rules and regulations and regulatory framework for GMOs in India.

Suggested Reading

1. Singh BD, 2021, Biotechnology Expanding Horizons, Kalyani Publishers.
2. Deepa G and Shomini P, 2013. IPR, Biosafety and Bioethics, Pearson Education.

Computational Biology 3(2+1)

Objectives

- To study the basics of web-based servers and software in genome analysis.
- To study the procedure and steps in DNA/RNA/protein sequence submission.

- To study the methods of analysing the sequences for similarity and phylogenetics.

Theory

Introduction to computational biology. Web-based servers and software for genome analysis. Ensembl, UCSC genome browser, MUMMER, BLASTZ. Sequence submission: sequence submission, whole genome sequence submission; NGS: basics and types. Introduction to bioprogramming; Perl, Python and R development of web server; basic concepts.

Protein interaction databases: BIND, DIP, GRID, STRING, PRIDE. Principles of Protein structure prediction. Fold Recognition (threading). Homology modeling. SCOP, CATH, PDB, PROSITE, PFAM. Methods for comparison of 3D structures of proteins.

Phylogenetic analysis. Evolutionary models, tree construction methods, statistical evaluation of tree methods; PHYLIP, dendroscope, MEGA; DNA barcoding database-BOLD.

Practical

Application of Genome browsers in genomic research. Exploring protein-protein interaction databases. Working with protein structural classification databases. SNP and SSR identification tools; PHYLIP.

Suggested Reading

1. Creighton TE, 1993, Proteins: Structures and Molecular Properties, 2nd Ed, W. H. Freeman.
2. Dov S, 2003, Microarray Bioinformatics, 1st Ed, Cambridge University Press.
3. Mount D, 2001, Bioinformatics: Sequence and Genome Analysis, 2nd Ed, Cold Spring Harbor Laboratory Press.
4. Malcolm Campbell A and Laurie JH, 2007, Discovering Genomics, Proteomics and Bioinformatics. 2nd Ed, Benjamin Cummings.
5. Setubal J and Meidanis J, 2004, Introduction to Computational Molecular Biology, PWS Publishing Company.

Introduction to Animal Breeding **3(2+1)**

Objectives

- To study the developments and goals of animal breeding.
- To study population genetics.
- To study the methods of animal breeding

Theory

Population and population genetics; Hardy- Weinberg law; Hardy Weinberg equilibrium. Approaching to equilibrium for sex-linked trait; linkage equilibrium. Effect of linkage on HW-equilibrium. Stochastic and deterministic forces acting on population; mutation; migration; selection.

Dissection of phenotype into its components. Transmitting ability, substitution effect of allele. Breeding value. Definition, concept. Heritability: definition, concept, estimation of heritability from regression of offspring to parents. Resemblance among relatives. Repeatability. Definition, concept and estimation. Correlated traits. Phenotypic and genetic correlation, environmental correlation, selection index. Basic concept and types. Basis of selection. Selection differential and genetic gain.

Breeding strategies in large ruminants (cattle, buffalo), small ruminants (sheep, goat) and swine. Poultry breeding. Lab animal breeding. Breed improvement programmes conducted in India. Molecular breeding: complementation of traditional breeding strategies with molecular genetics.

Practical

Chi-squared test for determining goodness of fit for HW-equilibrium. Estimation of effect of allelic substitution. Estimation of heritability, regression of offspring on parents. Estimation of repeatability. Phenotypic correlation, genetic correlation, environmental correlation. Chi-squared test for determining goodness of fit for HW-equilibrium. Linkage analysis from pedigree data. Selection index.

Suggested Reading

1. Mackay TFC and Falconer DS, 2009, Introduction to quantitative genetics, 4th Ed, Pearson.
2. Brah GS, 2014, Animal Genetics: Concepts and Implications, 2nd Ed, Kalyani Publishers.

Biostatistics **2(1+1)**

Objectives

- To study the variables and descriptive statistics.
- To study various distributions.
- To study experimental data analysis and interpretation.

Theory

Random variables: expected value and its variance; probability distribution of random variables. Conditional probability. Baye's theorem and its applications. Introduction to uniform, binomial, poisson, normal, exponential and gamma probability distributions.

Random mating populations, Hardy-Weinberg Law. Introduction to poisson process and Markov chains. Transition probability matrix, n-step transition probabilities, steady state. Random walk models. Sensitivity and specificity. Positive and negative predictive values.

Chi-square test: testing heterogeneity, use in the genetic experiment, detection of linkage, linkage ratios and its estimation. Analysis of variance. One-way and two-way classification with interaction. Analysis of covariance. Incomplete block designs. Estimation and significance of genotypic and phenotypic variation.

Practical
Expected value and variance of discrete and continuous distributions. Uniform, binomial, poisson, normal, nxponential and namma probability distributions. Hardy-Weinberg Law. Construction of transition probability matrix in Markov Chains. Calculation of sensitivity and specificity. Positive and negative predictive values. Detection and linkage using chi-square test; one-way and two-way analysis of variance. Analysis of covariance. Incomplete block designs. Estimation of heritability.

Suggested Reading
1. Kaps M and Lamberson WR, 2017, Biostatistics for Animal Science, 3rd Ed, CABI.
2. Triola MM, Triola MF and Roy J, 2017, Biostatistics for the Biological and Health Sciences, 2nd Ed, Pearson
3. Gupta SC, Kapoor VK, 2007, Fundamentals of applied statistics, 4th Ed, S Chand and Sons.

Food Science and Processing **3(2+1)**

Objectives
- To study food and nutrition for good health.
- To study food spoilage, processing and preservation.
- To study the methods of assessing physical and chemical qualities.

