UNIVERSITY OF KERALA

Career Related First Degree Programme
Under CBCS System

Group 2 (b) Multimajor

BIOTECHNOLOGY

With
Botany or Zoology and Chemistry

Learning Outcomes-based Curriculum Framework (LOCF) based
Course Structure & Syllabus
(*For those who joined from the Academic year 2023 onwards*)

Foundation Courses, Core Courses, Vocational Courses, Complementary courses and
Open / Elective Courses

2023

Foreword

The Board of Studies in Biotechnology (Pass) of the University of Kerala decided to revise the syllabus of the Biotechnology UG courses with effect from the academic year 2023-24 as part of its continued efforts to provide the latest information to the students and also convert it into Outcome based curriculum as per the UGC directions .Accordingly, the Board of studies in Biotechnology decided to convert accordingly the syllabus was revised as per the LOCF format'. The existing syllabi were updated by addition relevant information contents and online resources. The various directions of UGC and University of Kerala regarding courses on Disaster Management, Informatics, and Environmental Studies etc. were discussed and included in the syllabus in the appropriate places.

The draft syllabi, prepared by considering the inputs from the members were discussed and approved by the Board of Studies held on 17th November 2022. After discussion and approval, the Chairman BOS submitted the syllabus to the University. The chairman takes this opportunity to appreciate the Members of the Board of Studies and the faculty for their active role in contributing to the revision of the syllabus and making it in the LOCF format. The syllabus will be effective from the academic year 2023-24. The Chairman places on record his deep sense of appreciation to the, Members of Board of Studies in Biotechnology (Pass), Comments and suggestions for improvement are welcome.

Thiruvananthapuram **Prof. Dr. A. Jayakumaran Nair**

17 -11-2022 Chairman, BOS in Biotechnology (Pass)

Career Related First Degree Programme in

Biotechnology (Multimajor 2 (b))

Programme Outcomes and Programme Specific Outcomes

Programme Outcomes (PO)

PO1- The major outcome of the Career related first degree programme in Group 2(b) Biotechnology is to develop a scientific attitude and an interest towards the modern areas of biotechnology in particular and life science in general.

PO2- The programme will help the students to become critical and curious in their outlook. The courses are designed to impart the essential basics in chemistry, Botany, Zoology and Biotechnology.

PO3- The various courses in the programme is aimed to develop proficiency in the theory as well as practical experiments, common equipments, laboratory, along with the collection and interpretation and presentation of scientific data in proper manner.

Programme Specific Outcomes (PSO)

After successfully completing the course the students will be able to:-

PSO-1. Develop basic understanding of the various streams of biotechnology. Apply the knowledge in the modern areas of biotechnology such as medical science, environment, agriculture, industry, proteomics, genomics, metabolomics, bioinformatics, nanobiotechnology etc.

PSO-2. Understand biotechnology and its power in developing the nation, and to create awareness about biotechnology that will help in eliminating public fear about the contribution of biotechnology and confusion on GM crops, GM foods and transgenic organisms etc. Enhance practical skills and competency to conduct experiments in biotechnology.

PSO-3. Understand the basic concepts of biotechnology and other interdisciplinary areas. Group project helps in creating analytical thinking and interpreting the inference

PSO-4. Pursue higher studies in Biotechnology and contribute significantly in its development. Inculcate skill to organize scientific events and effective communication. Ascertain their area of interest in research

SUMMARY OF THE PROGRAMME

Career Related First Degree Programme in

Biotechnology (Multimajor 2 (b))

Summary of Courses
Botany / Zoology, Chemistry and Biotechnology

	Study Components		No. of course	Credits/ course		Max. Total Credits
1	**Languages**					
	1	English	2	2		4
2	**Foundation Course**		2	2		
	1	Methodology and Perspective of Biotechnology		3		5
	2	Biophysics and Instrumentation		2		
3	**Complementary Courses (Botany / Zoology)**		4	3		12
	Botany			T	P	
	1	Phycology, Mycology, Lychenology, Bryology, Pteridology, Gymnosperms, & Plant Pathology		3		
	2	Plant Physiology, Angiosperm Anatomy & Reproductive Botany		3		
	3	Angiosperm Morphology & Systematic Botany		3		
	4	Practical COM II (Practical of 1, 2 & 3)			3	
	Zoology					
	1	Animal Diversity – Non Chordata & Chordata		3		
	2	Animal Physiology & Anatomy		3		
	3	Developmental Biology, Human Genetics & Applied Zoology		3		
	4	Practocal COM II (Practical of 1,2 & 3)			3	
4	**Core Courses** Botany / Zoology, Chemistry & Biotechnology		32	2-4		90
	Botany		12	2-4		31
	1	Phycology, Mycology, Lychenology, & Plant Pathology		2		
	2	Environmental Studies		4		
	3	Practical Botany I (Practical of 1 & 2)			2	
	4	Angiosperm anatomy, Reproductive Botany & Palynology		3		
	5	Bryology, Pteridology , Gymnosperms & Paleobotany		2		
	6	Plant physiology		2		
	7	Cell Biology, Plant breeding & Evolutionary Biology		2		
	8	Practical Botany II (Practical of 4,5,6 & 7)			2	
	9	Angiosperm Morphology & Systematic Botany		4		
	10	Economic Botany, Ethnobotany & Pharmacognosy		3		
	11	Genetics		2		
	12	Practical Botany III (Practical of 9,10 & 11)			3	
	Zoology		12	2-4		31
				T	P	
	1	Animal Diversity – Non Chordata		2		
	2	Environmental Studies		4		
	3	Practical Zoology I (Practical of 1 & 2)			2	
	4	Developmental Biology & Reproductive Biology		3		

	5	Animal Diversity II – Chordata		2		
	6	Animal Physiology		2		
	7	Cell Biology		2		
	8	Practical Zoology II (Practical of 4,5,6 & 7)			2	
	9	Systematics , Biodiversity & Animal Behaviour		3		
	10	Genetics		4		
	11	Evolution		2		
	12	Practical Zoology III (Practical of 9,10 & 11			3	
	Chemistry		9	2-4		28
				T	P	
	1	Inorganic Chemistry I		4		
	2	Inorganic Chemistry II		3		
	3	Practical Chemistry I (Practical of 1 & 2)			2	
	4	Physical Chemistry I		4		
	5	Physical Chemistry II		3		
	6	Practical Chemistry II			2	
	7	Organic Chemistry I		4		
	8	Organic Chemistry II		3		
	9	Practical Chemistry III (Practical of 7 & 8)			3	
	Biotechnology		11	2-4		31
	1	Biochemistry & Metabolism		4		
	2	Microbiology		2		
	3	Biotechniques I (Practical of 1 & 2)			2	
	4	Food and Industrial Biotechnology		4		
	5	Molecular Biology		4		
	6	Immunology		2		
	7	Recombinant DNA Technology		2		
	8	Biotechniques II (Practical of 4,5,6 & 7)			2	
	9	Environmental Biotechnology		3		
	10	Plant Biotechnology & Animal Biotechnology		4		
	11	Biotechniques III (Practical of 9 & 10)			2	
5	**Open Course (Semester V) & Elective Courses of Core Course (Semester VI)**					
	Botany*(One of the three elective courses as per the syllabus of BSc Botany)*					
	1	Horticulture		2		
	2	Mushroom Cultivation & Marketing		2		
	3	Forestry		2		
	Zoology *(One of three elective courses as per the syllabus of BSc Zoology)*					
	1	Economic Zoology– Vermiculture and Apiculture				
	2	Ornamental Fresh water fish production				
	3	Human Nutrition				
	Biotechnology Open (Semester V), Elective Course (Semester VI)					
	1	Bioinformatics and Nanotechnology		2		
	2	Food & Dairy Biotechnology		2		
	3	Genetic Engineering		2		
	4	Basics of Environmental Biotechnology		2		
6	**Project**				3	
				Total Credits		**120**
T- Theory P- Practical						

Course structure and syllabus of Career Related First Degree in Biotechnology (2b) as per the regulations of CBCS

The Career related first degree programme in Group 2(b) Biotechnology as one of the core subjects, consists of a total of 66 courses distributed in six categories. They are Language courses, Foundation courses, Complementary courses, Core courses, Open & Elective course of core subjects, and a Project. The project is compulsory and the students may be assigned a topic for the project in the 5th semester itself and should be completed and submitted during the practical assessment at the end of 6th semester.

There are two programmes within the group 2(b) of the career related First Degree Programme, which differ in one of the core subjects and complementary Courses. In one Programme one of the core subjects is Botany and its complementary courses will be from Zoology; and in the second programme one of the core subjects is Zoology and its Complementary courses are from Botany.

Each course title is represented by a course code consisting of a two letter subject code followed by four digits. The first digit indicates the first degree programme, which is always one. The second digit indicate the semester number which is 1-6, the 3rd digit denotes the category of the course which ranges from 1-6, since there are six categories and the last digit indicates the serial number of the course with in a semester. But in the case of Botany and Zoology, which are optional core courses, the course code consists of a 5th digit- .1 to denote the courses for optional botany and .2 for optional Zoology. The same is the case with open and elective courses. The following are the category of courses included in this first degree programme of 2(b) group.

The subject code is BV (Biotechnology Vocational)

1. Language
2. Foundation course subject
3. Complementary courses
4. Core Courses
5. Open Course
6. Elective Course for Core
7. Project (project is part of core course and so the number code is **4**)

CHOICE OF ELECTIVE COURSES

Students of Biotechnology should take up <u>Two Internal Elective courses</u> during the Sixth semester as given below:

<u>First Elective (All students)</u>

One Elective course from Biotechnology

<u>Second Elective</u>

a) Students of Botany, Chemistry, Biotechnology: One elective course from Botany

b) Students of Zoology, Chemistry, Biotechnology: One Elective course from Zoology

Course Structure
Career Related First Degree Programme

Biotechnology (Multimajor 2b)
Botany, Chemistry & Biotechnology

Semester I

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
EN 1111	English	2	36	2	3 hrs	20	80
BV1121	Methodology and Perspective of Biotechnology	4	72	3	3Hrs	20	80
BV 1131.1	Animal Diversity- Non-Chordata &Chordata	3	54	3	3Hrs	20	80
BV 1141.1	Microtechnique, Angiosperm anatomy, Reproductive botany and Palynology	3	54	2	3Hrs	20	80
	Practical	2	36				
BV 1142	Inorganic Chemistry -1	5	90	4	3Hrs	20	80
	Practical	2	36				
BV 1143	Biochemistry & Metabolism	3	54	4	3Hrs	20	80
	Practical	6	108				
	Total Hours	**30**	**540**	**18**			

Total Hrs: CH- 7, BO-8 (Core 5+Compl. 3), BT-(BC)9+4, EN-2=30

Semester II

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
EN 1211	English	2	36	2	3 hrs	20	80
BV1221	Biophysics and Instrumentation	2	36	2	3Hrs	20	80
	Practical	1	18				
BV 1231.1	Animal Physiology & Anatomy	3	54	3	3Hrs	20	80
BV 1241.1	Environmental Studies	4	72	4	3Hrs	20	80
	Practical	2	36				
BV 1242.1	**Practical Botany I** (Practical ofBV1141.1, BV1241.1)			2	3Hrs	20	80
BV 1243	Inorganic Chemistry II	6	108	3			
	Practical	3	54				
BV 1244	**Practical Chemistry-I** (Practical of BV1142 & BV1243)			2	3Hrs	20	80
BV 1245	Microbiology	4	72	2	3Hrs	20	80
	Practical	3	54				
BV 1246	**Biotechniques-I** (Practical ofBV1143 & BV1245			2	3Hrs	20	80
	Total Hours	**30**	**540**	**22**			

TotalHrs: CH-9,BO- 9 (core6+compl. 3), BT-10,EN-2=30

Semetsr III

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
BV 1331.1	Developmental Biology, Human Genetics & Animal behaviour	3	54	3	3 hrs	20	80
BV 1341.1	Phycology, Mycology, Lichenology & Phytopathology	2	36	3	3Hrs	20	80
	Practical	2	36				
BV 1342.1	Bryology, Pteridology, Gymnosperms & Paleobotany	2	36	2	3Hrs	20	80
	Practical	1	18		3Hrs	20	80
BV 1343	Physical Chemistry -I	7	126	4	3Hrs	20	80
	Practical	3	54				
BV 1344	Food & Industrial Biotechnology	3	54	4			
	Practical	2	36				
BV 1345	Molecular Biology	3	54	4	3Hrs	20	80
	Practical	2	36		3Hrs	20	80
	Total Hours	**30**	**540**	**20**			

TotalHrs: CH- 10,BO- 10(core 7+compl. 3), BT-10,=30

Semester IV

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
BV 1431.1	**Practical COMP (PracticalofBV1131.1, BV1231.1&BV1331.1)**	3	54	3	3 hrs	20	80
BV 1441.1	Plant Physiology	3	54	2	3Hrs	20	80
	Practical	1	18				
BV 1442.1	Cell Biology, Plant breeding & Evolutionary Biology	2	36	2	3Hrs	20	80
	Practical	1	18		3Hrs	20	80
BV 1443.1	**Practical Botany II** (Practical of **BV1341.1,BV1342.1,BV1441.1&BV1442.1**			2	3Hrs	20	80
BV 1444	Physical Chemistry II	7	126	3	3Hrs	20	80
	Practical	3	54				
BV 1445	**Practical Chemistry II** (Practical ofBV1344 & BV1444)			2	3Hrs	20	80
BV 1446	Recombinant DNA Technology	3	54	2	3Hrs	20	80
	Practical	2	36				
BV 1447	Immunology	3	54	2	3Hrs	20	80
	Practical	2	36				

BV 1448	**Biotechniques II** (Practical of BV-1344,BV1345, BV1446,BV1447)			2	3Hrs	20	80
	Total Hours	**30**	**540**	**20**			

Total Hrs: CH-10,BO-10(core7+compl.3),BT-10= 30

Semester V

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
BV 1541.1	Angiosperm Morphology & Systematic Botany	4	72	4	3 hrs	20	80
	Practical	2	36				
BV 1542.1	Economic Botany, Ethnobotany & Medicinal Botany	3	54	3	3Hrs	20	80
	Practical	1	18				
BV 1543	Organic Chemistry I	6	108	4	3Hrs	20	80
	Practical	4	72				
BV 1544	Environmental Biotechnology	2	36	3	3Hrs	20	80
	Practical	1	18				
BV 1545	Plant Biotechnology & Animal Biotechnology	3	54	4	3Hrs	20	80
	Practical	1	18				
	OPEN COURSES (For Non Biotechnology Students)						
BV 1551	Bioinformatics	3	54	2	3Hrs	20	80
BV 1552	Food & Dairy Biotechnology						
BV 1553	Genetic Engineering						
BV 1554	Basics of Environmental Biotechnology(Any one course shall be offered as open course for Non-Biotechnology students)						
	Total Hours	**30**	**540**	**20**			

Total Hrs: CH-10, BO-10, BT-(7+OC-3)–10 =Total =30

Semester VI

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
BV 1641	Genetics	5	90	2	3 hrs	20	80
	Practical	2	36				
ELECTIVE COURSE IN BOTANY(Any one out of three courses)							
BV 1661.1	Horticulture						
BV 1661.2	Mushroom cultivation & Marketing						
BV 1661.3	Forestry	3	54	2	3Hrs	20	80
BV 1642.1	**Practical Botany III** (Practical ofBV1541.1,BV1542.1&BV1641.1)				3Hrs	20	80
BV 1643	Organic Chemistry II	7	126	3	3Hrs	20	80
	Practical	3	54				
BV 1644	**Practical Chemistry-III**(PracticalofBV1543 & BV1643)			3	3Hrs	20	80
	ELECTIVE COURSE IN BIOTECHNOLOGY (Any one out of the three courses)						
BV 1663.1	Bioinformatics & NanoBiotechnology						
BV 1663.2	Food and Dairy Biotechnology						

BV 1663.3	Genetic Engineering	3	54	2	3Hrs	20	80
BV 1645	**Biotechniques III** (Practical of BV1544 & BV1545)	2	36	2	3Hrs	20	80
BV 1646	**Project**	**5**	**90**	**3**	Viva Voce	20	80
	Total Hours	**30**	**540**	**20**			

Total Hrs: CH-10,BO-10, BT-10 (5+Project-5)=30

Course Structure
Career Related First Degree Programme

Biotechnology (Multimajor 2b)
Zoology, Chemistry & Biotechnology

Semester I

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
EN 1111	English	2	36	2	3 hrs	20	80
BV1121	Methodology and Perspective of Biotechnology	4	72	3	3Hrs	20	80
BV 1131.2	Phycology, Mycology, Lichenology, Bryology, Pteridology, Gymnosperms and Plant Pathology	3	54	3	3Hrs	20	80
BV 1141.2	Animal Diversity I- Non-Chordata	3	54	2	3Hrs	20	80
	Practical Zoology I	2	36				
BV 1142	Inorganic Chemistry -1	5	90	4	3Hrs	20	80
	Practical	2	36				
BV 1143	Biochemistry & Metabolism	3	54	4	3Hrs	20	80
	Practical	6	108				
	Total Hours	**30**	**540**	**18**			

Total Hrs: CH- 7,ZOO-8(Core 5+Compl. 3),BT-(BC)9+4, EN-2=30

Semester II

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
EN 1211	English	2	36	2	3 hrs	20	80
BV1221	Biophysics and Instrumentation	2	36	2	3Hrs	20	80
	Practical	1	18				
BV 1231.2	Plant Physiology, Angiosperm Anatomy & Reproductive Botany	3	54	3	3Hrs	20	80
BV 1241.2	Environmental Studies	4	72	4	3Hrs	20	80
	Practical	2	36				
BV 1242.2	**Practical Zoology-I** (Practical of BV1141.2, BV1241.2)			2	3Hrs	20	80
BV 1243	Inorganic Chemistry II	6	108	3			
	Practical	3	54				

BV 1244	**Practical Chemistry-I** (Practical ofBV1142 & BV1243)			2	3Hrs	20	80
BV 1245	Microbiology	4	72	2	3Hrs	20	80
	Practical	3	54				
BV 1246	**Biotechniques-I** (Practical of BV1143 & BV1245			2	3Hrs	20	80
	Total Hours	**30**	**540**	**22**			

Total Hrs: CH-9, ZO- 9(Core 6+Compl. 3), BT-10, EN-2=30

Semester III

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
BV 1331.2	Angiosperm Morphology, Systematic Botany & Economic Botany	3	54	3	3 hrs	20	80
BV 1341.2	Developmental Biology & Reproductive Biology	3	54	3	3Hrs	20	80
BV 1342.2	Animal Diversity–II: Chordata	2	36	2	3Hrs	20	80
	Practical Zoology II	2	36				
BV 1343	Physical Chemistry -I	7	126	4	3Hrs	20	80
	Practical	3	54				
BV 1344	Food & Industrial Biotechnology	3	54	4	3Hrs	20	80
	Practical	2	36				
BV 1345	Molecular Biology	3	54	4	3Hrs	20	80
	Practical	2	36				
	Total Hours	**30**	**540**	**20**			

Total Hrs: CH- 10, ZO- 10(Core 7+Compl. 3), BT-10,=30

Semester IV

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
BV 1431.2	**PracticalCOMP(PracticalofBV1131.2, BV1231.2&BV1331.2)**	3	54	3	3 hrs	20	80
BV 1441.2	Animal Physiology	2	36	2	3Hrs	20	80
	Practical	1	18				
BV 1442.2	CellBiology& EvolutionaryBiology	2	36	2	3Hrs	20	80
	Practical	2	36		3Hrs	20	80
BV 1443.2	**Practical Zoology-II(Practical of BV1341.2,BV1342.2,BV1441.2&BV1442.2**			2	3Hrs	20	80
BV 1444	Physical Chemistry II	7	126	3	3Hrs	20	80
	Practical	3	54				
BV 1445	**Practical Chemistry II** (Practical			2	3Hrs	20	80

	ofBV1344 & BV1444)						
BV 1446	Recombinant DNA Technology	3	54	2	3Hrs	20	80
	Practical	2	36				
BV 1447	Immunology	3	54	2	3Hrs	20	80
	Practical	2	36				
BV 1448	**Biotechniques II** (Practical of BV1344, BV1345, BV1446, BV1447)			2	3Hrs	20	80
	Total Hours	**30**	**540**	**20**			

Total Hrs: CH-10, ZO-10 (core7+compl.3),BT-10= 30

Semester V

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
BV 1541.2	Systematics, Biodiversity & Animal Behaviour	3	54	3	3 hrs	20	80
	Practical	1	18				
BV 1542.2	Genetics	4	72	4	3Hrs	20	80
	Practical	2	36				
BV 1543	Organic Chemistry I	6	108	4	3Hrs	20	80
	Practical	4	72				
BV 1544	Environmental Biotechnology	2	36	3	3Hrs	20	80
	Practical	1	18				
BV 1545	Plant Biotechnology & Animal Biotechnology	3	54	4	3Hrs	20	80
	Practical	1	18				
	OPEN COURSES (For Non Biotechnology Students)						
BV 1551	Bioinformatics	3	54	2	3Hrs	20	80
BV 1552	Food & Dairy Biotechnology						
BV 1553	Genetic Engineering						
BV 1554	Basics of Environmental Biotechnology (Any one course shall be offered as open course for Non-Biotechnology students)						
	Total Hours	**30**	**540**	**20**			

Total Hrs: CH-10, ZO-10, BT- (7+OC-3)–10 =Total =30

Semester VI

Course code	Course Title	Contact hours /week	Total contact hours	Credits	Duration of University Exam	Marks for Evaluation	
						CE	ESE
BV 1641.2	Evolution	5	90	2	3 hrs	20	80
BV 1642.2	**Practical Zoology III** (Practical of BV1541.2,BV1542.2 & BV1641.2)	2	36	3	3 hrs	20	80
BV 1643	Organic Chemistry II	7	126	3	3Hrs	20	80
	Practical	3	54				
BV 1644	**Practical Chemistry III** (Practical of BV1543 & BV1643)			3	3Hrs	20	80
ELECTIVE COURSE IN ZOOLOGY(Any one out of three courses)							
BV 1662.1	Economic Zoology– Vermiculture and Apiculture						
BV 1662.2	Ornamental Fresh water fish production						
BV 1662.3	Human Nutrition	3	54	2	3Hrs	20	80
	ELECTIVE COURSE IN BIOTECHNOLOGY(Any one out of the three courses)						
BV 1663.1	Bioinformatics & NanoBiotechnology						
BV 1663.2	Food and Dairy Biotechnology						
BV 1663.3	Genetic Engineering	3	54	2	3Hrs	20	80
BV 1645	**Biotechniques III** (Practical of BV1544 & BV1545)	2	36	2	3Hrs	20	80
BV 1661	**Project**	**5**	**90**	**3**	Viva Voce	20	80
	Total Hours	**30**	**540**	**20**			

Total Hrs: CH-10, ZO-10, BT-10 (5+Project-5) =30

Distribution of Total Teaching Hrs. for Each of the Major Subjects

Botany / Zoology, Biotechnology and Chemistry

Course	IS	IIS	IIIS	IV S	V S	VI S	Total
EN	**2**	**2**	**0**	**0**			**4**
BT	**9 +4**	**7+3**	**10**	**10**	**8+2**	**10**	**63** (33+30)
BO/ZO	**5+3**	**6+3**	**10 (7+3)**	**10 (6+4)**	**10**	**10 (7+3)**	**57** (28+29)
CH	**7**	**9**	**10**	**10**	**10**	**10**	**56** (27+29)
FC	(4)	(3)					

CC	(3)	(3)	(3)	(4)			
EC					(3)	(3)	
Project						(10)	
Total	**30**	**30**	**30**	**30**	**30**	**30**	**180**

FOUNDATION COURSES

FOUNDATIONCOURSES

SEMESTER I

Foundation Course I

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1121	**Methodology and Perspective of Biotechnology**	**3**	**72**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will be able to understand how science works
CO 2	Students will learn how to apply statistics and IT in Biological science.
CO 3	They will receive a general awareness about biotechnology and its application in various fields.
CO4	The students will acquire knowledge on safety and ethics in biotechnology

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course content with Module outcome (MO)

Module I

MO: The students will have a basic understanding on how science works designing and planning of experiments.

Science and Scientific studies 6 hrs

Types of Knowledge: practical, theoretical and scientific knowledge. Information. What is science and what is not science, science vocabulary and science disciplines. Revolution in science

Experimentation in Science 12 hrs

Design of an experiment- Observation: Types of observations, direct and indirect observations, controlled and uncontrolled observations, human and machine observations, data collection; interpretation and deduction. Necessity of units and dimensions, repeatability and replication.

Types of experiments, Experiments to test a hypothesis, to measure a variable, or to gather data, Documentation of experiments, record keeping.

Planning of experiments: Design, selection of controls, observational requirements, and instrumental requirements, Scientific instruments (only an introduction of the instruments required) Historical development and evolution of scientific instruments, Accuracy, precision and errors, Robotics.

Module II

MO: The students will be able to understand basic data handling techniques

Data handling in science and Biostatistics 12 hrs

Types of Data- typical examples, data interpretation, collection of data: primary and secondary data, classification and tabulation, graphical and diagrammatic representation, significance of statistical methods in biological investigations, p-value.

Sampling techniques, statistical evaluation of results, probability theory, Probability calculation, variables in biological data, standard distribution with important properties, simple problems involving binomial, Poisson and normal variables, methods of sampling, confidence level, idea of sampling, distribution, standard deviation (SD) and standard error (SE), measurement of dispersion, basic idea of significance test, hypothesis testing, level of significance, Scientific writing

Module III

MO: The students will be able to understand basics and Social **applications of IT**

Overview of Information of Technology 12 hrs

Features of modern personal computers and peripherals, computer networks and Internet,internet as knowledge repository, Introduction to mobile phone technology and ATM, Purchase of technology- license, guarantee, warrantee, Overview of Operating systems and major application software. Academic search techniques, use of IT in teaching and learning- educational softwares, INFLIBNET, NICNET, BRNET-academic services.

Social Informatics 6 hrs

IT and Society, creating your cyber presence. Cyber ethics, cyber crime, security privacy issues, Overview of IT- application in medicine, healthcare, Business, Commerce, Industry, Defense, Law, crime detection, publishing, communication, resource management, weather forecasting, education, film and media, Introduction to Scilab and Matlab

Module IV

MO: The students will attain a broad understanding on the varied applications of Biotechnology for human and environmental well being

Origin and development of Biotechnology 6 hrs

Introduction and definitions, Historic perspectives- microorganisms and fermentation, Origin of genetics, DNA and genetic Engineering (general account only)–definition and tools of genetic engineering,Classical and modern concepts of Biotechnology, Scope and Commercial potential of Biotechnology, Biotechnology in India and its global trends, Major Biotechnology institutes and companies in India.

Application of Biotechnology 12 hrs

Industrial Biotechnology- Bioprocess and Fermentation Technology

Environmental Biotechnology-Biological fuel generation, Single cell protein, sewage and Effluent treatment

Medical Biotechnology- safer and cheaper medicines by biotechnology, antibiotics, medicines from cell cultures, new medicines through genetic engineering, Biopharming, Hybridoma technology

Agriculture Biotechnology- Traditional methods of Crop improvement, Crop improvement through Biotechnology, GM crops- Herbicide tolerance, Insect resistance, Virus resistance

Animal Biotechnology - Genetically modified Livestock and poultry

Food and Beverage Biotechnology- application of biotechnology in food processing, Traditional and modern food processing –cheese,curd, bread,wine

Module V 6 hrs

MO: The student will be able to understand the biosafety and ethics principles in Biotechnology

Safety and Ethics in Biotechnology-

Good Laboratory Practices (GLP), Good manufacturing Practices (GMP), Quality control in manufacturing, Marketing of Biotechnology Products. Impact of Biotechnology on Society, IPR and Patents in Biotechnology- basic concepts of IPR, patents and copyrights, plagiarism.

Suggested Readings

1. An Introduction to Biostatistics: A Manual for studies in Health Sciences., P. SundarRao, and J.Richard., Prentice Hall .
2. Biotechnologies and the Public: An International Study of Policy, Media Coverage and Public Attitudes from 1973 to 1996 (1995-1998), HelgeTorqersen, Institute of Technology Assessment.
3. Biotechnology and Ethics: A Blueprint for the Future, Daniel Callahan President, Hastings Center, Center for Biotechnology, Northwestern University.
4. Biotechnology: Issues, Ethics and Regulations, Tina M. Prow, Communications Specialist, Office of Agricultural Communications and Education.
5. Computers Today, Alexis Leon and Mathews Leon., Leon Vikas.
6. Conceptual Integrated science, Hewitt, Paul G, Suzanne Lyons, ohn A. Suchocki&enniferYeh., Addison-Wesley.2007.
7. Cultural Boundaries of Science, Gieryn, T.F. University of Chicago Press, 1999.
8. Fundamentals of Information Technology, Alexis and Mathew Leon., Leon Vikas
9. Introduction to Genetic Engineering & biotechn9ology, Nair, A.J., Infinity Science Press, USA.
10. Introduction to Information Technology, V.Rajaraman., Prentice Hll.
11. Learning Computer Fundamentals. Ramesh Bangia ., Khanna Book Publishers.Methods for Teaching Science as Inquiry, Bass, Joel,E and et. al., Allyn& Bacon, 2009 The truth of science, Newton R.G.,
12. Patenting in Biotechnology - Part I, R. Stephen Crespi, Tibtech, Vol. 9, 117-122, 1991.
13. People's Perception of Biotechnology, Renato Schibeci, Ian Barns.
14. Plant Biotechnology: Facts and Public Perception, D. Boulter, Department of Biological Sciences, University of Durham, South Road, Durham DH1 3LE, U.K. *'Phytochemistry' (Vol. 40, No.1, pp.1-9, 1995).*
15. Public Attitudes to Genetically Engineered Products, Wendy Ross, Katy Marsh, Alexi Jackson, JaquiSkoyles, (1998), John Innes Centre, Norwich, U.K.
16. Social issues in Science and Technology: An Encyclopedia, David E. Newton (ABC-CLIO, Santa Barbara), 1999.
17. The Golem: What everyone should know about science, Collins H. and T. Pinch, Cambridge University Press, 1993.

SEMESTER II

Foundation Course II

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1221	**Biophysics & Instrumentation**	**3**	**54** (T 36 + P 18)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will be able to understand the fundamentals of biophysics
CO 2	Students will learn sophisticated instrumental techniques used in biotechnology.
CO 3	They will get an understanding of molecular interactions
CO4	The students will acquire knowledge on working principles and applications of microscopy and autoradiography

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							**100**

Course content with Module outcome (MO)

Module I

MO: The students will have a basic understanding on thermodynamic principles and chemiosmotic hypothesis

Principles of thermodynamics: 6 hrs

Laws of conservation of energy- first and second laws and its relevance in the biological system, entropy and enthalpy, Gibbs free energy, bioenergetics- endothermic and exothermic reactions of biological systems, energy change in the biochemical reactions.

Electrical properties of biological compartments: 4 hrs

Electricity as a potential signal, electrochemical gradients, membrane potential, ATP synthesis, and chemi-osmotic hypothesis

Module II

MO: The students will have a basic understanding on biophysical principles of physiological events of plants and animals

Biophysics of Photosynthesis 6 hrs

Primary events in photosynthesis, light harvesting pigments, resonance energy transfer in photosynthetic pigments, fluorescence and phosphorescence, absorption spectra and action spectra of photosynthetic

pigments, photosynthetic reaction center and accessory pigments, light reception in microbes, plants and animals.

Biophysics of Vision, Muscle movements and Hearing 2 hrs

Mechanism of vision and hearing, muscular movements- an overview, correction of vision faults, generation and reception of sonic vibrations, hearing aids.

Intra and intermolecular interactions in biological systems 4 hrs

Various types of molecular interactions, inter and intra molecular interactions, special and charge compatibility in molecular interactions.

Module III

MO:The students will have a basic understanding on basic principles and modern developments of microscopy and other sophisticated instruments.

Microscopy 4 hrs

Principle of Microscopy, various types of Microscopy- Simple, phase contrast, fluorescence and electron microscopy (TEM and SEM), Modern developments in Microscopy

Basic principles and working of instruments 6 hrs

pH meter, spectrophotometer (UV and Visible) and colorimeter- Beer-Lambert law, Brief account of densitometry, fluorimetry, manometry, polarography, centrifugation, atomic absorption spectroscopy, IR, NMR and X-ray crystallography and Mass spectrometry.

Electrophoresis 2 hrs

Principle of electrophoresis- native gel electrophoresis, SDS PAGE, immuno electrophoresis, 2D gel electrophoresis, isoelectric focusing, agarose gel electrophoresis- Submarine.

Isotopes and radioisotopes 2 hrs

Isotopes and radioisotopes, radiations- ionizing radiations.Application of isotopes and radioisotopes in biological research, radioisotope tracer technique and autoradiography.

