

# **ACADEMIC CURRICULUM AND SYLLABI**

**UNDERGRADUATE DEGREE PROGRAMME**

**BACHELOR OF SCIENCES**

**IN**

**BOTANY**

**Three Years (Full-Time)**

**CHOICE BASED CREDIT SYSTEM**

**(For the Students Admitted from the Academic Year 2019 – 2020)**

**DEPARTMENT OF BOTANY  
SCHOOL OF BASIC SCIENCES**



**(Estd. Under SRMUS Act, 2013)**

**Shri Ramasamy Memorial University Sikkim**  
5<sup>th</sup> Mile, Tadong, Gangtok, East Sikkim - 737102, India

## DEPARTMENT OF BOTANY

1. Department Vision	
Stmt - 1	To provide quality education and develop a research temperament amongst a vast majority of learners in the realm of plant sciences.
Stmt - 2	To develop a knowledge repository on the rich plant diversity of the Eastern Himalayas and their sustainable conservation and management.
Stmt - 3	To develop a robust ethical and moral infra-structure amongst the learners of north-east and other parts of the country, as well as those hailing from neighboring countries who wish to undertake higher research.

2. Department Mission	
Stmt - 1	To provide a fecund ground to the learners where they can harness their knowledge towards different branches of plant sciences, their dynamics, and the industrial applicability.
Stmt - 2	To kindle scientific temperament which would lay a plinth for higher research leading to innovation amongst the learners within the framework of ethics and integrity.
Stmt - 3	To churn out highly motivated and competent individuals who with frontier technologies and subject knowledge will contribute meaningfully towards addressing the environmental sustainability issues.
Stmt - 4	To equip learners with effective written and oral communication skills and enable them to share their scientific findings and ideas to diverse stakeholders.

3. Program Objectives (POs)	
PO1	To enable the learners in acquiring the core competency, digital skills and integrate the fundamental concepts of plant sciences, and allied subject areas enabling them to pursue higher studies and research.
PO2	To enable the learners, develop holistic approach towards plant sciences which would include experimental as well as computational knowledge besides the classical knowledge of botany to decode beautiful yet complex processes governing plant sciences.
PO3	To help the young minds of learners inculcate a research aptitude for looking at diverse problems in plant sciences and thinking of solutions in an analytical, scientific and ethical manner.
PO4	To build the skills of the learners to make them employable in various sectors including academia, industry and entrepreneurial ventures.

4. Consistency of PO with Mission of the Department				
	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. - 3	Mission Stmt. - 4
PO - 1	<b>H</b>	<b>H</b>	<b>H</b>	<b>M</b>
PO - 2	<b>H</b>	<b>H</b>	<b>H</b>	<b>M</b>
PO - 3	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>
PO - 4	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>

H – High Correlation, M – Medium Correlation, L – Low Correlation

5. Consistency of POs with Program Learning Outcomes (PLO)											
Program Learning Outcomes (PLO)											
	1	2	3	4	5	6	7	8	9	10	11
	Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
PO - 1	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>
PO - 2	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>
PO - 3	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>
PO - 4	<b>H</b>	<b>H</b>	<b>M</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>	<b>H</b>