Theory
Definition: Food and nutrition. Food production and consumption trends in India. Major deficiencies of calories, proteins, vitamins and micronutrients. Food groups and concept of balanced diet. RDA, biotoxins, anti-nutritional factors and metabolites.

Causes of food spoilage. Principles of processing and preservation of food by heat, low temperature, drying and dehydration, chemicals and fermentation. Preservation through ultraviolet and ionizing radiations.

Post-harvest handling and technology of fruits, vegetables, cereals, oilseeds, milk, meat and poultry. Food safety, adulteration and food laws. Status of food industry in India

Practical
Physical and chemical quality assessment of cereals, fruits, vegetables, egg, meat and poultry. Value-added products from cereals, millets, fruits, vegetables, milk, egg and meat. Visit to local processing units.

Suggested Reading
1. Potter NN and Hotchkiss JH, 1995, Food Science, Chapman and Hall Publishers.
2. Swaminathan M, 2005, Handbook of Foods and Nutrition, Ganesh and Co. Pvt. Ltd.
3. Swaminathan M, 1990, Food Science, Chemistry and Experimental Foods, BAPPCO.
4. Vaclavik VA and Christian EW, 2003, Essentials of Food Science, 2nd Ed, Kluwer Academic/ Plenum Publishers, New York.

Detailed Syllabi for the Elective Courses

Semester VII

Applications of Genomics and Proteomics **4(3+1)**

Objectives

- To introduce the concepts of omics; genomics, transcriptomics and proteomics.
- To study the methods in genomics and their applications.
- To study the techniques in proteomics.

Theory

Genomes of Arabidopsis, rice, tomato, pigeon pea, wheat. Mutants and RNAi in functional genomics. Site-directed mutagenesis. Transposon tagging. Transient gene expression: VIGS and FACS based, targeted genome editing technologies, introductory genome editing principle and concepts.

Protein 3D structure modelling (homology modelling and crystallography). Proteome analysis. Protein-protein interaction. FRET, yeast two-hybrid and co-immunoprecipitation, Bimolecular Fluorescence Complementation (BiFC). Applications of genomics and proteomics in agriculture, human health and industry. Metabolomics and ionomics for elucidating metabolic pathways.

Practical

SDS-PAGE; 2D Electrophoresis. Protein characterization through HPLC. Specialized crop-based genomic resources: TAIR, Gramene, Graingenes, Maizedb, Phytozome, C e re a l d b, Citrusdb and miRbase.

Suggested Reading

1. Sangeetha J and Thangadurai D, 2015, Genomics and Proteomics: Principles Technologies and Applications, Taylor and Francis
2. Connor DO and Hames BD, 2007, Proteomics: Methods Express, Royal College of General Practitioners.
3. Pennington SR, Dunn MJ, 2001, Proteomics from protein sequence to function, BIOS Scientific Publishers Ltd.
4. Tropp BE, 2012, Molecular Biology Genes to Proteins, 4th Ed, Jones and Bartlett Learning.
5. Verma PS and Agarwal VK, 2014, Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand and Company Pvt. Ltd.

Principles of Molecular Breeding **4(3+1)**

Objectives

- To introduce the concept of molecular breeding with reference to conventional breeding.
- To study the mapping populations, genotyping, phenotyping and mapping.
- To study the validation of genomic resources and their employment in breeding.

Theory
Introduction to molecular breeding, advantages, requirements and methodologies. Limitations of conventional breeding. Development of specific mapping populations, association panels, MAGIC and NAM populations.

Phenotyping and genotyping of the populations, construction of the linkage maps, and linkage-disequilibrium maps. Analysing marker-trait associations, validation of QTL and markers, fine-mapping, and candidate gene discovery.

Marker-assisted selection (MAS) and marker-assisted backcross breeding. Foreground selection, background selection and recombination selection. MAS for major and minor genes, marker-assisted pyramiding, and marker-assisted recurrent selection.

Practical
Methodologies in phenotyping, genotyping, handling marker data, linkage analysis, candidate gene discovery, and fine-mapping. Software for linkage mapping and association mapping. Working on some genotyping and phenotyping datasets for linkage mapping using software such as Mapmaker, MapDisto and QTL mapping software such as WinQTL Cartographer.

Suggested Reading
1. Singh BD and Shekhawat NS, 2017, Molecular Plant Breeding, Scientific Publishers.
2. Xu Y, 2010, Molecular Plant Breeding, CABI, Science.
3. Bharadwaj DN, 2019, Molecular Plant Breeding: Meeting the Challenge of Food Security, Apple Academic Press.

Molecular Breeding of Horticultural Crops and Forest Trees 3(2+1)

Objectives
- To study the principles and applications of molecular breeding in horticultural crops and forest trees.
- To understand the reproduction and breeding Objectives in horticultural and forest crops.
- To study the success stories of molecular breeding in horticultural and forest crops.

Theory
Reproductive biology of major fruit and forest crops. Basic methods of fruit crop improvement. Target traits in major fruit crops. Limitations of fruit crop breeding. Breeding methods of self- and cross-pollinated vegetable crops. Breeding of commercial flower crops.

Molecular markers for germplasm characterization and genetic diversity analysis. Pseudo test cross-mapping strategy in fruit crops. Molecular mapping in vegetable crops. Marker-assisted breeding in horticultural crops and forest plants. Micropropagation for variety dissemination. Mutation breeding and characterization of mutants. Genomic resources for marker development. Transgenic approaches with tree crops and utility.

Practical
Modifications in DNA extraction methods for horticultural and forest crops. Agarose gel electrophoresis, and DNA quantification. Mapmaker; Diversity analysis using UPGMA. Identifying repeat sequences using MISA. Standard Gene cloning methods including construct making with the use of restriction enzymes. DNA ligases and standard molecular approaches.