Practical **18 hrs**

Familiarizing the working of the following instruments

- **pH Meter** – Use of pH Meter, Familiarization of the instrument and Preparation Phosphate buffers and determination of pH.
- **Spectrophotometer** – Familiarization of the working of the instrument , Quantitative estimation of Sugars by Dinitrosalysilic acid and Proteins by Lowry's Method
- Development of **absorption spectra** of chlorophyll or any other biological sample
- **Electrophoresis** – demonstration of PAGE and Agarose Gel Electrophoresis

Suggested Readings

1. A Textbook of Biophysics- R N Roy, New central Book Agency Pvt. Ltd, Calcutta.
2. Biochemistry ., Voet,D & Voet, J.G
3. Biophysics- S.Thiruvia Raj, Saras Publications, Tamilnadu.
4. Biophysics, Volkenstein, M.V
5. Introduction to biophysical chemistry Martin.
6. Introduction to Genetic Engineering & Biotechnology- A. J. Nair; Jones & Bartlett Publishers, Boston
7. Lehninger's Biochemistry , Nelson D.L and Cox, M.M., Worth Publishers, New York
8. Molecular Biology of the gene, Watson et al.
9. Principles of Biotechnology- AJ Nair, Laxmi Publications, New Delhi

Complementary Courses

Zoology

for

Botany, Chemistry & Biotechnology

Complementary Courses in Zoology
for
Botany, Chemistry & Biotechnology

SEMESTERI

Complementary Course I

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1131.1	**Animal Diversity – Non Chordata & Chordata**	**3**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will be able to learn about the basic understanding of animal biodiversity
CO 2	Students will learn about the Systematics of animal diversity and its importance in other biological science.
CO 3	It should give very good information about the morphological diversity and adaptations of the animal world. They will receive a general awareness about animal diversity and its relevance in biotechnology.
CO4	It should become aware about the animal resources of the globe and its relevance and application in Biotechnology

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I — 6 Hrs

Kingdom Protista

General features

Plasmodium (detailed study of life history and pathogenicity) eg. *Entamoeba, Noctiluca, Trichonympha, Paramecium*

Module II — 6 Hrs

Kingdom Animalia

Salient features

Phylum Porifera

General characters, e.g. Sycon

Phylum Cnidaria (Coelenterata), General characters

Class Hydrozoa: *Obelia* (structure of colony and medusa, polymorphism and alternation of generation)
Class Scyphozoa: e.g.*Aurelia*
Class Anthozoa: e.g. sea anemone

Module III 6 Hrs

Phylum Platyhelminthes

General characters
Class Turbellaria: e.g. *Bipalium*
Class Cestoda: e.g. *Taeniasolium*
Class Trematoda; e.g. *Fasciola*

Phylum Nematoda

General characters,

Human nematode parasites (e.g. *Ascaris*, *Ancylostoma*, *Wuchereria*, *Enterobius*)

Phylum Annelida

General characters

Class Polychaeta: e.g. *Nereis* (mention parapodium and heteronereis)

Class Oligochaeta; e.g. earthworm
Class Hirudunea: e.g. *Hirudunaria*

Module IV **12 Hrs**

Phylum Arthropoda

General characters
Type: *Penaeus*
Class Crustacea: *Sacculina*
Class Myriapoda: e.g. *Scolopendra*
Class Insecta: e.g. Cockroach (external features, mouth parts and digestive system); mosquitoes (*Anopheles*, *Culex*and *Aedes*)

Module V 6 Hrs

Phylum Mollusca

General characters
Class Polyplacophora: e.g. C*hiton*
Class Scaphopoda: e.g. *Dentalium*
Class Pelecypoda (Bivalvia): e.g. fresh water mussel, *Perna* and pearl oyster
Class Gastropoda: e.g. *Pila*
Class Cephalopoda: e.g. *Sepia,* Pearl culture

Phylum echinodermata

General characters

Class Asteroidea: e.g. star fish

Class Ophiuroidea: e.g. brittlestar

Class Echinoidea: e.g. sea urchin
Class Holothuroidea: e.g. sea cucumber
Class Crinoidea: e.g. sea lily

Module VI

18 Hrs

Phylum Chordata

Diagnostic characters and salient features

Sub phylum Urochordata:

General characters
e.g. *Ascidia* (morphology and retrogressive metamorphosis)

Subphylum Cephalochordata:

General characters; e.g. *Amphioxus*

Subphylum Vertebrata:

General characters
Super class Agnatha: e.g. *Petromyzon*
Super class Pisces: e.g. *Scoliodon*, *Etroplus*, *Anguilla*, *Echeneis,* mackerel and sardine.
Super class Tetrapoda

Class Amphibia:

General characters
e.g. *Rana*, *Ichthyophis*, *Amblystoma* and axolotl larva

Class Reptilia

General characters
e.g. *Calotes*, *Draco*, *Chameleon* and *Chelone*
Snakes: (1) Non-poisonous snakes: e.g. *Lycodon*and *Ptyas;*
(2) Poisonous snakes: e.g. *Naja,* Viper, *Bungarus* and *Enhydrina*
Identification of non-poisonous and poisonous snakes

Class Aves

General characters
Flightless birds: e.g. Ostrich and Kiwi
Flying birds: e.g. Pigeon (mention different types of feathers)
Flight adaptations of birds

Class Mammalia

General characters
Homo sapiens: Detailed study of anatomy (exclude skeleton, arteries and veins)
e.g. *Echidna*, kangaroo, bat, loris, tiger and whale
Adaptations of aquatic mammals

Suggested Readings

1. Brusca,R.C.and Brusca, G.J. *Invertebrates*.Sinauer Associates.
2. Chaudhury, S.K.*Concise Medical Physiology,* NCBA
3. Dhami, P.S.and Dhami,J.K.*InvertebrateZoology*.R.\Chand&Co.
4. Dhami, P.S.and Dhami,J.K.*VertebrateZoology*.R.\Chand&Co.
5. Ekambaranatha Ayyar,M.andAnanthakrishnan,T.N.*AManualofZoology,Vol.I& Vol.II*
6. GuytonandHall*ATextbookofMedicalPhysiology*
7. Jordan,E.L.and Verma,P.S.*InvertebrateZoology*.S.Chandand Co.
8. Jordan,E.L.and Verma,P.S.*VertebrateZoology*.S.Chandand Co.
9. Kotpal,R.L. *Modern Textbook of Zoology:Invertebrates*.RastogiPublications
10. Kotpal, R.L. Modern Text book of Zoology:Vertebrates.RastogiPublications

11. Nair, N.C. etal. A Text book of Invertebrates SARAS Publications
12. Nigam, H.C. Biology of Chordates.Vishal Pub. Co.
13. Parker and Haswell. A Text book of Zoology Vol.II
14. Ruppert,E. E.,Fox,R.and Barnes, R.D. Invertebrate Zoology. Thomson Books
15. Sherwood,L.Principles of Human Physiology, Brooks/Cole
16. Thangamani,A.etal.ATextbookofChordates,SARASPublications

SEMESTER II

Complementary Course II

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1231.1	**Animal Physiology & Anatomy**	**3**	**54**

Course Outcome / Learning outcomes

CO No. CO statement

CO1 The students will be able to learn about the principle of general animal physiology
CO 2 Students will understand the importance of various biochemical aspects of physiology.
CO 3 It should give very good information about the relation between physiology and anatomy of organisms and the adaptations developed.
CO4 This will provide the students the basic understanding of application of animal physiology in Biotechnology

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Module I 18 Hrs

Nutrition

Types of Nutrition– autotrophy and heterotrophy; outline classification of food components; brief mention of mal nutrition disorders.
Vitamins- physiological role and disorders (deficiency diseases)

Respiration

Respiratory pigments and their functions with special emphasis on haemoglobin; transport of oxygen and carbondioxide; neural and hormonal control of respiration in man; respiratory disturbances – very brief mention of apnoea, dyspnoea, hypoxia, hypocapnia and hypercapnia, asphyxia and carbon monoxide poisoning. Smoking and its physiological effects

Circulation

Blood- composition and functions; blood groups: mechanism of blood clotting (intrinsic and extrinsic pathways); anticoagulants; disorders of blood clotting (haemophilia and thrombosis).

Heart (neurogenic and myogenic); heart beat; pacemaker; blood pressure; ECG; angiogram and angioplasty. Cardiovascular disorders (hypertension, arteriosclerosis and myocardial infarction).

Module II 18 Hrs

Excretion and Osmoregulation

Classification of animals based on excretory wastes; human nephron – structure and urine formation (ultra filtration, selective reabsorption, tubular secretion and countercurrent mechanism); hormonal control of renal function; composition of urine; kidney diseases (proteinuria, uremia, acidosis and alkalosis). Dialysis and artificial kidney

Muscle Physiology

Striated, non-striated and cardiac muscle; ultra structure of a striated muscle fibre; mechanism of muscle contraction; latent and refractory periods; muscle twitch, summation, tetanus and tonus; all or none law; fatigue and rigor mortis.

Module III 18 Hrs

Nerve Physiology

Neuron–structure; nerve impulse and its transmission; synapse and synaptic transmission; all or none law; refractory period; neuro transmitters; saltatory transmission; EEG

Endocrinology

Various endocrine glands and their corresponding hormones, Very brief description of hormonal influence / action and hormonal disorders such as goitre, cretinism, exophthalmic goitre, diabetes mellitus, diabetes insipidus, dwarfism, gigantism, and acromegaly.

Hormonal disorders in man

SuggestedReadings

1. Arora,M.*Animal Physiology*,HimalayaPub.
2. Eckert,R.andRandall,D.*AnimalPhysiology*.CBS Publishers and Distributors
3. Ganong,W.F.*Review of Medical Physiology*, McGraw Hill
4. Guyton,A.C. *Text book of Medical Physiology*.W.B.Saunders Co.
5. Hoar,W.S. *General and Comparative Physiology*. Prentice Hall
6. Maria kuttikan and Arumugam, N.*Animal Physiology.* Saras Publication
7. Naga bhushanam R.,Kodarkar, M.S. and Sarojini,R . .*A Textbook of Animal Physiology*. Oxford IBH
8. Schmidt-Nielson,K.*Animal Physiology*. PHI
9. Sebastian,M.M. *Animal Physiology*. Madonna Books, Kottayam
10. VermaP.S.*etal Animal Physiology*

SEMESTER III

Complementary Course III

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1331.1	**Developmental Biology, Human Genetics & Animal Behaviour**	**3**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will be able to learn about the basics of aspects of Reproduction and General Embryology &Developmental Biology
CO 2	Students will understand the importance of Human Genetics and its importance in Medical conditions and its physiological outcome.
CO 3	Students are exposed to the topics of various behavioural features of animals and Human and its relations to social relations and various social adaptations.
CO4	Students will learn the relation of genetics and diseases, sex determination, disease inheritance.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I **18 Hrs**

Developmental Biology

Egg: types and classification of eggs. Fertilization: events and changes in fertilization. Cleavage: types and patterns of cleavage. Blastulation: the process of blastulation; different types of blastulae.

Gastrulation: morphogenetic movements (invagination, involution, epiboly and delamination); Embryonic induction: very brief description of organizers and embryonic induction. Nuclear transplantation experiments in amphibians. Prenatal diagnostic technique: amniocentesis, chorionic villus sampling and ultrasound scanning. Embryonic stem cell research, Animal cloning; Test tube babies

Module II **18 Hrs**

Human Genetics

Normal chromosome complement; karyotype study.

Mendelian traits: skin spotting; brown and blue eye colours. Polygenic inheritance: skin colour in man. Multiple alleles in man: genetics of ABO blood groups. Sex determination: autosomes and sex chromosomes; Barr bodies and Lyon's hypothesis;

Chromosomal basis of sex determination; XYY male, XXX syndrome and intersex. Sex-linked, sex-limited and sex-influenced inheritance.

Syndromes: autosomal syndromes (Downsyndrome and Edwards syndrome), sex chromosomal syndromes (Turner syndrome and Klinefelter syndrome)

Genetic disorders: sickle cell anemia and phenylketonuria. Genetics of cancer: oncogenes and tumour suppressor genes. Genetics and human welfare: eugenics and genetic counselling; human gene therapy.

Module III 18 Hrs

Animal Behaviour

Stimulus and Response: Stimulus-response theory; stimulus filtering; fixed action pattern; innate releasing mechanism; sign stimulus and social signal (social releasers). Instinctive behaviour: definition; characteristics of instinctive behaviour; comparison of instinct and learning; adaptive advantage.

Learning: types of learning; habituation; reflexes, latent learning, insight learning and imprinting; physiology of learning. Motivation: goal oriented behaviour and drive; (models of motivation not required). Sociobiology: social groups – merits and demerits; properties of societies; Societies in honey bee and elephants. Pheromones: types of pheromones; chemical nature of pheromones; human pheromones.

Suggested Readings

Developmental Biology

1. Arora,MohanP. *Embryology.1E*.Himalaya Publishing House.
2. Balinsky, B.I.*An Introduction to Embryology.5E.*Thomson Books/cole
3. Gilbert,S.F. *Developmental Biology.5E.*Sinauer Associates.
4. Majumdar,N.N.*Textbook of Vertebrate Embryology*. TMH
5. Rao,K.Vasudeva.*Developmental Biology A Modern Synthesis.*Oxford IBH
6. Verma, P.S.andAgarwalV.K.*ChordateEmbryology*.S.ChandandCo.

Genetics

1. Ahluwalia,K.B.*Genetics.*NewAgeInternational(P)Ltd.Publishers
2. Burns,G.W.&Bottino,P.J. *TheScienceofGenetics*.MaxwellMcMillan
3. CurtStein.*PrinciplesofHumanGenetics*.EuresiaPublishingHouse
4. Gardner,E.J.*etal. Principles ofGenetics*.JohnWiley &Sons.
5. Goodenough,U.*Genetics*.Halt,Reinharts &Winston
6. Gupta,P.K. *Cytogenetics*. Rastogi&Co.
7. Sinnott,W.E.,Dunn,L.C.andDobzhansky, T.*PrinciplesofGenetics*,TMH
8. Verma, P.S.andAgarwalV.K.*Genetics*.S.ChandandCo.

AnimalBehaviour

1. Alcock,J. *Animal Behaviour.*SinauerAssociates.
2. Arora,MohanP.*Animal Behaviour*.Himalaya Publishing House
3. Kumar, Vinod. *Animal Behaviou.*, Himalaya Publishing House Reena Mathur.
4. Manning, A.and Dawkins, M.S. *An Introduction to Animal Behaviour.* Cambridge University Press.
5. Ranga, M.M. *Animal Behaviour.* Agrobios
6. Scott,John Paul. *Animal Behaviour.*
7. Singh, Harjindra.*Textbook o fAnimal Behaviour.* Anmol Publishers
8. Slater,P.J. B. *Essentials of Animal Behaviour.* Cambridge University Press
9. WoodGush,D.G.M.*Elements of Ethology*

SEMESTER IV
Complementary Course IV

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1431.1	**Practical COMP** (**Practical of BV1131.1, BV1231.1, BV1331.1)**	**3**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This course is to introduce and train the students on the practical components of the theory course complementary course I- **Animal Diversity – Non Chordata & Chordata**.
CO 2	Students willlearn and practice the practical components of **Animal Physiology & Anatomy.**.
CO 3	Students are exposed to the practical components **Developmental Biology, Human Genetics & Animal Bewhaviour.**
CO4	Students may learn and try to solve the Genetic problems as per the syllabus.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Practical of BV1131.1
Animal Diversity
Study of the Specimens

1. Protista : *Noctiluca,Paramecium,Entamoeba,Trichonympha*(any2)
2. Porifera : Sycon
3. Cnidaria : *Obelia,Aurelia,*seaanemone(*Adamsia*)
4. Platyhelminthes : *Bipalium,Fasciola,Taeniasolium*
5. Nematoda : *Ascaris*(maleandfemale)
6. Annelida : *Nereis,Hirudanaria*
7. Arthropoda : *Limulus,* Scorpion, *Scolopendra, sacculina, Leptocorisa, Oryctes,*
   Larval stages of prawn (any five)
8. Mollusca : Freshwatermussel,*Sepia,Pila*
9. Echinodermata:Starfish,Seaurchin,Brittlestar,Seacucumber,Sealily
10. Chordates : *Branchiostoma (entire),*
    : *Ascidia*
    : *Petromyzon*
    : *Scoliodon,Narcine,Echeneis,Hippocampus,Anguilla(any three)*
    : *Ichthyophis, Amblystoma,axolotl larva, Rhacophorus (any2)*
    : *Chameleon, Bungarus, Naja,Vipera, Chelone (any3)*
    : *Pigeon–different types of feathers*
    : *Pteropus*

Mounting (Minor) [any three]

1. Earthworm–setae (insitu)
2. *Nereis*–Parapodium
3. *Panaeus*–Appendages
4. Shark – Placoid cale

Dissection (Major) [any two]

1. Earthworm–Digestivesystem
2. *Penaeus*–Nervoussystem
3. Cockroach–Digestive system (Alimentary canal and salivary apparatus)

Practical of BV1231.1

Animal Physiology

1. Preparations of human blood smear to study different types of leucocytes.
2. Human blood grouping: ABO and Rh systems.
3. Urine analysis for abnormal constituents: albumin and glucose.

Practical of BV1331.1

Developmental Biology

Study of slides /models of different types of eggs, blastula and gastrula

Human Genetics

1. Study of normal human karyotype.
2. Study of abnormal human karyotypes (Klinefelter, Turner, Down syndromes)

Applied Zoology

1. Study of beneficial insects: *Apis* (worker, drone and queen), *Bombyx* (life cycle, silk)
2. Study of the following items of economic importance: *Perna*, *Pinctada*, *Penaeus*, *Sardinella*, *Rastrelliger*

Complementary Courses

Botany

For

Zoology, Chemistry & Biotechnology

Complementary Courses in Botany
for
Zoology, Chemistry & Biotechnology

SEMESTER I
Complementary Course I

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1131.2	**Phycology Mycology, Lichenology, Bryology Pteridology,Gymnosperms and Plant Pathology**	**3**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will be able to learn about the plant classification Plant diversity.
CO 2	Students will learn about various classes of fungus and its importance. They also understand the existence and importance of Lichens.
CO 3	Students will receive the basic information about the lower plants such as Pteridophytes and Bryophytes
CO4	It should also provide basic information about the plant diversity and resources. The students will understand application of these resources in Biotechnology.

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Module I **12 hrs**

Phycology

Salient features of the following major groups with reference to the structure, reproduction and life cycle of the types given below (Excluding the developmental details) –

1. Cyanophyceae - *Nostoc*
2. Chlorophyceae - *Chlorella*, *Oedogonium* and *Chara*
3. Phaeophyceae – *Sargassum*
4. Rhodophyceae – *Polysiphonia*

Module II

Mycology **14 hrs**

Characteristic features of the following major groups with reference to the structure, reproduction and life cycle of the types given below (Excluding the developmental details) –

1. Zygomycotina – *Rhizopus*
2. Ascomycotina

   Plectomycetes – *Penicillium*

   Discomycetes – *Peziza*

3. Basidiomycotina

   Teliomycetes – Puccinia

4. Economic importance of Fungi

Lichenology

General account and economic importance; the structure, reproduction and life cycle of *Usnea*

Module III

Bryology **10 hrs**

1. Introduction and Classification
2. Study of the habit, thallus organization, vegetative and sexual reproduction and alternation of generation of the following types (Developmental details are not required). *Riccia, Funaria*
3. Economic Importance of Bryophytes.

Pteridology **8 hrs**

1. Introduction: General characters morphological and phylogenetic classification.
2. Study of the habitat, habit, internal structure, reproduction and life cycle of the following types (Developmental details not required).

   Selaginella, Pteris

Module IV

Gymnosperms **5 hrs**

Introduction and classification of gymnosperms

Study of the Habit, Anatomy, Reproduction and life cycle of - *Pinus* (Developmental detailsare not required*)*

Plant Pathology **5 hrs**

A brief account on the following plant diseases with reference to the symptoms, causative organism, spread of the disease and effective control measures.

1. Brown spot disease of Paddy
2. Powdery mildew of Rubber
3. Yellow vein mosaic of Lady's finger
4. Quick wilt of Pepper
5. Method of preparation and mode of action of the following fungicides- Bordeaux mixture, Lime sulphur, Tobacco decoction, Neem cake & oil.

Suggested Readings

1. Alexopoulos C.J & MIMS C.V (1988). Introductory Mycology, John Wiley & Sons.
2. Andrews H.N. (1967) - Studies on Palaeobotany – C .J. Felix.
3. Arnold C. A (1947) - Introduction to Palaeobotany - McGraw Hill Co. New Delhi.
4. Bower F.O. (1935) - Primitive Land Plants - Cambridge, London.
5. Fritsch F. B (1945) Structure and Reproduction of Algae Vol.I & II. Cambridge University Press.
6. Gupta V .K. and Varshneya U. D (1967) – An Introduction to Gymnosperms – Kedarnath, Ramnath
7. Jim Deacon (2007) Fungal Biology, 4th edition, Blackwell Publishing, Ane Books Pvt. Ltd.
8. Kanika Sharma (2009) Manual of Microbiology, Ane Books Pvt. Ltd.
9. Mamatha Rao (2009) Microbes and Non flowering plants, Impact and applications; Ane Books Pvt. Ltd.
10. Parihar N .S. – An introduction to Bryophyta - Central Book Depot. Alahabad
11. Singh V, Pandey PC and Jam D.K (1998) A Text Book of Botany for Under Graduate Students, Rastogi Publications.
12. Singh V., Pandey P.C and Jain D.K (1998) A Text book of Botany for Undergraduate Students, Rastogi Publications.
13. Smith G. M (1955) Cryptogamic Botany Vol.I, McGraw Hill
14. Smith G. M (1955) Cryptogamic Botany, Vol.I McGraw Hill.
15. Smith G. M. (1955) - Cryptogamic Botany – Vol.II – Mc Graw Hill Co. New Delhi
16. Sporne K. R. (1966) - Morphology of Pteridophytes - Hutchin University Library , London
17. Sporne K. R. (1967) - Morphology of Gymnosperms - Hutchin University Library , London
18. Vashishta B. R. - Bryophyta - S. Chand and Co. New Delhi
19. Vashishta B.R (1990) Botany for Degree Students, Algae, S.Chand & Co.
20. Vashishta B.R. (1990) Botany for Degree Students, Fungi, S.Chand & Co.
21. Vashista B. R. (1993) - Pteridophyta – S.Chand and co. New Delhi
22. Vashista B. R. (1993) Gymnosperms - S. Chand and co. New Delhi
23. Webster J (1970) Introduction to Fungi, Cambridge University Press.

Complementary Course II
SEMESTER II

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1231.2	**Plant Physiology, Angiosperm Anatomy & Reproductive Botany**	**3**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will be able to understand the basic principles of Plant physiology and its contribution to Biotechnology.
CO 2	Students will learn about the importance of water in biological systems , various physiochemical process related to photosynthesis , water relations, solute transport and its importance in maintain the life activities.
CO 3	Students will receive the basic information about the Angiosperm anatomy, various tissue types and its relation to its physiology and adaptations.
CO4	Students will learn the relation between, anatomy and physiology; and also the principles behind plant Reproduction and Development.

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Module I

Plant Physiology **22 hrs**

1. **General introduction**: physiological processes, their significance and applications.

2. **Water relations of plants**: Importance of water to plant life.

   a. Absorption of water- organs of absorption, root and root hair. Physical aspects of absorption-imbibition, diffusion and osmosis. Plant cell as an osmotic system; water potential and osmotic potential. Plasmolysis and its significance, practical applications. Mechanism of water absorption- active and passive absorption, root pressure. Pathway of water across root cells.

   b. Ascent of sap- vital and physical theories.

   c. Loss of water from plants: transpiration - cuticular, lenticular and stomatal mechanisms – theories: starch sugar hypothesis, potassium - ion theory. Significance of transpiration -guttation, anti - transpirants, factors affecting transpiration.

   d. Water stress and its physiological consequences to drought.

3. **Photosynthesis**: Introduction, significance and general equation. Photosynthetic apparatus, structure and function of chloroplast, quantasomes - solar spectrum and its importance - Fluorescence and Two pigment systems- raw material for photosynthesis- Mechanism of photosynthesis- Light reaction - cyclic and non cyclic photophosphorylation. Hill reaction - Dark reaction: Calvin cycle. Comparative study of C3, C4, and CAM plants. Photorespiration

   Bacterial photosynthesis and chemosynthesis - 4.Factors affecting photosynthesis - Law of limiting factor.

4. **Translocation of solutes**: Path way of movement, phloem transport, mechanism of transport - Munch hypothesis, protoplasmic streaming theory - activated diffusion hypothesis,electro osmotic theory.

5. **Growth:** Phases of growth - vegetative and reproductive growth - growth curve - plant growth regulators - Auxins, Gibberellins, Cytokinins, Ethylene, Abscisic acid - synthetic plant hormones - practical applications.

6. Senescence and abscission, Photoperiodism

Module II

Angiosperm anatomy **22 hrs**

1. Objective and scopes of plant anatomy
2. Tissues – Meristems, Definition, Classification based on origin, position, growth patterns,functions.
3. Apical meristems & theories on apical organization - Apical cell theory, Histogen theory,Tunica - Corpus theory. Organization of root apex in dicots & monocots.
4. Permanent tissues – Definition, classification - simple, complex and secretory.
5. Tissue systems – Epidermal tissue systems, Ground tissue systems & vascular tissue systems.Different types of vascular arrangements
6. Primary structure – Root, stem and leaf [Dicot & Monocot]. Secondary growth (stelar and extra stelar) Root and stem- cambium (structure and function) annular rings, heart wood and sap wood, tyloses, ring porous wood and diffuse porous wood, periderm formation-phellem, phellogen and phelloderm; lenticels
7. Anomalous secondary growth –*Boerhaavia*

Module III

Reproductive Botany **10 hrs**

1. Micro sporogenesis - structure and functions of wall layers.
2. Development of male gametophyte - Dehiscence of anther.
3. Megasporogenesis - Development of female gametophyte - Embryo sac - Development and types - Monosporic – *Polygonum* type
4. Pollination - Fertilization - Double fertilization. Structure of Embryo- Dicot [*Capsella*]

Suggested Readings

1. Devlin & Witham – Plant Physiology (C B S publishers).
2. Esau K. (1965) - Plant Anatomy – Wiley Eastern, New York.
3. Esau K. (1965) - Plant Anatomy – Wiley Eastern, New York.
4. Fahn A. (1985) - Plant Anatomy – Pergamon Press, Oxford.
5. Fahn A. (1985) - Plant Anatomy – Pergamon Press, Oxford.
6. Kochhar P. L. & Krishnamoorthy H. N. – Plant Physiology. (Atmaram & Sons-Delhi,Lucknow).
7. Kumar & Purohit – Plant Physiology - Fundamentals and Applications (Agrobotanicalpublishers)
8. Maheswari P. - Embryology of Angiosperms - Vikas Pub:
9. Malic C. P. & Srivastava A. K. – Textbook of Plant Physiology (Kalyani Publishers-NewDelhi).
10. Nair PKK Palynology of Angiosperms
11. Noggle G R & Fritz G J – Introductory Plant physiology (Prentice Hall of India).
12. P. Maheswari - Embryology of Angiosperms - Vikas Pub:
13. Pandey S.N. & Sinha B. K. – Plant physiology (Vikas publishing House- New Delhi).
14. Pandey, B .P. (1997) - Plant Anatomy - S.Chand and co. New Delhi Biology - McGraw HillCo, New York.
15. Pandey, B .P. (1997) - Plant Anatomy - S.Chand and co. New Delhi Biology - McGraw HillCo , New York.
16. Prasad and Prasad (1972) Out lines of Botanical Micro technique, Emkay publishers, New DelhiCoutler E. G. (1969) Plant Anatomy – Part I Cells and Tissues – Edward Arnold, London.
17. Richard F Venn 2004, Principles and Practice of Bioanalysis, Taylor & Francis, Ane Books Pvt. Ltd
18. Salisbury F. B. & Ross C. W. - Plant physiology. (Wadsworth publishing company).
19. Vashista .P. C (1984) - Plant Anatomy – Pradeep Publications – Jalandhar
20. Vashista .P. C (1984) - Plant Anatomy – Pradeep Publications – Jalandhar
21. Verma V 2007, Text Book of Plant Physiology. Ane Books Pvt. Ltd
22. Verma V, 2009 TextBook of Economic Botany; Ane Books Pvt. Ltd.

Complementary Course-III
SEMESTER III

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1331.2	**Angiosperm Morphology, Systematic Botany & Economic Botany**	**3**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will learn about morphology of plant parts and its modifications, its importance in adaptations and its physiology.
CO 2	Students will understand about the various methods of classification of Plants, binomial nomenclature and systematic identification of plants.
CO 3	Students will study about some of the plant families, its systematic positions and some examples with morphological adaptations and modifications.
CO4	Students will learn the economic importance of useful plant parts, its adaptations, uses, medicinal importance and applications and the systematic positions of the plants.

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Module I

Morphology 4 hrs

Brief account on the various types of inflorescence including special types (Cyathium, Verticillaster, Hypanthodium, Coenanthium and Thyrsus) with examples; floral morphology- Flower-as a modified shoot, Flower parts, their arrangements, relative position, numeric- plan, cohesion, adhesion, symmetry of flower, aestivation types, placentation types; floral diagram and floral formula Fruit types: simple, aggregate and multiple. Seeds: albuminous and exalbuminous.

Module II

Systematic Botany 8 hrs

Definition, scope and significance of Taxonomy, Systems of classification:
Artificial- Linnaeus sexual system
Natural - Bentham and Hooker (detailed account)
Phylogenetic- Engler and Prantl (Brief account only)
Basic rules of Binomial Nomenclature and International Code of Botanical nomenclature (ICBN).
Importance of Herbarium, Herbarium techniques and Botanical gardens. A brief account on the modem trends in taxonomy; Chemotaxonomy, Numerical Taxonomy, Cytotaxonomy and Molecular taxonomy

Module III 30 Hrs

A study of the following families with emphasis on the morphological peculiarities and economicimportance of its members (Based on Bentham and Hooker's System)

1. Annonaceae
2. Malvaceae
3. Rutaceae9.
4. Leguminosae
5. Rubiaceae
6. Asteraceae
7. Apocynaceae
8. Solanaceae
9. Verbenaceae
10. Euphorbiaceae
11. Poaceae

Module III 12 hrs

Economic botany

Study of the Botanical name, Family, Morphology of useful parts, and utility of the following;

Cereals and Millets	-	Paddy and Ragi
Legumes	-	Ground nut, Black gram.
Sugar yielding plants	-	Sugarcane.
Spices & condiments	-	Cumin, Clove, Cardamom and Pepper
Fibre	-	Cotton
Dyes	-	Henna
Resins	-	Asafoetida.
Tuber crops	-	Tapioca, Colocasia.
Tropical Fruits	-	Banana, Jack Fruit.
Oil yielding	-	Sesame oil, Coconut.
Medicinal plants	-	*Ocimum, Adhatoda, Sida,* Turmeric.

Suggested Readings

1. Davis, P.H. and Haywood, V.H. 1963. Principles of Angiosperm Taxonomy. Oliver andRoyd, London.
2. Heywood, V.H. and Moore D.M. 1984. Current Concepts in Plant Taxonomy. AcademicPress, London.
3. Jefftey, C. 1982. An Introduction to Plant Taxonomy. Cambridge University Press,Cambridge London.
4. Jones, S.B. Jr. and Luchsinger, A.E. 1986. Plant Systematics (2nd edition). McGraw-HillBook Co., New York
5. Kapoor LD, 2001 Hand Book of Ayurvedic Medicinal Plants, CRC Press New York, AneBooks Pvt. Ltd.
6. Lawrence. G.H.M. 1951. Taxonomy of Vascular Plants. Macmillan, New York.
7. Naik, V.N. 1984. Taxonomy of Angiosperms. Tata McGraw Hill, New York.
8. Nordenstam. B.., El-Gazaly, G. and Kassas. M. 2000. Plant Systematics for 21st CenturyPortland Press Ltd., London.
9. Pandey SN and Misra SP, 2008 Taxonomy of Angiosperms; Ane Books Pvt.Ltd.
10. Pandey, B .P. (1997) - Plant Anatomy - S.Chand and co. New Delhi Biology - McGraw HillCo., New York.
11. Radford. A.E. 1986. Fundamentals of Plant Systematics Harper and Row, New York.
12. Singh. G. 1999. Plant Systematics: Theory and practice Oxford & IBH Pvt, Ltd. New Delhi.
13. Sivarajan,V.V. Introduction to the principle of plant taxonomy, Oxford and IBH 14.Stace.
14. C.A. 1989. Plant Taxonomy and Biosystematics. 2nd ed. Edward Arnold, London.
15. Verma V, 2009 Text Book of Economic Botany; Ane Books Pvt. Ltd.

Complementary Course- IV
SEMESTER IV

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1431.2	**Practical COMP (Practical of BV1131.2, BV1231.2 & BV1331.2)**	**3**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will learn about morphology of plant parts and its modifications, its importance in adaptations and its physiology.
CO 2	Students will understand about the various methods of classification of Plants, binomial nomenclature and systematic identification of plants.
CO 3	Students will study about some of the plant families, its systematic positions and some examples with morphological adaptations and modifications.
CO4	Students will learn the economic importance of useful plant parts, its adaptations, uses, medicinal importance and applications and the systematic positions of the plants.

Practical of 1131.2

Phycology **6 hrs**

1. Make micro preparations of vegetative and reproductive structures of the types mentionedin the syllabus.
2. Identify the algal specimens up to the generic level and make labelled sketches of thespecimens observed
   - *a.* Cyanophyceae - *Nostoc*
   - *b.* Chlorophyceae - *Chlorella, Oedogonium* and *Chara*
   - *c.* Phaeophyceae - *Sargassum*
   - *d.* Rhodophyceae – *Polysiphonia*

Mycology **6 hrs**

A detailed study of structure and reproductive structures of types given in the syllabus and submission of record,

Rhizopus, Penicillium, Peziza, Puccinia and Usnea

Bryology **2 hrs**

1. *Riccia* – Habit - Internal structure of thallus – V. S. of thallus through archegonia, antheridia andsporophyte
2. *Funaria* – Habit, V. S. of archegonial cluster, V .S. of antheridial cluster, Sporophyte V. S.

Pteridology

1. *Selaginella*: Habit, rhizophore T. S , stem T . S, axis with strobilus, V .S. ofstrobilus, Megasporophyll and microsporophyll.

2. Pteris - Habit, Rhi

zome and petiole T. S., sporophyll T.S

4 hrs

Gymnosperms **2 hrs**

Pinus - Branch of indefinite growth, spur shoot, T. S of old stem and needle,

Male and Female cone, Vertical Section of male and female cone

Plant Pathology **2 hrs**

Students are expected to observe the symptoms and causal organisms of all plant diseases mentioned below.

1. Brown spot disease of Paddy
2. Powdery mildew of Rubber
3. Yellow vein mosaic of Lady's finger
4. Quick wilt of Pepper

Practical of BV1231.2 **4 hrs**

Plant Physiology

Demonstration of the following Experiments

- Water potential of onion peel / *Rhoeo* peel by plasmolytic method.
- Papaya petiole osmoscope.
- Determination of water absorption and transpiration ratio.
- Measurement of rate of transpiration using Ganong's potometer or Farmer's potometer.
- Evolution of oxygen during photosynthesis.
- Geotropism using clinostat.
- Measurement of growth using Arc auxanometer.

Angiosperm Anatomy **10 hrs**

- Simple permanent tissue – Parenchyma, Chlorenchyma, Aerenchyma, Collenchyma andSclerenchyma
- Primary structure – Dicot stem: *Hydrocotyle*
- Monocot stem: Grass
- Dicot root: Pea, *Limnanthemum*
- Monocot root: *Colocasia*.
- Secondary structure - Stem [Normal type] - *Vernonia* or any normal type
- Secondary structure - Root [Normal type] - *Tinospora, Ficus, Carica papaya,* or any normal typeAnomalous secondary thickening –*Boerhaavia*

Practical of BV1331.2

Practicals of Angiosperm Taxonomy **16 Hrs**

Students must be able to identify the angiosperm members included in the syllabus (listed below).

1. Annonaceae
2. Malvaceae
3. Rutaceae
4. Leguminosae
5. Rubiaceae
6. Asteraceae
7. Apocynaceae
8. Solanaceae
9. Verbenaceae
10. Euphorbiaceae
11. Poaceae

Draw labeled diagram of the habit, floral parts, L.S of flower, T.S of ovary, floral diagram, floral formula and describe the salient features of the member in technical terms.

Students must submit the practical records at the time of practical examination.

Practical of Economic Botany **2 hrs**

Identify the economic products obtained from the plants mentioned under Economic Botany

- Cereals and Millets - Paddy and Ragi
- Legumes - Ground nut, Black gram.
- Sugar yielding plants - Sugarcane.
- Spices & condiments - Cumin, Clove, Cardamom and Pepper
- Fibre - Cotton
- Dyes - Henna
- Resins - Asafoetida.
- Tuber crops - Tapioca, Colocasia.
- Tropical Fruits - Banana, Jack Fruit.
- Oil yielding - Sesame oil, Coconut.
- Medicinal plants - *Ocimum* , *Adhatoda*, *Sida*, Turmeric

CORE COURSES

Botany
Chemistry
&
Biotechnology
(Vocational Core Course)

CORE COURSES

Core Courses of Botany I

SEMESTER I

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1141.1	**Microtechnique, Angiosperm Anatomy and Reproductive Botany**	**2**	**90 (T54+P36)**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The course should imparts the basic understanding about Microtechnique used in Biology experiments.
CO 2	Students will should learn the basics of anatomy of the flowering plants and its relationship to the physiology and environmental adaptability of the plants
CO 3	It should also give a basic idea on the development of the flowering plants and its adaptation to suit to its environment.
CO4	Students will learn about the structure of flowers and its reproductive parts with respect to the process of reproduction, seed development and propagation of plants.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I

Microtechnique 10hrs

1. Introduction-microscopy-simple and compound –phase contrast; dark field illumination and electron microscopes (SEM and TEM).
2. Micrometry, Cameralucida
3. Sectioning- hand and microtome– rotary and sledge
4. Killing and fixation agents– Carnoy's formula, Farmers formula, F.A.A
5. Dehydration- reagents
6. Stains and staining techniques- double staining. General account; Stains: safranin, haematoxylin, aceto- carmine.

7. Mounting media-D.P.X and Canada balsam
8. Whole mounts- cytological methods: maceration, smear and squash preparation

Module II

Angiosperm Anatomy **6hrs**

Objective and scope of plant anatomy
Cell wall organization- Gross structure- Primary and secondary wall
Pits– plasmodesmata - microscopic and submicroscopic structures – Extra cell wall material.
Non living inclusions of the cell – Reserve food - secretary products, by-products

Module III **12hrs**

Tissues– Meristems, Definition, Classification based on origin, position, growth patterns, functions, Apical meristems & theories on apical organization - Apical cell theory, Histogen theory, Tunica – Corpus theory. Organization of root apex in dicots & monocots.
Permanent tissues– Definition, classification-simple, complex and secretory tissues.
Tissue systems –Epiderma ltissue systems -stomata, structure and functions, Ground tissue systems & vascular tissue systems. Different types of vascular arrangements

Module IV **10hrs**

Primary structure– Root, stem and leaf [Dicot & Monocot].
Secondary growth - Root and stem- cambium (structure and function) annular rings, heart wood and sapwood, tyloses, ring porous wood and diffuse porous wood,
Peri derm formation- phellum, phellogen and phelloderm; lenticels
Anomalous secondary growth-*Bignonia, Boerhaavia*.