H – High Correlation, M – Medium Correlation, L – Low Correlation

### B.Sc. (Honours) Botany Curriculum

Course category	Course code	Course Name	L	T	P	C
<b>SEMESTER-I</b>						
AECC	LAE1811	English-I(LSRW)	2	1	0	3
C	BOT1812	Microbiology and Phycology	4	0	0	4
C	BOT1813	Plant Morphology and Plant Systematics	4	0	0	4
GE	ZOLA1831	Animal Diversity	3	0	0	3
SEC	BOT1814	Microbiology and Phycology Practical	0	0	4	2
SEC	BOT1815	Plant Morphology and Plant Systematics Practical	0	0	4	2
SEC	ZOLA1832	Animal Diversity Practical	0	0	4	2
*SWAYAM	EVS1817	Environmental Studies (Internal Evaluation)	2	0	0	2
		<b>TOTAL</b>			<b>12</b>	<b>22</b>
<b>SEMESTER-II</b>						
Course category	Course code	Course Name	L	T	P	C
AECC	LAE1821	English-II (Communication Skill)	2	1	0	3
C	BOT1822	Mycology and Phytopathology	4	0	0	4
C	BOT1823	Archegoniate and Palaeobotany	4	0	0	4
GE	ZOLA1841	Aquatic Biology	3	0	0	3
SEC	BOT1824	Mycology and Phytopathology Practical	0	0	4	2
SEC	BOT1825	Archegoniate-Practical	0	0	4	2
SEC	ZOLA1842	Aquatic Biology Practical	0	0	4	2
Extension	EX*will be S/C/Y	NSS / NCC /Yoga (Internal Evaluation)				
		<b>TOTAL</b>			<b>12</b>	<b>20</b>
<b>SEMESTER-III</b>						
Course category	Course code	Course Name	L	T	P	C
C	BOT1831	Plant Anatomy	3	0	0	3
C	BOT1832	Economic Botany	3	0	0	3
C	BOT1833	Plant Genetics	3	0	0	3
GE	CHM1812	Structure and Bonding in Chemistry	4	0	0	4
SEC	BOT1834	Ethnobotany	2	0	0	2
SEC	BOT1835	Plant Anatomy-Practical	0	0	4	2
SEC	BOT1836	Economic Botany-Practical	0	0	4	2
SEC	BOT1837	Plant Genetics-Practical	0	0	4	2
SEC	CHM1814	Inorganic Qualitative Analysis-I	0	0	4	2
		<b>TOTAL</b>			<b>16</b>	<b>23</b>
<b>SEMESTER-IV</b>						
Course category	Course code	Course Name	L	T	P	C
C	BOT1841	Molecular Biology	3	0	0	3
C	BOT1842	Plant Ecology and Phytogeography	3	0	0	3
C	BOT1843	Biomolecules and Cell Biology	3	0	0	3
GE	CHM1823	Basic Concepts of Organic Chemistry	4	0	0	4
SEC	BOT1844	Herbal Technology	2	0	0	2
SEC	BOT1845	Molecular Biology Practical	0	0	4	2
SEC	BOT1846	Plant Ecology and Phytogeography Practical	0	0	4	2
SEC	BOT1847	Biomolecules and Cell Biology Practical	0	0	4	2
SEC	CHM1844	Laboratory Course on Methods and Synthesis in Organic Chemistry	0	0	4	2
		<b>TOTAL</b>			<b>16</b>	<b>23</b>
<b>SEMESTER-V</b>						
Course category	Course code	Course Name	L	T	P	C
C	BOT1851	Reproductive Biology of Angiosperms	4	0	0	4
C	BOT1852	Plant Physiology	4	0	0	4

DSE	BOT1853	Horticultural Practices and Post-Harvest Technology	4	0	0	4
DSE	BOT1854	Plant Breeding				
SEC	BOT1855	Reproductive Biology of Angiosperms Practical	0	0	4	2
SEC	BOT1856	Plant Physiology Practical	0	0	4	2
SEC	BOT1857	Horticultural Practices and Post-Harvest Technology Practical	0	0	4	2
SEC	BOT1858	Plant Breeding Practical				
		<b>TOTAL</b>			<b>12</b>	<b>18</b>
<b>SEMESTER-VI</b>						
<b>Course category</b>	<b>Course code</b>	<b>Course Name</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
C	BOT1861	Plant Metabolism	4	0	0	4
C	BOT1862	Plant Biotechnology and Bioinformatics	4	0	0	4
DSE	BOT1863	Industrial and Environmental Microbiology	4	0	0	4
DSE	BOT1864	Biostatistics				
SEC	BOT1865	Plant Metabolism-Practical	0	0	4	2
SEC	BOT1866	Plant Biotechnology and Bioinformatics Practical	0	0	4	2
SEC	BOT1867	Industrial and Environmental Microbiology Practical	0	0	4	2
SEC	BOT1868	Biostatistics Practical				
		<b>TOTAL</b>			<b>12</b>	<b>18</b>

C-Core

SEC-Skill Enhancement Course

DSE-Discipline Specific Elective Course

AECC- Ability Enhancement Compulsory Courses

\*These courses are suggested to complete through online SWAYAM and credit will be displayed on the mark sheet.