Suggested Reading
1. Bal JS, 2013, Fruit Growing, Kalyani Publishers.
2. Kumar N, 2006, Breeding of Horticultural crops: Principles and Practices, New India Publishing Agency.
3. Chada KL, 2012, Handbook of Horticulture, ICAR.
4. Schnell RJ and Priyadarshan PM, 2012, Genomics of Tree Crops, Springer.
5. Singh J, 2014, Basic Horticulture, Kalyani Publishers.
6. Singh R, 2012, Fruits. National Book Trust.
7. Spangenberg G, 2001, Molecular Breeding of Forage Crops, Kluwer Academic Publishers.
8. Kumar N, 2018, Breeding of Horticultural Crops: Principles And Practices: 3rd Ed, NIPA.

Molecular Breeding in Field Crops **3(2+1)**

Objectives
- To study the principles and applications of molecular breeding in field crops.
- To understand breeding Objectives in field crops.
- To study the success stories of molecular breeding in field crops.

Theory
MAS for specific traits with examples from field crops with success stories. Development, testing and release of improved genotypes developed using MAS. Specific case studies.

Practical
Use of gene-based and closely linked markers for foreground selection for target traits in target crops. Hands-on training on MAS with a specific crop.

Suggested Reading
1. Nagat T, Lorz H and Widholm JM, 2008, Biotechnology in Agriculture and Forestry, Springer.
2. Trivedi PC, 2000, Plant Biotechnology: Recent Advances, Panima Publishers.
3. Singh BD and Shekhawat NS, 2017, Molecular Plant Breeding, Scientific Publishers.
4. Xu Y, 2010, Molecular Plant Breeding, CABI, Science.
5. Bharadwaj DN, 2019, Molecular Plant Breeding: Meeting the Challenge of Food Security, Apple Academic Press.

Seed Biology, Production and Management **3(2+1)**

Objectives

- To provide an overview of the aspects of seed biology.
- To study the principles and methods of quality seed production.
- To study the techniques and management for seed processing.

Theory

Seed structure, seed development and maturation. Seed germination. Seed senescence- causes, quality characters.

Principles of quality seed production. Factors affecting quality seed production. Causes of varietal deterioration and maintenance of genetic purity during seed production.

Post-harvest handling of seeds - threshing methods - drying methods - advantages and disadvantages. Seed processing principles and sequencing. Seed enhancement technologies (coating, priming, pelleting and hardening)

Practical

Seed production in rice varieties and hybrids. Seed production in sorghum varieties and hybrids. Seed production in pearl millet varieties and hybrids. Seed production in maize. Hybrid seed production in maize. Seed production in pulses (black gram and green gram and red gram). Seed production in groundnut and gingelly. Seed production in sunflower varieties and hybrids. Seed production in cotton. Seed production in solanaceous vegetables. seed production techniques of bhendi and onion. Seed production in cucurbits (snake gourd, bitter gourd, ash gourd, ridge gourd and pumpkin).

Suggested Reading

1. Basra A, 2006, Handbook of Seed Science and Technology (Seed Biology, Production, and Technology), CRC Press.
2. Khedar OP, Singh RV, Sinsinwar YK and Ved Prakash V, 2013, Seed Production Technology in Field Crops, Pointer, ISBN 10: 817132746XISBN 13: 9788171327461

Plant Genetic Transformation **3(2+1)**

Objectives

- To study the historical developments of plant transformation.
- To study the methods of plant transformation.
- To get acquainted with the methods used for analysing the transgenics.

Theory

History of plant genetic transformation. Development of gene constructs. Methods of genetic transformation: *Agrobacterium*-mediated, biolistics, electroporation, liposome, polyethylene glycol, in planta methods.

Selection and characterization of transgenic plants using selectable and reportable markers. PCR; qRT-PCR; Southern and Northern hybridization, ELISA and Western blotting. Application of

genetic transformation for improvement of important traits. Biosafety aspects of transgenic plants and regulatory framework.

Practical
Preparation of stock solutions. Construction of binary vector. Preparation of competent cells of *Agrobacterium tumefaciens* and transformation. Restriction analysis of plasmids, confirmation of transformed bacterial colonies. *Agrobacterium tumefaciens* mediated and biolistic plant transformation.

Suggested Reading
1. Sambrook JF and Russell DW (Ed), 2001, Molecular Cloning: A Laboratory Manual, 3rd Ed, Vols 1, 2 and 3, Cold Spring Harbor Laboratory Press.
2. Grierson D, 2012, Plant Genetic Engineering, Springer Netherlands.
3. Primose SB and Twyman RM, 2006, Principles of Gene Manipulation and Genomics, 7th Ed, Black Well Publishing.
4. Stewart NC, 2008, Plant Biotechnology and Genetics: Principles, Techniques and Applications, John Wiley and Sons Inc.
5. Gardener EJ, Simmons MJ and Snustad DP, 1991, Principles of Genetics. John Wiley and Sons, Inc, New York, USA.

Principles and Procedures of Animal Cell Culture 4(3+1)

Objectives
- To study the principles and importance of animal cell culture.
- To study the basic requirements for animal cell culture.
- To study the techniques in cryopreservation and applications of animal cell culture.

Theory
History, importance and development of animal cell culture techniques. Basic requirements for animal cell culture. Sterilization procedures for cell culture work. Different types of cell culture media, growth supplements, serum-free media and other cell culture reagents.

Different cell culture techniques including primary and secondary cultures; continuous cell lines, suspension culture, organ culture etc. Commonly used animal cell lines: CHO, HeLa, BHK-21, VERO, Sf9, C636, their origin and characteristic, growth kinetics of cells in culture, differentiation of cells. Characterization and maintenance of cell lines. Applications of animal cell cultures.