Module V

Reproductive Botany 12hrs

Introduction to angiosperm embryology, Micro sporogenesis - structure and functions of wall layers, Development of male gametophyte- Dehiscence of anther.
Mega sporogenesis- Development of female gametophyte- Embryosac- Development and types- Monosporic– *Polygonum* type, Bisporic- *Allium* type, Tetrasporic– *Adoxa* type.
Pollination- Fertilization- Barriers of fertilization- Germination of pollengrains– Double fertilization- Polyspermy and Hetero fertilization.
Structure of Embryo- Dicot [*Capsella*], Monocot [*Sagittaria*] Endospermtypes

Module VI 4 hrs

Palynology: pollen structure, pollen morphology, pollen allergy, viability test for pollen grains, Economic importance and its importance in taxonomy.

Practical **Total Hrs. 36**

Microtechnique 6 hrs

1. Familiarize stains, fixatives and mounting media
2. General awareness of Microtechnique -maceration, smears & squash
3. Demonstration of microtome sectioning and hand sectioning
4. Measurement of specimens using micrometer (Demonstration only).

Anatomy 26hrs

1. Non living inclusions- Cystolith, Raphide, Sphaero-raphide, Aleurone grains. Starch grains (Eccentric, concentric, compound)
2. Simple permanent tissue–Parenchyma, Chlorenchyma, Aerenchyma, Collenchyma and Sclerenchyma
3. Primary structure– Dicot stem: *Hydrocotyle, Eupatorium.*
4. Monocotstem: Grass and *Asparagus*. Dicot root: Pea and *Limnanthemum*
5. Monocot root: *Colocasia* or any monocot root. Secondary structure- Stem [Normaltype] – *Vernonia*
6. Secondary structure- Root [Normal type]-*Tinospora, Carica papaya,* or any normal type
7. Secretory tissue: Resin canal, Nectary, Latex vessel, Lysigenous and Schizogenous cavities. Laticifers: Articulated and non-articulated.
8. Epidermal structures– Stomata.
9. Anomalous secondary thickening - *Bignonia, Boerhaavia*
10. Leaf anatomy- Dicot leaf: *Ixora*. Monocot leaf: Grass

Reproductive Botany 2 hrs

Students should be familiar with the structure of anther and embryo (Permanent slides can be used)

Palynology 4hrs

Study of pollen morphology of the following plants– *Hibiscus, Vinca*, *Balsam*, *Ixora*, *Crotalaria*, *Bougainvillea* by microscopic observation

Suggested Readings

1. Coutler E.G.(1969) Plant Anatomy–Part I Cells and Tissues–Edward Arnold, London.
2. Donald A. Johansen- Plant Microtechnique- Mac Graw Hill Book company
3. Esau K.(1965)- Plant Anatomy –Wiley Eastern, NewYork.
4. Fahn A. (1985)- Plant Anatomy– Pergamon Press, Oxford.
5. Pandey, B .P.(1997)-Plant Anatomy-S.Chand and co.New Delhi Biology-Mc GrawHill Co, NewYork.
6. Prasad and Prasad (1972) Outlines of Botanical Micro technique, Emkay publishers, New Delhi
7. Richad Grey– Hand book of Microtechnique – Mac Graw Hill Book company
8. Vashista.P.C(1984)- Plant Anatomy–Pradeep Publications,Jalandhar
9. Maheswari P.-Embryology of Angiosperms -Vikas Pub:
10. Nair P K K Palynology of Angiosperms

SEMESTER II

Core Courses of Botany II

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1241.1	**Environmental Studies**	**4**	**108 (T72 + P36)**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should acquire a basic understanding about the structure function of the environment and its interaction with the living systems.
CO 2	It should impart the students the geographical distribution of plants and there by the biodiversity in each and every ecosystems.
CO 3	Students will learn delicate balance of various factors in the environment and the plants and animals.
CO4	It should make the student to learn the importance of biodiversity and the influence of environmental pollution on the biodiversity.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Module I **18hrs**

Definition- Scope and relevance to society and human environment, Need for public awareness

Natural Resources

- Renewable and non-renewable resources.
- Forest resources: Use and over exploitation. Deforestation,
- Mineral resources: Use and exploitation, Environmental effects of extracting and using mineral resources.
- Water resources: Use and over exploitation of surface water and ground water, floods, drought.
- Food resources: Changes caused by agriculture and over grazing, effects of modern agriculture, fertilizer- pesticide problems, water logging and salinity.
- Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of Alternate energy sources.

- Land resources: Land as a resource, land degradation, Man induced landslides, soil erosion and desertification.
- Role of an individual in conservation of natural resources

Module II 14 hrs

- Ecosystems-Concept of an ecosystem- structure and function of an ecosystem
- Biotic and abiotic components-Energy flow in an ecosystem.
- Ecological succession- Definition & types. Food chains- Food web & ecological Pyramids.
- Introduction-types, characteristic features, structure and functions of the following ecosystems.
    1. Forest ecosystem
    2. Grass land ecosystem
    3. Desert ecosystem
    4. Aquatic ecosystems-Ponds, Streams, Rivers, Oceans, Estuaries.

- Morphological, anatomical & physiological adaptations of–Hydrophytes, Xerophytes, Halophytes, Epiphytes, Parasites.

Module III 14 hrs

Biodiversity and its conservation

1. Introduction– Definition- genetic, species and ecosystem diversity. Bio-geographical classification of India.
2. Value of bio-diversity: social, ethical, aesthetic and option values.
3. Biodiversity at global, National and local levels. India as mega-biodiversity nation.
4. Hot-spots of biodiversity. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts
5. Endangered and endemic species of India, Conservation of biodiversity: *In-situ* and *Ex-situ*
6. Conservation of biodiversity. National parks and wildlife sanctuaries.
7. Species concept and diversity. α, β, γ diversity.
8. Ecological niche, eco-types & ecological indicators.

Environmental pollution

a. Definition causes, effects and control measures of–
    1. Air pollution
    2. Water pollution
    3. Soil pollution
b. Marine pollution
c. Noise pollution
d. Thermal pollution
e. Nuclear hazards.
f. Solid waste Management (brief account only): Causes, effects and control measures of urban and industrial wastes.
g. Disaster management (brief account only): Floods, earthquake, cyclone and land slides

Module IV 14hrs

Social issues and the Environment

1. From unsustainable to sustainable development. Urban problems related to energy.
2. Water conservation, Rain water harvesting, and water shed management.
3. Environmental ethics: Issues and possible solutions.

4. Climate change. Global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust.
5. Environment protection Act. Air [prevention and control of pollution] Act. Water [prevention and control of pollution] Act. Wild life Protection Act. Forest conservation Act. Hill preservation Act. Public awareness.
6. Forest Management. Brief study of the major forests in India. Influence of forest on environment. Social forestry.
7. Mangrove vegetation of Kerala. Conservation of mangrove vegetation.

Module V

Phytogeography **6hrs**

Principles and vegetational types of India- tropical rain forest, shoals and deciduous forest- sand dunes and mangroves, scrub jungle, phytogeographical regions of India.

Module VI **6hrs**

Natural hazards and disaster management

1. Introduction to Hazards- Hazard classification- types of hazards.
2. Natural Hazards: causes, (continental drift, plate tectonics, sea floor spreading, isostacy, etc.,) distribution pattern, consequences and mitigation: Earthquake, Tsunami, Volcanoes, Cyclone, Flood, Drought, Landslide, cold and heat hazards, forest fire, etc.,- causes, types, distribution, adverse effects etc.
3. Man-made hazards, Bomb threat, explosion, hazardous material spill, Fire, Terror attacks, Nuclear hazards.
4. Disaster - Introduction, disaster Management, Capability, Vulnerability, risk-preparedness and mitigation. Disaster management cycle, community planning, education and Engineered structural strengthening techniques- Hazard zonation and mapping, Risk reduction measures- Unexpected loss of income, Financial emergency and Insurance

Practical **36hrs**

- Study of ecological and anatomical modifications of Xerophytes, Hydrophytes, halophytes, epiphytes and Parasites.
- Study of plant community by quadrat method.
- Observation and study of different ecosystems mentioned in the syllabus.
- Determination of frequency and density constituent of plant species in a terrestrial community through quadrate and transect (line, belt).
- Phytogeographical regions of India.

Suggested Reading

1. Ecology, Students and Friends & Co.Varanashi.
2. Kumaresan B.–*Plant Ecology & Phytogeography* – Rastrogi Pub:
3. Odum EugeneP– Fundamentals of Ecology, Edn. Philladephia &Saunders,Tokyo, Toppon.
4. Periasamy, K.–Elements of Plant Ecology,(M.K.Publications).
5. Sharma, P.D.–Elements of Ecology (Rastogi's Company Ltd., Publications).
6. The Geography of Flowering Plants-Good
7. Vashista P.C–Plant Ecology Edu.Vishali Publications.

SEMESTER II
Core Courses of Botany III

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1242.1	**Practical Botany-I** **(Practical of BV1141.1 & BV1241.1)**	**2**	**P 72 (36 + 36)**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should learn the Procedures of Micro techniques and use of Microtome for anatomy and tissue studies
CO 2	Students should be made familiar to the anatomy of various plant parts and types. They should learn to identify the type of tissue and plant type and parts by tissue samples
CO 3	Students should be made familiar with the structure of reproductive parts of flowers like anther, pollen morphology and embryo with specific plant tissue samples or permanent slides.
CO4	Students should learn the major ecological and anatomical modifications of different ecosystems and Parasites. Students are supposed to study various plant communities by quadrat method. Students should be encouraged to observe and study different ecosystems and phytogeographical regions.

Practical of
BV1141.1
Microtechnique, Angiosperm Anatomy and Reproductive Botany

Microtechnique **6 hrs**

1. Familiarize stains, fixatives and mounting media
2. General awareness of Microtechnique -maceration, smears & squash
3. Demonstration of microtome sectioning and hand sectioning
4. Measurement of specimens using micrometer (Demonstration only).

Anatomy **26 hrs**

1. Nonliving inclusions-Cystolith, Raphide, Sphaero-raphide, Aleurone grains. Starch grains (Eccentric, concentric, compound)
2. Simple permanent tissue– Parenchyma, Chlorenchyma, Aerenchyma, Collenchyma and Sclerenchyma
3. Primary structure–Dicot stem: Hydrocotyle, Eupatorium. Monocot stem: Grass and Asparagus.
4. Dicotroot: Pea and Limnanthemum
5. Monocot root: Colocasia or any monocot root. Secondary structure- Stem [Normal type]- Vernonia
6. Secondary structure- Root [Normal type]- Tinospora,Carica papaya or any normal type
7. Secretary tissue: Resin canal, Nectary, Latex vessel, Lysigenous and Schizogenous cavities. Laticifers, Articulated and non-articulated.
8. Epidermal structures–Stomata.
9. Anomalous secondary thickening- Bignonia, Boerhaavia Leaf anatomy-Dicot leaf: Ixora.

10. Monocot leaf : Grass

Reproductive Botany **2 hrs**

Students should be familiar with the structure of anther and embryo (Permanent slides can be used)

Palynology **2 hrs**

Study of pollen morphology of the following plants–*Hibiscus, Vinca, Balsam, Ixora, Crotalaria, Bougainvillea* by microscopic observation

Practical of BV1241.1 **36 hrs**
Environmental Studies

1. Study of ecological and anatomical modifications of Xerophytes, Hydrophytes, halophytes, epiphytes and Parasites.
2. Study of plant community by quadrat method.
3. Observation and study of different ecosystems mentioned in the syllabus.
4. Determination of frequency and density constituent of plant species in a terrestrial community through quadrate and transect (line, belt).
5. Phytogeographical regions of India.

SEMESTER III
Core Course Botany IV

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1341.1	**Phycology, Mycology, Lichenology & Phytopathology**	**3**	**72 (T 36 + P 36)**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should be exposed to the world of cryptograms and other lower forms of plants. They should understand the various aspects of algae, fungi, lichens.
CO 2	They should be exposed to various aspects of algae, its classification and economic importance.
CO 3	Students should understand about Lichens and its morphology and structure.
CO4	They should understand the importance of lower forms of plants and their economic importance and diseases caused by them.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	Understanding	Apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I — 22 hrs

Phycology

Introduction –Rangeofthallusstructure–Phylogenictrends–Pigments–Reproduction–Lifecycle,

Classification based on F.E Fritsch

Salient features of the following major groups with reference to the structure, reproduction and lifecycle of the types given below *(Excluding the developmental details)*–

1. Cyanophyceae – *Nostoc*
2. Chlorophyceae- *Chlorella, Volvox, Oedogonium, Cladophora,*and *Chara*
3. Xanthophyceae– *Vaucheria*
4. Bacillariophyceae– *Pinnularia*
5. Phaeophyceae– *Sargassum*
6. Rhodophyceae– *Polysiphonia*

Economic importance of algae

a) Role of algae in soil fertility- Fertilizer–Nitrogen fixation- Symbiosis

b) Commercial products of algae– Agar, Alginates, Carrageenin, Diatomaceous earth

c) Algae-medicinal aspects, algal blooms and redtides

Module II — 22 hrs

Mycology

Introduction, structure, reproduction, life cycle, evolutionary trends, Classification based on Ainsworth

Distinguishing characters of different classes of fungi representing the following genera

(Excluding Developmental details)

1. Myxomycotina- General characters
2. Zygomycotina - *Rhizopus*
3. Ascomycotina
    a. Hemi ascomycetes- *Saccharomyces*
    b. Plectomycetes- *Penicillium*
    c. Pyrenomycetes- *Xylaria*
    d. Discomycetes– *Peziza*
4. Basidiomycotina
    a. Teliomycetes- *Puccinia*
    b. Hymenomycetes - *Agaricus*
5. Deuteromycotina - *Cercospora*.

Economic importance of Fungi

Module III

Lichenology — 3 hrs

Lichens - nature of association- classification- habit and habitat- Type Usnea - thallus morphology – internal structure– reproduction- economic importance

Module IV

Plant Pathology — 7 hrs

Introduction to Pathology– Classification of plant diseases on the basis of causative organisms, and symptoms– Host parasite interaction

Study of the following diseases with emphasis on symptoms, disease cycle and control measures of Leaf mosaic of Tapioca, Citrus Canker, Blast disease of Paddy, Root wilt of Coconut

Brief account of the following fungicides-

Bordeaux mixture, Lime sulphur, Tobacco decoction, Neem cake & oil

Practical — 36 hrs

Phycology — 16 hrs

Make micro preparations of vegetative and reproductive structures of the types mentioned in the syllabus.

Identify the algal specimens up to the generic level and make labelled sketches of the specimens observed

Mycology 14hrs

A detailed study of structure and reproductive structures of the types given in the syllabus and submission of record

Rhizopus, Saccharomyces, Penicillium, Xylaria, Peziza. Puccinia. Agaricus and *Cercospora*

Lichenology 2 hrs

Make micro preparation of vegetative and reproductive parts of Usnea. Make sketches of the specimens observed.

Plant Pathology 4 hrs

Identify the Diseases mentioned with respect to causal organism and symptoms
Students should be trained to prepare the fungicide Bordeaux mixture & Tobacco decoction.

Suggested Readings

1. AlainDurieux2009,AppliedMicrobiology,SpringerInternationalEdition
2. AlexopoulosC.J&MIMSC.V1988.IntroductoryMycology,JohnWiley&Sons.
3. ChapmanV.J &Chapman D.J,The Algae, Macmillan.
4. Dr.G.Gunasekharan –Labortary Manual of Microbiology– NewAgePub:
5. FritschF.B1945, Structure and Reproduction of Algae Vol.I&II. Cambridge University Press.
6. Heritage.L.2007,IntroductoryMicrobiology,Cambridge UniversityPressIndiaPvtLtd
7. JimDeacon2007,Fungal Biology, 4th edition,BlackwellPublishing,AneBooksPvt.Ltd.
8. KanikaSharma2009, Manual of Microbiology,AneBooksPvt.Ltd.
9. MamathaRao2009,Microbes and Non flowering plants, Impact and applications; AneBooksPvt.Ltd.
10. R.C.Dubey&D.K.Maheswari-Atext BookofMicrobiology–Chand& Co:
11. Schlegel,2008GeneralMicrobiology,CambridgeUniversityPressIndiaPvtLtd
12. SinghV,PandeyPCandJamD.K1998,AText Book of Botany for Under Graduate Students, Rastogi Publications.
13. SinghV., Pandey P.C and Jain D.K1998, A Textbook of Botany for Under graduate Students, Rastogi Publications.
14. SmithG.M1955,Cryptogamic Botany Vol.I, McGraw Hill
15. SmithG.M1955,Cryptogamic Botany, Vol.I McGraw Hill.
16. Vashishta B.R.1990, Botany for Degree Students, Fungi, S.Chand & Co.
17. VasishtaB.R1990, Botany for Degree Students, Algae, S.Chand&Co.
18. Webster J1970, Introduction to Fungi, Cambridge University Press.

SEMESTER III

Core Course Botany V

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1342.1	**Bryology, Pteridology, Gymnosperms & Paleobotany**	**2**	**54**(T 36 + P 18)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This course will help students to understand about the lower plants and its classification.
CO 2	They will learn the classification, morphology, anatomy and life cycle of Bryophytes, Pteridophytes and Gymnosperms.
CO 3	Its study will equip the students to learn and to get proper understanding of the Biosphere and about the lower plants
CO4	It also imparts the importance of these plants in the ecosystem and its taxonomic and evolutionary relation with other plants in the Biosphere with the study of fossil plants.

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Course Content

Module I

Bryology **10hrs**

Introduction and Classification

Study of the habit, thallus organization, vegetative and sexual reproduction and alternation of generation of the following types *(Developmental details are not required)*. *Riccia, Marchantia, Funaria*

Economic Importance of Bryophytes

Module II **12 hrs**

Pteridology

Introduction: General characters, morphological features and classification by Smith.

Study of the habitat, habit, internal structure, reproduction and life cycle of the following types *(Developmental details not required)*. *Psilotum, Lycopodium, Selaginella, Equisetum, Pteris* and *Marsilea.*

Module III 2 hrs

General Topics: Stelar evolution in Pteridophytes, heterospory and seed habit, relationships of Pteridophytes with bryophytes and gymnosperms, economic importance of pteridophytes.

Module IV 8hrs

Gymnosperms

Introduction and classification of gymnosperms -
Study of the Habit, Anatomy, Reproduction and life cycle of the following types *(Developmental details are not required)– Cycas, Pinus* and *Gnetum*
Evolutionary trends in Gymnosperms- Relationship of Gymnosperm with Pteridophytes and Angiosperms

Economic importance of gymnosperms

Module V

Palaeobotany 4hrs

Introduction to Palaeobotany, Fossil formation –Techniques of study
Geological timescale, Evolutionary trends
Fossil pteridophytes – *Rhynia, Lepidodendron, Lepidocarpon*. Fossil Gymnosperm *Lyginopteris*. Applied aspects of Palaeobotany- Exploration of fossils

Practical 18Hrs

Bryology 4hrs

1. *Riccia*–Habit-Internal structure of thallus – V.S.of thallus through archegonia, antheridia and sporophyte
2. *Marchantia* –Habit- thallus T. S., thallus with Archegonial receptacle, Antheridial receptacle, Male receptacle V.S., Female receptacle VS., T.S. of thallus through gemma, Sporophyte V.S.
3. *Funaria* –Habit,V.S. of archegonial cluster, V.S. of antheridial cluster, Sporophyte V.S.

Pteridology 8hrs

1. *Psilotum*: External features, stemT.S., synangiumT.S.
2. *Lycopodium*: Habit, stemT. S., strobilus V.S.
3. *Selaginella*: Habit, rhizophore T.S, stem T.S, axis with strobilus, V.S.of strobilus, Megasporophyll and microsporophyll.

4. *Equisetum* -Habit, rhizome and stemT.S. and V.S. of strobilus.
5. *Pteris*- Habit, Petiole T.S., sporophyll T.S., prothallus
6. *Marsilea* - Habit, Rhizome and petiole T.S., sporocarp T.S, V.S. & R.L.S.

Gymnosperms 5 hrs

1. *Cycas* – seedling, coralloid root and coralloid root T. S., T. S. of leaflet and petiole, micro and mega sporophyll, male cone V.S., micro sporophyll T.S., entire and V.S of ovule.
2. *Pinus* –Dwarf shoot, T.S of needle, male and female cone, V.S. of male and female cone.
3. *Gnetum*-:Habit, stemT.S (young and mature), leafT.S, male and female strobilus,V.S.of male and female cone, ovule V. S. And seed

Paleobotany **1 hr**

1. Fossil pteridophytes– *Rhynia* Stem, *Lepidodendron*, *Lepidocarpon*.
2. Gymnosperm - *Lyginopteris*

Suggested Reading

1. Andrews H.N. (1967)-Studies on Palaeobotany –C.J.Felix.
2. Arnold C.A(1947)- Introduction to Palaeobotany-Mc Graw Hill Co.New Delhi.
3. Chopra RN and P.K.– Biology of Bryophytes-Wiley Eastern Ltd. New Delhi
4. Coutler.J.M.-and Chamberlain C.J.(1958)– Morphology of Gymnosperms –Central Book Depot, Allahabad
5. GuptaV.K.andVarshneyaU.D(1967)–An Introduction to Gymnosperms–Kedarnath, Ramnath Meerut.
6. Parihar N.S.–An Introduction to Bryophyta - Central Book Depot. Alahabad
7. Smith G.M.(1955)- Cryptogamic Botany–Vol.II–McGraw Hill Co. New Delhi
8. SporneK.R.(1966)-MorphologyofPteridophytes-HutchinUniversityLibrary,London
9. SporneK.R.(1967)-MorphologyofGymnosperms-HutchinUniversityLibrary,London
10. Vashista B.R.(1993)- Pteridophyta– S.Chandandco. New Delhi10.
11. Vashista B.R.(1993) Gymnosperms- S. Chandand Co. New Delhi
12. Vasishta B.R.-Bryophyta -S.Chand and Co. New Delhi

SEMESTER IV
Core Course Botany VI

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1441.1	**Plant Physiology**	**2**	**54**(T 36 + P 18)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This course will help students to understand about the basic principles of Plant Physiology.
CO 2	Thecourseshouldgivethefundamentalsaboutthebiophysicalandbiochemical aspects on the functioning of the plant system.
CO 3	Students should learn the functions of various plant system through very specific experiments, which are very important to understand the basis of life activities.
CO4	The course should prepare the students and encourage them to pursue higher studies in plant science as well as in Biotechnology.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Module I — 10hrs

General introduction- physiological processes, their significance and applications

Water relations of plants: Importance of water to plant life.

1. Absorption of water- organs of absorption, root and root hair. Physical aspects of absorption- imbibition, diffusion and osmosis. Plant cell as an osmotic system; water potential and osmotic potential. Plasmolysis and its significance, practical applications. Mechanism of water absorption – active and passive absorption, root pressure. Pathway of water across root cells.
2. Ascent of sap- vital and physical theories.
3. Loss of water from plants: transpiration- cuticular, lenticular and stomatal mechanism– theories- Starch sugar hypothesis, potassium-ion theory.

Significance of transpiration- guttation, anti transpirants, factors affecting transpiration.

4. Water stress and its physiological consequences to drought.

Mineral nutrition: Gross chemical analysis of the plant body, ash analysis, criteria for essentiality of elements, macro and micro elements, role of essential elements and their deficiency symptoms. **Culture methods** - sand culture, hydroponics and aeroponics. Mechanism of mineral absorption (a) passive absorption- ion exchange and Donnan equilibrium (b) active absorption- carrier concept, Lundegardh hypothesis.

Module II **8 hrs**

Photosynthesis: Introduction, significance and general equation.

Photosynthetic apparatus, structure and function of chloroplast, quantasomes- solar spectrum and its importance- Fluorescence and phosphorescence, Red drop, Emerson effect- Two pigment systems- raw material for photosynthesis- Mechanism of photosynthesis- Light reaction- cyclic and noncyclic photo phosphorylation. Hill reaction- Dark reaction: Calvin cycle. Comparative study of C3, C4, and CAM plants, Photorespiration, Factors affecting photosynthesis- Law of limiting factor

Module III **6 hrs**

Respiration: Introduction, definition and significance and general equation. Respiratory substances, types of respiration- aerobic and anaerobic, Aerobic respiration - glycolysis, Krebs'scycle, terminal oxidation, Anaerobic respiration– fermentation: alcoholic and lactic acid fermentation. Energy relation of respiration- R.Q and its significance- Factors affecting respiration.

Module IV **7hrs**

Translocation of solutes: Path way of movement, phloem transport, mechanism of transport –Munch hypothesis, protoplasmic streaming theory

Nitrogen metabolism: Source of nitrogen- Biological nitrogen fixation- symbiotic and asymbiotic. Reduction of nitrate- reductive amination and trans amination. Nif genes, Leg-haemoglobin.

Enzymes-general account- structure, classification and nomenclature (recommended by Commission on Enzymes),

Mechanism of enzyme action - inhibition of enzymes - regulation of enzymes - allosteric inhibition - Isoenzymes, coenzymes and cofactors - effect of temperature on enzyme action– effect of pH.

Module IV **5hrs**

Growth: Phases of growth - vegetative and reproductive growth - growth curve - plant growth regulators - Auxins, Gibberellins, Cytokinins, Ethylene, Absciscic acid - synthetic plant hormones – practical applications. Senescence and abscission.

Photo periodism and Vernalization- phyto chrome and its significance,

Plant movements: Tropic and nastic movements. Circadian rhythm and biological clock.

Stress physiology: water stress, saltstress.

Practical

18hrs

1. Water potential of onion peel /*Rhoeo* peel by plasmolytic method.
2. Imbibition of water by different types of seeds.
3. Effect of temperature on permeability.
4. Papaya petiole osmoscope.
5. Determination of stomatal index.
6. Compare the rate of transpiration by the upper and lower surface of the leaf by cobalt chloride method.
7. Determination of water absorption and transpiration ratio.
8. Measurement of rate of transpiration using Ganong's potometer or Farmer's potometer.
9. Separation of plant pigments by paper chromatography.
10. Evolution of oxygen during photosynthesis.
11. Measurement of photosynthesis by Wilmot's bubbler.
12. Evolution of CO_2 during respiration.
13. Ganong's respirometer and measurement of R.Q.
14. Simple respiroscope.
15. Alcoholic fermentation using Kuhnen's fermentation vessel.
16. Geotropism using clinostat.
17. Measurement of growth using Arc auxanometer.

Suggested readings

1. Devlin &Witham–Plant Physiology (CBS publishers).
2. Kochhar P.L.& Krishnamoorthy H.N.– Plant Physiology.(Atmaram & Sons- Delhi, Lucknow).
3. Kumar &Purohit– PlantPhysiology-Fundamentals and Applications (Agrobotanical publishers]
4. Malic C.P.& Srivastava A.K.–Text book of Plant Physiology (Kalyani Publishers-NewDelhi).
5. Noggle GR & Fritz G J– Introductory Plant physiology (Prentice Hall of India).
6. Pandey S.N.& Sinha B.K.–Plant physiology(VikaspublishingHouse-NewDelhi).
7. Richard F Venn 2004, Principles and Practice of Bioanalysis,Taylor & Francis, Ane Books Pvt. Ltd
8. Salisbury F.B.& RossC.W.- Plant physiology.(Wadsworth publishingcompany).
9. SundaraRajan S.– College BotanyVol.IV (Himalaya publishing House).

10. VermaV2007,TextBook of Plant Physiology. Ane Books Pvt.Ltd
11. William G. Hopkins–Introduction to Plant Physiology (JohnWiley &Sons,NewYork).

SEMESTER IV

Core Course Botany VII

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1442.1	**Cell Biology, Plant Breeding & Evolutionary Biology**	**2**	**54** (T 36 + P 18)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This course will equip the students to understand the basic concept of Cell and Plant cell biology. It should equip the students to understand the fine cellular and molecular details of the plant system in total.
CO 2	Students should understand the fundamental principles of biophysical and biochemical aspects on the Cell Biology, structural and functional relations of cellular components.
CO 3	Students should learn the Genetical and cellular importance of Plant breeding and its impact in Agriculture.
CO4	The course should prepare the students to study about the fundaments of Biological evolution and various principles and factors underlying it.

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Module I

Cell biology **20hrs**

1. History and progress of cell biology
2. Ultra structure and functions of the cell components and organelles (A brief account only)-Cell wall; The cell membrane, Endoplasmic reticulum, Ribosomes, Golgi apparatus, Lysosomes, Peroxisomes, Vacuole, Mitochondria, Chloroplast& Nucleus

3. The chromosomes- Chromosome morphology- Eukaryotic chromosomes and its molecular organization. Chromatin- composition and structure; heterochromatin and euchromatin; Chemical organization. Nucleoproteins – histones and non – histones. Nucleosome model of DNA organization.
4. Special types of chromosomes- Salivary gland, Lamp brush and B chromosomes
5. Variation in Chromosome number (Numerical aberrations)- anueploidy and Euploidy- haploidy, polyploidy- significance.
6. Variation in Chromosome structure (Structural aberrations)- deletion, duplication, inversion and translocation; significance.
7. Mitosis and Meiosis: Transmission of genetic information – cell cycle :Significance of mitosis and meiosis

Module II **10 hrs**

Plant breeding

1. Introduction, objectives in plant breeding.
2. Plant introduction. Agencies of plant introduction in India, Procedure of introduction – Acclimatization- Achievements.
3. Selection-mass selection, pure line selection and clonal selection. Genetic basis of selection methods.
4. Hybridization: Procedure of hybridisation, inter generic, inter specific, inter varietal hybridisation with examples. Composite and synthetic varieties.
5. Heterosis and its exploitation in plant breeding.
6. Mutation breeding–method–achievements in India.
7. Breeding for pest, diseases and stress resistance.

Module-III

Evolutionary Biology **6hrs**

1. Progressive and Retrogressive evolution.
2. Parallel and Convergent evolution.
3. Micro and Macro evolution.
4. Theory of Lamarck, Wiesman and DeVries, Darwinism, Neo-Darwinism
5. Isolation, Mutation, Genetic drift, Speciation
6. Variation and Evolution–Hybridization and Evolution– Polyploidy and evolution– Mutation and evolution.

Practical

18 hrs

1. Study of Microscopes- different magnification of light microscopes

2. Examination of different types of cells- single celled and multi cellular systems
3. Make aceto carmine squash preparation of onion root tip and to identify different stages of mitosis
4. Determination of Mitotic Index
5. Make squash preparation of the flower buds of any of the following plants. *Rhoeo, Capsicum*
6. (To identify Meiosis)
7. Preparation of Karyotype
8. Microscopical examination and assessment of starch granules from potato, rice, tapioca etc
9. Fixation of specimens for cytological studies, Preparation of cytological stains like aceto carmine and safranin.

Suggested Readings

1. Aggarwal S K (2009) Foundation Course in Biology,2nd Edition, Ane Books Pvt.Ltd
2. Allard R W(1960) Principles of Plant Breeding. John willey and Sons. Inc. New York
3. B D Singh (2003) Plant Breeding. Kalyani Publishers
4. Cohn, N.S.(1964) Elements of Cytology. Brace and World Inc, New Delhi
5. Darnel, J. Lodish, Hand Baltimore, D.(1991) Cell and molecular biology. Lea and Fibiger, Washington.
6. De Robertis, E.D.Pand Robertis, E.M. P (1991) Cell and molecular biology Scientific American books.
7. Dobzhansky, B(1961) Genetic and origin of species, Columbia University Press New York
8. Durbin (2007) Biological Sequence Analysis. Cambridge University Press India Pvt. Ltd
9. Gerald Karp (1985) Cell biology, Mc Graw Hill company..
10. Lewin, B,(1994)Genes, Oxford University Press, New York.
11. Lewis, W.H (1980) Polyploidy. Plenum Press, NewYork.
12. NichollT (2007) An Introduction to Genetic Engineering, Cambridge University Press India Pvt. Ltd
13. Roy S.C.and Kalayankumar De (1997 Cell biology.New central Boos Calcutta
14. Sandhyamitra,(1998) Elements of molecular biology. Macmillan, India Ltd.
15. Sharma J R (1994) Principles and Practices of Plant Breeding. Tata Mc Graw-Hill Pub.Co. NewDelhi
16. Sharma,A. K and Sharma a (1980) Chromosome technique Theory and practice, Aditya Books, New York
17. Swanson,C.P(1957) Cytology and Genetics. Engle wood cliffs, NewYork.
18. Taylor (2008) Biological Sciences. Cambridge UniversityPress India Pvt. Ltd
19. Twymann,R.M.(1998)Advanced molecular biology Viva books NewDelhi.
20. Veer Bala Rastogi(2008), Fundamentals of Molecular Biology AneBooks, Pvt.Ltd

SEMESTER IV

Core Course Botany VIII

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1443.1	**Practical Botany II** (PracticalofBV1341.1,BV1342.1,BV1441.1&BV1442.1)	**2**	Practical hours of the respective courses

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This course will train the students do the practical experiments of phycology, Mycology, Lichenology and Plant Pathology.
CO 2	This covers the Practical experiments of Bryology, Pteridology, Gymnosperms and Paleobotany.
CO 3	Students are supposed to learn the experiments of plant physiology listed in the syllabus through this course.
CO4	The course should prepare the students to carry out the experiments related to Cell Biology, Plant Breeding and Evolutionary Biology.

Details of Practical Experiments

Practical of BV1341.1 **36 hrs**

Phycolcogy 16hrs

Make micro preparations of vegetative and reproductive structures of the types mentioned in the syllabus.

Identify the algal specimens up to the generic level and make labeled sketches of the specimens observed

Mycology 14hrs

A detailed study of structure and reproductive structures of types given in the syllabus and

submission of record

Rhizopus, Saccharomyces, Penicillium, Xylaria, Peziza, Puccinia, Agaricus and *Cercospora*

Lichenology 2hrs

Make micropreparation of vegetative and reproductive parts of Usnea. Make sketches of the specimens observed.

Plant Pathology 4hrs

Identify the Diseases mentioned with respect to causative organism and symptoms

Students should be trained to prepare the fungicide Bordeaux mixture &Tobacco decoction.

BV1342.1

Bryology, Pteridology, Gymnosperms & Paleobotany **18hrs**

Bryology 4hrs

1. *Riccia* – Habit - Internal structure of thallus – V. S. of thallus through archegonia, antheridia and sporophyte
2. *Marchantia*–Habit-thallusT.S.,thallus with Archegonial receptacle, Antheridial receptacle, Male receptacle V .S., Female receptacle VS., T.S . of thallus through gemma, Sporophyte V. S .
3. *Funaria*– Habit, V.S.of archegonial cluster, V.S. of antheridial cluster, SporophyteV.S.

Pteridology 8hrs

1. *Psilotum*: External features, stemT.S., synangium T.S.
2. *Lycopodium*: Habit, stem T.S., stobilus V.S.
3. *Selaginella*: Habit, rhizophore T.S, stemT .S, axis with strobilus, V.S.of strobilus, Megasporophyll and microsporophyll.
4. *Equisetum*- Habit, rhizome and stem T.S. and V.S.of strobilus.
5. *Pteris*- Habit, Petiole T.S., sporophyll T.S., prothallus
6. *Marsilea* - Habit, Rhizome and petiole T.S.,sporocarpT.S, V.S.& R.L.S.

Gymnosperms 5hrs

1. *Cycas*–seedling, coralloid root and coralloid root T.S., T.S.of leaflet and petiole, micro and mega sporophyll, male cone V.S., micro sporophyll T.S., entire and V. S of ovule.
2. *Pinus*– Dwarf shoot, T.S of needle, male and female cone, V.S. of male and female cone.
3. *Gnetum*-:Habit, stem T.S (young and mature), leaf T.S, male and female strobilus, W.S. of male and female cone, ovule V. S. and seed

Palaeobotany 1hr

1 Fossil pteridophytes– Rhynia Stem, Lepidodendron, Lepidocarpon.
2. Gymnosperm–Lyginopteris

BV1441.1
Plant Physiology **18 hrs**

1. Water potential of onion peel /Rhoeo peel by plasmolytic method.
2. Imbibition of water by different types of seeds.
3. Effect of temperature on permeability.
4. Papaya petiole osmoscope.

5. Determination of stomatal index.
6. Compare the rate of transpiration by the upper and lower surface of the leaf by cobalt chloride method.
7. Determination of water absorption and transpiration ratio.
8. Measurement of rate of transpiration using Ganong's potometer or Farmer' s potometer.
9. Separation of plant pigments by paper chromatography.
10. Evolution of oxygen during photosynthesis.
11. Measurement of photosynthesis by Wilmot's bubbler.
12. Evolution of CO2 during respiration.
13. Ganong's respirometer and measurement of R.Q.
14. Simple respiroscope.
15. Alcoholic fermentation using Kuhnen's fermentation vessel.
16. Geotropism using clinostat.
17. Measurement of growth using Arc auxanometer.