**6. B.Sc. Botany (Honours) Programme Structure (Total Credit: 124)**

Professional Core Courses (C) 14 Courses								
S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
Theory								
1	C	BOT1812	Microbiology and Phycology	4	0	0	4	4
2		BOT1813	Plant Morphology and Plant Systematics	4	0	0	4	4
3		BOT1822	Mycology and Phytopathology	4	0	0	4	4
4		BOT1823	Archegoniate and Palaeobotany	4	0	0	4	4
5		BOT1831	Plant Anatomy	3	0	0	3	3
6		BOT1832	Economic Botany	3	0	0	3	3
7		BOT1833	Plant Genetics	3	0	0	3	3
8		BOT1841	Molecular Biology	3	0	0	3	3
9		BOT1842	Plant Ecology and Phytogeography	3	0	0	3	3
10		BOT1843	Biomolecules and Cell Biology	3	0	0	3	3
11		BOT1851	Reproductive Biology of Angiosperms	4	0	0	4	4
12		BOT1852	Plant Physiology	4	0	0	4	4
13		BOT1861	Plant Metabolism	4	0	0	4	4
14		BOT1862	Plant Biotechnology and Bioinformatics	4	0	0	4	4
Total Credit							50	

Discipline Specific Elective Courses (DSE) 2 Courses								
S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
Theory								
1	DSE	BOT1853/ BOT1854	Horticultural Practices and Post-Harvest Technology/ Plant Breeding	4	0	0	4	4
2		BOT1863/ BOT1864	Industrial and Environmental Microbiology/ Biostatistics	4	0	0	4	4
Total Credit							8	

Generic Electives (GE) 4 Courses								
S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
Theory								
1	GE	ZOLA183 1	Animal Diversity	3	0	0	3	3
2		ZOLA184 1	Aquatic Biology	3	0	0	3	3
3		CHM1812	Structure and Bonding in Chemistry	4	0	0	4	4
4		CHM1823	Basic Concepts of Organic Chemistry	4	0	0	4	4
Total Credit							14	

Ability Enhancement Compulsory Courses (AECC) 2 Courses								
Theory								
1	AECC	LAE1811	English-I(LSRW)	2	1	0	3	3
2		LAE1821	English-II (Communication Skill)	2	1	0	3	3
				Total Credit				6

Skills Enhancement Courses (SEC) 23 Courses								
1	SEC	BOT1814	Microbiology and Phycology Practical	0	0	4	4	2
2		BOT1815	Plant Morphology and Plant Systematics Practical	0	0	4	4	2
3		ZOLA183 2	Animal Diversity Practical					
4		EVS1817	Environmental Studies	2	0	0	2	2
5		BOT1824	Mycology and Phytopathology Practical	0	0	4	4	2
6		BOT1825	Archegoniate-Practical	0	0	4	4	2
7		ZOLA184 2	Aquatic Biology Practical	0	0	4	4	2
8		BOT1835	Plant Anatomy-Practical	0	0	4	4	2
9		BOT1836	Economic Botany-Practical	0	0	4	4	2
10		BOT1837	Plant Genetics-Practical	0	0	4	4	2
11		CHM1814	Inorganic Qualitative Analysis-I	0	0	4	4	2
12		BOT1834	Ethnobotany	2	0	0	2	2
13		BOT1845	Molecular Biology Practical	0	0	4	4	2
14		BOT1846	Plant Ecology and Phytogeography Practical	0	0	4	4	2
15		BOT1847	Biomolecules and Cell Biology Practical	0	0	4	4	2
16		CHM1844	Laboratory Course on Methods and Synthesis in Organic Chemistry	0	0	4	4	2
17		BOT1844	Herbal Technology	2	0	0	2	2
18		BOT1855	Reproductive Biology of Angiosperms Practical	0	0	4	4	2
19		BOT1856	Plant Physiology Practical	0	0	4	4	2
20		BOT1857/ BOT1858	Horticultural Practices and Post-Harvest Technology Practical/ Plant Breeding Practical	0	0	4	2	2
21		BOT1865	Plant Metabolism-Practical	0	0	4	4	2
22		BOT1866	Plant Biotechnology and Bioinformatics Practical	0	0	4	4	2
23		BOT1867/ BOT1868	Industrial and Environmental Microbiology Practical/ Biostatistics Practical	0	0	4	2	2
				Total Credit				46