Cryopreservation and revival of cells. Hybridoma technology. Scaling up methods, bioreactors. Overview of insect cell culture. Stem cell culture and its application, overview of induced pluripotent stem cells (iPSCs). Common cell culture contaminants and their management.

Practical
Basic equipments used in animal cell culture laboratories. Washing, packing and sterilization of glass and plastic wares for cell culture. Preparation of media and reagents for cell culture. Primary

culture technique of chicken embryo fibroblast/any other animal tissue. Culture and sub-culturing of continuous cell lines. Viability assay by trypan blue dye exclusion method. Isolation and cultivation of lymphocytes. Cryopreservation of primary cultures and cell lines. Cytopathic effect of viruses on cultured mammalian cells.

Suggested Reading

1. Freshney I, 2016, Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications.

Animal Genomics **4(3+1)**

Objectives

- To study the genome sequencing and organisation of the animal genome and chromosomal aberrations.
- To study the application of genomics in the development of molecular markers.
- To study the application of genomics and molecular markers in animals.

Theory

Genome organization in eukaryotes. Satellite DNA: VNTRs and families, LINE and SINE. Sex determination: chromosomal basis of sex determination, molecular markers for sex determination, environmental sex determination. Chromosomal aberrations: euploidy, chromosomal non-disjunction and aneuploidy, polyploidy, induced polyploidy, syndromes, structural aberrations. Robertsonian translocations, position effect, chromosomal mosaics, Philadelphia chromosome, chromosomal aberrations and evolution.

Molecular markers: markers, genetic markers: RAPD, STR, DNA fingerprinting, SSCP, RFLP, SNP, EST; SNP Analysis. Karyotyping. Somatic cell hybridization, SNP-array. Radiation hybrid maps. FISH technique. Major histocompatibility complex. Concept and its relevance in disease resistance and immune response. Quantitative trait Loci. Marker Assisted Selection: concept, linkage equilibrium, application in animal sciences. Genomic selection: concept, linkage disequilibrium. Methodologies of genomic selection. Mitochondrial DNA analysis and its application in livestock; applying DNA markers for breed characterization, molecular signatures.

Practical

Extraction of genomic DNA from peripheral blood. Analysis of DNA by agarose or polyacrylamide gel electrophoresis. Checking the quality and quantity of genomic DNA. Restriction digestion and analysis. Sanger sequencing data analysis. Extraction of mitochondrial DNA. Extraction of RNA from PBMC. Quality checking of total RNA. cDNA synthesis.

Suggested Reading

1. Sue C, Heather BM, Scott DW and Melissa CS, 2019, Molecular Biology Techniques: A Classroom Laboratory Manual, Academic Press.
2. Dale JW, Schantz MV and Plant N, 2012, From Genes to Genomes: Concepts and Applications of DNA Technology, John Wiley and Sons.

3. Green and Sambrook JF and Russel DW, 2014, Molecular Cloning: A Laboratory Manual, 4th Ed, Vol I, II and III, Cold Spring Harbor Laboratory Press.
4. Brown TA, 2006, Genomes. 5th Ed, Wiley-Blackwell.
5. Reece RJ, 2004, Analysis of Genes and Genomes, Wiley.

Transgenic Animal Production **3(3+0)**

Objectives

- To study the historical developments of developing transgenic animals.
- To study the methods of animal transformation.
- To get acquainted with the methods used for analysing the transgenics.
- To study the applications of transgenic animals.

Theory

History of transgenesis. Isolation of gene, preparation of gene construct. Methods of transgenic animal production. Calcium chloride mediated transfection, lipofection, electroporation, microinjection, nano delivery.

Production of gene knockouts: cre-lox, zinc finger nucleases; CRISPR; TALENs. Production of chimeric animals, gene silencing by lentivirus system.

Stem cell technology, isolation and characterization of stem cell lines from different sources: embryo, mesenchymal, induced pluripotent stem cell. Introduction to animal cloning. Application of stem cells in transgenesis and animal cloning.

Fundamental assays of transgenic products: confirmation of integration of transgene. Validation of transgenic products like isolation of transgenic protein from milk and characterization. Application of transgenics in production of disease resistance models and carcinogenesis. Regulatory issues associated with transgenic animal production.

Suggested Reading

1. Pinkert CA, 2014, Transgenic Animal Technology.

Molecular Virology and Vaccine Production **3(2+1)**

Objectives

- To study the viruses to develop vaccines.
- To study the antigens and methods of producing the vaccines.
- T study the properties of ideal vaccines.

Theory

Properties of viruses. Classification of viruses. Virus replication. Cell transformations, cultivation of viruses, assay techniques for detection/quantification. Important animal viruses. Virus-host

interactions. Viral infections. Immune responses to viruses. Interferon and other cytokines. Bio-safety and bio-security principles.

Properties of an ideal vaccine. Classification of vaccines. Methods of inactivation and attenuation of viruses. New generation vaccines: subunit, synthetic, rDNA, marker and edible. Adjuvants and vaccine delivery systems. Novel immunomodulators and vaccine delivery using nanotechnology. Vaccine preparation. Stabilizers, preservatives and vehicles. Quality control and testing of vaccines. Sero-surveillance and sero-monitoring.

Practical

Outline of a virology lab and guidelines to work in a virology lab. Processing of clinical specimens for isolation of viruses. Cultivation of viruses in cell cultures and embryonated eggs. Harvesting of virus. Study of cytopathic effects. Titration of virus and estimation of TCID50. Haemagglutination and haemagglutination inhibition test. Detection of virus by SNT, AGID and ELISA.