BV1442.1

Cell Biology, Plant Breeding and Evolutionary Biology 18Hrs

1. Study of Microscopes-different magnification of light microscopes
2. Examination of different types of cells- single celled and multicellular systems
3. Make acetocarmine squash preparation of onion root tip and to identify different stages of mitosis
4. Determination of Mitotic Index
5. Make squash preparation of the flower buds of any of the following plants. *Rhoeo, Capsicum* (To identify Meiosis)
6. Preparation of Karyotype
7. Microscopical examination and assessment of starch granules from potato, rice, tapioca etc.
8. Fixation of specimens for cytological studies, Preparation of cytological stains like acetocarmine and safranin.

SEMESTER V

Core Course Botany IX

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1541.1	**Angiosperm Morphology and Systematic Botany**	**4**	**108** (T 72 + P36)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This course should give a basic understanding on the morphology of angiosperms and its significance in plant identification and applications.
CO 2	This course will impart the students about the various scientific methods of plant classification and nomenclature.
CO 3	Students will learn about the morphological modifications and other morphological parts important for systematic Classification of flowering plants and its economic importance.
CO4	The course is designed to give a basic awareness in systematic botany and morphology of higher plants and the course will generate interest on students to pursue continuous studies in systematic botany.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Module I

Morphology **12hrs**

Brief account on the various types of inflorescence including special types (Cyathium, Verticillaster, Hypanthodium, Coenanthium and Thyrsus) with examples;

Floral morphology- Flower-as a modified shoot, Flower parts, their arrangements, relative position, numeric- plan, cohesion, adhesion, symmetry of flower, aestivation types, placentation types; floral diagram and floral formula

Fruit types: simple, aggregate and multiple.

Seeds: albuminous and exalbuminous.

Module II **8 hrs**

Systematic Botany

Definition, scope and significance of Taxonomy,
Systems of classification, Artificial- Linnaeus sexual system, Natural - Bentham and Hooker (detailed account)
Phylogenetic- Engler and Prantl (Brief account only)

Module III **7 hrs**

Basic rules of Binomial Nomenclature and International Code of Botanical nomenclature (ICBN), Importance of Herbarium, Herbarium techniques and Botanical gardens, A brief account on the modern trends in taxonomy; Chemotaxonomy, Numerical Taxonomy, Cytotaxonomy and Molecular taxonomy

Module IV **45 hrs**

Study of the following families with emphasis on the morphological peculiarities and economic importance of its members (based on Bentham & Hooker's system)

1	Annonaceae	8	Cucurbitaceae	15	Solanaceae	22	Arecaceae
2	Nymphaeaceae	9	Apiaceae	16	Acanthaceae	23	Poaceae
3	Malvaceae	10	Rubiaceae	17	Verbenaceae		
4	Rutaceae	11	Asteraceae	18	Amaranthaceae		
5	Anacardiaceae	12	Sapotaceae	19	Euphorbiaceae		
6	Leguminosae	13	Apocynaceae	20	Orchidaceae		
7	Myrtaceae	14	Asclepiadiaceae	21	Liliaceae		

Practical **36 hrs**

1. Study on various types of inflorescences with vivid record of practical work.
2. Students must be able to identify the angiosperm members included in the syllabus up to the level of families.
3. Draw labelled diagram of the habit, floral parts, LS of flower,TS of ovary, floral diagram, floral formula and describe the salient features of the member in technical terms
4. Students must submit practical records, Herbarium sheets (25Nos:) and Field book at the time of practical examination.
5. Field trips are to be conducted for three days either as continuous or one day trips.

Suggested Reading

1. Davis,P.and Haywood,V.H,1963.Principles of AngiospermTaxonomy.OliverandRoyd,London.
2. Heywood,V.H.and Moore D.M.1984.CurrentConceptsinPlantTaxonomy.AcademicPress,London.
3. Jeffrey,C.1982.An Introduction to Plant Taxonomy. Cambridge UniversityPress,CambridgeLondon.
4. Jones,S.B.Jr.and Luchsinger,A.E.1986.PlantSystematics (2ndedition).McGraw-HillBookCo.,New York.
5. KapoorLD,2001HandBookofAyurvedicMedicinalPlants,CRCPressNewYork,AneBooksPvt.Ltd
6. Lawrence.G.H.M.1951.TaxonomyofVascularPlants.Macmillan, NewYork.
7. Naik,V.N.1984.Taxonomy of Angiosperms.TataMcGrawHill,NewYork.
8. Nordenstam.B.,El-Gazaly,G.andKassas.M.2000.PlantSystematicsfor21st Century
9. Pandey SN and MisraSP,2008Taxonomy of Angiosperms; Ane BooksPvt.Ltd.
10. Radford.A.E.1986.FundamentalsofPlantSystematicsHarperandRow,NewYork.
11. Singh.G.1999.PlantSystematics:Theory and practice Oxford & IBHPvt,Ltd. NewDelhi.
12. Sivarajan,V.V.Introduction totheprinciple ofplanttaxonomy,OxfordandIBHPublishingCompany
13. Stace.C.A.1989.PlantTaxonomyandBiosystematics.2nded.EdwardArnold,London.
14. VermaV,2009 Text Book of Economic Botany; AneBooksPvt.Ltd.
15. Woodland.D.E.1991.ContemporaryPlantSystematics.PrenticeHall,NewJersay.

SEMESTER V
Core Course Botany X

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1542.1	**Economic Botany, Ethnobotany & Medicinal Botany**	**3**	**72** (T 54+P18)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This course should expose the students to major crops and its useful parts and economic importance.
CO 2	This course should make the students to learn about the various aspects traditional use of medicinal and other plants by various communities and groups of people.
CO 3	Students will learn about the morphological parts used as medicine and its phytochemical aspects.
CO4	The course is designed to understand the importance of ethno medicines, types of various folk medicines, and its importance in modern medicines.

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	Understanding	Apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
Total							100

Module I **5hrs**

Economic botany

1. Study of the major crops in Kerala with special reference to their Methods of cultivation, Botanical description, morphology of the useful part and economic importance– Coconut and Paddy.
2. A brief account on the utility of the following plants, specifying the Binomial, family and morphology of the useful parts. **12 hrs.**

3 Fruits & Vegetables- Banana, Jackfruit, Pineapple, citrus, Apple, Cashew, Watermelon, Tomato, Brinjal, Common bean, Sword bean, Pumpkin, Cucumber, Snake gourd, Bitter gourd, Ash gourd, Bottlegourd.

4. Cereals and millets - Wheat and Ragi
5. Pulses - Blackgram and Bengalgram
6. Sugar yielding Plants - Sugarcane
7. Spices - Pepper and Cardamom
8. Beverages - Coffee
9. Fibre yielding plant - Cotton
10. Dye Yielding plants - Henna and *Bixaorellana*
11. Resins - Asafoetida
12. Tuber crops - Tapioca
13. Oil yielding Plants - Sesame and Coconut
14. Insecticides - Neem

Module II

Ethnobotany **12hrs**

Definition: -importance, scope, categories and significance.

Study of various methods to collect Ethno botanical data,

Plant parts used by tribes in their daily life as food, clothing, shelter, agriculture and medicine,

Study of common plants used by tribes : *Aegle marmelos, Ficus religiosa, Cynodon dactylon, Ocimum sanctum* and *Trichopus zeylanicus*

Ethnobotanic aspect of conservation and management of plant resources

Preservation of primeval forests in the form of sacred groves of individual species

Module III **15 hrs**

Medicinal botany

1. Importance and the need for its conservation-Sacred groves.
2. Role of NBPGRI, ICAR, IMPB and BSI in conservation and cultivation of medicinal plants
3. A general account of the medicinal value of plant parts-
4. Rhizome of Curcuma and Z*ingiber;* Bulbs of *Allium cepa* and *A. sativum*;
5. Root of *Asparagus, Hemidesmis, Acorus calamus, Adhatoda vasica.*
6. *Catharanthus roseus, Phyllanthus amarus, Andrographis paniculata;*
7. Leaves- *Aloe vera, Centella asiatica* Asoka (*Saraca indica*) and Brahmi (*Bacopa monnieri*) Aswagandha (*Withania somnifera*), Sarpagandha (*Rauvolfia serpentina*)
8. Production of herbal drugs. Extraction procedure- Adulteration of drugs

Module IV

10hrs

Definition and scope of Pharmacognosy – Ancient and modern medicines -Sidha, Ayurveda, Unani, Acupuncture, Homoeopathy and Allopathy

Sources of crude drugs: – roots, rhizome, bulb, corm, leaves, stems, flowers, fruits and seeds

Practical **18hrs**

1. Collection and study of economically important plants and morphology of the useful parts.
2. Identify the economic products obtained from the plants mentioned under Economic Botany
3. Visit a tribal area and collect information on their traditional method of treatment using crude drugs.
4. Familiarize with at least 5 folk medicines and study the cultivation, extraction and its medicinal application.
5. Observe the plants of ethno botanical importance in your area
6. Visit to an Ayurveda college or Ayurvedic institution /Research centre

Suggested Readings

1. Davis, P.11. and Haywood, V.H, 1963. Principles of Angiosperm Taxonomy, Oliver and Royd, London.
2. K. Jain.Glimpses of Ethnobotany. Oxfordand IBH Publishing Company, New Delhi.
3. Kapoor LD, 2001 Hand Book of Ayurvedic Medicinal Plants,CRCPressNewYork,
4. Rajiv K Sinha.Ethnobotany.
5. S.K.Jain,1987.A Manual of Ethnobotany.Scientific Publishers, Jodhpur
6. T.EWalles.Textbook ofPharmacognosy,
7. VermaV,2009 TextBook of Economic Botany;Ane Books Pvt. Ltd.

SEMESTER VI
Core Course Botany XI

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1641.1	**Genetics**	**2**	**126** (T 90+P36)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This course should give thorough knowledge in classical genetics as the basis of all genetic studies and research.
CO 2	Students are made to understand the principles of Genetics and its modifications, sex determination, linkage crossing over etc.
CO 3	Students will acquire the basic principle of all genetic studies, the basic as well as applied aspects including genetic engineering and gene therapy.
CO4	The course is designed to understand the importance of genetics and this will prepare the students to pursue higher studies in genetics and molecular biology.

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Course Content

Module I

Classical Genetics **50 hrs**

1. Mendelian Genetics- Mendel and his experiments, Mendel's success, Mendelian principles, Mendelian ratios, monohybrid and dihybrid crosses, back cross and test cross Genetics after Mendel-Modified Mendelian ratios; Incomplete dominance-Flower color in Mirabilis; Interaction of genes-Comb pattern in poultry. 9:3:3:1. Epistasis - Recessive. Coat color inmice.9:3:4; Dominant epistasis.
2. Fruit colour in summer squash. 12:3:1; Complementary genes. Flower color in Lathyrus 9:7; Duplicate gene with cumulative effect. Fruit shape in summer squash. 9:6:1; Duplicate dominant genes in shepherd'spurse.15:1; Inhibitory factor. Leaf color in Paddy.13:3
3. Multiple alleles-General account. ABO blood group in man. Rh factor. Self sterility in *Nicotiana*.
4. Quantitative characters- General characters of quantitative inheritance, polygenic inheritance; Skin color in man, ear size in Maize.

Module II

7. Linkage and crossing over- Linkage and its importance, linkage and independent assortment. Complete and incomplete linkage. Crossing over – a general account, two point and three point test cross. Determination of gene sequence. Interference and coincidence. Mapping of chromosomes.
8. Sex determination- Sex chromosomes, chromosomal basis of sex determination XX- XY,XX-XO mechanism. Sex determination in higher plants (*Melandrium album*) Genic balance theory of sex determination in *Drosophila.*
9. Sex chromosomal abnormalities in man. Klinefelter's syndrome, Turner's syndrome.
10. Sex linked inheritance. Sex influenced and sex limited traits, Eye colour in *Drosophila,* Haemophilia in man. Y-Linked inheritance.
11. Extra nuclear inheritance- General account, maternal influence.
12. Plastid inheritance in *Mirabilis*.
13. Shell coiling in snails, kappa particle in *Paramecium*.

Module III

Molecular Genetics **30 hrs**

1. DNA as genetic material- Structure of DNA; A, B and Z forms of DNA, satellite and repetitive DNA sequences
2. Replication of DNA, Circular and helical DNA. Semi conservative model, experimental support, Meselson and Stahl experiment. Enzymology of replication: topoisomerase, helicase, primase, polymerase and ligase.
3. DNA repairing mechanism.
4. RNA structure- Properties and functions of tRNA, mRNA and rRNA .Genetic code.
5. Synthesis of protein: Transcription, translation- Central dogma- reverse transcription
6. Concept of gene- Units of a gene, cistron, recon, muton; Types of genes- House keeping genes (constitutive genes), Luxury genes (non constitutive genes), interrupted genes (Split genes) - introns, overlapping gene.
7. Transposable genetic elements- General account, Characteristic, Transposons (jumping genes), Cellular oncogenes (general account only).

Module IV **10Hrs**

Population Genetics

1. Gene frequency and genotype frequency,
2. Hardy Weinberg Law, factors affecting equilibrium: –Mutation, migration and selection.

Practical **36hrs**

Workout problems in

1. Mono hybrid cross (Dominance and incomplete dominance) Dihybrid cross (Dominance and incomplete dominance)
2. Gene interactions (All types of gene interactions mentioned in the syllabus) Recessive epistasis 9:3:4.
3. Dominant epistasis 12:3:I
4. Complementary genes 9:7
5. Duplicate genes with cumulative effect 9:6:1
6. Inhibitorygenes13:3
7. Duplicatedominantgene15:1
8. Combpatterninpoultry9:3:3:1Linkage andcrossing over

9. Two point and three point crossesConstructionofgenetic map.
10. Application of Hardy Weinberg formula to population genetics

Suggested Readings

1. AggarwalSK(2009),FoundationCourseinBiology,2nd Edition,AneBooksPvt.Ltd
2. Dobzhansky, B (1961) Genetic and origin of species,Columbia university Press New York
3. Gardner,E .J and Snustad,D.P (1984) Principles of Genetics. John Wiley, NewYork.
4. Durbin (2007) Biological Sequence Analysis. Cambridge University Press India Pvt.Ltd
5. GuptaP.K.–Genetics (Rastogi publications).
6. Gupta,P. K. Genetics, Rastogi Publications.
7. JohnRingo (2004) Fundamental Genetics.Cambridge University Press India Pvt.Ltd.
8. Lewin, B,(1994)Genes,Oxford University Press, NewYork.
9. Lewis,W. H (1980) Polyploidy.Plenum Press,NewYork.
10. NichollT(2007) An Introduction to Genetic Engineering, Cambridge University Press India Pvt.Ltd
11. Sharma,A.K and Sharma A (1980) Chromosome technique Theory and practice, Aditya Books, New York
12. Swanson, C. P (1957) Cytologyand Genetics. Engle wood cliffs, NewYork.
13. Taylor (2008) Biological Sciences. Cambridge University Press India Pvt. Ltd
14. Veer Bala Rastogi (2008), Fundamentals of Molecular Biology An eBooks Pvt. Ltd

SEMESTER VI
Core Course Botany XII

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV1642.1	**Practical Botany** (Practical of BV1541.1, BV1542.1& BV1641.1)	**2**	**Practical Hours of the respective courses**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	This practical course should train the students to understand the morphology of angiosperms, its modifications and its relevance in plant classification and identification families.
CO 2	Students will learn floral morphology and will use it for identification of plants to the level of family and should study to draw the floral diagram and generate floral formula.
CO 3	Students will familiarize with economically important plant parts, its type of modifications and uses. They also learn about traditional medicines and the contribution of ethno botany.
CO4	Students should practice to learn to solve various types of Genetics problems of Mendalian Genetics, Linkage & Crossing over, other modifications and problems of Population Genetics.

BV1541.1

Angiosperm Morphology and Systematic Botany **36hrs**

1. Study on various types of inflorescences with vivid record of practical work.
2. Students must be able to identify the angiosperm members included in the syllabus up to the level of families.
3. Draw labeled diagram of the habit, floral parts, LS of flower, TS of ovary, floral diagram, floral formula and describe the salient features of the member in technical terms
4. Students must submit practical records, Herbarium sheets (25 Nos:) and Field book at the time of practical examination.
5. Field trips are to be conducted for three days either as continuous or one day trips.
6. The members of the following families should be studies in detail with its floral and other morphological characters; plants should be collected and submitted in the form of a herbarium

1	Annonaceae	9	Apiaceae	17	Verbenaceae
2	Nymphaeaceae	10	Rubiaceae	18	Amaranthaceae
3	Malvaceae	11	Asteraceae	19	Euphorbiaceae
4	Rutaceae	12	Sapotaceae	20	Orchidaceae
5	Anacardiaceae	13	Apocynaceae	21	Liliaceae
6	Leguminosae	14	Asclepiadiaceae	22	Arecaceae
7	Myrtaceae	15	Solanaceae	23	Poaceae
8	Cucurbitaceae	16	Acanthaceae		

BV1542.1
Economic Botany, Ethnobotany &Medicinal Botany 18hrs

1. Collection and study of economically important plants and morphology of the useful parts. Identify the economic products obtained from the plants mentioned under Economic Botany
2. Visit a tribal area and collect information on the traditional method of treatment using crude drugs.
3. Familiarizewithatleast5folkmedicinesandstudythecultivation, extraction and its medicinal application.
4. Observe the plants of ethno botanical importance in your area
5. Visit to an Ayurveda college or Ayurvedic institution / Research centre

BV1641.1
Genetics 36hrs

Workout the following problems in

1. Monohybrid cross (Dominance and incomplete dominance)
2. Di hybrid cross (Dominance and incomplete dominance)
3. Gene interactions (All types of gene interactions mentioned in the syllabus)
4. Recessive epitasis 9:3:4.
5. Dominant epistasis 12:3:I
6. Complementary genes 9:7
7. Duplicate genes with cumulative effect 9:6:1
8. Inhibitory genes13:3
9. Duplicate dominant gene15:1
10. Comb pattern in poultry 9:3:3:1
11. Linkage and crossing over
12. Two point and three point crosses
13. Construction of genetic map.
14. Application of Hardy Weinberg formula to population genetics

Core Courses

Zoology

For

First Degree Programme under CBCS

Biotechnology Multimajor 2 (b)

With

Zoology, Chemistry & Biotechnology

SEMESTER I
Core Course Zoology I

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1141.2	**Animal Diversity I: Nonchordata**	**2**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will learn about morphology of plant parts and its modifications, its importance in adaptations and its physiology.
CO 2	Students will understand about the various methods of classification of Plants , binomial nomenclature and systematic identification of plants.
CO 3	Students will study about some of the plant families, its systematic positions and some examples with morphological adaptations and modifications.
CO4	Students will learn the economic importance of useful plant parts, its adaptations, uses, medicinal importance and applications and the systematic positions of the plants.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I **10 hrs**

Kingdom Protista

General characters

Morphology, life history, pathogenicity and prophylaxis of

(1) *Entamoeba* and (2) *Plasmodium*

Examples: *Trypanosoma, Noctiluca, Paramecium, Opalina*

Kingdom Animalia

Outline of classification – Sub kingdom Mesozoa, (e.g. *Rhopalura*),

Subkingdom Parazoa,

Subkingdom Eumetazoa.

Levels of organization– cellular, tissue, organ and organ system

Divisions of Eumetazoa– Radiata, Bilateria, Acoelomata, Pseudocoelomata, Eucoelomata,

Protostomia, Deuterostomia.

Module II 6 hrs

Phylum Porifera

General characters

Examples: *Sycon, Spongilla and Euplectella;* mention gemmule.

Phylum Coelenterata [=Cnidaria]

General characters

Type: *Obelia* (Structure of colony and medusa, polymorphism, life cycle and alternation of generation)

Class Hydrozoa– e.g. *Hydra, Obelia, and Physalia*

Class Scyphozoa– e.g .*Aurelia*

Class Anthozoa– e.g. sea anemone and *Madrepora*

Corals and coral reefs

Module III 8 hrs

Phylum Platyhelminthes

General characters

Class Turbellaria – e.g. *Planaria*

Class Trematoda – e.g. *Fasciola*

Class Cestoda– e.g. *Taeniasolium*

Phylum AschelmInthes [=Nematoda]

General characters

Examples: *Ascaris*, *Ancylostoma,* and *Wuchereria*

Module IV 4 hrs

Phylum Annelida

General characters

Class Polychaeta: e.g. *Nereis* (structure of parapodium, heteronereis), *Aphrodite*, *Arenicola.*

Class Oligochaeta: e.g. Earthworm (Morphology, structure of seta, digestive system and nervous system)

Class Hirudinea– e.g. Leech (*Hirudinaria*) Vermiculture

Module V 12 hrs

Phylum Onychophora

General characters
Example: *Peripatus* (distribution, morphology and affinities)

Phylum Arthropoda

General characters
Type: *Penaeus*
Class Crustacea – e.g. *Penaeus*, Hermitcrab (*Eupagurus*), *Sacculina*

Class Myriapoda–e.g.Millipede, Centipede

Class Insecta– e.g. Cockroach (morphology, mouth parts, digestive system, and nervous system), *Lepisma*, termite, honeybee,silkmoth, *Belostoma, Leptocoriza, Oryctes.*

Mosquitoes (Anopheles, culex, Aedes)

Tse-Tsefly, Sandfly, vector borne diseases (Dengue, Chicken Guinea, Filariasis, Sleeping sickness, Kala-Azar, Malaria)

Class Arachnida– e.g.spider, scorpion, *Limulus*
Pest of coconut, paddy, stored food grains- any three in each
Sericulture, Apiculture

Module VI 8 hrs

Phylum Mollusca

General characters
Class Monoplacophora: e.g. *Neopilina*

Class Aplacophora: e.g. *Neomenia*

Class Amphineura: eg. *Chiton*

Class Scaphopoda: eg: *Dentalium*

Class Pelecypoda: e.g. *Lamellidens, Perna*, pearloyster.

Class Gastropoda: e.g. *Pila, Xancus*

Class Cephalopoda: e.g. *Sepia, Loligo, Octopus and Nautilus.*

Pearl culture

Module VII 6 hrs

Phylum Echinodermata

General characters

Class Crinoidea: e.g. sealily (*Antedon*)

Class Asteroidea: e.g. starfish (*Asterias*); Water vascular system

Class Ophiuroidea : e. g. brittle star (*Ophiothrix*)

Class Echinoidea; e.g. sea urchin (*Echinus*)

Class Holothuroidea: e.g. sea cucumber (*Holothuria*)

Phylum Hemichordata

General characters (Classification not required)

E.g. *Balanoglossus* (morphology, tornaria larva and affinities)

Suggested Readings

1. Anderson, D. T.(Ed.)v*Invertebrate Zoology*. OxfordUty. Press
2. Barrington,E.W.J.*Invertebrate Structure and Function*
3. Borradaile, L. A. etal. *The Inveretebrates*.Cambridge University Press.
4. Dhami, P.S.& Dhami,J.K. *Invertebrate Zoology*. R.Chand & Co, NewDelhi
5. Ekambaranatha Ayyar, M. & Ananthakrishnan, T. N. *A Manual of Zoology Vol. I (Part I &II*),S. Viswanathan,Madras
6. Hyman, L.H.*Invertebrate Volumes*, McGraw Hill Book Co.
7. Jordan, E. L.& Verma,P.S. *Invertebrate Zoology*. S.Chand & Co, New Delhi
8. Kotpal, R. L. *Modern Textbook of Zoology: Invertebrates*. Rastogi Pub.
9. Nair,N.C.etal.*A Text book of Invertebrates* SARAS Publications
10. Parker and Haswell (Ed. Marshall and Williams). *A Textbook of Zoology, Invertebbrates Vol.I*. CBS Pub. &Distributors, New Delhi
11. Ruppert, E.E., Fox, R.S.and Barnes, B. D. *Invertebrate Zoology*, Thomson Books.

SEMESTER II
Core Course Zoology II

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1241.2	**Environmental Studies**	**4**	**72**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should acquire a basic understanding about the structure function of the environment and its interaction with the living systems.
CO 2	It should impart the students the geographical distribution of plants and there by the biodiversity in each and every ecosystems.
CO 3	Students will learn delicate balance of various factors in the environment and the plants and animals.
CO4	It should make the student to learn the importance of biodiversity and the influence of environmental pollution on the biodiversity.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course content

Environmental Biology

Module I — 18 hrs

Introduction: Ecology- definition and relation to humanity; subdivisions- autecology and synecology; definitions of ecological niche, habitat, population, community, ecosystem and biosphere.

Module II — 14 hrs

Concept of an ecosystem- structure and function of an ecosystem

Components of ecosystem: abiotic and biotic components; autotrophs and heterotrophs; producers, consumers, decomposers and transformers.

Ecosystem function: production, consumption, decomposition and transformation; productivity- primary and secondary productivity; trophic structure, food chain and food web; ecological pyramids; keystone species.

Ecological energetics: energy flow in ecosystem and the laws of thermodynamics.

Pond as an ecosystem

Module III 10 hrs

Biogeochemical cycles: Types of cycles– gaseous and sedimentary cycles with examples;

Carbon cycle and nitrogen cycle

Limiting factors: concept of limiting factor– Leibig's law of minimum, Shelford's law of tolerance and combined concept of limiting factors,

Ecological factors: Light and temperature Light as a limiting factor, Temperature as a limiting factor

Module IV 10 hrs

Community ecology: concept of biotic community with examples; community structure; species diversity; dominance; composition and stratification; ecotone and edge effect; Gause's competition exclusion principle; ecological indicators.

Ecological succession: definition; types of succession with examples; serial stages and concept of climax.

Ecological succession in a pond

Module V 12 hrs

Population ecology: Population– definition and properties- density, mortality, natality, age distribution; biotic potential, intrinsic rate of natural increase, environmental resistance and carrying capacity; growth forms- J- and S- shaped curves; life history immigration; population regulation – density –independent and density-dependent.

Population interactions (positive and negative)

Module VI 18 hrs

Habitat Ecology: physic-chemical features, characteristic flora and fauna and adaptations of the following:

Terrestrial habitat: concept of biomes; Arctic tundra, deserts, grasslands and forests (various types)

Fresh water habitat: lentic and lotic habitats; ponds, lakes, rivers and streams.

Marine habitat: pelagic and benthic; littoral and deep sea; estuaries.

Global Ecology: global environmental change– global warming; green house effect.

Pollution: Air pollution; Water pollution

Module VII 8 hrs

Conservation Biology

Introduction: Need of conservation biology

Extinction: causes of extinction; rates of extinction; human caused extinction. Conservation of Biodiversity: *in situ* and *ex situ* conservation; gene bank.

Environmental conservation: natural resources- various types; reasons for conservation of natural resources;

Forest and wildlife – importance and conservation; importance of wet lands with special reference to mangroves

Module VIII 10hours

Disaster Management: Understanding the Concepts and definitions of Disaster, Hazard, and Vulnerability, Risk, capacity and disaster management.

Natural Disaster Management in India:

1. Water and Climate Related Disasters: floods and drainage management, Cyclones, Hail storm, Cloud Burst, Heat Wave and Cold Wave, Snow Avalanches, Droughts, landslides, Sea Erosion, Thunder and Lightning.
2. Geologically related disasters: Landslides and Mudflows, Earthquakes, Dam Failures /Dam Bursts and Mine Fires
3. Chemical, Industrial & Nuclear related disasters
4. Accident related disasters: Forest Fires, Urban Fires, Mines, Flooding Oil Spill, Major Building Collapse, Serial Bomb Blasts, Festival related disasters, Electrical disasters and Fires, Air, Road and Rail Accidents
5. Biologically related disasters: Epidemics, Pest Attacks, Cattle epidemics and Food poisoning.

Main elements of Mitigation & strategy for disasters, Management and mitigation of major natural disasters in India: Floods, Cyclones, Earthquakes and Landslides.
Disaster Management Cycle, Three stages of Disaster Management:

1. Pre-disaster Stage (preparedness),
2. Emergency Stage and
3. Post Disaster stage- Rehabilitation

Hazardous material spill and release; Bomb threat, explosion, campus shooting and terrorist incidence Guidelines for fire & Emergency drill and evacuation procedures for educational buildings

Suggested readings

1. Arumugam,N.Concepts of Ecology. Saras Publications.
2. Chapman,J.L.and Reiss,M.J. Ecology.Cambridge UniversityPress.
3. Dash,M.C.FundamentalsofEcology. TMH
4. Dr.S.Arulsamy and J.JEYADEVI Disaster Management Neelkamal Publishers
5. HarshK.Gupta. Disaster Management. Orient Blackswan
6. Kendeigh. Animal Ecology. Prentice Hall
7. Kormondy. E.J. Concepts of Ecology. Prentice Hall
8. Kumar,H.D.Modern Concepts of Ecology. Vikas Publishing House.
9. Mukherjee,B. Environmental Biology.TMH
10. Odum,E.P. Ecology. Amerind Pub.Co.
11. Odum,E.P. Fundamentals of Ecology. Natraj Publishers
12. RKBhandani, An over view on natural &man-made disasters and their reduction, CSIR,
13. Sharma,P.D.Ecology and Environment. Rastogi.
14. Sing,H.R. Introduction of Animal Ecology. S.Chand &Co.
15. Stiling,P. Ecology Theories and Applications. PHI
16. Verma,P.S. and Agarwal, V.K. Environmental Biology. S.Chand &Co.
17. Wright, R.T. Environmental Science.PHI

SEMESTER II
Core Course Zoology III

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1242.2	**Practical Zoology-I** (Practical of BV1141.2 & BV1241.2)	**2**	Practical hours of BV1141.2 & BV1241.2

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should be trained to conduct the experiments and familiarize with the specimens and permanent slides related to the organisms.
CO 2	Practical classes should train the students to conduct the morphological studies with live or preserved specimens.
CO 3	Students should learn to handle the specimens of their study should conduct experiments related to dissections of the specimens and study the anatomy.

1. Study of permanent slides / specimens

Protista (2), Sponges (1), Coelenterata (4), Platyhelminthes (2), Aschelminthes (2), Annelida (2), Arthropoda (4), Mollusca (2), Echinodermata (2), Hemichordata (1), Prochordates (2), Cyclostomata (1), Pisces (8), Amphibia (3), Reptilia (4), Aves (2), quill feather, Mammalia (2).

2. Osteology

Human skeleton: pectoral girdle, pelvic girdle, typical vertebra, atlas, axis.

3. Study of Animal anatomy Minor practical (any five)

1. Nereis : Parapodiummounting
2. Earthworm : mounting ofsetae
3. Penaeus : mountingofappendages
4. Cockroach : mountingofmouthparts,salivaryapparatus(insitu)
5. Shark : Placoidscalemounting
6. Mackerel : Cycloidscalemounting(minor)
7. Mullet : Ctenoidscalemounting(minor)

4. Major practical (any two)

1. Earthworm - Nervoussystem
2. Cockroach - Digestivesystem
3. Prawn - Nervoussystem

SEMESTER III
Core Course Zoology IV

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1341.2	**Developmental Biology & Reproductive Biology**	**3**	**36**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should acquire a basic understanding about the historic perspective of developmental process by studying this course.
CO 2	By studying the course students should understand the developmental pattern fertilized egg to and embryo with different stages and its peculiarities.
CO 3	Students will be able to talk about the biological events leading to the development of egg, sperm , fertilization and development of embryo with clarity.
CO4	It should make the student to understand the practical application of embryology in medicines , medical and industrial biotechnology

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Module I **8 hrs**

Introduction and developmental processes

1. Historical perspective- preformation, epigenesis, germplasm and biogenetic law;
2. Aim and scope of Developmental Biology
3. Egg: structure of a typical egg; classifications based on the amount and distribution of yolk; polarity and egg envelopes.
4. Cleavage: types –holoblastic and meroblastic; meridional, equatorial, vertical and latitudinal; patterns– radial, spiral, bilateral, rotational; morula stage; celllineage.
5. Blastulation: types of blastula –stereoblastula, coeloblastula, discoblastula, periblastula, blastocyst.
6. Fatemap: Definition, presumptive organ forming areas.
7. Gastrulation: Definition; definition and types of morphogenetic movements – epiboly, emboly, invagination, involution, delamination, convergence, divergence. Germ layers and fate of germ layers.
8. Cell Differentiation: potency- unipotency, pluripotency and toti potency of embryonic cells, commitment, competence, determination and differentiation; stem cells.
9. Parthenogenesis

Module II 10 hrs

Animal development

1. Development of Amphioxus: cleavage, morula, blastulation, gastrulation.
2. Development of Frog: cleavage, morula, blastulation, gastrulation, neurulation, formation of notochord and mesoderm; organogeny of brain, eye and, heart.
3. Development of Chick: cleavage, blastulation, gastrulation; Study of Primitive streak stage and 24 hour embryo.
4. Embryonic membranes in mammals: Types and functions (development not required)
5. Senescence

Module III 6 hrs

Experimental Embryology

1. Fate map construction: vital staining, carbon particle marking and radioactive tracers.
2. Spemann's constriction experiments.
3. Nuclear transplantation in amphibians.
4. Embryonic induction: concept of induction and organizer; primary, secondary and tertiary induction and organizers.
5. Embryonic stem cells and stem cell research.
6. Cloning in animals

Module IV 12 hrs

Reproductive Biology

1. Reproductive cycles: oestrous and menstrual cycles and their hormonal control.
2. Gonads: Ovary, Graafian follicle, ovulation.
3. Gametes: structure of ovum and spermatozoa.
4. Gametogenesis: Spermatogenesis and oogenesis.
5. Fertilization: agglutination; activation of spermatozoa; activation of ovum;
6. Cell surface molecules in sperm- egg recognition; amphimixis; polyspermy.
7. Development of man: fertilization, blastocyst; implantation; brief account of pregnancy, gestation, parturition and lactation; teratology (definition).
8. Prenatal diagnosis- amniocentesis, chorionic villous sampling, ultrasound scanning.
9. Infertility: causes (male and female); Assisted Reproductive techniques –artificial insemination, *in vitro* fertilization, surrogate birth, and embryo transfer (in farm animal sandman); test-tube babies.
10. Fertility control: contraception, birth control methods; abortion and MTP.

Suggested Readings

1. Arora, MohanP. Embryology. Himalaya Publishing House.
2. Arumugam, N. Developmental Zoology. SARASPub.
3. Balinsky, B.I.An Introduction to Embryology. Thomson Books
4. Bejley, D.J.etal. Human Reproduction & Developmental Biology. McMillan
5. Berril,N.J.& Karp,G.*Development*.TMH.
6. Gayatri Prakash. Reproductive Biology. Narosa Pub. House
7. Gilbert, S.F.*Developmental Biology*. Sinauer Associates.
8. Majumdar, N.N.Text book of Vertebrate Embryology.TMH
9. McEven. *Vertebrate Embryology*. Oxford and IBH
10. Patten, B.M. *Early Embryology of the Chick* .TMH.
11. Patten, B.M. *Foundations of Embryology*. Mc Graw Hill.
12. Rao, K. Vasudeva. Developmental Biology A Modern Synthesis. Oxford IBH
13. Rugh, R. *Frog Reproduction and Development*.
14. Verma, P.S. and Agarwal V.K.Chordate Embryology. S. Chand and Co.

SEMESTER III
Core Course Zoology V

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1342.2	**Animal Diversity - Chordata**	**2**	**36**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should acquire a basic understanding about the historic perspective of developmental process by studying this course.
CO 2	By studying the course students should understand the developmental pattern fertilized egg to and embryo with different stages and its peculiarities.
CO 3	Students will be able to talk about the biological events leading to the development of egg, sperm, fertilization and development of embryo with clarity.
CO4	It should make the student to understand the practical application of embryology in medicines , medical and industrial biotechnology

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I **2 hrs**

Introduction

Chordate characters (diagnostic, general and advanced); comparison of chordates and non-chordates,

Sub phylum 1. Urochordata (Tunicata)
General characters
Examples: *Ascidia* (morphology and metamorphosis), *Oikopleura, Salpa*

Sub phylum 2. Cephalochordata

General characters
E.g. *Amphioxus*

Module II **6 hrs**

Sub phylum 3. Vertebrata, General characters

Division 1 Agnatha , General Characters

Class Cyclostomata: e.g.: *Petromyzon* (mention ammocoete larva)

Division 2 Gnathostomata, General characters

Super class Pisces, General characters

Class Chondrichthyes (Cartilaginous fishes)

Sub class Elasmobranchii: *Scoliodon* (morphology, structure of placoid scale and development), *Narcine,*

Sub class Holocephali: *Chimaera*

Class Osteichthyes (Bony fishes)

Sub class Choanichthyes

Order 1. Crossopterygii (coelacanths): *Latimeria*

Order 2. Dipnoi (lung fishes): *Protopterus, Lepidosiren,* and *Neoceratodus* (comment on distribution of lung fishes)

Sub class Actinopterygii

Super order1. Chondrostei*: Acipenser*

Super order 2. Holostei: *Lepidosteus*

Super order 3.Teleostei: *Clarias, Anabas, Saccobranchus, Etroplus, Mugil, Echeneis, Sardinella, Rastrelliger*

Accessory respiratory organs in fishes

Module III **2 hrs**

Super class Tetrapoda, General characters

Class Amphibia, General characters

Order Apoda: *Ichthyophis*

Order Urodela (Caudata): *Ambystoma* (mention Axolotl larva and neoteny)

Order Anura: Frog (*Rana*), *Bufo, Hyla, Rhacophorus*

Module IV **4 hrs**

Class Reptilia, General characters

Sub class1.Anapsida

Order Chelonia: *Chelone*

Sub class 2. Parapsida: *Ichthyosaurus*

Sub class3. Diapsida

Order1. Rhynchocephalia: *Sphenodon*

Order2. Squamata

Sub order1.Lacertilia: Calotes, *Hemidactylus, Chamaeleon,, Draco*

*S*ub order2. Ophidia: *Typholops, Dryophis, Ptyas, Naja, Bungarus, Enhydrina,* Viper

Order3. Crocodilia: *Crocodylus, Alligator*

Sub class 4.Synapsida: *Cynognathus*

Identification of poisonous snakes using identification key

Module V **4 hrs**

Class Aves, General characters

Sub class 1. Archaeornithes: *Archaeopteryx* (brief account and affinities)

Sub class 2. Neornithes

Super order 1.Palaeognathae (=Ratitae)

Examples: *Apteryx* (kiwi), *Struthio* (ostrich), Emu

Super order 2. Neognathae (=Carinatae)

Examples: peafowl, sparrow (*Passer*), Crow, koel, parrot, pigeon, Kite, *penguin*, vulture, owl, hornbill

Flight adaptations in birds, Migration of birds

Module VI

Class Mammalia
General Characters
Homo sapiens– detaied study of anatomy (exclude skull, arteries, veins and nerves)

Subclass 1.Prototheria : Platypus (*Ornithorhynchus*), *Tachyglossus* (= *Echidna*)
Subclass 2. Metatheria : Opossum (*Didelphis*), Kangaroo (*Macropus*)
Subclass3. Eutheria

Order1. Pholidota pangolin(*Manis*)
Order 2. Lagomorpha rabbit (*Oryctolagus*), hare (*Lepus*)
Order 3. Rodentia Rat (*Ratus*)
Order 4. Insectivora hedgehog (*Paraechinus*),*Suncus*(=*Crocidura*)
Order 5. Chiroptera *Pteropus,Vampyri*
Order 6. Primata
Order 7. Carnivora
Order8. Cetacea
Order9. Artiodactyla
Order10 Perissodactyla
Order 11. Sirenia
Order 12. Proboscidea
Macaca, Gorilla, Pongo, Hylobates, Homo
Seal (*Phoca*), walrus (*Odobenus*),*Panthera(=Leo)* sps, *Canis*,
Herpestes
Delphinus (dolphins), *Balaenoptera* (baleen whale) Giraffe, *Hemitragus* (tahr), Camel, Hippopotamus *Equus* (horse), *Rhinoceros*
Dugong
Elephasmaximus indicus (Indian elephant), *Loxodontaafric ana* (African savanna elephant), *Loxodonta cyclotis* (African forest elephant)
Aquatic mammals and their adaptations

Suggested Readings

1. Bhaskaran, K.K. & BijuKumar,A. *Chordate Zoology*, Manjusha Pub.
2. Chaudhury,S.K. *Concise Medical Physiology*, NCBA
3. Daniel,J.C. *The Book of Indian Reptiles and Amphibians*. BNHS-OUP
4. Dhami,P.S.& Dhami, J.K. *Chordate Zoology.* R. Chand & Co
5. Ekambaranatha Ayyar, M. & Ananthakrishnan, T.N. *A Manual of Zoology*. *Vol.IIPartI& II*
6. Guyton and Hall *A Textbook of Medical Physiology*
7. Induchoodan. *Keralathile Pakshikal*. Kerala Sahitya Academy, Trichur
8. Jordan,E.L.& Verma, P.S. *Chordate Zoology.*S. Chand & Co, New Delhi
9. Kardong,K.V.*Vertebrates.*
10. Kotpal,R.L. *Modern Textbook of Zoology*: *Vertebrates.* RastogiPub.
11. McMinnR.M.H.*etal* A Colour Atlas of Human Anatomy, Wolfe
12. Parker and Haswell. *A Textbook of Zoology Vol.II*
13. Prater,S.H.*The Book of Indian Animals*. BNHS-Oxford
14. SalimAli. *BirdsofKerala*.OUP
15. SalimAli.*TheBookof IndianBirds*.BNHS-Oxford
16. Sedgwick.*StudentsTextbookofZoology,Vol.II*
17. Sharma, B.D.*IndianPoisonousSnakes.*Anmol Publications,NewDelhi
18. Sherwood,L.*Principles of Human Physiology*, Brooks/ Cole
19. Thangamani, A.etal.A Textbook of Chordates, SARAS Pub.
20. Young, J.Z. *Life of Vertebrates.* Clarendon Press, Oxford

SEMESTER IV
Core Course Zoology VI

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1441.2	**Animal Physiology**	**2**	**36**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	At the end of the course students should acquire a basic knowledge on basic physiological process of animals in general.
CO 2	Studying should learn details of the biochemical process behind the physiological process of cellular respiration and Nutrition at the end of this course.
CO 3	Students will be able to talk about the physiology and biochemistry of circulatory system, functioning of heart and other related processes in general.
CO4	By attending this course students should be able to talk confidently about the nervous system, neurons, and nerves and the functioning of the nervous system

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I — 4 hrs

Nutrition: Types of nutrition; Mechanical and chemical digestion of carbohydrates, proteins and fats; hormonal control of digestion; absorption mechanism; BMR Vitamin deficiency diseases.

Module II — 4 hrs

Respiration: respiratory pigments and their role; gas transport – oxygen and CO_2 transport; Oxyhaemoglobin curve; Bohr effect; Carbon monoxide poisoning. Physiological effects of smoking

Module III — 8 hrs

Circulation: Body fluids – importance and types; closed and open types of circulatory system; **Blood Composition and functions**; blood groups –A B O and Rh systems, M N, Lewis and Bombay groups;

Blood clotting – intrinsic and extrinsic mechanisms and their factors; anticoagulants,

Heart: Detailed structure and types of heart – tubular and chambered; neurogenic and myogenic; pace makers and conducting system of human heart; cardiac rhythm; blood pressure; electro cardiogram.
Common cardiovascular diseases (hypertension, arteriosclerosis, myocardial infarction)

Module IV 8 hrs

Excretion: nitrogenous wastes; ammonotelic, ureotelic and uricotelic modes of excretion;
Structure of human Nephron; urine formation in human – detailed account with counter current system;
Normal and abnormal constituents of urine; hormonal regulation of renal function;
Dialysis and artificial kidney
Muscle physiology: types of muscles; ultra structure of striated muscle fibre;
Muscle contraction – theories of contraction; chemistry of contraction; neuro-muscular junction; fatigue: muscle twitch; latent and refractory periods; rigor mortis

Module V 12 hrs

Nerve Physiology: Sense organs- eyes, (physiology of vision), ear (structure and functions- hearing and balancing), olfactory organs and taste receptors;

Neurons: structure of a typical neuron; types of neurons; myelinated and non myelinated nerve fibres; structure and types of synapse; initiation and conduction of nerve impulse; neuro-transmitters; synaptic transmission; reflex action and reflex arc; EEG; Nervous disorders -epilepsy, Alzheimer's disease, Parkinson's disease.

Endocrinology: **hormones** – definition and types of hormones; mechanism of hormone action- at the levels of cell membrane, organelles and genes; positive and negative feedback regulation; structure and functions of endocrine glands – thyroid, parathyroid, thymus, islets of Langerhans, adrenal, pituitary, hypothalamus, pineal body, gonads and placenta; brief account of prostaglandins Hormonal disorders

Suggested Readings

1. Arora, MohanP. Animal Physiology. Himalaya Publishing House
2. Berry,A.K. A Text book of Animal Physiology, Emkay Publications.
3. BestandTaylor's Physiological Basis of MedicalPractice.West, J.B. (Ed.) B.I. Waverly.
4. Chatterjee, C.C. Human Physiology. Medical Allied Agency.
5. Guyton, A.C. and Hall, J.E. Text book of Medical Physiology. Harcour
6. Hill, R.W.,Wyse,G.A. and Anderson, M. Animal Physiology. Sinauer Associates.
7. Hoar,W.S. General and Comparative Animal Physiology.PHI.
8. Kay,Jan. Introduction to Animal Physiology. Bios Scientific Publishers.
9. Mariakuttikan and Arumugam, N. Animal Physiology. Saras Publication
10. Moyes, C.D. and Schulte, P.M. Principles ofAnimal Physiology. Pearson Education
11. Moyes,C.D.and Schulte,P.M. Principles of Animal Physiology. Pearson Education
12. Nagabhushanam,R.etal. Textbook of Animal Physiology. Oxford&IBHS
13. Oser,B. Hawk's Physiological Chemistry.TMH.
14. Oser,B.Hawk's Physiological Chemistry.TMH.
15. Rastogi,S.C. Essentials of Animal Physiology. Wiley Eastern Ltd.
16. Schmidt-Nielsen, K. Animal Physiology Adaptation and Environment. Cambridge Uni.Press.
17. Schmidt-Nielsen,K. Animal Physiology Adaptation and Environment. Cambridge Uni.Press.
18. Sebastian, M.M. Animal Physiology. Madonna Books, Kottayam
19. Verma,P.S.Tyagi,B.S.and Agarwal, V.K. Animal Physiology. S .Chand &Co.
20. Voet,D.andVoet,J.G. Biochemistry. JohnWiley & Sons
21. Voet,D. and Voet,J.G. Biochemistry.John Wiley & Sons

SEMESTER IV
Core Course Zoology VII

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1442.2	**Cell Biology**	**2**	**36**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	At the end of the course students should acquire a basic knowledge on basic physiological process of animals in general.
CO 2	Studying should learn details of the biochemical process behind the physiological process of cellular respiration and Nutrition at the end of this course.
CO 3	Students will be able to talk about the physiology and biochemistry of circulatory system, functioning of heart and other related processes in general.
CO4	By attending this course students should be able to talk confidently about the nervous system, neurons, and nerves and the functioning of the nervous system

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I **2 hrs**

History and scope of Cell Biology; Discovery of cells. Cell theory and its modern version, General classification of cell types: prokaryotes and eukaryotes, PPLOs, bacteria, plant cell and animal cell

Module II **8 hrs**

1. Cell membrane – Chemical composition, ultra structure, Fluid mosaic model, modifications and functions; transmembrane transport, cell signaling and signal transduction.
2. Structure and function of cell organelles –Endoplasmic reticulum: morphology, types, formation and functions.
3. Ribosomes: Types, sub units and functions. Golgibodies –morphology, types, formation and functions.
4. Lysosomes: morphology, classification, polymorphism and functions.
5. Centrioles: structure and functions.
6. Mitochondria: structure and functions; (mention oxidative phosphorylation and electron transport).
7. Microbodies: Morphology, peroxisomes, glyoxisomes and functions. Cytoskeleton: microtubules, microfilaments and intermediate filaments.
8. Interphase Nucleus – structure and function Nuclear membrane: pores and pore complex; nuclear lamina; Nucleoplasm: nature and importance,
9. Nucleolus: structure; nucleolar organizer and functions.

10. Chromatin: Euchromatin and heterochromatin

Module III 8 hrs

1. Chromosomes: Chemical composition; structure of a typical metaphase chromosome; centromeres, telomeres, nucleosome organization.
2. Classification of chromosomes; Giant chromosomes (polytene and lampbrush chromosomes; endo mitosis); chromosome banding pattern
3. Chromosomal aberrations: Variations in number and structure.

Module IV 9 hrs

1. Cell cycle: G_1, S, G_2 and M phases (mention G_0 and D_0 stages and their significance) Mitosis: description of all stages.
2. Meiosis: description of all stages; synaptonemal complex and its significance.

Module V 9 hrs

1. Cell differentiation: General characteristics; apoptosis, necrosis.
2. Cancer Cells: characteristics of cancer cells;
3. Types of tumor;
4. Factors responsible for cancer

Suggested Readings

1. Alberts, B. *etal. Molecular Biology of the Cell.* Garl and Science.
2. Arumugam N, Cell Biology, SARAS Pub.
3. Bhaskaran, K. K.& BijuKumar, A. Cell Biology, Gnetics and Molecular Biology, Manjusha Pub.
4. De Robertis, E.D.P.and De Robertis, E.M.F. *Cell and Molecular Biology*, Lippincott Williams and Wilkins
5. Gupta,P.K. *Cell and Molecular Biology*, Rastogi Pubs., Meerut.
6. Karp,Gerald. *Cell and Molecular Biology*. John Wiley and Sons
7. Lodish, Harvey *etal. Molecular Cell Biology*. Scientific American Books
8. Powar,C.B. *Cell Biology.* Himalaya Publishing House.
9. Sadava, D.E.*Cell Biology*. Jones and Barlette Publishers.
10. Sharma,A. *Chromosomes*, Oxford & IBH
11. Wolfe,S.L. *Molecular and CellularBiology*.Wads worthPub. Co.
12. Verma,P.S.& Agarwal,V.K. *Cytology*, S.Chand&Co.

SEMESTER IV
Core Course Zoology VIII

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1443.2	**Practical Zoology II** (Practical of BV1341.2, BV1342.2, BV1441.2 & BV1442.2)	**2**	**Practical hours of BV1341.2, BV1342.2, BV1441.2 & BV1442.2)**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	At the end of the course students should acquire a basic knowledge to conduct and experiments and understand the samples of cell biology.
CO 2	Students should learn various types of genetic problems and details of cytogenetics using experimental samples .
CO 3	Students will be able to do and understand the development of egg and embryology of frog and embryo development through slides and samples.
CO4	Students should be able to conduct the listed experiments and exercises of animal physiology practical syllabus .

Course Content

Cell Biology

1. Measurement of size of microscopic objects using ocular and stage micrometers
2. Study of different types of cells (prokaryotes and eukaryotes) using slides / models / charts,
3. Study of cytoplasmic organelles and cell inclusions (through permanent slides, models and charts)
4. Study of Interphase nucleus in human buccal smear and Barr bodies.
5. Study of mitochondria in insect flight muscles /human buccal smear,
6. Study of stages of mitosis–squash preparation of onion root tip,
7. Calculation of mitotic index and metaphase index in onion root.

Genetics

1. Study of monohybrid ratio using colored beads,
2. Study of normal chromosome complement and karyotype of man,
3. Preparation of karyo ideogram from microphotographs
4. Study of abnormal karyotypes and genetic syndromes of man (Down syndrome,Turner's syndrome and Klinefelter's syndrome)
5. Construction of pedigree chart–any two

6. Frequency of genetic traits in humans: blood groups, eye colour, widow's peak (any two traits).

Developmental Biology (charts / models / permanent slides)

1. Study of different types of eggs: frog, chick and man.
2. Frog development: Cleavage, Blastula, Gastrula
3. Chick embryology: Primitive streak stage and 24 hours embryo.

Physiology

1. Paper partition chromatography of amino acids (3 amino acids and a mixture) Blood smear preparation – identification of leucocytes
2. Determination of human blood group– A, B, AB and O, and Rh+ and Rh-
3. Osmotic properties of RBCs– effect of isotonic, hypotonic and hypertonic solutions.
4. Activity of human salivary amylase on starch
5. Detection of Abnormal constituents of urine (glucose and albumin)

SEMESTER V
Core Course Zoology VIII

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1541.2	**Systematics, Biodiversity & Animal Behavior**	**3**	**54**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should be able to understand systematic related to animal Kingdom, scientific methods of Nomenclature and various types of classifications of animals.
CO 2	Students should learn details of the biodiversity related to animals and ecosystems and its relations to Biodiversity, animal plant interactions, material cycles and energy flow.
CO 3	After completing this course students should be able to teach about animal behavior and its importance in human social systems.
CO4	By attending this course students should be able to talk confidently about the various aspects of systematic and taxonomy , animal behavior and Biodiversity and ecosystem.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I — 8 hrs

Systematics

Introduction: definition of classification, taxonomy and Systematics;

Nomenclature - binomial and trinomial nomenclature; International rules of Zoological nomenclature (brief account).

Principles of classification: Procedures and rules of Taxonomy; hierarchy, taxon, phenon, category; concept of species and subspecies.

Methods of Systematics: numerical taxonomy (phenetics), cladistics (phylogenetic Systematics), evolutionary classification and molecular systematics,

Module II — 10 hrs

Biodiversity

Introduction: definition; global biodiversity, biodiversity of India; levels of biodiversity – species diversity, community and ecosystem diversity and genetic diversity; types of biodiversity – alpha, beta and gamma diversities; species diversity and ecosystem stability; keystone species.

Biodiversity hotspots: Global biodiversity hotspots; Indian region (Western Ghats, SreeLanka, Eastern Himalaya & Indo-Burma)

Threats to biodiversity: habitat modification, pollution and poaching; invasive species . Loss of biodiversity and its causes

Biodiversity Convention: IUCN categories and Red Data Book.

Module III 8 hrs

Ethology (Animal Behavior)

Introduction: History and scope of animal behavior, methods used in Ethology

Stimulus and Response: Stimulus-response theory; stimulus filtering; fixed action pattern; innate releasing mechanism; sign stimulus and social signal (social releasers).

Behavior patterns, behavior systems and social behavior (definitions)

Categories of behavior systems (definition and examples): shelter seeking, agonistic, ingestive, sexual, care giving, care soliciting, eliminative, allelomimetic and investigative behavior.

Module IV 18 hrs

Instinctive behavior: definition; characteristics of instinctive behavior; comparison of instinct and learning; adaptive advantage.

Learning: types of learning; habituation; reflexes, latent learning, insight learning and imprinting. Physiology of learning,

Motivation: goal oriented behavior and drive; models of motivation (Deutsch's model and Lorenz's psycho hydraulic model).

Module V 10 hrs

Circadian rhythm: definition; biological clock; chrono biology; role of pineal gland. Hormones and behavior (brief account).

Socio biology: social groups– merits and demerits; properties of societies; Societies in honey bee and elephants.

Pheromones: types of pheromones; chemical nature of pheromones; human pheromones.

Suggested Readings:

1. Agrawal, K.C. Biodiversity, Agrobios
2. Alcock, J. Animal Behaviour. Sinauer Associates.
3. Ananthakrishnan T. N. Animal Biodiversity Patterns and Process. Scientific Publishers
4. Animal Behaviour, Rastog I & Co., Meerut.
5. Arora, Mohan P. Animal Behaviour. Himalaya Publishing House
6. Boulenger, E.G. Animal behaviour, Atlantic Pub.& Distributors
7. Dethier,V.G.and Stellar,E. Animal Behaviour
8. Dewsbury,D.A. Comparative Animal Behaviour. Mc Graw Hill Book Co.
9. Donald, L.S.Principles and Techniques of Contemporary Taxonomy.
10. Eibl- Eibes feldt,I.Ethology:The Biology of Behaviour
11. Kapoor,V.C. Theory and Practice of Animal Taxonomy, Oxford & IBH
12. Kumar,Vinod. Animal Behaviour. Himalaya Publishing House Reena Mathur.
13. Manning, A. and Dawkins,M.S. An Introduction to Animal Behaviour. Cambridge University Press.
14. Mayr,E. Principles of Systematic Zoology, TMH
15. Prakash M.etal.Recent Advances in Animal Behaviour.7 Vols., Anmol.
16. Ranga, M.M. Animal Behaviour. Agrobios

17. Scott, John Paul. Animal Behaviour.
18. Singh, Harjindra.Text book of Animal Behaviour. Anmol Publishers
19. Slater, P.J.B.EssentialsofAnimalBehaviour.CambridgeUniversityPress
20. Wood Gush, D.G.M. Elements of Etholog

SEMESTER V
Core Course Zoology IX

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1542.2	**Genetics**	**4**	**90**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	By undergoing this course Students should be able to understand the Mendal and his work which resulted in the major principles of Genetics. They should understand the importance of classic genetics and its modifications.
CO 2	Students should learn about the multiple alleles and its examples from different characters. They should know polygenic characters, genetics of blood grouping etc.
CO 3	After completing the course students should be aware of genetic phenomenon like Linkage, crossing over, recombination, Mutations, Types of mutation, and Extra chromosomal inheritance.
CO4	By studying this course students should understand the chromosomal and genetic basis of sex determination, autosomes, sex chromosomes, karyotyping of human, pedigree analysis, chromosome basis of genetic diseases.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I — 18 hrs

Mendelian Genetics: Mendel and his experiments; Mendelian laws of inheritance.

Genetic terminology: gene, allele, genotype, phenotype, genome; wild type and mutant type; testcross, backcross and reciprocal cross.

Gene interactions: Allelic- incomplete dominance; codominance; lethal genes.

Non-allelic- complementary genes; epistasis; co-epistasis, dominant (feather coat) and recessive (coat colour),

Polygenic or quantitative inheritance: skin colour in man.

Multiple alleles: blood group alleles –A B O system and its inheritance.

Module II — 18 hrs

Linkage, crossing over and recombination: linked genes, linkage group; complete and incomplete

linkage; chromosome theory of linkage; crossing over – mechanism and kinds of crossing over; significance of crossing over; sex linkage; chromosome mapping (brief account).

Mutations: Types of mutations: somatic and germinal, spontaneous and induced, autosomal and allosomal, chromosomal and gene mutation; molecular basis of mutation; induction of mutation – physical and chemical mutagens.

Extra chromosomal inheritance: maternal effects in Drosophila, mitochondrial DNA and kappa particles in Paramecium.

Module III **18 hrs**

Sex determination: autosomes and sex chromosomes; Barr bodies and Lyon's hypothesis; Chromosomal basis of sex determination (XX-XY, XX-XO, ZZ-ZW types); Genic balance theory; sex mosaics; environmental control of sex determination; intersex, gynandromorphs,

Sex-linked, sex-limited and sex-influenced inheritance

Module IV **18 hrs**

Concept of gene: structural and functional concept; genome; split genes; introns and exons; overlapping genes; transposable elements; pseudo genes.

Genetics of development: role of gene in development; homeotic genes and Hoxgenes; transgenics and knock out mutations.

Module V **18 hrs**

Human genetics

Karyotyping: human chromosome complement; pedigree analysis.

Chromosomal anomalies and human disorders– autosomal anomalies-Down's syndrome, Edwards syndrome; Sex chromosome anomalies- Klinefelter's syndrome, Turner's syndrome.

Sex linked disorders: Colour blindness, Haemophilia

Biochemical Genetics-albinism, alkaptonuria, phenylketonuria and sickle cell anemia (brief account).

Eugenics and Genetic counseling

Human Genome Project

Suggested Readings

1. Ahluwalia, K.B. *Genetics*. New Age International (P)Ltd. Publishers
2. ArumugamN, Genetics, SARAS Pub.
3. Burns,G.W.& Bottino,P.J. *TheScience of Genetics*. MaxwellMcMillan
4. CurtStein. *Principles of Human Genetics*.Euresia Publishing House
5. Gardner,E.J.et al. *Principles of Genetics*. JohnWiley & Sons.
6. Goodenough, U. *Genetics*.Halt, Reinharts & Winston
7. Gupta,P.K. *Cytogenetics*. Rastogi & Co.
8. Sarin,C. *Genetics*.TMH

9. Sinnott,W.E., Dunn,L.C. and Dobzhansky, T. *Principles of Genetics*
10. Verma,P.S.& Agarwal,V.K. *Genetics,* S.Chand&Co.

SEMESTER VI
Core Course Zoology X

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1641.2	**Evolution**	**2**	**90**

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	By undergoing this course Students should be able to understand the Mendal and his work which resulted in the major principles of Genetics. They should understand the importance of classic genetics and its modifications.
CO 2	Students should learn about the multiple alleles and its examples from different characters. They should know polygenic characters, genetics of blood grouping etc.
CO 3	After completing the course students should be aware of genetic phenomenon like Linkage, crossing over, recombination, Mutations, Types of mutation, and Extra chromosomal inheritance.
CO4	By studying this course students should understand the chromosomal and genetic basis of sex determination, autosomes, sex chromosomes, karyotyping of human, pedigree analysis, chromosome basis of genetic diseases.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**understanding**	**apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I

10 hrs

Geological time scale: various eras, periods and epochs with characteristic fauna.

Fossils: dating of fossils; significance of fossils.

Module II **8 hrs**

Origin of Life: origin of basic biomolecules, proteinoids, coacervates and microspheres; concept of Oparin and Haldane;

Experiment of Miller

Module III **10 hrs**

Evidences of organic evolution- morphological, embryological, palaeontological, biochemical, physiological, and biogeographical;

Living fossils

Module IV **18 hrs**

Early Evolutionary thoughts: Theories and their criticism– Lamarckism, Darwinism, Mutation theory.

Population genetics: gene pool and gene frequencies; Hardy- Weinberg law. Genetic polymorphism and its evolutionary significance,

Genetic load and genetic death

Factors that change gene frequency: Evolutionary forces – natural selection and genetic drift. Other factors– migration, bottle neck effect and founder effect

Module V **18 hrs**

Process of Evolution

Modern synthetic theory: Development; concepts; operation (variations, natural selection, isolation, speciation).
Variations– nature and sources- recombination, chromosomal variations, gene mutations,
Natural selection: significance; types– stabilizing, directional, and disruptive selection.
Isolation: Isolating mechanisms– types and significance
Speciation: types and process

Module VI **8 hrs**

Products of Evolution

Evolution of Biosphere (anaerobic and aerobic metabolism, photosynthesis, oxygen build up and its consequences), Origin of Prokaryotes and Eukaryotes, Evolution of eukaryotic organelles (mitochondria and chloroplast)

Evolution of man (brief accounts of Ramapithecus, Australo pithecus, Neanderthal man, Cromagnon and Modern man)

Module VII **12 hrs**

Tempo of evolution

Micro evolution, macro evolution, mega evolution, quantum evolution, gradualism, punctuated equilibrium,

Molecular evolution: rates of molecular change; evolutionary clocks.

Patterns of Evolution

Convergent evolution, Divergent evolution (Adaptive radiation), Coevolution, Parallel evolution, Orthogenesis, Orthoselection, Anagenesis, Cladogenesis, and preadaptation

Adaptive radiation in Darwin's finches

Module VIII **6 hrs**

Populations and Evolution,

Mimicry: Batesian and Mullerian mimicry and their significance.

Altruism; kin selection; sexual selection

Suggested Readings

1. Arora,MohanP.*Evolutionary Biology.* Himalaya Publishing House
2. Arumugam,N. *Organic Evolution.* SarasPublications.
3. Darwin,C. *TheOrigin of Species*, OUP.
4. Dobzhansky, T.*etal*: *Evolution*, Surjeet Pubn., Delhi.
5. Dobzhansky, T.*Evolution, Genetics and Man.* John Wilkey
6. Dobzhansky,T.*Genetics and the Origin of Species,* ColumbiaUty. Press.
7. Hall,B.K.and Hallgrimson, B. *Strickberger's Evolution.*.
8. Kardong,K.V.*An Introduction to Biological Evolution.* McGrawHill.
9. Lull,R.S. *Organic Evolution.* Light Life Publication
10. Marshall,J. *Evolution*. McMillan Publishing Co.Inc.N.Y.
11. Mayr,E. *Animal Species and Evolulation*. Academic Press
12. Moya, A. and Font, E. *Evolution from Molecules to Ecosystem.* OUP
13. Rastogi,V.B. *Organic Evolution.* KedarNathRamNath
14. Savage,J.N. *Evolution Process and Product*. Affiliated EastWest Press,NewDelhi
15. Simpson,G.G.*The Major Features of Evolution*. Columbia University Press
16. Stebbins,G.L.*Process of Organic Evolution*. Prentice HallEast WestPress, NewDelhi

SEMESTER VI
Core Course Zoology XI

Course Code	Title of the Course	Credits	Total Contact Hours
BV 1642.2	**Practical Zoology** (Practical of BV1541.2, BV1542.2 & BV1641.2)	**3**	Practical hours of BV1541.2, BV1542.2 & BV1641.2 (**72 hrs**)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should be trained to carry out t5he following experiments and demonstrations by undergoing this practical courses.
CO 2	Students should be trained to conduct the practical by themselves during the respective courses of BV1541.2, BV1542.2 & BV1641.2
CO 3	Students should be trained to identify the organisms and give the taxonomic positions and classification with correct binomial nomenclature.
CO4	Students should be made to understand the theories of evolution with the help of available living data and fossil evidences. They also should be trained to understand the ecosystem, environmental factors and importance of microorganisms that keep the environment clean and healthy by making them to understand BOD COD etc,

Course Content

1. Preparation of dichotomous key up to Orders/Families for identification of any two groups (insects /mollusks /fishes /snakes)
2. Identification (Generic and specific name) and systematic position of animals belonging to different groups and habitats of the locality (based on slides, specimens, photos or figures). Non- chordates (Coelenterates /Crustaceans /Insects /Molluscs): 10;
3. Chordates (fishes/ Snakes/ Birds/ Mammals):10
4. Study of models /charts /specimens related to any four of the following:

   Homologous organs (limbs of 5 different groups of vertebrates) Analogous organs (wings of bird, insect and bat)
5. Vestigial organs in humans (any four)
6. Connecting links (*Archeopteryx* and *Peripatus*)
7. Adaptive radiation in reptiles /mammals /Darwin's finches Evolution of man based on three hominid fossils
8. Study of food web (Construction and comment)

9. Estimation of dissolved oxygen in two samples of water.
10. Estimation of dissolved carbon dioxide in two samples of water.
11. Demonstration of primary productivity by light and dark bottles.
12. Determination of pH of different sample solutions using indicator paper or pH meter.
13. Determination of concentration of unknown solutions (nitrates/sulphates) using photo colorimeter / spectrophotometer
14. Extraction of soil insects by Berle's funnel Demonstration).
15. Alarm pheromones in insects (Demonstration).

Field study / Study tour

- Field trip and /or Study Tour are a compulsory element of the curriculum.
- The students are required to visit different ecological habitats and /or places or institutions of biological interest for not less than 5 days.
- The study is preferably spread over the first, second and third years. They are expected to visit Research Institutes / Wildlife sanctuaries / Zoological Museums / Zoos / ecosystems/local areas of biological interest. A detailed report of the field study/study tour specifying the habitats, places and institutions visited, date and time of visit, details of observations made, description of the observed fauna etc. must be submitted by each student fore valuation on the day of practical examination of Semester VI.
- The Study tour/ Field study report is compulsory for each student appearing for practical examination.

Core Courses

Chemistry

SEMESTER I
Core Course Chemistry I

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1142	**Inorganic Chemistry I**	**4**	**126** (T 90 + P36)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students will learn and understand the structure of atomic nucleus, properties of elements in relation to electronic configuration.
CO 2	They should learn the principles of chemical analysis of materials..
CO 3	Upon course completion, the student will be able to appreciate how the inner structure of elements dictates the chemical properties of elements.
CO4	They will learn how elements bond together to form compounds. Students will acquire basic laboratory skills required for chemical analysis and become familiar with data collection, record keeping and data analysis in a chemical laboratory.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Module I

Atomic Structure 21hrs

Introduction- Wave mechanical concept of the atom - Dual Character of electron- de Broglie equation - matter waves and electromagnetic waves - experimental verification of de Broglie relation - Heisenberg's uncertainty principle - expression and physical significance,
Schrodingers wave equation - Charge cloud and probability concepts - orbitals, radial and angular probability distribution curves, shapes of orbitals. Particle in a one- dimensional box, eigen functions and eigen values, Particle in a three dimensional box

Electronic Configuration and Periodicity

Quantum numbers - Pauli's exclusion Principle - Aufbau Principle – Hund's rule - Electronic

configuration of atoms - classification of elements into s, p, d, f blocks - atomic radii, ionization enthalpy, electron gain enthalpy and electronegativity- Pauling's scale, Mullikan and Alred - Rochow scale- ionic character - periodicity - horizontal, vertical and diagonal relationships - anomalous behaviour of the first element of a group.

Module II

Analytical Principles - I

21hrs

Qualitative Analysis - Common ion effect - solubility product - principle and procedure of elimination of interfering anions - precipitation of cations,

Quantitative Analysis - Calibration and use of apparatus and weights for titration.

Theory of titration - acid-base, redox, precipitation and complexometric titrations. Theory of indicators - acid-base, redox, adsorption and metallochromic indicators,

Gravimetric Analysis - Mechanism of precipitate formation - Factors affecting solubility of precipitates - coprecipitation and post precipitation - Effect of digestion - washing, drying and ignition of precipitates.

Chromatography - classification of methods - Elementary study of adsorption, paper, thin layer, ion exchange and gas chromatographic methods

Module III

Chemical bonding **21 hrs**

Ionic bond: ionic solids and their structures, Rock salt, Rutile, Zinc blend, Wurtzite, radius ratio effect and coordination number, limitations of Radius ratio rule-lattice energy of ionic compounds- Born-Lande equation, Born-Haber cycle, solvation energy and solubility of ionic solids- covalent character of ionic bond, Fajan's rules

Covalent bond- valence bond theory and its limitations- hybridization, VSEPR theory and its applications- structure of XeF_2, XeF_4, XeF_6, ClF_3, IF_5, IF_7, NH_3,H_3O^+ & H_2O
VB theory of H_2 molecule, MO theory, LCAO of H_2 ion, homonuclear diatomic molecules-C_2, B_2, N_2, O_2 and ions like O_2^+- heteronuclear diatomic molecules (HF, NO, and CO) – comparison of VB and MO theories, Polarity of Covalent bond- dipole moment- percentage ionic character- dipole moment and molecular structure

Module IV

Chemical Bonding II **21 hrs**

Metallic bonding- free electron theory, VB theory and band theory(Qualitative treatment only)- weak electrical forces – hydrogen bond, inter and intramolecular hydrogen bond, intermolecular interaction – induction forces and dispersion forces such as van der Waals forces, ion –dipole, dipole-dipole, ion-induced dipole, dipole-induced dipole, induced dipole- induced dipole interactions.

(a) Concepts of Acids and Bases
Arrhenius theory, Lowry – Bronsted theory, Lewis theory, Hard and soft acids and bases, the SHAB principle, relative strength of acids and bases, effect of solvent on acid and base strengths

(b) Evaluation of analytical data, Significant figures, types of errors. standard deviation, relative standard deviation, Student t test , F test, Q test.

Module V **21 hrs**

Nuclear Chemistry

Natural radioactivity, modes of decay, Geiger –Nuttal rule, artificial transmutation and artificial radioactivity- nuclear stability, n\p ratio, mass defect and binding energy, nuclear fission and nuclear fusion, elementary idea of subatomic particles like neutrino, anti neutrino - applications of radioactivity- C^{14} dating, rock dating , neutron activation analysis and isotopeas tracers

Module VI **21 hrs**

Non Aqueous Solvents

General properties- classification- self ionization and levelling effect- reaction in non-aqueous solvents- protic and aprotic non aqueous solvents- examples- solutions of metals in liquid ammonia- self ionization of liquid ammonia- liquid SO_2, liquid HF.

Suggested Readings

1) Manas Chanda, “Atomic structure and Chemical Bond including Molecular spectroscopy”
2) E.S. Gilreath “Fundamental concepts of Inorganic Chemistry”
3) Puri, Sharma and Kalia “Inorganic Chemistry”
4) Madan “Inorganic Chemistry”.
5) Manku , “Theoretical principles of Inorganic Chemistry” -
6) M. C. Dey and J. Selbin “Theoretical Inorganic Chemistry”.
7) F A Cotton and G. Wilkinson “Basic Inroganic Chemistry”.
8) A. I. Vogel, “Text book of Qualitative Analysis”
9) A. I. Vogel, “Text book of Quantitative Inorganic Analysis”.
10) A. K. Srivasthava and P. C. Jain, “Chemical Analysis”.