Suggested Reading

1. Maclachlan NJ and Dubovi EJ, 2016, Fenner's Veterinary Virology, 5th Ed, Elsevier.

Embryo Transfer Technologies **3(2+1)**

Objectives

- To study the veterinary reproductive technologies used to obtain offspring from animals as an alternative to natural mating.
- To study the techniques in embryo transfer.
- To study gene transfer and biopharming in conjunction with embryo transfer.

Theory

History, advantages, limitations and scope of embryo transfer technology. Estrus cycle and its detection in animals. Methodology of superovulation. Ovum pick up (OPU). Preparation of sperm for in vitro fertilization (IVF). Embryo grading and culture. Micromanipulation and immuno-modulation for enhancement of fecundity.

Different methods of gene transfer and their limitations; embryo splitting; embryo sexing by different methods; production of transgenic livestock by nuclear transfer and its application. Animal Biopharming, animal gene bank; regulatory issues (social, ethical, religious and environmental). Cloning of domestic animals. Conservation of endangered species. Characterization of embryonic stem cells and applications.

Practical

Demonstration of estrus detection methods. Estrus synchronization. Superovulation. Oocyte collection from slaughterhouse ovaries. Grading of oocytes from slaughterhouse ovaries. Collection and preparation of semen samples. In vitro fertilization. Collection of embryos using

non-surgical procedures. Grading and culture of embryos. Embryo sexing by different methods. Embryo splitting. Embryo freezing.

Suggested Reading

1. Gordon I, 2004, Reproductive Technologies in Farm Animals, CABI.
2. Hafez ESE, 2000, Reproduction in Farm Animals, Lippincott, Williams and Wilkins.

Animal Reproductive Biotechnology 3(2+1)

Objectives

- This course aims to study the basics of animal reproductive technologies used to analyse, understand and enhance the fertility of animals.
- To study male and female reproduction and methods of checking the quality of gametes.
- To study the direct and indirect methods of checking pregnancy.

Theory

Follicle development, oogenesis, endocrinology of female reproduction, spermatogenesis, endocrinology of male reproduction, structure of spermatozoa and oocyte, semen: composition and contribution to semen by different accessory glands, capacitation of spermatozoa, acrosome reaction, estrus cycle, estrus detection.

Oocyte maturation analysis, methods of semen collection, semen analysis (morphological, microscopic, biochemical or molecular, computer assisted sperm analysis), semen extenders, cryopreservation of semen, oocytes and embryos (history and methods: slow, rapid/ vitrification), polyspermy. fertilization, embryo development, gastrulation, pregnancy diagnosis: different methods (direct and indirect).

Basic terms related to infertility, morphological abnormality in semen, male infertility: terms and causes (genetic and infectious), female infertility: terms and causes (genetic and infectious), artificial gametes, sex sorting of semen.

Practical

Semen collection by artificial vagina, semen analysis (color, volume etc., live dead staining, mass motility, progressive motility, concentration of semen, HOST, abnormality in semen, TUNEL assay, Free Radical Assay). Preparation of semen extender, calculation for semen doses preparation, semen doses preparation, oocyte Maturation assessment.

Suggested Reading

1. Hafez ESE and Hafez B, 2000, Reproduction in Farm Animals, 7th Ed, Blackwell Publishing.
2. Yadav PS, Singh B, Singh I and Sethi RK, 2010, Reproductive Biotechnology in Buffalo, SSPH, ISBN: 8189304801.
3. Dugwekar YG, 2006, Reproductive Biotechnology of Farm Animals, Agrotech Publishing Academy.

Fundamentals of Molecular Pharming and Biopharmaceuticals 4(3+1)

Objectives

- To provide a basic understanding and principles of molecular pharming.
- To study various hosts and techniques for molecular pharming.
- To study the biopharmaceuticals that are successfully pharmed.

Theory

Concept of molecular pharming and production of biopharmaceuticals. Mammalian cell culture manufacturing and microbial fermentation. Fermentation and cell culture processing. Protein purification and processing. Industrial fermentation: batch and continuous cultures, production of biopharmaceuticals, immobilization techniques.

Biopharmaceutical analytical techniques. Biopharma drug discovery and development; production of specific vaccines and therapeutic proteins, click chemistry/ bioorthogonal chemistry for application in plant science.

Practical

Isolation and purification of proteins from microbes and plants. Production of recombinant proteins in prokaryotes. Analysis of proteins by one and two-dimensional gel electrophoresis. Affinity chromatography. Immunoblotting. Cell culture and immobilization techniques. Visit to biopharmaceutical industry.

Suggested Reading

1. Brown TA, 2010, Gene Cloning and DNA Analysis: An Introduction, 6th Ed, Wiley-Blackwell Publishing.
2. Kirkosyan A and Kaufman PB, 2009, Recent Advances in Plant Biotechnology, Springer.
3. Primrose SB and Twyman RM, 2013, Principles of Gene Manipulation and Genomics, John Wiley and Sons.

Microbial Biotechnology 4(3+1)

Objectives

- To study the scope and methods of using industrially useful microorganisms.
- To study the applications of microbes in industry and agriculture.
- To study the methods used for improving the microorganisms.

Theory

Microbial biotechnology, scope and techniques. Industrially important microorganisms. Gene transfer mechanisms in microbes. Transformation, transduction, conjugation and recombination. Genetic variability in microorganisms. Biotechnological tools to improve the microbial strains with respect to industry and agriculture.

Biotransformation and biodegradation of pollutants, biodegradation of lignocelluloses and agricultural residues. Biotechnological treatment of wastewater, sewage and sludge. Industrial production of alcohols, ethanol, acids (citric acid, acetic acid), solvents (glycerols, acetone, butanol), antibiotics (penicillin, streptomycin, tetracycline), amino acids (lysine, glutamic acid), single-cell proteins. Recombinant and synthetic vaccines.