SEMESTER II
Core Course Chemistry II

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1243	**Inorganic Chemistry II**	**3**	**162** (T 108 + P 54)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students will learn this course as the continuation of the previous course and understand the peinciple of inorganic chemistry.
CO 2	They should learn the principles of inorganic chemistry with respect to Bioinorganic chemistry and about transition elements.
CO 3	Upon course completion, the student will be able to appreciate how inorganic chemistry important in the chemical analysis materials and chemical properties of elements.
CO4	It will prepare the students to pursue studies in the biochemical and molecular aspects of biology and biotechnology

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Course Content

Module I — 32 hrs

Transition and inner transition elements

Transition elements

Electronic configuration and general characteristics - Comparison of 3d, 4d and 5d transition series – Colour, catalytic activities and spectral properties with reference to d^1 to d^{10} systems. Preparation, properties and uses of $K_2Cr_2O_7$, $KMnO_4$ and $TiCl_4$.

Lanthanides and actinides

Lanthanides - electronic configuration and general properties – Occurrence and isolation of

lanthanides from monazite – Lanthanide contraction – Magnetic properties and complexation behaviour,
Actinides – Oxidation states, ionic radii, colour, complex formation in comparison with lanthanides.

Module II 30 hrs

Coordination Chemistry

Nomenclature – EAN rule – Chelates – Stability of complexes – Factors affecting stability of complexes – Isomerism – Structural and stereoisomerism – Geometrical and optical isomerism Bonding in complexes – V.B. Theory, CFT, M.O.Theory – Effect of crystal field splitting – CFSE – Spectrochemical series - Magnetic properties and colour of metal complexes – Application of coordination compounds in quantitative and qualitative analysis

Module III 25 hrs

Organometallic Compounds and Bioinorganic Chemistry

Organometallic Compounds

Definition – Nomenclature and classification – sigma complex – Pi complex – those containing both sigma and Pi bonds – 18 electron rule – Metal carbonyls – mononuclear and polynuclear (give examples of carbonyls of Fe, Co, Ni) – preparation and properties of carbonyls of iron and nickel – Bonding in organometallic compounds like ferrocene, dibenzene chromium, Ziese's salt – Dinitrogen complexes – Applicationof organometallic compounds.

Bioinorganic Chemistry

Role of metal ions in biological systems – Biochemistry of iron, haemoglobin and myoglobin (elementary idea of the structure and mechanisms of their actions) – Photosynthesis – Sodium-Potassium pump - Biochemistry of magnesium and calcium (brief study only)

Module IV 25 hrs

Compounds of non-transition elements

Manufacture and uses of the following
Glass – different types of glasses, Silicates, Zeolites and Silicones.

Inorganic Polymers

Phosphorus, boron and silicon based polymers – Structure and industrial applications.Borax - boron hydrides, boron nitrides, borazole and carboranes.

Oxides and oxyacids of phosphorus

Oxides and oxyacids of halogens (structure only) – Inter halogen compounds and pseudo halogens – Compounds of noble gases – Uses of noble gases

Refractory carbides, nitrides, salt-like carbides, borides, and silicides

Module V 25 hrs

Instrumental Methods of Analysis

Atomic absorption spectroscopy- flame emission spectroscopy- applications -spectrophotometry- laws of spectrophotometry- applications of spectrophotometry-colorimetry,thermal methods- introduction to TG, DTA and DSC- instrumentations and applications

Module VI 25 hrs

Chemistry of Nanomaterials

Evolution of Nanoscience – Historical aspects- Preparations containing nano gold in traditional medicine Lycurgus cup- Faraday's divided metal, Nanosystems in nature,

Preparation of nanoparticles: Top-down approaches and Bottom to top approach

Sol–gel synthesis, Colloidal precipitation, Co–precipitation, Combustion technique, Sonochemistry, Hydrothermal technique, High energy ball milling,

Carbon nanotubes and fullerenes

Suggested Readings

1. F. A. Cotton, G. Wilkinson and P. L. Gaus, "Basic Inorganic Chemistry" ; Willey
2. J. D. Lee, "Concise Inorganic Chemistry", ELBS
3. M. C. Day and Selbin,"Theoretical Inorganic Chemistry".
4. J. E. Huheey ,"Inorganic Chemistry- Principles and Structure and Reactivity".
5. H. S.Arniker, "Essentials of Nuclear Chemistry".
6. Sisler,"Non-aqueous Solvents".
7. E. S. Gilreath, " Fundamentals of Inorganic Chemistry" .
8. Willard, Merrit ,"Instrumental Methods of Analysis".
9. Shriver and Atkins,"Inorganic Chemistry" .
10. Bosolo and Johnson ,"Coordination Chemistry".

11. S. F. A. Kettle, “Coordination Chemistry”.
12. J. E. Hueey,“Inorganic Chemistry”.
13. 13 . T. Pradeep, “Nano, The Essentials”, Mc Graw- Hill Education.

SEMESTER II

Core Course Chemistry III

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1244	**Practical Chemistry I** (Practical of BV1142 & BV1243)	**2**	Practical hours of BV1142 & BV1243

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students will learn experiments of the course BV 1142 Principle of inorganic chemistry.
CO 2	They should learn the experiments of the principles of inorganic chemistry with respect to Bioinorganic chemistry of the course BV1243
CO 3	Upon course completion, the student will be able to appreciate how inorganic chemistry important in the chemical analysis materials and chemical properties of elements.
CO4	It will give a working knowledge on the analysis of inorganic compounds.

1. Volumetry

(a) Acidimetry and alkalimetry

Preparation of carbonate free sodium hydroxide- Use of constant boiling hydrochloricacid Titrations using (1) Strong acid – strong base (2) Strong base – weak acid (3) Strong acid, weak base, determination of Na_2CO_3 and $NaHCO_3$ in a mixture by indicator method and NH_3 in an ammonium salt by direct and indirect methods.

(b) Permanganometry

The following determinations are to be done using standardised permanganate solution

(1) Ferrous iron (2) Oxalic acid (3) Mohr's salt (4) Hydrogen peroxide (5) Calcium (6) Nitrte and (7) MnO_2 in pyrolusite

(c) Dichrometry

Determination of Ferrous iron using internal and external indicators and Ferric ironafter reduction with $SnCl_2$

(d) Cerimetry

Standardisation of ceric ammonium sulphate with Mohr's salt. Determination of oxalicacid using ceric ammonium sulphate

(e) Iodometry\Iodimetry

Standardisation of thiosulphate using KIO_3, electrolytic copper and potassium dichromate,

Determination of a copper salt

(f) Precipitation titration

Determination of chloride in neutral medium

(g) Complexometry (using EDTA)

Standardisation of EDTA solution with $ZnSO_4$ – determination of Zn, Mg, Ni and Ca –determination of permanent and temporary hardness of water

(h). Colorimetry (Using photo electric colorimeter)

Determination of Iron using thiocynate and ammonia using Nessler's reagent

Suggested Readings

1. F. A. Cotton, G. Wilkinson and P. L. Gaus, "Basic Inorganic Chemistry" ; Willey
2. J. D. Lee, "Concise Inorganic Chemistry", ELBS
3. M. C. Day and Selbin,"Theoretical Inorganic Chemistry".
4. J. E. Huheey ,"Inorganic Chemistry- Principles and Structure and Reactivity".
5. H. S.Arniker,"Essentials of Nuclear Chemistry".
6. Sisler,"Non-aqueous Solvents".
7. E. S. Gilreath, " Fundamentals of Inorganic Chemistry" .
8. Willard, Merrit ,"Instrumental Methods of Analysis".
9. Shriver and Atkins,"Inorganic Chemistry" .
10. Bosolo and Johnson ,"Coordination Chemistry".
11. S. F. A. Kettle, "Coordination Chemistry".
12. J. E. Hueey,"Inorganic Chemistry".
13. T. Pradeep, "Nano, The Essentials", Mc Graw- Hill Education

SEMESTER III
Core Course Chemistry IV

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1343	**Physical Chemistry I**	**3**	**180** (T 126 + P 54)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students will learn the different states of matter – solid, liquid and gas : and various theories dealing with properties and behaviour of the molecules and atoms
CO 2	They should learn the principles of Thermodynamics and group theory related to chemical reactions.
CO 3	Upon course completion, the student will be able to familiarizes with the important topics like defects in crystals and point groups of molecules like water.
CO4	Students become aware of the different states of matter, liquid crystals, basics of group theory and thermodynamic properties like entropy, enthalpy and free energy.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Course Content

Module I

Gaseous state and solid state **36 hrs**

Gaseous state

Ideal gas equation, Behaviour of real gases, Deviation from ideal behaviour, Compressibility factor, Boyle temperature - van der Waal's equation of state – derivation and importance, Virial equation of state, Collision frequency, Collision number, Collision diameter and mean free path.

Types of molecular velocities and their inter relations, Maxwell Boltzmann distribution of molecular velocities, Statement of equation and explanation (No derivation), Effect of temperature on most probable velocity, Derivation of root mean square, most probable and average velocities from the equation.

Critical phenomena: Isotherms of CO_2, continuity of states, Critical constants and their experimental determination, relation between critical constants and van der Waals constants.

Solid state

Isotropy and anisotropy, Space lattice and unit cell, Elements of symmetry of crystals, Bravais lattices, Crystal systems, Laws of crystallography, Miller indices, Representation of lattice planes of cubic crystals, Determination of Avogadro number from crystallographic data, X-ray diffraction studies of crystals, Bragg's equation – derivation and applications, Rotating crystal and powder method, Structure of NaCl and KCl Imperfections in crystals, point defects – Schottky and Frenkel defects, Non-stoichiometric defects.

Module II

Liquid state and Dilute solutions **36 hrs**

Properties of liquids: Surface tension and its measurement by capillary rise and stalagmometer method, factors affecting Surface tension, Viscosity, Poisuelle's equation, Determination of viscosity by Ostwald's viscometer, Refractive index and its determination by Abbe refractometer.

Dilute solutions: Molarity, Molality, Normality and Mole fraction. Colligative properties, relative lowering of vapour pressure Thermodynamic derivation of$\Delta T_b = K_b \times m$ and $\Delta T_f = K_f \times m$, Osmotic pressure, van't Hoff equation and molecular mass, Isotonic solutions,

Determination of molecular mass of solutes by Beckmann's method, Rast's method and cooling curve method, Abnormal molecular mass, van't Hoff factor, Determination of degree of dissociation and association

Module III

Thermodynamics I **36hrs**

Basic concepts- system, surroundings, types of systems. Extensive and intensive properties, macroscopic properties. State functions and path functions. Types of Processes, Zeroth law of thermodynamics

Definition of internal energy and enthalpy. Heat capacities at constant volume (Cv) and at constant pressure (Cp), relationship between Cp and Cv. Mathematical statement of first law. Reversible process and maximum work. Calculation of work, heat, internal energy change and enthalpy change for the expansion of an ideal gas under reversible isothermal and adiabatic condition.

The Joule-Thomson effect – derivation of the expression for Joule-Thomson coefficient. Sign and magnitude of Joule-Thomson coefficient, inversion temperature.

Thermochemistry – standard states. Enthalpies of formation, combustion and neutralization.

Integral and differential enthalpies of solution. Hess's law and its applications. Kirchoff's equation

Need for IInd law. Different statements of IInd law, Thermodynamic scale of temperature.Carnot cycle and its efficiency, Carnot theorem,
Concept of entropy- Definition and physical significance. Entropy as a function of volume and temperature, Entropy as a function of pressure and temperature, Entropy as a criteria of spontaneity and equilibrium.

Gibbs and Helmholtz free energies and their significances- criteria of equilibrium and spontaneity. Gibbs-Helmholtz equation, dependence of Gibbs free energy change on temperature, volume and pressure. Maxwell's relations

Partial molar quantities- Chemical potential-Gibbs-Duhem equation, Concept of fugacity, determination of fugacity by graphical method

Module IV

Chemical Kinetics **36 hrs**

Order of reaction, Derivation of integrated rate equation of zero, first, second and third order reactions, nth order reaction, determination of order of reactions:- Graphical and analytical methods using integrated rate equations, Fractional life- method, Differential rate equation method, Isolation method. Types of complex reactions:- (a) opposing reactions (b) consecutive reactions (c) parallel reactions (d) chain reactions (explanation and examplesonly).

Influence of temperature on rate of reaction: Arrhenius equation, Determination of Arrhenius parameter, Energy of activation and its significance. Collision theory, Derivation of the rate equation for a second order reaction based on collision theory, collision theory of unimolecular reactions, Lindemann mechanism, steady state approximation, Theory of absolute reaction rate. Photochemistry**:** Grothus-Draper, Beer- Lambert and Stark- Einstein laws, Quantum yield, Reason for very low and very high quantum yields, Rate equation for decomposition of hydrogen iodide, Qualitative treatment of H_2-Cl_2 reaction and H_2-Br_2 reaction, Fluorescence and phosphorescence, chemiluminescence and photosensitization, Explanation and examples

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Module V

Group theory & Liquid crystals **10 hrs**

Group theory: Elements of symmetry – Proper and improper axis of symmetry, plane of symmetry, centre of symmetry and identity element. Combination of symmetry elements, Point groups, C_{2V}, C_{3V} and D_{3h}, Group multiplication table of C_{2V}, Determination of point groups of simple molecules like H_2O, NH_3 and BF_3.

Liquid crystals: Types of liquid crystals – smectic, nematic and cholesteric, Swarm theory of liquid crystals, uses of liquid crystals.

Module VI

Phase Equilibria 26 hrs

Phase Equilibria:-Terminology, the phase rule, thermodynamic derivation of phase rule and its application to (a) water system (b) sulphur system (c) solid-liquid equilibria involving simple eutectic system such as Pb-Ag system, KI-water system, freezing mixtures, thermal analysis and desilverisation of lead (d) solid-liquid equilibria involving compound formation with congruent and incongruent melting points:- $FeC1_3$-H_2O system and Na_2SO_4-H_2O system (e) solid–gas system- decomposition of $CaCO_3$, dehydration of $CuSO_4.5H_2O$, deliquescence and efflorescence.

Chemical and Ionic equilibria

Equilibrium constant and free energy, Thermodynamic derivation of law of mass action, relation between Kp,Kc and Kx, Reaction isotherm, Temperature dependence of equilibrium constant , Pressure dependence of equilibrium constant, Clausius-clapeyron equations and its applications.

Ionic equilibrium:

Ionic product of water, Effects of solvents on ionic strength, levelling effect, Pk_a and Pk_b values, solubility product and common ion effect and their applications, pH and its determination by indicator methods, buffer action, Henderson's equation, hydrolysis of salts of all types, degree of hydrolysis and hydrolytic constant, determination of degree of hydrolysis, relation between hydrolytic constant and ionic product of water.

(At least 100 problems are to be worked out from all units together. 30% of the questions for Examination shall contain problems.)

Suggested Readings

1. P W Atkins, "Physical Chemistry", Oxford University Press
2. R J Silby and R A Alberty, "Physical Chemistry", John Wiley & Sons
3. G W Castllan, "Physical Chemistry", Narosa Publishing House
4. F Daniels and R A Alberty, "Physical Chemistry", Wiley Eastern
5. E A Moelwyn Hughes, " Physical Chemistry", Pergamon Press
6. Puri, Sharma and Pathania, "Principles of Physical Chemistry", Millennium Edition,Vishal Publishing Co
7. R. Stephen Berry, Stuart A .Rice, John Ross, "Physical Chemistry",2nd edition, Oxford".
8. Gurdeep Raj, "Advanced Physical Chemistry", Goel Publishing House
9. S Glasstone, "Thermodynamics for Chemists", Affiliated East West Publishers
10. L V Azaroff, " Introduction to Solids", McGraw Hill
11. N B Hannay, " Solid State Chemistry", Prentice Hall

12. Anthony R West, " Solid State Chemistry and its Applications", Wiley Eastern
13. V Ramakrishnan and M S Gopinathan, "Group Theory in Chemistry",Vishal Publishing Co.

SEMESTER IV
Core Course Chemistry V

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1444	**Physical Chemistry II**	**3**	**180** (T 126 + P 54)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The course will introduce the basics of the developing fields such as spectroscopy, quantum mechanicsand statistical thermodynamics.
CO 2	The course will make the students aware of the different states of matter and various theories dealing with properties and behaviour of the molecules
CO 3	Students should brcome the aware of quantum mechanics, statistical thermodynamics and its importance in chemistry.
CO4	Upon course completion, the student will be able to familiarize with the principles of spectroscopic and non-spectroscopic methods of studying molecules and adsorption phenomena. And its application in understanding the properties of molecules.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Course Content

Module I

Binary liquid systems & catalysis **36 hrs**

Liquid-Liquid system:- Completely miscible, ideal and non-ideal mixtures, Raoult's law, vapour pressure- composition and temperature-composition curves, fractional distillation, deviation from Raoult's law, Azeotropic mixtures, partially miscible liquid system, critical solution temperature, Conjugate layers, example for upper, lower and upper cum lower CST, Theory of steam distillation, distribution law, its thermodynamic derivation, limitations of distribution law, application of

distribution law to the study of association and dissociation of molecules, solvent extraction.

Catalysis:
Theories of catalysis, Intermediate compound formation theory, steady state method, Enzyme catalysis, Michaelis-Menten law.

Colloids and Adsorption

Colloidal state: Types of solutions – true, colloid and suspensions, Purification of colloids – ultra filtration and electrodialysis, Kinetic, optical and electrical properties of colloids. Ultra microscope, Electrical double layer and zeta potential. Coagulation of colloids, Hardy-Schulz rule. Gels: Elastic and non-elastic gels, Imbibition and syneresis, Micelles and critical micelle concentration, sedimentation and streaming potential, Application of colloids – Cottrell precipitator, purification of water and delta formation.
Adsorption: Physical and chemical adsorption, Freundlich adsorption isotherm, Derivation of Langmuir adsorption isotherm, Statement and explanation of BET and Gibbs isotherms, determination of surface area of adsorbents by Langmuir equation. Applications of adsorption.

Module II

Electro motive force 36 hrs

Electrochemical cells (brief explanation) Reference electrodes-standard hydrogen electrode, calomel electrode, Types of electrodes-Metallic electrodes, anion reversible electrodes and redox electrodes, Electrode reactions and cell reactions, Derivation of Nernst equation for electrode potential and cell potential, Gibb's Helmholtz equation and EMF of a cell, calculation of ΔG, ΔH and ΔS from EMF data.
Concentration cells with and without transference, electrode and electrolyte concentration cells, derivation of equation for the EMF of concentration cells with and without transference, Liquid Junction Potential,

Fuel cells :- Hydrogen-Oxygen fuel cell, Hydrocarbon – Oxygen fuel cell. Redox electrodes and redox systems, formal redox potential, principle of redox indicators, overvoltage and polarization.

Applications of potential measurement:- Determination of ionic product of water, hydrolysis constant and solubility product, pH value using quinhydrone and glass electrode, potentiometric titrations of acid-base and redox reaction.

Electrical conductance

Inter ionic attraction theory, Debye-Huckel-Onsager equation (Qualitative treatment only) activity and activity co-efficient of electrolytes, Kohlrausch's law and its applications , wein effect, Debye-Falkenhagen effect, Walden's rule.
Ionic mobilities:- Transference number and its determination by Hittorff's and moving boundary

methods, abnormal transference numbers, Applications of conductivity measurements:- Determination of degree of dissociation of weak electrolytes, degree of hydrolysis, solubility of sparingly soluble salts, conductometric titrations involving strong acid- strong base, strong acid-weak base, weak acid-strong base, weak acid-weak base and precipitation.

Module III

Thermodynamics III & Statistical thermodynamics **36 hrs**

Nernst heat theorem, proof and its consequences. Statement of IIIrd law-Plank's statement,Lewis Randall statement. Concept of perfect crystal, evaluation of absolute entropies of solid,liquid and gas. Exception to IIIrd law with reference to examples- CO, NO, N_2O and H_2O

Phase space, system, assembly and ensemble-types of ensembles and uses. Thermodynamic probability, Boltzmann distribution law (no derivation). Partition function, entropy and probability. Thermodynamic functions in terms of partition functions - internal energy, enthalpy, pressure, work function and free energy function.

Module IV

Quantum mechanics **36 hrs**

Radiation phenomena- blackbody radiation, photoelectric effect, Compton effect and atomic spectra. Planck's quantum theory and explanation of the radiation phenomena.
Schrodinger wave equation – significance of Ψ, well behaved functions, Concept of operators and some operators of interest (properties of operators not required), Postulates of quantum mechanics
Application of quantum mechanics to simple systems- particle in 1 D box, normalization of wave function, Particle in 3 D box. Concept of degeneracy,
Application to hydrogen atom (no derivation) Schrodinger wave equation in Cartesian and spherical polar co-ordinates, Quantum numbers.

Module V

Spectroscopy **36 hrs**

Electromagnetic Spectrum Regions of electromagnetic spectrum. Different units of energy (erg, joule, calorie, cm^{-1}, Hz, $_0$A and eV) and their inter conversions. Interaction of radiations with matter. Various types of molecular spectra. Born-Oppenheimer approximation.

Rotational spectroscopy: microwave spectra of diatomic molecules, energy expression, selection rule, rotational energy levels, determination of bond length, effect of isotopic substitution.

Vibrational spectroscopy: Harmonic oscillator. IR spectra of diatomic molecules. Energy expression. Selection rules, frequency of separation, calculation of force constant, anharmonic oscillators. Morse equation. Fundamental and overtone transitions, combination bands, degree of freedom of polyatomic molecules.

Raman spectroscopy: Stoke's and antistoke's lines and their intensity difference, rotational Raman

spectrum. Selection rule. Frequency of separation, vibrational Raman spectrum, Mutual exclusion principle.

Electronic spectroscopy: Franck-Condon principle. Singlet and triplet states dissociation and pre-dissociation. Electronic spectra and diatomic molecules. Dissociation energy, electronic spectra of polyatomic molecules (qualitative idea only).

NMR spectroscopy: Principle of NMR, nuclear spin. Interaction of nuclear spin with external magnet. Precession. Relaxation, Chemical shift. Low resolution spectra. Delta and tau scales. Spin-spin coupling and high resolution spectra.

Electron spin resonance spectroscopy: principle. Types of substances with unpaired electrons, interaction of electron magnet with external magnet. Energy level splitting. Lande splitting factor, presentation of ESR spectrum. The normal and derivative spectra. Hyperfine splitting. Simple examples like methyl and benzene radicals.

.**Surface properties**: Examination of surfaces using ESCA, Auger, Scanning TunnelingMicroscopy (STM) and Scanning Electron Microscopy (SEM).
At least 100 problems are to be worked out from all units together. 30% of the questions forExamination shall contain problems.

Suggested readings

1. P W Atkins, “Physical Chemistry”, Oxford University Press
2. R J Silby and R A Alberty, “Physical Chemistry”, John Wiley & Sons
3. G W Castllan, “Physical Chemistry”, Narosa Publishing House
4. Puri, Sharma and Pathania, “Principles of Physical Chemistry”, Millennium Edition,Vishal Publishing Co.
5. Gurdeep Raj, “Advanced Physical Chemistry”, Goel Publishing House.
6. S Glasstone, “Thermodynamics for Chemists”, Affiliated East West Publishers
7. M C Guptha, “Elements of Statistical Thermodynamics”, New Age International (P)Ltd.
8. L K Nash, “Elements of Statistical Thermodynamics”, Addison Wesley
9. A W Adamson, “The Physics and Chemistry of Surfaces”, Interscience
10. N K Adam, “ The Physics and Chemistry of Surfaces”, Oxford University Press
11. M W Hanna, “Quantum Mechanics in Chemistry”, Benjamin
12. I N Levine, “Quantum Chemistry”, Prentice Hall
13. C N Banwell, “Fundamentals of Molecular Spectroscopy”, Tata McGraw Hill
14. Manas Chanda, “Atomic structure and Chemical bonding in Molecular Spectroscopy”,Tata McGraw Hill
15. Physical Chemistry, R. Stephen Berry, Stuart A Rice $ John Rose 2nd Edn , Oxford.

SEMESTER IV
Core Course Chemistry VI

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1445	**Practical Chemistry II** (Practical of BV1343 & BV1444)	**2**	Practical hours of BV1343 & BV1444

Course Content

BV1343 & BV1444
Practicals of Physical Chemistry

The following experiments are to be practiced by the students,

Determination of

1. Partition coefficient of iodine between CCl_4 and H_2O
2. Transition temperature of a salt hydrate. Molar mass of a solute using transition pointdepression of a salt hydrate.
3. Molar mass of a solute. Depression in freezing point of a solid solvent by cooling curve method.
4. Critical solution temperature of phenol – water system.
5. Viscosity of binary mixtures and then concentration of an unknown mixture.
6. Surface tension of binary mixtures and then concentration of an unknown mixture.
7. Refractive index of KCl solutions of different concentrations and then concentration ofan unknown solution.
8. Conductometric titration of NaOH Vs HCl.
9. Potentiometric titration of Fe^{2+} vs $Cr_2O_7^{2-}$
10. Potentiometric titration of $KMnO_4$ Vs KI
11. Determination of water equivalent of a calorimeter and heat of neutralisation of strongacid – strong base.
12. Kinetics of hydrolysis of an ester
13. Influence of KCl impurity on miscibility temperature of phenol – water system and thenthe determination of concentration of a given KCl solution

SEMESTER V
Core Course Chemistry VI

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1543	**Organic Chemistry I**	**4**	**180** (T 108 + P 72)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The course should make the students to learn the basics of Organic chemistry with its various braches. It should impart basics of Hybridisation and various types of reagents.
CO 2	The course will get basic idea about aromatic compounds and make the students aware of Arenes & Aromaticity
CO 3	Students should undersatand the basic chemistry of aliphatic and aromatic compounds and substituted compounds.
CO4	Upon course completion, the student will be able to describe the behaviour of aliphatic and aromatic compounds like aromatic aldehydes, ketones and halides. By studying these topics the students get an idea of the mechanism of reactions of organic compounds and hybridization.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Course Content

Module I

Hybridisation and various types of reagents — 36 hrs

Hybridisation – sp^3, sp^2 and sp, structure and shapes of simple organic molecules, bond lengths, bond angles and bond energy, Electron displacement effects – inductive effect, electromeric effect, hyperconjugation, resonance, steric effect. Homolytic and heterolytic fission.

Types of organic reactions, energy considerations. Reaction intermediates – carbocations, carbanions, free radicals, carbenes, benzynes. Methods of determination of reaction mechanism,
product analysis, intermediates, isotope effect, kinetic and stereochemical studies.

Reaction mechanisms

Mechanism of addition of hydrogen, electrophilic and free radical addition, Markownikoff's rule and kharasch effect. Mechanism of nucleophilic and electrophilic addition reactions, Nucleophilic and electrophilic substitution reactions, elimination reactions – E1, E2, S_N1, S_N2 and S_Ni reactions and mechanisms. Study of reactions of hydroboration, epoxidation, ozonolysis, hydration, cis-hydroxylation.

Module II

Arenes & Aromaticity 36 hrs

Nomenclature of benzene derivatives, Aromaticity, Huckel's rule, Non- benzenoid aromatic compounds, – 5 membered and 7 membered ring compounds- structure of benzene.
Mechanism of aromatic electrophilic substitution in benzene– halogenation, nitration, sulphonation, Friedel-Crafts alkylation, acylation,
Energy profile diagram. Orienting effect of substituents like –OH, $-NH_2$, $-NO_2$, $-CH_3$ and halogens. Nucleophilic aromatic substitution. Elimination-addition mechanism, reactivity and orientation- aromatic electrophilic substitution in naphthalene- Friedel- Crafts alkylation and nitration.
Substituted Arenes, Alkyl halides & Aryl halides
Methods of formation of alkyl benzenes, alkynyl benzenes, and biphenyl. Preparation and properties of aryl halides.

Alkyl halides: Nomenclature and classes of alkyl halides, preparation and properties, Synthetic uses of vinyl chloride, chloroform, carbon tetrachloride, trichloroethylene, chloroprene, Freon- 12, DDT, BHC.

Module III

Alcohols & Phenols 36 hrs

General methods of preparation and properties of alcohols. Methods to distinguish primary, secondary and tertiary alcohols. ascent and descent in alcohol series.
Oxidation of alcoholswith acidified $KMnO_4$, $K_2Cr_2O_7$.
Jones reagent and PCC (Pyridinium Chloro Chromate).
Polyhydric alcohols: - Preparation and properties of ethylene glycol and glycerol, their industrial importance.
Phenols: - Preparation and properties of phenols. Acidity of phenols and its comparison with alcohols and acids.
Effect of substituents on acid strength of Phenols. Industrial Importance of methanol, ethanol – Absolute alcohol methylated spirit, power alcohol, allyl alcohol, benzyl alcohol, picric acid, quinol and nitro phenols.

Aldehydes and Ketones

Aldehydes and Ketones: - General methods of preparation and properties of aldehydes and ketones (both aliphatic and aromatic).
Reduction with $LiAlH_4$, Sodium borohydride, Aluminium Iso Propoxide Wolf-Kishner reduction, Clemmenson reduction.
Test to distinguish aldehydes and ketones.
Condensation reactions and its Mechanisms – Aldol condensation, mixed and crossed aldol condensation and benzoin condensation. Preparation and uses of croton aldehyde, mesityl oxides, cinnamaldehyde, salicylaldehyde, vanillin, naphthaquinone and anthraquinone.

Module. IV

Ethers, Carboxylic acids and their derivatives 18 Hrs

Ethers: -Preparation and properties. Zeisel method of estimation of alkyl group. Brief Study ofepoxides and crown ethers.
Carboxylic acids and their derivatives: - Preparation and properties of aliphatic and aromatic carbojxylic acids. Ascent and descent series in aliphatic carboxylicacids.
Effect of substituents on acidity of aliphatic and aromatic carboxylic acids. Preparation,properties and uses of anthranilic acid, cinnamic acid, lactic acid, salicylic acid, adipic acid,acid anhydrides, amides, esters, coumarin, malic acid, tartaric acid and citric acid.

Module V

Stereochemistry of Organic Compounds. 27 hrs.

Optical isomerism: elements of symmetry, chirality, steriogenic centre, enantiomers, chiral and achiral molecules with two stereogenic centres, dia stereo isomers, meso compounds, resolution, inversion and racemization reaction. Aymmetric synthesis, absolute configuration, sequence rule, D-L, R-S systems of nomenclature. Optical activity of compounds having no chiral carbon (Allenes and Biphenyls).

Geometrical isomerism: E - Z systems of nomenclature. Geometric isomerism in maleic and fumaric acid and butadiene.

Conformational isomerism: Configurational analysis of ethane, n – butane and cyclohexane. Newmann projection formula and Sawhorse formula

Module VI

Carbohydrates 27 Hrs

Classification and Nomenclature of monosaccharides. Configuration of monosaccharides. Preparation, properties and structural elucidation of glucose, fructose and sucrose. Anomers, epimers and mutarotation. Mechanisms of Epimerization and Mutarotation. Ascent and descent series in aldoses and ketoses. Conversion of aldoses to ketoses and ketoses to aldoses. Conversion of glucose to mannose

Polysaccharides: - Starch and Cellulose - Preparation, properties and structure of starch and cellulose (structural elucidation not expected).

Industrial application of cellulose.

Suggested readings

1. I L Finar, “Organic Chemistry - Vol. I”, Longman
2. M K Jain, “Principles of Organic Chemistry”,
3. Morrison & Boyd, “Organic Chemistry”, Prentice Hall
4. Peter Sykes, “A Guide book to Mechanisms in Organic Chemistry”, Longman
5. Jerry March, “Advanced Organic Chemistry”, Wiley
6. Bahl & Bahl, “Advanced Organic Chemistry”
7. Tewari & Mahrotra, “A text book of Organic Chemistry”
8. P L Soni, “Organic Chemistry”
9. Rein hard Bruckner, “Advanced Organic Chemistry Reaction Mechanisms”
10. Arun Parikh, Hansa Parikh, Khyati Parikh, “Name Reactions in Organic Synthesis”.

SEMESTER VI
Core Course Chemistry VII

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1643	**Organic Chemistry II**	**3**	**180** (T 126 + P 54)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	By studying this course students should be able to understand basics of specific organic compounds like ethers, esters , amino acids, carbohydrates etc.
CO 2	The course will give a basic idea about a large number of organic compounds of bioloigical importance and its structural and functional characteristics.
CO 3	Students should undersatand the basic chemistry of proteins, nucleic acids, oils, fats, detergents, vitamins, terpenes, alkaloids, hormones and enzyme
CO4	Upon course completion, the students should get an interesting idea about the stereochemistry of organic compounds and the preparation and properties of organic compound

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	**Understanding**	**Apply**	**Analyse**	**Evaluate**	**Create**	**Total**
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						Total	**100**

Course Content

Module I

Amino acids, Proteins and Nucleic acids **36 hrs**

Amino acids: - Classification, structure and stereochemistry of amino acids, essential and nonessential amino acids, zwitter ion, isoelectric point, General methods of preparation andreactions of α - amino acids.
Peptides: structure and synthesis (Carbo benzoxy method, Sheehan method only).
Proteins: - Structure of proteins, denaturation and colour reactions.
Nucleic acids: - Classification and structure of DNA and RNA. Replication of DNA, GeneticCodes.

Module II

Oils, Fats, Detergents, Alkaloids and Terpenes **18 hrs**

Oils and Fats: - Occurrence and extraction. Common fatty acids, soap, saponification value,iodine value, acid value, synthetic detergents and detergent action, alkyl and aryl sulphonates
Alkaloids: -Extraction and structural elucidation of conine, nicotineand importance ofquinine, morphine and codeine.
Terpenes: -Essential oils, isolation of citral and geraniol (No structural elucidation)

Isoprene and special isoprene rule.

Module III

Vitamins, Hormones, Enzymes and Synthetic Reagents 36 hrs

Vitamins: - Classification and important sources, physiological action and deficiencysymptoms of vitamin A, B_1, B_2, and B_{12}. C, D, E and K.

Hormones: - Introduction, steroid and sex hormones – examples and functions (Structure not expected).

Enzymes: - General nature and classification, specificity of enzymes.Synthetic reagents: - **Acetoaceticester**-synthesis and tuatomerism-syntheic application of Acetoaceticester, Synthesis and synthetic application of Diethylmalonate. Grignard reagents, organic zinc reagents, Reformatsky reaction

Module IV

Organic Synthesis, Rearrangements, Synthetic Polymers and Dyes 36 Hrs

Study of reactions and mechanisms of Meerwin-Pondorf- Verley reductions, Gattermann-Kochreaction, Gattermann aldehyde synthesis, Claisen condensation, Knoevenangal reaction, Perkinreaction, Cannizaro reaction, Reimer- Tiemann reaction, Sandmeyer reaction & Wittig reaction,
Mechanism of Pinacol-Pinacolone rearrangement, Claisen rearrangement, Fries rearrangement, Benzidine rearrangement and Beckmann rearrangement.
Polymers- Types of polymerization- addition, condensation and coordination polymerization.
Zieglar –Natta catalyst. Synthesis and applications of urea – formaldehyde resins, Bakelite, polythene, PVC, PMMA, Nylon-6,6.
Natural and synthetic resins. Buna-N , Buna-S, Neoprene,Polystyrene.
Biodegradable polymers- two examples- starch and cellulose. Number average molecular weight and weight average molecular weight of polymers.
Composites (refer any two)
Dyes- Theory of colour and constitution, classification of dyes, synthesis of methyl orange, congo red, malachite green, crystal violet, phenolphthalein, fluorescein, alizarin and indigo

ModuleV

Organic Sulphur and Nitrogen compounds 18 Hrs

Aromatic sulfur compounds –Preparation and applications of benzene sulphonic acids, toluene sulphonic acid, benzene sulphonyl chloride, sulphanilic acid , sulphanilamide and sulpha drugs- sulphapyridine, sulphathiazole, sulphadiazine, sulphaguanidine and sulphaacetamide.
Organic Nitrogen Compounds- Nitro compounds- preparation of nitroalkanes and nitroarenes, tautomerism, reduction of nitrobenzene in acid , base and neutral medium. General methods of preparation and reactions of aliphatic and aromatic amines, classification of amines, separation of mixture of amines, methods to distinguish primary, secondary and tertiary amines, basicity of amines, effect of substituents , quarternary ammonium compounds- Hofmann elimination.
Diazonium and diazo compounds- preparation, structure and their synthetic importance.