Practical

Isolation and preservation of industrially important microorganisms. Microbial fermentation, production of proteins and enzymes using bacteria, yeast and fungus. Microbial biomass production, utilization of plant biomass by recombinant microorganisms. Production of secondary metabolites from microbes.

Suggested Reading

1. Glaze AN and Nikaido H, 2007, Microbial Biotechnology: Fundamentals of Applied Microbiology. 2nd Ed, Cambridge University Press.
2. Mohapatra PK, 2006, Text Book of Environmental Biotechnology, International Publishing House Pvt. Ltd.

Bioprospecting of Genes and Molecules 3(3+0)

Objectives

- To study the concepts of bioprospecting.
- To study the methods and techniques used for producing bioactive molecules.
- To study the IPR in relation to novel genes and molecules.

Theory

Concepts and practices of bioprospecting. Traditional and modern bioprospecting. Gene prospecting. Isolation, synthesis and purification of new bioactive molecules; clinical and field trials; intellectual property rights and the legal framework. Patenting of new genes and/or novel biomolecules and their applications.

Principles of the Convention on Biological Diversity, biodiversity conservation and biotechnology. Development and management of biological, ecological, taxonomic, and related systematic information on living species and systems.

Bioprospecting of microorganisms and their components. Bioprospecting of biodiversity for new medicines. Identification and collection of material by random and traditional (medicinal) approaches. Screening for particular bio-activities. Elucidation of novel molecular form, process technology. Development of techniques for large scale industrial production of the bioactive product and developing market linkage.

Suggested Reading

1. Upadhyay SK and Singh SP, 2021, Bioprospecting of Plant Biodiversity for Industrial Molecules, ISBN: 978-1-119-71721-8.

2. Mohapatra PK, 2006. Text Book of Environmental Biotechnology, International Publishing House Pvt. Ltd.
3. Sharma PD, 2012, Ecology and Environment, 11th Ed, Rastogi Publications.
4. Upadhyay SK and Singh SP, 2021, Bioprospecting of Microorganism-Based Industrial Molecules, John Wiley and Sons.

Molecular Ecology and Evolution **3(3+0)**

Objectives

- To study the meaning and concepts of molecular evolution.
- To study the concepts of speciation and domestication in conjunction with evolution.
- To study the application of molecular tools for understanding molecular evolution.

Theory

Molecular Evolution. Concept, molecular divergence and molecular clocks. Speciation and domestication. Evolution of earth and earlier life forms. Primitive organisms, their metabolic strategies and molecular coding. New approaches to taxonomical classification including ribotyping. Ribosomal RNA sequencing. Molecular tools in phylogeny, classification and identification.

Protein and nucleotide sequence analysis. Origin of new genes and proteins. Gene duplication and divergence. Genome evolution, components of genomes, whole genome duplications, chromosome rearrangements and repetitive sequence evolution.

Application of molecular genetics and genomics to ecology and evolution. Assessment of genetic diversity, phylogeny, inbreeding, quantitative traits using molecular tools. Mutations. Regulations of gene expression.

Suggested Reading

1. Beebee T and Rowe G, 2008, An Introduction to Molecular Ecology, 2nd Ed, Oxford University Press.
2. Brown TA, 2007, Genome 3, Garlan Science Publishing.
3. Carvalho GR, 2002, Advances in Molecular Ecology, IOS Press Netherland.

Food Biotechnology **3(2+1)**

Objectives

- To study the meaning and concepts of food biotechnology.
- To study the techniques in food processing and preservation.
- To study the application of microorganisms and genetic engineering in food biotechnology.

Theory

Food Biotechnology. Introduction, history and importance. Applications of biotechnology in food processing; recent developments, risk factors and safety regulations. Food spoilage and

preservation process. Food and beverage fermentation: alcoholic and non-alcoholic beverages, food additives and supplements.

Industrial use of microorganisms. Commercially exploited microbes: *Saccharomyces, Lactobacillus, Penicillium, Acetobactor, Bifidobacterium, Lactococcus* and *Streptococcus*; dairy fermentation and fermented products. Prebiotics and probiotics. Genetic engineering for food quality and shelf life improvement. Bioactive peptides. Labelling of GM foods.

Practical

Isolation, culture and maintenance of biotechnologically important micro-organisms. Use of laboratory and industrial scale shakers. Batch and continuous cultures. Use of fermentors. Detection of pathogens in food and feed. Detection of GM food. Visit to the food processing industry.

Suggested Reading

1. Hui YH and Khachatourians GG, 1995. Food Biotechnology: Microorganisms, Wiley-VCH
2. Shetty K, Paliyath G, Pometto A and Levin RE, 2006, Food Biotechnology, 2nd Ed, CRC Press.

Green Biotechnology **3(2+1)**

Objectives

- To study the meaning and concepts of green biotechnology.
- To study the methods and products for better plant growth.
- To study carbon sequestration and other biosafety approaches for a better environment.

Theory

Green biotechnology: definition, concept and implication. Bio-fertilizers and bio-pesticides. Plant growth promoting rhizobacteria. Production of biofuels, biodiesel and bioethanol. Biomass enhancement through biotechnological interventions. Generation of alternate fuels in plants. Identification and manipulation of micro-organisms for biodegradation of plastics and polymers. GMOs for bioremediation and phytoremediation, their roles. Strategies for detection and control of soil, air and water pollutants, circular economy-based resource utilization for biofuel generation.

Carbon sequestration; methanogenic microbes for methane reduction. Microbes for phytic acid degradation. Genetic engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency. Marker-free transgenic development strategies. Development of disease-resistant and pest-resistant crops through biotechnological tools. Biotechnology and sustainable development: sustainable agriculture practices and biotechnology, biotechnological solutions for food security, biotechnology in the context of climate change mitigation and policy and regulatory aspects of green biotechnology.

Practical

Identification and efficiency assays of micro-organisms for biodegradation and bioremediation. Isolation of *Bacillus thuringiensis* and plant growth promoting rhizobacteria. Production of biofertilizers, biopesticides and biofuel. Assays for removal of oil spillage.

Suggested Reading

1. Kirkosyan A and Kaufman PB, 2009, Recent Advances in Plant Biotechnology, Springer.
2. Kumar A, 2004, Environmental Biotechnology, Daya Publishing House.
3. Murray DC, 2011, Green Biotechnology, Dominant Publishers and Distributors.

Programming in Bioinformatics **4(2+2)**

Objectives

- To study the importance and essentials of programming in bioinformatics.
- To study the operating system, algorithms, languages and functions for bioinformatics with hands-on practical.
- To study programming language.

Theory

Introduction: operating systems, programming concepts, algorithms, flow chart, programming languages, compiler and interpreter. Computer number format: decimal, binary, octal and hexadecimal.

C-Language: history, constant, variables and identifiers, character set, logical and relational operators, data input and output concepts. Decision making: if statement, if-else statement, for loop, while loop and do-while loop. Arrays and functions, file handling. Programmes related to arithmetic operations, arrays and file handling in C.

Practical

PERL-Language: introduction, variables, arrays, string, hash, subroutines, file handling, conditional blocks, loops string operators and manipulators, pattern matching and regular expressions in PERL; sequence handling in PERL demonstrating string, array and hash. Shell Programming: concepts and types of UNIX shell, Linux variables, if statements, control and iteration, arithmetic operations, concepts of awk, grep and sed; Sequence manipulations using shell scripting.

Suggested Reading

1. Balagurusamy E, 2008, Programming in ANSI C, Tata McGraw-Hill Education.
2. Tisdall J, 2003, Mastering Perl for Bioinformatics, O'Reilly Media.
3. Christiansen T, Foy BD, Wall L and Orwant J, 2012, Programming Perl, 4th Ed, O'Reilly Media.
4. Kanetkar Y, 2013, Let Us C, BPB Publications.

Bioinformatics Tools and Biological Databases **3(2+1)**

Objectives

- To study various tools of bioinformatics for sequence analysis.
- To study biological data, databases and their applications.
- To study algorithms and methods for bioinformatic analysis, and visualization of results.

Theory

Introduction: biological data types, collection, classification schema of biological databases. Biological databases retrieval systems. Sequence and molecular file formats.

Biological databases: nucleotide database, protein database, structural database, genome databases, metabolic pathway database, literature database, chemical database, gene expression database, crop database with special reference to BTISNET databases.

Bioinformatics tools: concept of alignment, scoring matrices, alignment algorithms, heuristic methods, multiple sequence alignment, phylogenetic analysis, molecular visualization tools.

Practical

NCBI; Expasy: SwissProt; EBI; Search engines: ENTREZ and SRS; Perform local alignment using all BLAST variants. Multiple sequence alignment using ClustalW. T Coffee. phylogenetic analysis by PHYLIP. MEGA.

Suggested Reading

1. Baxevanis AD and Ouellette BFF, 2001, Bioinformatics: A practical guide to the analysis of genes and proteins, John Wiley and Sons.
2. Mount DW, 2001, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor.
3. Xiong J, 2006, Essential Bioinformatics, Cambridge University Press.

Structural Bioinformatics **3(2+1)**

Objectives

- To acquaint the students with the creation of new methods of analysing and manipulating biological macromolecular data in order to solve problems in biology and generate new knowledge.
- To study the analysis and prediction of the three-dimensional structure of biological macromolecules such as proteins, RNA, and DNA.

Theory

Introduction to structural databases of macromolecules, natural and synthetic small molecules. Structure of amino acids. Protein structure classification, Ramachandran plot. Experimental structure determination methods. Motifs, domain, profiles, fingerprint and protein family databases.

Structural features of RNA, RNA secondary structure predictions. RNA folding. Small RNA prediction.

Structure prediction; basics of protein folding, protein folding problem, molecular chaperons. Secondary structure prediction methods and algorithms: homology, ab initio and folding-based tertiary structure prediction. Structure validation tools, energy minimization techniques. Introduction to molecular dynamics and simulation, Monte-Carlo methods, Markov chain and HMM. Structure visualization and comparison methods.

Practical

Protein structural classification databases, 3D-Structural databases searching and retrieval, Ramachandran Plot, structural visualization tools, tools for protein secondary and tertiary structure prediction; RASMOL, Cn3D, CHIMERA, SWISSPDBviewer, CPH, MODELLER, SWISS Model, EasyModeler, Procheck. GROMAC. SANJIVNI. BHAGIRATH.

Suggested Reading

1. Malcolm CA, and Laurie JH, 2007, Discovering Genomics, Proteomics and Bioinformatics, Benjamin Cummings.
2. Allan H, 2008, Modeling for Beginners, Wiley.
3. Creighton TE, 1993, Proteins: Structures and Molecular Properties, W. H. Freeman.
4. Mount DW, 2001, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor.
5. Setubal J, and Meidanis J, 1997, Introduction to Computational Molecular Biology, PWS Publishing Company.

Pharmacogenomics **3(2+1)**

Objectives

- The students are exposed to develop strategies for individualizing therapy for patients, to optimize outcomes through knowledge of human genome variability and its influence on drug response.
- To study the research on genes and medications which has advanced the understanding of the genetic basis of individual drug responses.