Module VI

Organic Spectroscopy 36 Hrs

UV-Visible Spectroscopy- absorption, types of electronic transitions, effect of conjugation, concept of chromophore, auxochrome, bathochrome, hypochromic shifts, hyperchromic and hypochromic effects. UV-Visible spectra of enes. Calculation of λmax.

IR Spectroscopy- molecular vibrations, factors influencing vibrational frequencies, inductve effect and hydrogen bonding. Finger print region and interpretation of IR spectra of simple organic molecules such as phenol, acetone, acetanilide, benzaldehyde.

NMR spectroscopy- Proton NMR- shielding and deshielding effect, chemical shift, factors influencing chemical shift, spin-spin splitting, coupling constant, interpretation of PMR spectrum of simple molecules like ethylbromide, pure ethanol and impure ethanol(acidic impurities), acetaldehyde and toluene. Basic knowledge of C^{13} NMR

Mass spectrometry- Theory of mass spectrum, base peak and molecular ion peak, types of fragmentation, Mclafferty rearrangement, isotopic effect.

Applications- determination of molecular mass

Suggested Readings

1. Morrison & Boyd,"Organic Chemistry". :
2. F. Carey, Mc Graw Hill,"Organic Chemistry". :
3. I.L. Finar, "Organic Chemistry", Vol I & II Longmann.
4. L.G. Wade, "Organic Chemistry".
5. P.Y. Bruice,"Organic Chemistry".
6. Stanley, H. Pine, Mc Graw Hill,"Organic Chemistry".
7. Jerry March,"Advanced Organic Chemistry".
8. S.M. Mukherji and S.P. Singh, " Reaction Mechanism in Organic Chemistry" MacMillan.
9. Rein hard Bruckner ,"Advanced Organic Chemistry Reaction Mechanism".
10. Bahl & Bahl," Advanced Organic Chemistry".
11. Tewari, Mehrotra," A text book of Organic Chemistry".
12. M.K. Jain ,"Principles of Organic Chemistry".
13. Fieser & Fieser," Advanced Organic Chemistry".
14. D. Nasipuri, "Stereo Chemistry of Organic compounds" .

15. Arun Parikh, Hansa Parikh, Khyati Parikh ,“Name Reactions in Organic Synthesis”.

SEMESTER VI
Core Course Chemistry VIII

Course Code	Title of the Course	Credit	Total Contact Hrs.
BV1644	**Practical Chemistry III** (Practical of BV1543 & BV1643)	**3**	Practical Hours of BV1543 & BV1643

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	Students should learn to do the experiments of the course BV 1543
CO 2	They should learn to conduct the experiments included in the course BV1643
CO 3	They should learn the identifications procedures of various important organic comounds
CO4	They should also learn to conduct the quantitative analysis of biological and other organic compounds.

Course content

1. Gravimetry

The following determinations are to be done using silica crucible (1) Ba as $BaSO_4$ (2) Sulphateas $BaSO_4$ (3) Iron as Fe_2O_3 (4) Calcium as $CaCO_3$ (5) Aluminium as Al_2O_3 and Magnesium as $Mg_2P_2O_7$.

The following determinations are to be done using sintered crucible

(1) Magnesium as oxinate

(2) Nickel using dimethyl glyoxime

(3) Copper as copperthiocyanate and (4) Silver as silver chloride

II. Organic Chemistry Practicals

1. Tests for elements : Nitrogen, halogens and sulphur
2. Determination of physical constants
3. Studies of the reactions of common functional groups using known organic compounds.

Qualitative analysis with a view to characterization of the functional groups. Thefollowing compounds may be given for the analysis : chlorobenzene, benzyl chloride, phenol, o – m – p – cresols, naphthols, resorcinol, benzaldehyde, acetophenone, benzophenone, benzoic, phthalic, cinnamic and salicylic acids, ethyl benzoate, methyl salicylate, benzamide, urea, aniline, o, m, p – toluidines, dimethylaniline, nitrobenzene, o – nitro toluene p – nitro toluene, m – dinitrobenzene, naphthalene, anthracene,glucose and sucrose.

Organic preparations involving halogenation, nitration, oxidation, reduction, acetylationbenzoylation, hydrolysis and diazotisation.

III. Chromatography

1. Paper chromatographic separation of mixture of nitroanilines, amino acids andsugars.
2. Separation of a mixture of dyes by column chromatography.

IV. Organic estimation

1. Molar mass determination of an acid and base by titration method
2. Determination of the phenol/aniline by bromate – bromide mixture.

Suggested Readings

1. A.I.Vogel, “A text book of Qualitative Analysis including semi micro methods”Longmans.
2. V.V.Ramanujam, “Semi micro Qualitative Analysis”
3. E.S.Gilreath “Qualitative Analysis using semi micro method” Mc Graw Hill
4. A.I.Vogel, “A text book of Qualitative Inorganic Analysis” Longmass
5. A.I.Vogel, “Elementary Practical Organic Chemistry” Longmass
6. Day and Raman, “Laboratory Mannual of Organic Chemistry”. Viswanathan
7. Mann and Saunders, “Practical Chemistry”
8. A.Findlay, “Practical Physical Chemistry”
9. R.C.Das and E.Behara, “Experimental Physical Chemistry”, Tata Mc Graw Hill
10. N.K.,Vishnoi, “Advanced practical organic chemistry” Vikas publishing house, NewDelhi.

Core Course

in

Biotechnology

SEMESTER I
Core Course Biotechnology I

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1143	**Biochemistry & Metabolism**	**4**	**126** (T 54+ P 72)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will be able to describe the biochemical basis of life and basic understand about the biochemical reactions The course will impart a basic understanding about the concept of the biochemical basis of phenomenon life and metabolic reaction of cells that are essential for the sustenance of life.
CO 2	Students should learn about the various bio molecules and its functions in the cellular metabolism. It specially focuses on the development of analytical skills in biochemistry by giving more importance to the laboratory experiments of biochemistry.
CO 3	They will get an understanding about the basic concepts of energy transactions of the biological systems
CO4	The students will acquire knowledge on bioenergetics, molecular biology and various applications of biomolecules and its productions and use as medicines and food supplements.

Assessment pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course content
Module I

Water: Structural features of water molecule, dissociation of water, ionic product of water, acids and bases, concepts of pH, pOH, theoretical calculations of pH and pOH, dissociation of weak acids , buffers buffer action and buffer capacity, buffers in biological system, Henderson – Hasselbalch equation, titration curve of weak acids, simple numerical problems involving application of this equation.

Module II

Solutions: Expression of concentration- normality, molality, molarity, percentage solution, mole fraction, parts per million, Problems related to concentrations.
Colloids: Definition of true solution, suspension, colloids and crystalloids, lyophilic and lyophobic colloids, Properties of colloids, biological significance of colloids, emulsions and emulsifying agents,
Diffusion, osmosis, osmotic pressure, Vant Hoff's laws of osmotic pressure, definition of isotonic, hypotonic and hypertonic solutions, biological importance of osmosis, surface

tension, viscosity.

Module III

Carbohydrates : Classification, optical isomerism, D and L series, epimers, aldoses and ketoses, structural relationships of aldoses, ring structure of monosaccharides, anomers, mutarotation, chemical reactions of glucose and fructose, glycosides, deoxy sugars, amino sugars, sugar alcohols and sugar acids, O- acyl O-methyl derivatives of monosaccharides, ozazone, disaccharides, structure and important properties of sucrose, maltose, isomaltose, lactose and cellobiose, Trisaccharide (examples only), structure and important properties of polysaccharides- starch, glycogen, cellulose, and chitin.

Metabolism of carbohydrates: Carbohydrate digesting enzymes- alpha amylase, breakdown of starch and cellulose, Glycolysis, Citric acid cycle, electrontransport system and oxidative phosphorylation, Energy balace of cellular oxidation of glucose

Biosynthesis of carbohydrate- photosynthesis- photochemical reaction, dark reaction, alternate pathways of glucose synthesis, glycogen synthesis.

Qualitative test for various types of carbohydrates

Module IV

Lipids: Classification of lipids, chemical composition of tryglycerides, fatty acids, structure and properties , reactions of fatty acids, triglycerides- general structure and properties, acid number, Saponification number and iodine number fats, glycerol, Acrolein test,

Phospholipids, derivatives of phospholipids- glycerophosphates, sphingosine phosphate, non- phosphorylated sphingolipids,- cerebrosides, gangliosides, sulphatides, (structure only) Steroids- structural features, sterols, structure of cholesterol and ergosterol . Colour reactionsof sterols.

Biosynthesis and breakdown of lipids- scheme of β-oxidation (stearate and palmitate as examples) and regulation, Basics of ω amd α- oxidation, Ketone body formation,

Fatty acid biosynthesis and regulation, essential fatty acids, outline of the synthesis of triglycerides.

Module V

Amino acids and proteins: Classification of amino acids, amino acids occurring in proteins, optical activity, UV absorption, Zwitterions, chemical reactions of amino acids, proteins, biological significance, classification – fibrous proteins, globular proteins, conjugated proteins,hydrolysis of proteins and separation of amino acids.

Proteins: Physical properties, solubility, isoelectric point and isoelectric precipitation,

Protein structure: study of primary secondary, tertiary and quaternary structure of proteins, colour reactions, precipitation reactions, denaturation, oligopeptides, amino acid analysis of proteins, hemoglobin- functions and components of plasma proteins.

Module VI

Enzymes: Classification and nomenclature, units of enzyme activity, progress curve, effect of enzyme concentration, substrate concentration, temperature and pH on reaction velocity of enzyme catalyzed reactions. Michaelis- Menten constant, enzyme affinity, Michaelis- Menten equation (Derivation not expected),Enzyme specificity, different types , enzyme activation, enzyme inhibition- competitive and non-competitive, Line weaver – Burk plot, application of LB plot, allosteric regulation (Brief study) purification of enzymes, criteria of purity, coenzymes.

Module VII

Nucleic acids: Base compositions, structure of purines and pyrimidines, ribose and deoxy ribose, nucleoside structure, nucleotides- nomenclature, structure of polynucleotide– DNA,RNA primary structure and inter nucleotide linkage Watson and Crick double helix

model of DNA, different types of RNA.

Practical

Familiarization and Practice of the following techniques and concepts

1. Weighing in Chemical balance
2. Preparation of solutions
3. Percentage, molar & normal solutions, dilution from stock solution etc.
4. Demonstration of dialysis
5. Demonstration of PAGE
6. Demonstration of Paper Chromatography
7. Demonstration of Thin Layer Chromatography
8. Colorimetry and Spectrophotometry techniques
9. Verification of Beer Lambert's law
10. Verification of molar extinction coefficient of any known compound

Carbohydrates

Qualitative analysis of Carbohydrates

Carbohydrates-Glucose, Fructose, Galactose, Xylose, Sucrose, Maltose, Lactose, Starch &Dextrin

Tests- Molisch's test, Anthrone test, Fehling's test, Benedict's test, Picric acid test, Barfoed's test, Bial's test, Seliwanoff's test, Foulger's test, Phloroglucinol test, Mucic acid test, Iodine test, Hydrolysis of Sucrose and Starch, Osazone test.

Quantitative Analysis of carbohydrates

Estimation of glucose by Nelson-Somogyi method
Estimation of reducing sugar by anthrone method
Estimation of pentose by Orcinol method
Estimation of ketose by Roe-Papedopaulose method

Lipids

Qualitative analysis of Lipids

Fatty acids:

Stearic acid, Oleic acid.
Tests- Solubility, Translucent spot tests, Test for Unsaturation

Glycerol

Tests- Acrolein, Solubility.

Triglycerides

Tests- Solubility, Saponification, Translucent spot test

Cholesterol

Tests- Solubility, Salkowski reaction, Liebermann- *Burchard reaction*

Quantitative Analysis of Lipids

Estimation of Cholesterol by Carr-Drecktor method
Estimation of Cholesterol by Zak's method
Determination of Acid Value
Determination of Saponification value
Determination of Iodine number of oil

Amino acids and Proteins

Qualitative analysis of Amino acids and Proteins

Amino acids- (Tyrosine, Glycine, Tryptophan, Histidine, Arginine, Cysteine, Cystine, Proline, Methionine) (single components only need to be given)

Tests- Solubility, Ninhydrin reaction, Xanthoproteic reaction, Millons test, Morners test, Glyoxalic acid test, Ehrlich's test, Nitroprusside test, Lead acetate, Test for Methionine, Aldehyde test, Sakaguchi reaction, Isatin test

Proteins-Ovalbumin and Casein

Tests- Solubility, Ninhydrin reaction, Xanthoproteic reaction, Folin's test, Lowry's test, Biuret test, Heat denaturation, TCA precipitation, Metal precipitation, Alcohol precipitation.

Quantitative Analysis of Amino acids and Proteins

Estimation of Tyrosine by Folin-Lowry method.
Estimation of Protein by Biuret method.
Estimation of Protein by Folin-Lowry method.
Estimation of Protein by Bradford's method.

Nucleic Acids

Quantitative Analysis of Nucleic Acids

Estimation of DNA by diphenylamine method.
Estimation of RNA by Orcinol method

Enzyme Assays

Assay of any two of the following enzymes

Salivary amylase / Acid phosphatase/ Lysozyme
Kinetics of salivary amylase / Acid phosphatase (Effect of pH, substrate Concentration, enzyme concentration and temperature)
Progress curve of salivary amylase / Acid phosphatase

Suggested Readings

1. Lehninger Principles of Biochemistry, 4th Edition by David L. Nelson David L. Nelson(Author)
2. Michael M. Cox Publisher: W. H. Freeman; Fourth Edition (April 23, 2004)
3. Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & VijayDeshpande (ed), I.K International Pvt. LTD, New Delhi .
4. Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) NarosaPublishing House, New Delhi,
5. Standard Methods of Biochemical Analysis, S. K. Thimmaiah (Ed), Kalyani Publishers,Ludhiana.
6. Hawks Physiological Chemistry, Bernard L.Oser (ed).TATA McGRAW HillPublishing Company LTD, New Delhi.
7. ES West, WR Todd, HS Mason and JT van Bruggen. A text Book of Biochemistry,Oxford and IBH Publishing Co., New Delhi, 1974.
8. Text Book of Biochemistry, 5th edition by DM Vasudevan and Sreekumar S, JAYPEEPublishers, New Delhi
9. E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book ofBiochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
10. Biochemistry (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc
11. Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008)Publishers: S. Chand & Co Ltd
12. Principles and Techniques of Practical Biochemistry by Keith M. Wilson, John M.Walker Cambridge University Press

13. A Biologist's Guide to Principles and Techniques of Practical Biochemistryby BryanL.Williams, Keith Wilson Hodder Education

SEMESTER II

Core Course in Biotechnology II

Course Code	Title of the Course	Credits	Total Contact Hrs.
BV 1245	**Microbiology**	**4**	**108** (T 72 + P 36)

Course Outcome / Learning outcomes

CO No.	CO statement
CO1	The students will be able to understand the structure and classification of microorganisms
CO 2	Students will learn sterilisation techniques used in microbiology.
CO 3	They will get an understanding of bacterial genetics and recombination mechanisms
CO 4	The students will acquire knowledge on industrial applications of microorganisms

Assessment pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course content with Module outcome (MO)

Module I 10 hrs

MO: The students will have a basic understanding on sterilization methods in microbiology and bacterial classification

Introduction: Scope and history of microbiology: Pasteur's experiments, concept of sterilization, methods of sterilization -dry heat, wet heat or steam, radiation, chemical and filtration.

Classification of microorganisms: bacteria, archae, virus, fungi, protozoa, mycoplasma (PPLO)

Concept of microbial species and strains, microbial cell surfaces (gram positive and gram negative bacteria)

Classification of bacteria by Haeckel, Woese et al and Cavalier Smith- a brief account

Nutritional classification of bacteria.

Motility in bacteria, flagella-structure and distribution in bacterial cell.

Viruses: Bacteriophage, DNA and RNA phages, T4 phage, Phage culture, Lytic and lysogenic life cycles.

Module II 18 hrs

MO: The students will have a basic understanding on bacterial cell growth and metabolism

Bacterial cell structure and Growth-

Eukaryotic cells and prokaryotic cells, Glycocalyx, bacterial cell membranes, bacterial cell wall, cytoplasm, spores, organs of locomotion, chemotaxis, ribosomes and nucleoid- bacterial chromosome.
Bacterial Growth curve, Measurement of growth, factors affecting growth of bacteria.
Bacterial culture media: composition, types (synthetic media, simple and complex media), uses.
Isolation of pure culture: Spread plate, streak plate, pour plate etc.
Isolation of anaerobs and its culture techniques, sub culture methods (slant culture and stab culture.)

Bacterial Metabolism

Nutrition in bacteria- classification based on nutrition- autotrophic and heterotrophic organisms, Photosynthetic and chemosynthetic organisms- purple sulfur bacteria, photosynthetic bacteria, Saprophytes and pathogenic parasites.

Energy production in bacteria: Energy and ATP. **Aerobic respiration**: Glycolysis and tricarboxylic acid cycle, Electron transport and oxidative phosphorylation in Bacteria, catabolism of other carbohydrates. **Anaerobic respiration:**- Fermentation- alcohol fermentation by yeasts and bacteria, lactic acid fermentation by lactobacillus, acetic acid fermentation by acetobacter, Methanogenic bacteria, Application of bacterial metabolism in industry and agriculture

Module III 15 hrs

MO: The students will have a basic understanding on bacterial genetics and recombination.

Bacterial genetics

Transfer of genetic information in bacteria, Bacterial chromosomes- DNA, Plasmids (definition and types - non-conjugative, conjugative (mobilizable plasmids), R, Col, F plasmids)

Bacterial Mutation – Spontaneous mutation, induced mutations, Repair mechanisms, transposons in bacteria, overlapping genes.

Bacterial recombination:

Transformation-Griffith's effect, evidence of DNA as genetic material

Transduction- characteristics of transducing bacteriophages, Lambda phage- structure & multiplication in bacteria (lytic phase and lysogenic phase), bacterial recombination through transduction- generalized and specialized.

Conjugation- Fertility factors, F+ and F- cells, Hfr
Phages and plasmids as vectors for genetic engineering
Bacterial recombination and transferable drug resistance mechanism

Genetic homogeneity
Spontaneous and induced variations in microbes, Isolation of auxotrophs- replica plating technique and analysis of mutations in biochemical pathways, Microbial assays for vitamins and antibiotics.

Module IV 7 hrs

MO: The students will have a basic understanding on applications of extremophiles and role of bacteria on biogeochemical cycles

Microbes in extreme environments: Thermophiles and alkalophiles,

Microbial associations: symbiosis and antibiosis among microbial population, nitrogen fixing bacteria in agriculture and forestry, pathogenic microorganisms- bacteria, fungi, viruses, protozoans and mycoplasma, defense mechanism against microorganisms,

Bio geo chemical cycles: Role of bacteria in carbon, nitrogen, sulphur and phosphorous cycle in nature.

Module V 7 hrs

MO: The students will gain a broad understanding on industrial applications of microorganisms

Industrial microbes and their uses

Production of food (dairy and SCP) and drugs (antibiotics such as penicillin & streptomycin), products of fermentation, Strain improvement by mutation and recombination, production of heterologous proteins of interest in microorganisms by recombinant DNA technique.

Module VI 15 hrs

MO: The students will have a thorough knowledge on various kinds of bacterial diseases

Microbial Diseases of Humans

Bacterial diseases of Humans

1. Airborne bacterial diseases- tuberculosis, Pneumonia (streptococcal, Pneumococcal), Diphtheria, Pertussis
2. Foodborne and waterborne bacterial diseases- A) intoxications- Botulism, Staphylococcal food poisoning. B) infections- Typhoid fever, salmonellosis, Cholera, Shigellosis, *E.coli* Diarrheas, Brucellosis
3. Soil borne bacterial diseases – Anthrax, Tetanus, Leptospirosis.

Viral diseases of Humans-

1. Pneumotropic viral diseases-Influenza, Adenoviral infections, Rhinoviral infections,
2. Dermatoviral diseases- Herpes simplex, Chickenpox, Measles, Rubella.
3. Viscerotropic Viral diseases- yellow fever, Dengu fever, AIDS

4. Neurotropic viral diseases- Rabies, Polio
5. Control of microorganisms
6. Physical agents, chemical agents, antibiotics and other therapeutic agents.

Experiments for Microbiology Practical **54 hrs**

1. Use of Microscope
2. Sterilization and aseptic techniques-preparation and sterilization of glassware and solutions
3. Media Preparation- Preparation of Luria-Bertani medium and Nutrient agar and sterilization (Broth and plates)
4. Isolation and identification of E.coli from water samples and its identifications.
5. Screening of enterobacteria from water samples and its identification
6. Examination of microbial flora of the available soil and water samples
7. Serial dilution of bacterial cultures and plating to find out population density of microbes in a given sample
8. Isolation of bacteria from soil, water and air-a) Pour plate method, b) Streak plate method for isolation and colony purification.
9. Isolation of microorganisms from spoiled food materials
10. Microbiological examination of various types of waters including commercial and ordinary drinking water
11. Staining of bacteria-simple staining (Methylene blue stain), Gram staining, Acid fast staining, Negative staining, bacterial spore staining
12. Microscopic tests for bacterial motility (Hanging drop method)
13. Identification of bacterial and fungal cultures microscopically: Gram staining and lactophenol cotton blue method
14. Antibiotics sensitivity tests: Kirby bauer method
15. Growth of Bacteria in liquid media: Determination of kinetics of bacterial growth,bacterial growth curve
16. Isolation of starch degrading microorganisms- fungus and bacteria and the assay of the enzymes (α-amylase assay)
17. Fermentation techniques- Determination of substrate utilization with respect to growth kinetics
18. Curdling of milk, Isolation of lactobacillus from curd and its identification
19. Isolation of yeast from fruit samples and its culturing.
20. Examination of microbial flora of the skin and mouth.
21. Environmental distribution of microorganisms- extremophiles
22. Isolation and examination of Throat and nasopharyngeal cultures
23. Inhibition and destruction of microorganisms by antibacterial chemicals
24. Production of exoenzymes by bacteria- isolation of alpha amylase producing bacteria and its culturing for the production of alpha amylase
25. Plaque-forming Bacteriophage

Suggested Readings

1. A Textbook of Microbiology – P. Chakraborthy, New central Book agency Pvt. Ltd, calcutta
2. Advances in Microbiology – J P Tewari, T N Lakhanpal, I Singh, R Gupta and B P Chanola; A P H Publishing Corporation, New Delhi.
3. Introduction to Genetic Engineering & Biotechnology- A. J. Nair; Jones & Bartlett Publishers, Boston,USA.
4. Introduction to Microbiology- J Heritage, E G V Evans, R A Killington; Cambridge University Press.
5. Microbiology – L M Prescott, Brown Publishers, Australia
6. Microbiology: Principles and Explorations – Jacquelyn G. Black. Prentice Hall, New Jersey

7. Modern concept of Microbiology – D D Kumar, S Kumar; Vikas Publishing House Pvt. Ltd. New Delhi
8. Principles of Biotechnology – A. J. Nair Laxmi Publications New Delhi

SEMESTER II

Core Course Biotechnology III

Course Code	Title of the Course	Credits	Contact Hours
BV 1246	**Biotechniques I** (Practical of BV1143 BV1245)	**2**	Practical hours of BV1143 & BV1245

CO No. CO statement

CO1 This course is the practical of the course BV1143 Biochemistry & Metabolism and BV1245 Microbiology.

CO 2 The course will impart the students hands on training on the analytical techniques and experiments of Biochemistry and Microbiology

CO 3 They will get an understanding of principles of various experimental protocols and laboratory procedures and safety measures.

CO4 The students will acquire knowledge on industrial applications of biochemistry & Microorganisms which are the core components of Biotechnology experiments

BV1143
Experiments for Biochemistry and Metabolism 72 hrs

Familiarization and Practice of the following techniques and concepts

1. Weighing in Chemical balance
2. Preparation of solutions- percentage, molar & normal solutions, dilution from stock solution etc.
3. Demonstration of dialysis
4. Demonstration of PAGE
5. Demonstration of Paper Chromatography
6. Demonstration of Thin Layer Chromatography
7. Colorimetry and Spectrophotometry techniques
8. Verification of Beer Lambert's law
9. Verification of molar extinction coefficient of any known compound

Carbohydrates

Qualitative analysis of Carbohydrates

Carbohydrates- Glucose, Fructose, Galactose, Xylose, Sucrose, Maltose, Lactose, Starch & Dextrin

Tests- Molisch's test, Anthrone test, Fehling's test, Benedict's test, Picric acid test, Barfoed's test, Bial's test, Seliwanoff's test, Foulger's test, Phloroglucinol test, Mucic acid test, Iodine test, Hydrolysis of Sucrose and Starch, Osazone test.

Quantitative Analysis of carbohydrates

1. Estimation of glucose by Nelson-Somogyi method
2. Estimation of reducing sugar by anthrone method.
3. Estimation of pentose by Orcinol method.
4. Estimation of ketose by Roe-Papedopaulose method.

Lipids

Qualitative analysis of Lipids

Fatty acids: Stearic acid, Oleic acid.

Tests- Solubility, Translucent spot tests, Test for Unsaturation Glycerol

Tests- Acrolein, Solubility.

Triglycerides

Tests-Solubility, Saponification, Translucent spot test Cholesterol Tests- Solubility, Salkowski reaction, Liebermann-Burchard reaction

Quantitative Analysis of Lipids

1. Estimation of Cholesterol by Carr-Drecktor method.
2. Estimation of Cholesterol by Zak's method.
3. Determination of Acid Value.
4. Determination of Saponification value.
5. Determination of Iodine number of oil

Amino acids and Proteins

Qualitative analysis of Amino acids and Proteins

Amino acids- (Tyrosine, Glycine, Tryptophan, Histidine, Arginine, Cysteine, Cystine, Proline, Methionine) (Single components only need be given)

Tests- Solubility, Ninhydrin reaction, Xanthoproteic reaction, Millons test, Morners test, Glyoxalic acid test, Ehrlich's test, Nitroprusside test, Lead acetate, Test for Methionine,

Aldehyde test, Sakaguchi reaction, Isatin test

Proteins- Ovalbumin and Casein

Tests- Solubility, Ninhydrin reaction, Xanthoproteic reaction, Folin's test, Lowry's test, Biuret test, Heat denaturation, TCA precipitation, Metal precipitation, Alcohol precipitation.

Quantitative Analysis of Amino acids and Proteins

1. Estimation of Tyrosine by Folin-Lowry method.
2. Estimation of Protein by Biuret method.
3. Estimation of Protein by Folin-Lowry method.
4. Estimation of Protein by Bradford's method.

Nucleic Acids

Quantitative Analysis of Nucleic Acids

1. Estimation of DNA by diphenylamine method
2. Estimation of RNA by Orcinol method

Enzyme Assays

Assay of any two of the following enzymes

Salivary amylase / Acid phosphatase/ Lysozyme

Kinetics of salivary amylase / Aacid phosphatase (Effect of pH, substrate Concentration, enzyme concentration and temperature) Progress curve of salivary amylase / Acid phosphatase

BV1245
Experiments for Microbiology 54 hrs

1. Isolation of lactic acid bacteria from curd.
2. Lactic acid fermentation using lactose as substrate.
3. Isolation of yeast from fruit samples.
4. Isolation of starch degrading microorganisms- fungus and bacteria and the assay of the enzymes.
5. Production of alpha amylase by *Aspergillus niger*.
6. Fermentation techniques- Determination of substrate utilization with respect to growth kinetics
7. Isolation and identification of E.coli from water samples and its identifications.
8. Environmental distribution of microorganisms -Examination of microbial flora of the available soil and water samples,
9. Isolation of microorganisms from spoiled food materials
10. Isolation of lactobacillus from curd and its identification
11. Examination of microbial flora of the skin
12. Examination of the microbial flora of mouth.
13. Isolation and examination of Throat and nasopharyngeal cultures.
14. Inhibition and destruction of microorganisms by antibacterial chemicals.
15. . Production of exoenzymes by bacteria- isolation of alpha amylase producing bacteria and its culturing for the production of alpha amylase
16. Plaque-forming Bacteriophage

SEMESTER III

Core Course Biotechnology IV

Course Code	Title of the Course	Credits	Contact Hours
BV 1344	**Food and Industrial Biotechnology**	**3**	**90 (**T 54 + P 36)

Learning outcomes

CO No.	CO statement
CO1	The students will be able to understand the potential of Food and Industrial biotechnology
CO 2	Students will learn industrial applications of Food Biotechnology and Bioprocess technology.
CO 3	They will be trained to understandthe commercialimportance of Biotechnology
CO4	The students will acquire knowledge on career opportunities in industries R&D

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
						TOTAL	100

Course content

Module I 6 hr

MO:The students will have a basic understanding on industrially important microbes and microbial products.

Concepts and development;-
Microbes in industry, Industrially important microorganisms, screening and isolation;
Important industrial fermentation products- an overview.

Module II 8 hrs

M O: Students will have a basic understansing on fermentor types and design

Fermentation

The biological process of fermentation:- various types of fermentation, alcohol fermentation, scale up of biological reactions in to bioprocess; Bioreactors:- types of bioreactors / Fermentors, parts of a bioreactor.

Module III 10 hr

MO:-The students will have a basic understanding on upstream and downstream processing

Upstream Processing: Media for fermentation, characteristics of ideal production media, media sterilization, aeration, pH, temperature; batch fermentation, continuous fermentation, chemostatic cultures

Downstream processing: Downstream processing and product recovery, Different physical and chemical methods for the separation of fermentation products

Module IV 10 hrs

MO:-The students will have a thorough knowledge on valuable fermentation products

Agricultural waste and food industry wastes as the substrate for fermentation, solid state fermentation; production of single cell proteins, microbial production of enzymes- protease and amylase; Immobilization of cells and enzymes-applications

Module V 6 hrs

MO:-The students will have a thorough knowledge on commercial products of industrial Biotechnology

Microbial production of antibiotics-Penicillin, vitamins- B_{12}, amino acids- Glutamic acid; Organic acid-Citric acid; Beverages- beer, wine; solvents- ethanol, butanol.

Module VI 14 hrs

MO:-The students will have a thorough knowledge on commercial products of Food Biotechnology

Food Biotechnology

Fermented foods- Industrial process of cheese, yoghurt, sauerkraut making.

Food spoilage: types of spoilage, microbes in food spoilage -canned foods, meat, fish. Hazardous effect of food spoilage- food poisoning, mycotoxins, food borne diseases and intoxications

Food preservation- principles of preservation of foods, methods of food preservation, bio preservatives

Dairy Biotechnology-Microbes in dairy industry, contamination, spoilage, dairy products, Pasteurization, milk borne diseases

Practical **36 hrs**

Experiments for Industrial Biotechnology Practical

8. Isolation of yeast from fruit samples and its culturing.
9. Preparation of media for alcohol fermentation by yeast.
10. Preparation of Ethyl alcohol from glucose by Yeast fermentation
11. Separation and quantification of ethanol by distillation (demonstration)
12. Production of wine (Demonstration)
13. Isolation of microorganisms from spoiled food and identification
14. Isolation of organisms from curd/ milk and fermentation of lactose
15. Demonstration of setting laboratory fermentor- basic features, purpose, procedure

Industrial Visit:

The students are required to visit an industry related to the subject in semester 3. A detailed report of the one day industrial visit must be submitted by each student for evaluation on the day of practical examination Biotechniques II, in semester 4.

Suggested Reading

1. Fermentation technology- Whittaker,
2. Food Microbiology- M R Adamas & M O Moss; Panima Publishing Corporation, New Delhi.
3. Food Processing – Biotechnolgical Applications- S S Marwaha & J K Arora, Asiatech Publishers Inc., New Delhi
4. Fundamentals of Microbiology, Jones & Bartlett Publishers, Boston, USA.
5. Industrial Microbiology – A H Patel, Panima Publishing House New Delhi.
6. Introduction to Genetic Engineering & Biotechnology- A. J. Nair; Jones & Bartlett Publishers, Boston, USA.
7. Microbiology (7^{th} Ed)- Prescott L. M., Harley, J. P., and Klein D. A. Mc Graw Hill, New York
8. Modern Concept of Biotechnology- H D Kumar; Vikas Publishing House Pvt. Ltd., New Delhi

SEMESTER III
Core Course Biotechnology V

Course Code	Title of the Course	Credits	Contact Hours
BV 1345	**Molecular Biology**	**3**	**90 (**T 54 + P 36)

Learning outcomes

CO No. CO statement

CO1 The students will be able to understand the scope and importance of Molecular Biology

CO 2 Students will be able to learn structure, function, regulation of gene

CO 3 They will be trained to understand the molecular basis of life

CO4 The students will gain a very essential foundation for the proper understanding of life at molecular level, which is essential for further studies related to genetic engineering, immunology and other modern applied aspects of biology.

Assesement Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course content with Module outcome (MO)

Module I 8 hrs

MO: The students will have a basic understanding on structure and replication of DNA

Introduction

History and significant discoveries in molecular biology, Molecular basis of life, Experiments demonstrating DNA as the genetic material, Structure of DNA, replication of DNA – both prokaryotic and eukaryotic, enzymes of DNA replication

Module II 8 hrs

MO: The students will have a basic understanding on structure of gene

Genes

Structure of prokaryotic gene: operon, organization of operon, polycistronic mRNA and its translation, polysomes.

Eukaryotic genes: structure of a gene, reading frame, regulatory sequences, promoters and enhancers

Module III 12 hrs

MO: The students will have a basic understanding on gene expression mechanisms

Gene expression:

Transcription- transcription products, types of RNA-mRNA, tRNA, rRNA and small nuclear RNA (snRNA), miRNA.

Eukaryotic transcription, post-transcriptional modification of mRNA.

Translation- translation of prokaryotic and eukaryotic mRNA, different stages of protein synthesis. Genetic code: properties of genetic code, codon assignment, start codon and termination codons

Module IV 12 hrs

MO: The students will have a basic understanding on gene regulation

Gene regulation: prokaryotic gene regulation, regulation of operon, (lac and trp operon), catabolic repression. Regulation of eukaryotic gene expression, level of control of gene expression, transcriptional factors, regulation of RNA processing, mRNA translation, mRNA degradation and protein degradation control, post translational modification of proteins.

Module V 8 hrs

MO: The students will have a basic understanding on molecular organisation of eukaryotic chromosomes

Eukaryotic chromosomes- molecular organization, nucleosomes, transposons, IS elements and other types of transposons.

Module VI

MO: The students will have a basic understanding on cytoplasmic genome 6 hrs

Cytoplasmic genome: mitochondrial DNA (mt DNA) and Chloroplast DNA (cp DNA), structure and important genes.

Practical 36 hrs

Experiments for Molecular biology

1. Instruments and equipments used in molecular biology and rDNA techniques.
2. Preparation of solutions and buffers for DNA isolation
3. Isolation of Genomic DNA from a suitable source- bacteria, plant or animal tissue
4. Examination of the purity of DNA by agarose gel electrophoresis.
5. Quantification of DNA by UV-spectrophotometer
6. Isolation and purification of plasmid DNA
7. Agarose gel analysis of plasmid DNA
8. Restriction digestion of plasmid DNA
9. Restriction analysis of λ phage DNA

Suggested Readings

1. Applied Molecular genetics – R L Miesfeld; Wiley.Liss , New Delhi.
2. Basic Biotechnology- A. J. Nair, Laxmi Publications, New Delhi
3. Essential molecular Biology- A practical Approach, T A Brown; Oxford, New York
4. Gene VIII- Benjamin Lewin; Offord University Press.
5. Introduction to Genetic Engineering & Biotechnology- A. J. Nair; Jones & Bartlett Publishers, Boston,USA.
6. Introduction to Molecular biology- P. Paolella; Mc Graw Hill, New York
7. Molecular Biology of the gene – Watson, Baker, Bell Gann, Lewinw, Losick; Pearson Education Pvt.Ltd, New Delhi
8. Molecular cell biology H S Bhamrah; Anmol Publications Pvt. Ltd., New Delhi.
9. PCR 3 - Practical Approach – C. Simon Hearington & John J O'Leary; Oxford, New York
10. Principles of Gene manipulation- R.W.Old & S.B. Primrose; Blackwell Scientific Publications

SEMESTER IV

Core Course Biotechnology VI

Course Code	Title of the Course	Credits	Contact Hours
BV 1446	**Recombinant DNA Technology**	**3**	**90 (**T 54 + P 36)

Course / Learning outcomes

CO No. CO statement

CO1 The students will be able to understand basics of gene manipulation methods and principles-

CO 2 Students will be able to understand special features of tools needed genetic engineering procedures

CO 3 They will be trained to understand the construction of a recombinant DNA

CO4 The students will gain a very essential understanding of the tools needed for the analysis and identification of a gene and bio safety and ethics in genetic engineering

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course content with Module outcome (MO)

Module I

10 hrs

MO:-The students will have a basic understanding ontools of recombinant DNA technology

Introduction to gene cloning and its applications: Tools of recombinant DNA technology- Restriction endonucleases, classification and general characteristics of RE, other enzymes used in the recombinant DNA technique- DNA ligase, alkaline phosphatase.