Theory

Basic concepts of pharmacogenomics, clinical application and challenges in pharmacogenomics. Human Genome Project, genetic diseases, personalized medicine and pharmacogenomics necessity in drug designing. Prediction of structural changes among sequence variants and genetic analysis. Microsatellites for studying genetic variations. Drug databanks. Gene therapy.

Drug Design: study of important drug targets and their variations. Pharmacophore designing, prediction of ADME properties. Computational tool for toxicity prediction. SAR and QSAR techniques in drug designing. Drug receptor interactions. Structural-based drug design. Lipinski's rule in drug design.

Practical

Receptor-Ligand interactions, pharmacophore development. OSDD. DrugBank. PubChem. Molecular representation using SMILES. Chemsketch: 2D and 3D structure. Structure analyses using Chimera/VMD. Detection of the active site of proteins using various software; bioavailability using Mol inspiration. Docking using HEX and AUTODOCK.

Suggested Reading

1. Allan H, 2008, Modeling for Beginners, Wiley- Blackwell Publishing.
2. Holtje HD, Wolfgang S, Didier R, and Hans D, 2003, Molecular Modeling: Basic Principles and applications, Wiley-VCH.
3. Gupta SP, 1996, Quantum Biology, New Age International Pvt. Ltd.
4. Lisa B, 2014, Combinatorial Library Methods and Protocols, Humana Press.

Metabolomics and Systems Biology **4(3+1)**

Objectives

- To comprehensively identify and quantify all endogenous and exogenous small molecule metabolites in a biological system in a high-throughput manner.
- To study the model and discover emergent properties, properties of cells, tissues and organisms functioning as a system.

Theory

Introduction to metabolomics, metabolomic databases, metabolite architecture, metabolic footprinting, enzyme discovery, *E. coli* metabolomics, fungal exo-metabolome, and diagnostic biomarkers in metabolomics.

introduction to systems biology, transcriptome analysis, simple synthetic networks, noise in gene expression, structure of biological networks, pathway architecture, applications of systems biology in the discovery of disease signatures, drug targeting and design, and metabolomics in systems biology.

Practical

Metabolic pathway databases KEGG, BRENDA, Biosilico, Protein-protein interaction databases, Swiss 2D PAGE, E-PCR. Creating networks using Cytoscape, DAVID, MAS3; in silico functional annotation using GO, AGRIGO, PANTHER, BLAST2GO.

Suggested Reading

1. Berg JM, Tymoczko JL and Stryer L, 2002, Biochemistry, 5th Ed, W. H. Freeman and Company.
2. Fersht A, 1999, Structure and mechanism of protein science, W. H. Freeman and Company.
3. Klipp E, Herwig R, Kowald A, Wierling C and Lehrach H, 2006, Systems biology in practice, concepts, implementation and application, Wiley VCH.
4. Vaidynathan S, Harrigan GG and Royston G, 2005, Metabolome analysis: Strategies for system biology, Springer VD and Voet J, (Ed) Biochemistry, 3rd Ed, John Wiley and Sons.
5. Nielsen J, and Jewett MC, 2007, Metabolomics, A Powerful Tool in Systems Biolog, Springer-Verlag Berlin Heidelberg, ISBN 978-3-540-74718-5.

6. Tomita M, and Nishioka T, 2005, Metabolomics, The Frontier of Systems Biology, Springer-Vertag, ISBN 4-431-25121-9.

Computational Methods for Data Analysis **3(2+1)**

Objectives

- To apply statistical analysis and technologies to data to find trends and solve problems.
- To introduce students to some of the key computational techniques used in modelling and simulation of real-world phenomena.
- To study the applications of computational methods in biology using sequence data.

Theory

Introduction to UNIX/LINUX operating system. Knowledge discovery and data mining techniques. Machine learning and pattern recognition, hidden Markov models. Artificial neural networks, support vector machines.

Principal component analysis, ANOVA. AMOVA and different clustering methods. Gene prediction algorithms and phylogeny algorithms. Basics of R statistical package.

Practical

Gene prediction: FGENESH. R statistical package installation and configuration, GUI for R: R-commander, R Studio, RKWard. Analysis of gene expression using R; GNU PSPP, Scilab, QtiPlot.

Suggested Reading

1. Gareth J, Daniela W, Trevor H, and Robert T, 2013, An Introduction to Statistical Learning: with Applications in R, Springer.
2. Mathur KS, 2010, Statistical Bioinformatics with R, Elsevier.

MOOCs/Online Courses

The students will register for online courses of 10 credit hours comprising one or more courses at the approved portals during the third and fourth years with prior approval from the Head of the institution.

Acknowledgement

Acknowledgement is extended to the following teachers for their invaluable inputs in finalizing this report.

1. Dr. Yashpal Singh Malik, Former Dean, College of Animal Biotechnology, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, and
   Joint Director, ICAR-Indian Veterinary Research Institute (ICAR-IVRI), Mukteswar, Nainital.

2. Dr. B. V. Sunil Kumar, Biochemist, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana.

3. Dr. (Mrs.) Parveen Chhuneja, Director, School of Agricultural Biotechnology, Punjab Agricultural University, Ludhiana.

4. Dr. Senthil Natesan, Director, Centre for Plant Molecular Biology and Biotechnology, Tamil Nadu Agricultural University, Coimbatore.

5. Dr. B. T. Krishnaprasad, Professor (Dept. of Agri. Biotechnology), College of Agriculture, Hassan, Karekere, Hassan.

6. Dr. R. K. Salgotra, Coordinator, School of Biotechnology, SKUAST-Jammu.

7. Dr. (Mrs.) Rashmi Singh, Professor, Department of Veterinary Microbiology, Uttar Pradesh Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya (DUVASU), Mathura.

8. Dr. Daya Shankar, Professor and Head, Department of Parasitology, Uttar Pradesh Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya (DUVASU), Mathura.