Module II

15 hrs

MO:-The students will have a basic understanding on special features of different kinds of vectors used in rDNA technology

Vectors, the vehicle for cloning: special features needed for a vector,

Various types of cloning vectors:

Plasmid cloning vectors- pBR322, Expression vectors- the pUC series.

Bacteriophage cloning vectors – λ phage cloning vectors, M13 phage based vector.

Combination vectors- Phagmid and Cosmid vectors.

Artificial Chromosomes:

Yeast artificial chromosome vectors (YACs), Bacterial artificial chromosome vectors (BACs), Application for YAC and BAC in genome sequencing. Shuttle vectors for animals and plants, mammalian vectors.

Gene Therapy- Vectors for gene therapy.

Module III

14 hrs

MO:-The students will have a basic understanding on steps involved in construction of recombinant DNA and screening methods for rDNA

Construction of recombinant DNA, host cells, competent cells, bacterial transformation, screening methods of transformed cells, DNA libraries: genomic DNA libraries and cDNA libraries- applications. Various methods of genetic transformation in eukaryotes- Direct gene transfer and vector mediated gene transfer. Screening methods of transformed cells and organisms.

Module IV

15 hrs

MO:-The students will have a basic understanding on tools involved in Gene identification and gene expression analysis

Molecular hybridization techniques for genome analysis: RFLP, AFLP, RAPD, Southern hybridization

PCR: Principle, types and applications

Nucleic acid sequencing: Principle and applications, Genome sequencing methods, Human genome project– a brief account.

Gene expression analysis – Northern hybridization and microarrays

Transgenic organisms and its impact in agriculture, Medicine and Environment

Bio safety and Ethics in Genetic Engineering

Practical

36 Hrs

Experiments for Practical of rDNA Technology

1. Preparation of the reagents for rDNA experiments
2. Purification of Plasmid from bacterial Cultures.
3. Electrophoresis and evaluation of plasmid DNA- pUC 18 / pBR 322
4. Estimation of plasmid DNA by UV-VIS spectrophotometer
5. Restriction Digestion of pUC 18 and analysis by agarose gel electrophoresis
6. Transformation of *E. coli* with pUC 18 and selection of ampicillin resistant clones
7. Extraction and purification of Genomic DNA

Suggested Readings

1. Animal cell culture- John R W Master; Oxford University Press
2. Basics of Biotechnology- A. J. Nair; Laxmi Publications, New Delhi.
3. Biotechnology – B D SinghKalyani Publishers, New Delhi
4. Cuture of animal cells – A manual of basic technique, R Ian Freshney; Wiley- Liss Publication, New York.
5. Introduction to Biotechnology & Genetic Engineering, Jones & Bartlett Publishers, Boston.
6. Introduction to Genetic Engineering & Biotechnology- Nair, A. J., Jones & Bartlett Publishers, Boston,USA.
7. Modern concept of Biotechnology- H D Kumar; Vikas Publishing House, Pvt. Ltd., New Delhi

SEMESTER IV
Core Course Biotechnology VII

Course Code	Title of the Course	Credits	Contact Hours
BV 1447	**Immunology**	**3**	**90 (**T 54 + P 36)

Learning outcomes

CO No. CO statement

CO1 The students will be able to understand basics of immune system, immune response and immunology related techniques

CO 2 Students will learn about Immune system and different kinds of immunity

CO 3 They will be trained to understand antibody structure and function, and antibody diversity

CO4 The students will acquire knowledge on immunological techniques and its implications in disease diagnosis

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course content with Module outcome (MO)

Module I 18 hrs

MO: - The students will have a basic knowledge on human immune system and tissues involved in creating immunity.

The Human Immune System: Organs and cells of immune system

Module II I8 hrs

MO:- The students will have a basic understanding on various kinds of immunity in our body

Historical perspective of immunology: Immune system and immunity, innate and specific or acquired immunity, Immune system- organs, tissues and cells involved in immunity, Humoral immunity and cell mediated immunity, antigens, antibodies, immunogens, haptens.

Module III 10 hrs

MO:The students will have a basic understanding on anibody structure,types and functions

Immunoglobulins:

Antibody structure in relation to function and antigen binding: types of antibodies and their structures: isotypes, allotypes and idiotypes.

Module IV 10 hrs

MO:The students will have a basic understanding on different kinds of immunological techniues

Measurment of antigen

Antibody-antigen interaction, antigen-antibody reactions, agglutination, immuno-diffusion, immuno-electrophoresis, ELISA, RIA, production of monoclonal (hybridoma technology) and polyclonal antibodies.

Module V 8 hrs

MO:-The students will have a basic understanding on how anibody diversity and classes arise in body, and its clinical implications.

Immunoglobulin gene- Genetic basis of antibody diversity

T cell functions.

Immunity to infections of diseases: vaccines - attenuated and recombinant vaccines, vaccination.

Module VI 6 hrs

MO:-The students will have a basic understanding on clinical applications of antibody like immunotherapy

Antibodies in targeting therapeutic agents- therapeutic antibodies

Introduction to tumor and transplantation immunology. Immunotherapy

Module VII 4 hrs

MO:-The students will have a basic understanding on mechanim of autoimmunty and various autoimmune disorders.

Autoimmunity and autoimmune diseases: Hashimoto's thyroiditis; Myasthenia gravis; Rheumatoid Arthritis, Pernicious anemia, Systemic lupus erythematosus (SLE).

Experiments for Immunology Practical **36 hrs**

1. Immune cells –observation by staining and cell counting
2. Separation of immune cells from lymphoid organs of lab animals / blood.
3. Blood grouping –Determination of blood groups
4. Agglutination tests and immunological precipitation
5. Neutralization and complement fixation reaction
6. Demonstration of Radio immunoassay and ELISA
7. Demonstration of Immuno-electrophoresis

Suggested Readings

1. An Introduction to Immunology – C V Rao, Narosa Publishing House, New Delhi
2. Basics of Biotechnology- A J Nair; Laxmi Publications, New Delhi
3. Immunology – Joshi, Osama; AgroBotanica, New Delhi
4. Immunology – R A Goldsby, T J Kindt, B A Osborne, Janis Kuby; W H Freeman & Company, New York
5. Instant Notes in Immunology – P M Abbas, A H Lichtman, M W Fanger; Viva Books Pvt.Ltd, New Delhi.
6. Introduction to Genetic Engineering & Biotechnology- A. J. Nair; Jones & Bartlett Publishers, Boston, USA.
7. Principle Cellular and Molecular Immunology- Jonathan M Austyn 7 Kathryn J Wood; Oxford, New York

SEMESTER IV
Core Course Biotechnology VIII

Course Code	Title of the Course	Credits	Contact Hours
BV 1448	**Biotechniques II** (Practical of BV1344, BV1345, BV1446, BV1447)	**2**	Practical Hours of the respective courses

Practical

BV 1344

Experiments for Industrial Biotechnology Practical 36 hrs

1. Isolation of microorganism for the production of alpha amylase
2. Culturing of Aspergillus niger and students should familiarize the industrial products from this fungus
3. Isolation of yeast from natura sources- grapesw and other types of fruits
4. Isolation of lactic acid producing bacteria fron curd and production of lactic acid
5. Preparation of media and sterilization for alcohol fermentation by yeast.
6. Preparation of Ethyl alcohol from glucose by Yeast fermentation- separation of ethanol by distillation (demonstration)
7. Growth Curve of bacteria or yeast cultures in nutrient broth
8. Isolation of microorganisms from spoiled food and identification
9. Isolation of organisms from curd / milk and fermentation of lactose
10. Demonstration of setting laboratory fermentor- basic features, purpose, procedure and application-Demonstration of running a laboratory fermentor.

(BV1345)

Experiments for Molecular Biology Practical 36 Hrs

1. Instruments and equipments used in molecular biology and rDNA techniques.
2. Isolation of Genomic DNA
3. Examination of the purity of DNA by agarose gel electrophoresis.
4. Quantification of DNA by UV-spectrophotometer
5. Isolation and purification of plasmid DNA
6. Agarose gel analysis of plasmid DNA
7. Restriction digestion of plasmid DNA

(BV1446)

Experiments for Practical of rDNA Technology 36 Hrs

1. Preparation of the reagents for rDNA experiments
2. Purification of Plasmid from bacterial Cultures.
3. Electrophoresis and evaluation of plasmid DNA-pUC 18 / pBR 322
4. Estimation of plasmid DNA by UV-VIS spectrophotometer
5. Restriction Digestion of pUC 18 and analysis by agarose gel electrophoresis
6. Transformation of E. coli with pUC 18 and selection of ampicillin resistant clones
7. Extraction and purification of Genomic DNA

BV1447

Experiments for Immunology Practical 36 hrs

1. Immune cells –observation by staining and cell counting
2. Separation of immune cells from lymphoid organs of lab animals / blood.
3. Blood grouping –Determination of blood groups
4. Agglutination tests and immunological precipitation
5. Neutralization and complement fixation reaction
6. Demonstration of Radio immunoassay and ELISA
7. Demonstration of Immuno-electrophoresis

Industrial Visit Report:

A detailed report of the one day industrial visit during semester 3 must be submitted by each student for evaluation on the day of practical examination Biotechniques II, in semester 4.

SEMESTER V
Core Course Biotechnology IX

Course Code	Title of the Course	Credits	Contact Hours
BV 1544	**Environmental Biotechnology**	**2**	**54** (T 36+ P 18)

Course outcome

CO No. CO statement

CO1 The students will be able to understand the application of biotechnology in keeping the environment clean and healthy and application of biotechnology in energy production

CO 2 Students will learn about ecosystem, biodiversity

CO 3 They will be trained to understand Pollution types ,sources of pollution, general characteristics of pollutants and controlling measures and biological methods of degradation of pollutants

CO4 The students will acquire knowledge on renewable energy sources especially biomass energy and other biological methods

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I **5 hrs**

MO:-The students will have basic understanding types of ecosystem, biodiversity, factors and abiotic factors maintaining ecosystem and biodiversity

Introduction, Ecosystem, Biodiversity,

Biosphere and Types of ecosystem

Module II **5 hrs**

MO:-The students will have a basic understanding on types of pollution, pollutants and controlling measures

Pollution: sources of pollution, general characteristics of domestic wastes, community wastes, agricultural wastes, effect of solid waste in the environment

Module III 6 hrs

MO:-The students will have a basic understanding on water pollution, air pollution, factors causing pollution, quality analysis of water, air, and biological measures to remediate pollutants

Pollution

Air pollution: aerosol, smog. Air quality standards.

Water pollution: Organic load in aquatic systems, BOD and COD,

Microbial quality of water, drinks and food

Use of biotechnology in the treatment of municipal wastes and hazardous industrial effluents

Module IV 8 hrs

MO:-The students will have a basic understanding on biological measures to remediate pesticides, controlling pests by biological means and application of biotechnology in the production of bio-fertilizers

Bioremediation: Microbial degradation of pesticides, herbicides and other toxic chemicals in the environment, Biological control of pests and insects, Biopesticides- Bacillus thuringiensis, bioherbicides; Application of biotechnology in the production of biofertilizers and nitrogen fixation – nitrogen fixing microorganisms, mycorrhiza

Module V 4 hrs

MO:-The students will have a basic understanding on scope of renewable and non renewable energy resources and environmental impacts of conventional fuels

Renewable and non renewable energy resources

Conventional fuels and their environmental impacts (fire wood, vegetable oils, animal fats, coal, and petroleum)

Module VI 5 hrs

MO: - The students will have a basic understanding on non-conventional energy sources and its processing methods

Non-conventional energy sources

Biomass: utilization of biomass as energy source– application of microbes in production of fuels from biomass-biogas and methanogenic bacteria, microbial hydrogen production, production of methanol, ethanol and other types of chemicals from biomass and agricultural wastes, the gasohol experiment.

Solar energy converter, artificial photosynthesis- artificial leaf
Vegetable oils as engine fuels- biodiesel, energy crops- jojoba, jatropha
Possibility of plant based petroleum industry and cellulose degradation for combustible fuels.

Module VII 3 hrs

MO:-The students will have a basic understanding on biological methods to extracts ores and metals

Bioleaching, Enrichment of ores by microorganisms- bioaccumulation and biomineralisation.
Bio-assessment of environmental quality.Biosensors.

Practical 18 hrs

Experiments for Environmental Biotechnology

1. Microbiological assessment of drinking water- water from well, river, pipeline and packaged drinking water
2. Isolation of microbes from the environment- from air, soil, floor of the lab and water.
3. Assessment of organic load in aquatic systems and factory effluent- Determination of BOD and COD.
4. Biogas production by methanogenic bacteria or by mixed culture.
5. Isolation of nitrogen fixing bacteria from leguminous plants
6. Determination of N, P and K in biofertilizers

Suggested readings

1. Biodiversity- Status and Prospects- Pramod tandon etal Narosa Publishing House, New Delhi
2. Biological Conservation – Spellergerg I F
3. Biological waste water treatment 2nd Edition- Grady C P L
4. Biotechnology – B D Singh; Kalyani Publishers, New Delhi
5. Biotechnology fundamentals and applications – Purohit & Mathur; Agrobotanica, India
6. Ecology 2nd Edn, Subrahmanyam N S, Sambamurty V.S.S; Narosa Publishing House.
7. Environmental Biotechnology - Alan Scragg; Longman, England
8. Environmental issues and Options – Mishra C.

SEMESTER V
Core Course Biotechnology X

Course Code	Title of the Course	Credits	Contact Hours
BV 1545	**Plant Biotechnology & Animal Biotechnology**	**3**	**90** (T 72+ P 18)

Course outcome

CO No.	CO statement
CO1	The students will be able to understand the basic knowledge in the applied aspects of plant biotechnology and animal biotechnology for the improvement of agriculture and plant based and animal based industries.
CO 2	Students will learn about fundamentals of plant tissue culture
CO 3	They will be trained to understand the various techniques of animal cell culture, cloning and tissue culture of plants and animals.
CO4	The students will acquire knowledge on generating transgenic animal and plants with various applications

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I **10 hrs**

MO:- Students will learn about fundamentals of plant tissue culture

Fundamental principles of *in vitro* plant cultures: use of plant growth regulators, composition of tissue culture media- media components and its functions.

Sterilization Methods - Steam sterilization, Dry sterilization, Filter sterilization, surface sterilization of explants.

Types of *in vitro* cultures: callus cultures, cell suspension cultures, organ cultures- root cultures, hairy root cultures, embryo cultures, anther culture.

Module II 10 hrs

MO:-Students will learn about application of in vitro cultures like Plant secondary metabolites production through cell culture system.

Application of in vitro cultures: embryogenesis and organogenesis- a brief understanding, clonal multiplication and micropropagation- meristem culture, axillary bud and shoot tip culture, anther and pollen culture- production of haploids and its uses.

Plant secondary metabolites production through cell, tissue and organs cultures

Advantages and disadvantages of *in vitro* culture methods

Module III 10 hrs

MO:- Students will learn about application different culture methods

Somaclonal variation

Possible reasons of Somaclonal variations, applications, merits and demerits of Somaclonal variations.

Protoplast culture

Protoplast: - isolation and culturing of protoplast- principle and application, regeneration of protoplasts, protoplast fusion and somatic hybridization- selection of hybrid cells.

Module VI 12 hrs

MO:-students will learn about Genetic engineering techniques of plants and its application in agriculture and horticulture area

Genetic engineering of plants: Methods of gene transfer in plants –Physical, chemical and biological methods *Agrobacterium tumefaciens*, tumor formation in plants by *A. tumefaciens*, application of *A. tumefaciens* inplant genetic engineering, Virus mediated gene transfer in plants.

Transgenic plants

Transgenic crops, Impact of transgenic plants in agriculture and Horticulture, Non Agricultural applications of transgenic plants- Biopharming- production of therapeutic proteins in transgenic plants, edible vaccines, disease resistant, salt tolerant, pest resistant and stress tolerant crop and medicinal plants; Metabolic engineering of plants for enhanced and controlled production of plant products.

Animal Biotechnology

Module I 10 hrs

MO:- students will learn aboutAnimal cell culture techniques

Animal cell culture: History, animal cell, tissue and organ culture.

Animal cell culture techniques, Primary cell cultures and secondary cell cultures, immortalized cell cultures, cell lines-types and characterisation, Media – media components and physical parameters, Instruments and equipments needed for animal cell cultures, uses of animal cell cultures.

Module II 10 hrs

MO:-students will learn about Animal Cell Culture application and expression of transgene in animal cells and scale up process

Application of Animal Cell Cultures: Products of animal cell cultures- hormones (insulin, growth hormones), interferon, t-plasminogen activator, factorVIII, Factor IX and as hosts for virus cultivation.

Expression of cloned proteins in animal cells, production of vaccines in animal cells, production of monoclonal (hybridoma technology) and polyclonal antibodies.

Scale up of animal cell cultures: Special bioreactors for large-scale cultivation of animal cells, anchorage depended cells and suspension cultures, Roller bottles and spinner flasks.

Module III 10 hrs

MO:-students will learn about application of animal culture like gene therapy and ethical approaches in transgenics

Stem cell technology: Stem cell culture and its clinical uses, types of stem cells.

Gene therapy and tissue grafting, Growth factors promoting proliferation of animal cell cultures. Preservation and maintenance of animal cell cultures- cryopreservation and transport of animal cell cultures. Transgenic animals and its practical uses.

Bioethics in animal cell culture, stem cell technology and transgenic animals.

Practical **18 Hrs**

Experiments for Practical in Plant Biotechnology 10 hrs

1. Preparation of plant tissue culture medium, and sterilization, Preparation of stock solutions of nutrients for MS Media.
2. Preparation of M S Media
3. Surface sterilization of plant materials for inoculation (implantation in the medium)
4. Development of callus cultures and its sub-culturing
5. Organogenesis- shoot regeneration, root regeneration, somatic embryogenesis
6. Micropropagation of potato/tomato/ - Demonstration
7. Familiarization of instruments and special equipments used in the plant tissue culture experiments- Laminar Airflow chamber,
8. Protoplast isolation and culturing – Demonstration

Experiments for Practical in Animal Biotechnology 8 hrs

1. Familiarization of methods, equipments and techniques of animal cell culture
2. Isolation of lymphocytes from blood
3. Cell viability assay by die exclusion method and cell counting
4. MTT assay of cells Evans blue assay of pollen grains or blood cells
5. Demonstration of ELISA technique
6. Protein purification by ion exchange chromatography from serum

Suggested readings

1. An Introduction to Plant Tissue Culture – M K Raxdan; Oxfird & IBH Publishing Co.Pvt. Ltd., New Delhi
2. Animal cell culture- John R W Master; Oxford University Press
3. Basics of Biotechnology- A. J. Nair; Laxmi Publications, New Delhi.
4. Biotechnology-Fundamentals and Application- S S Purohit and S K Mathur; Agrobotanica, India.
5. Culture of animal cells – A manual of basic technique, R Ian Freshney; Wiley- Liss Publication, New York.
6. Introduction to Genetic Engineering & Biotechnology- A. J. Nair; Jones & Bartlett Publishers, Boston,USA.
7. Introduction to Plant Biotechnology- H S Chawla; Oxford & IBH publishing Co.Pvt.Ltd., New Delhi.
8. Modern concept of Biotechnology- H D Kumar; Vikas Publishing House, Pvt. Ltd., New Delhi.
9. Plant biotechnology, Recent Advances- P C Trivedi; Panima Publishing Corporation, New Delhi.
10. Plant vell, Tissue and Organ Culture- Fundamental Methods, O L Gamborg, G C Philips; Narosa Publishing House, New Delhi.
11. Role of Biotechnology in Medicinal and aromatic plants- Irfan A Khan and Atiya Khanum ; Ukaaz Publications, Hyderabad.

SEMESTER VI
Core Course Biotechnology XI

Course Code	Title of the Course	Credits	Contact Hours
BV 1651	**Biotechniques III** (Practical of BV1544 and BV1545)	**2**	**practical hrs of the respective courses**

BV1545

Experiments for Practical in Plant Biotechnology & Animal Biotechnology **90 hrs**

Plant Biotechnology 40 hrs

1. Preparation of plant tissue culture medium and sterilization, Preparation of stock solutions of nutrients for MS Media.
2. Preparation of M S Media
3. Surface sterilization of plant materials for inoculation (implantation in the medium)
4. Development of callus cultures and its sub-culturing
5. Organogenesis- shoot regeneration, root regeneration, somatic embryogenesis
6. Micropropagation of potato/tomato/ - Demonstration
7. Familiarization of instruments and special equipments used in the plant tissue culture experiments- Laminar Airflow chamber,
8. Protoplast isolation and culturing – Demonstration

Animal Biotechnology **30 hrs**

1. Familiarization of methods, equipments and techniques of animal cell culture.
2. Isolation of lymphocytes from blood
3. Cell viability assay by die exclusion method and cell counting.
4. MTT assay of cells Evans blue assay of pollen grains or blood cells.
5. Demonstration of ELISA technique.
6. Protein purification by ion exchange chromatography from serum

BV1544

Experiments for Environmental Biotechnology **20 hrs**

1. Microbiological assessment of drinking water- water from well, river, water supply department and packaged drinking water
2. Isolation of microbes from the environment- from air, soil, floor of the lab, from water.
3. Assessment of organic load in aquatic systems and factory effluent- Determination of BOD and COD.
4. Biogas production by methanogenic bacteria or by mixed culture.
5. Isolation of nitrogen fixing bacteria from leguminous plants
6. Determination of N, P and K in biofertilizers

Open Courses and Elective Courses

Elective Courses of Biotechnology

The students have the freedom to opt any one of the open courses from the departmentand another one from outside the department.

Students of Biotechnology should take up an internal elective from the following courses andanother one from other departments.

Elective Course for Biotechnology students

& Open course for students from other Departments

CHOICE OF OPEN COURSE

The students have the freedom to opt any one of the open courses during the **fifth semester** offered by other departments.

Open Course of Biotechnology shall be offered only to students from other B.Sc. Programmes (Non-Biotechnology students).

One open course shall be offered from the following choices:

1. **BV1551 Bioinformatics**
2. **BV1552 Food & Dairy Biotechnology**
3. **BV1553 Genetic Engineering**
4. **BV1554 Basics of Environmental Biotechnology**

Elective Courses of Biotechnology

Elective course of biotechnology shall be offered to B.Sc. Biotechnology students during the **sixth semester**. One course to be selected from the following choices

1. **BV1663.1 Bioinformatics & Nano biotechnology**
2. **BV1663.2 Food & Dairy Biotechnology**
3. **BV1663.3 Genetic Engineering**

Open Course of Biotechnology

Course Code	Title of the Course	Credits	Contact Hours
BV 1551	**Bioinformatics**	**2**	**54 hrs**

Course outcome

CO No. CO statement

CO1 The course should introduce the subject of bioinformatics to the students of non-biology streams

CO 2 Students should be familiarized to the importance of the bioinformatics with respect to other biological subjects

CO 3 Students should be familiarized to the subjects of bioinformatics, databases, genomics and proteomics

CO4 Students should learn the important software and other tools of bioinformatics at the elementary levels. The students get a broad understanding of applications of IT in Biological data analysis

Assessment Pattern

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I **18hrs**

Bioinformatics: Definition.

History and evolution of bioinformatics, Impact of bioinformatics in modern biology,

Databases- various types of databases, Biological Databases- Importance of databases in biotechnology, NCBI, Gene bank, PubMed. Etc.

Module II **18hrs**

Internet resources for Biotechnology,

A short introduction to genome analysis, genome sequencing projects, genome similarity,

Tools (software) in Bioinformatics,

Tools for sequence alignments- BLAST and Fasta.

Module III **18hrs**

Genomics and Proteomics: Definitions, Gene and Genomes, Protein and proteome

Application of Proteomics and genomics in Biotechnology.

Practical in Bioinformatics

1. Use of Computers in Biological science; Data base creation, Data base retrieval –Online use of Computational tools.
2. Identification of a given sequence as DNA, RNA or Proteins
3. To analyze the sequence of agiven DNA and find out sequence composition
4. To find out the number of times a sequence is repeated in a given DNA sequence.
5. To find out the complementary sequence of a given nucleotide sequence

Suggested Readings

1. Bioinformatics-GenomicsandPost- genomics, Frederich Dardel & Francois Kepes; JohnWiley & Sons.
2. IntroductiontoBioinformatics –V.Kothekar,DruvPublication
3. Introduction to Genetic Engineering & Biotechnology-A.J.Nair; Jones&Bartlett Publishers, Boston, USA.

Open & Elective course

Course code BV 1552 is Open Course
Course code BV 1663.2 is Elective Course

Course Code	Title of the Course	Credits	Contact Hours
BV 1552	**Food & Diary Biotechnology**	**2**	**54 hrs. (open course)**
BV 1663.2			**36 hrs. (Elective)**

Course outcome

CO No. CO statement

CO1 The students will be able to understand the basic knowledge in the applied aspects of food microbiology and importance of fermented foods

CO 2 Students will learn about food spoilage and causative agents of food spoilage

CO 3 They will be trained to understand principles of food preservation and various methods of preservation techniques

CO4 The students will acquire knowledge on different kinds of fermented dairy , meat products etc.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I

MO:-students will learn about microbes involved in food processing and culturing techniques

Microbes of food and fermented food:

Curd, wheat and rice flour,

Meat and fish, Poultry and eggs, Breads and bakery products, Grains

Microbiological contamination of foods:

Indicator organisms, culture techniques, direct methods, immunological methods

Module II

MO:-students will learn about spoilage of food and causative factors involved in contamination of food

Food spoilage

Microbes involved in food spoilage: Spoilage of Canned foods, Meat and dairy products.

Conditions of food spoilage: pH, physical structure, chemical composition, oxygen and temperature.

Chemistry of food spoilage: microbial toxins and food poisoning.

Food borne diseases and its prevention.

Module III

Mo:-students will learn about methods of food preservation and techniques involved in food preservation

Food Preservation: Mmethods of food preservation,

Physical & Chemical Methods,

Osmotic pressure, preserving foods in sugar and salt, chemical preservatives,

Radiation as a preservation method

Module IV

MO:-students will learn about industrially important products and its processing

Microbes of Dairy industry: Dairy products Microbes in fermented food production

Industrial production of antibiotics (penicillin & streptomycin) and organic acids (acetic acid & Citric acids)

Microorganisms as food : fermented food, microalgae, Single cell protein, Edible mushrooms.

Suggested Readings

1. Food Microbiology- MR Adams and Moss
2. Food Processing- Biotechnological applications Marwah &Arora
3. Food Microbiology-William C Frazer
4. Industrial microbiology -LE Casida

Open & Elective Course Biotechnology

Course code BV 1553 is Open Course
Course code BV 1663.3 is Elective Course

Course Code	Title of the Course	Credits	Contact Hours
BV 1553 **BV 1663.3**	**Genetic Engineering**	**2**	**54 hrs (open)** **36 hrs (Elective)**

Course outcome

CO No.	CO statement
CO1	The students will be able to understand the basic principle of Molecular Cloning
CO 2	Students will learn about Genes and its chemical nature as DNA and its involvement in the formation of protein
CO 3	They will be trained to understand central dogma of Molecular biology and the flow of information from DNA to protein through RNA
CO4	The students will acquire knowledge Genetic Engineering and rDNA technology and its contribution in the development of various products and medicines.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I

Introduction to gene cloning and its applications,Tools of recombinant DNA technology
Restriction endonucleases, classification and general characteristics of endonucleases;
Other enzymes used in the recombinant DNA technique- DNA ligase, alkaline phosphatase;

Module II

Vectors, the vehicle for cloning: special features needed for a vector,Various types of cloning vectors- plasmid cloning vectors- pBR322, Expression vectors, the pUC series,
Bacteriophage cloning vectors – λ phage cloning vectors, M13 based vectors,
Phagmids and Cosmid vectors,

Module III

Construction of recombinant DNA, host cells, competent cells, bacterial transformation, screening methods of transformed cells,
DNA libraries: genomic libraries and cDNA libraries. Application of genomic libraries and **cDNA libraries**. Various methods of genetic transformation in eukaryotes- Direct gene transfer and vector mediated gene transfer. Screening methods for transformed cells and organisms

Module IV

Molecular hybridization techniques for genome analysis Genome analysis:

Southern hybridization, RFLP, AFLP,RAPD,

PCR: Principle and applications

Nucleic acid sequencing: Principle and applications, Genome sequencing methods,

Humangenome project– a brief account.

Suggested Reading

1. Animal cell culture- John R W Master; Oxford University Press
2. Cuture of animal cells – A manual of basic technique, R Ian Freshney; Wiley-Liss Publication, New York.
3. Basics of Biotechnology- A. J. Nair; Laxmi Publications, New Delhi.
4. Introduction to Biotechnology & Genetic Engineering, Jones & Bartlett Publishers, Boston.
5. Modern concept of Biotechnology- H D Kumar; Vikas Publishing House, Pvt.Ltd., New Delhi.
6. Introduction to Genetic Engineering & Biotechnology- Nair, A. J., Jones &Bartlett Publishers, Boston,USA.
7. Biotechnology – B D Singh, Kalyani Publishers, New Delhi

Open Course Biotechnology IV

Course Code	Title of the Course	Credits	Contact Hours
BV 1554	**Environmental Biotechnology**	**2**	**54 hrs (open)**

Course outcome

CO No.	CO statement
CO1	The students should be able to describe the understand the basic concept of Ecosystem
CO 2	Students should understand the involvement of Biotechnology in dealing with the problems of ecosystem and biodiversity
CO 3	They will be able to solve the problems of pollution by using the principles of Biotechnology.
CO4	The students be able to apply their knowledge of biotechnology in cleaning the environment and protecting the ecosystem and it's Biodiversity.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I **8hrs**

Introduction
Ecosystem, Biodiversity, Types of ecosystem and biosphere;

Module II **8 hrs**

Pollution: sources of pollution, general characteristics of domestic wastes, community wastes,agricultural wastes, effect of solid waste in the environment

Module III **12 hrs**

Water pollution

Organic load in aquatic systems, BOD and COD, microbial quality of water, drinks and foodUse of biotechnology in the treatment of municipal wastes and hazardous industrial effluents

Module IV 12 hrs

Bioremediation: Microbial degradation of pesticides, herbicides and other toxic chemicals in the environment,

Biological control of pests and insects,

Biopesticides- *Bacillus thuringiensis*,

bioherbicides;

Application of biotechnology in the production of biofertilizers and nitrogen fixation – nitrogen fixing microorganisms, mycorrhiza

Module V 14 hrs

Renewable and non renewable energy resources: conventional fuels and their environmentalimpacts (fire word, animal oils, coal, and petroleum)

Non-conventional energy sources

Biomass: utilization of biomass as energy source– application of microbes in production of fuels from biomass- biogas and methanogenic bacteria, microbial hydrogen production, production of methanol, ethanol and other types of chemicals from biomass and agricultural wastes, the gasohol experiment

Solar energy converter, hopes from photosynthetic pigments, vegetable oils as engine fuels,energy crops-jojoba;

Possibility of plant based petroleum industry and cellulose degradation for combustible fuels

Bioleaching

Enrichment of ores by microorganisms (bioaccumulation and biomineralisation);Bio-assessment of environmental quality

Suggested readings

1. Environmental Biotechnology - Alan Scragg; Longman, England
2. Biotechnology fundamentals and applications – Purohit & Mathur; Agrobotanica, India
3. Biotechnology – B D Singh; Kalyani Publishers, New Delhi
4. Biological waste water treatment 2nd Edition- Grady C P L
5. Biological Conservation – Spellergerg I F
6. Environmental issues and Options – Mishra C.
7. Biodiversity- Status and Prospects- Pramod tandon etal Narosa Publishing House, New Delhi
8. Ecology 2nd Edn, Subrahmanyam N S, Sambamurty V.S.S; Narosa PublishingHouse.

Elective course for Biotechnology students

Course Code	Title of the Course	Credits	Contact Hours
BV 1663.1	**Bioinformatics and Nanobiotechnology**	**2**	**36 hrs.**

Course Outcome

CO No.	CO statement
CO1	The students will be able to understand the basic knowledge in methods and application of bioinformatics and modern Nano biomolecules
CO 2	Students will learn about various tools used in bioinformatics
CO 3	They will be trained to understand various databases and learn about important biological databases
CO4	The students will acquire knowledge on different kinds of nanomaterials and its applications.

Assessment Pattern (Internal and external)

Assessment	BLOOM'S CATEGORY						
	Remember	understanding	apply	Analyse	Evaluate	Create	Total
Internal Assessment (assignments ,seminar, Internal examination)	5	10	0	3	1	1	20
Terminal Evaluation (end semester)	20	30	5	10	5	10	80
TOTAL							100

Course Content

Module I 8 hrs

Bioinformatics- definition, scope, limitations History and evolution of bioinformatics, Impact of bioinformatics in modern biology and research. Databases- various types of databases, Biological Databases- Importance of data bases in biotechnology, NCBI, Genebank, PubMed.

Module II 6 hrs

Sequence alignment- Pair wise sequence alignment-sequence homology vs similarity; similarity andidentity. Database similarity searching- BLAST, FASTA format; Multiple sequence alignment,scoring function, CLUSTALW

Module III 6hrs

Phylogenetic tree construction- distance based methods and character based methods, PHYLIP

Module IV 6hrs

Proteomics–technology of protein expression analysis, 2D PAGE, MS, Protein identification through data base search, protein databank Functional Genomics- Sequence based approaches, Microarray based approaches Applications of proteomics and genomics

Module V **10 hrs**

Nanobiotechnology: Introduction to nano world, classification of nano materials, application of nano crystals, DNA chip, nano biosensors– DNA sensors;

Quantum dots; Drug delivery systems and techniques- prosthesis and implants-

Diagnosis and screening;

Applications of Nanobiotechnology in medicine and health.

Suggested Readings

1. Atext book of Biotechnology, R. C. Dubey,S.Chand Publications, New Delhi
2. Bioinformatics-Genomics and Post-genomics, Frederich Dardel & Francois Kepes; JohnWiley&Sons.
3. Essential Bioinformatics- JinXiong, Cambridge University Press, UK.
4. Introduction to Bioinformatics–V. Kothekar, Druv Publication
5. Introduction to Genetic Engineering & Biotechnology, - A.J.Nair; Jones & Bartlett Publishers,Boston, USA.
6. Nanobiotechnology: Concepts, Applicationsand Perspectives- C.M. Niemeyerand C.A. Mirkin, Wiley,US

BV1646 Project Work / Dissertation

An independent project or dissertation work related to Biotechnology has to be carried out by each student during the VI semester under a faculty member of the college, with in the college or an external Institute/ Department / University duly certified by the Head of the Department and supervising teacher, has to be submitted for evaluation at the time of examination in VI semester.

It can be carried out individually or by a group not exceeding five students. The topic of the project should be innovative and relevant to the field of Biotechnology. The topics are either be allotted by the supervising teacher or be selected by the students in consultation with the supervising teacher. The project report duly attested by the Supervising teacher and certified by the HOD has to be submitted on the day of Viva voce examination. The project shall be evaluated by two external examiners. The report (not less than 40 pages) should be prepared as per the following formats.

1. Title page
2. Declaration by the student
3. Certificate (Supervising teacher and HOD)
4. Acknowledgement if any
5. Table of contents
6. Abbreviations if any
7. Introduction and Review of literature
8. Materials and Methods
9. Results and Discussion
10. Summary and Conclusions
11. References

Care should be taken to represent the data in tables/graphs /figures.