### Course Structure

Semester	Professional Core Courses (C)	Discipline Specific Electives (DSE)	Generic Electives (GE)	Skill Enhancement Courses (S)	Ability Enhancement Compulsory Courses (AECC)	Total Credits	Total Hours
SEM I	2T		1T	1T+3P	1T	22	420
SEM II	2T		1T	3P	1T	20	390
SEM III	3T		1T	1T+4P		23	465
SEM IV	3T		1T	1T+4P		23	465
SEM V	2T	1T		3P		18	360
SEM VI	2T	1T		3P		18	360
<b>Total Credit</b>						<b>124</b>	<b>2460</b>

## 7. Implementation Plan

### B.Sc. Botany (Honours) Curriculum

Semester I								
S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
1	AECC	LAE1811	English – I LSRW	2	1	0	3	3
2	Core	BOT1812	Microbiology and Phycology	4	0	0	4	4
3		BOT1813	Plant Morphology and Plant Systematics	4	0	0	4	4
4	SEC	BOT1814	Microbiology and Phycology Practical	0	0	4	4	2
5		BOT1815	Plant Morphology and Plant Systematics Practical	0	0	4	4	2
6	GE	ZOLA1831	Animal Diversity	3	0	0	3	3
7	SEC	ZOLA1832	Animal Diversity Practical	0	0	4	4	2
8	SWAYAM	EVS1817	Environmental Studies	2	0	0	0	2
							Total Credit	22

Semester II								
S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
1	AECC	LAE1821	English-II (Communication Skill)	2	1	0	3	3
2	Core	BOT1822	Mycology and Phytopathology	4	0	0	4	4
3		BOT1823	Archegoniate and Palaeobotany	4	0	0	4	4
4	SEC	BOT1824	Mycology and Phytopathology Practical	0	0	4	4	2
5		BOT1825	Archegoniate-Practical	0	0	4	4	2
6	GE	ZOLA1841	Aquatic Biology	3	0	0	3	3
7	SEC	ZOLA1842	Aquatic Biology Practical	0	0	4	4	2
							Total Credit	20

Semester III								
S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
1	Core	BOT1831	Plant Anatomy	3	0	0	3	3
2		BOT1832	Economic Botany	3	0	0	3	3
3		BOT1833	Plant Genetics	3			3	3
4	SEC	BOT1835	Plant Anatomy-Practical	0	0	4	4	2
5		BOT1836	Economic Botany-Practical	0	0	4	4	2
6		BOT1837	Plant Genetics-Practical	0	0	4	4	2
7	GE	CHM1812	Structure and Bonding in Chemistry	4	0	0	4	4
8	SEC	CHM1814	Inorganic Qualitative Analysis-I	0	0	4	4	2
9	SEC	BOT1834	Ethnobotany	2	0	0	0	2
							Total Credit	23

Semester IV								
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S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
1	Core	BOT1841	Molecular Biology	3	0	0	3	3
2		BOT1842	Plant Ecology and Phytogeography	3	0	0	3	3
3		BOT1843	Biomolecules and Cell Biology	3			3	3
4	SEC	BOT1845	Molecular Biology Practical	0	0	4	4	2
5		BOT1846	Plant Ecology and Phytogeography Practical	0	0	4	4	2
6		BOT1847	Biomolecules and Cell Biology Practical	0	0	4	4	2
7	GE	CHM1823	Basic Concepts of Organic Chemistry	4	0	0	4	4
8	SEC	CHM1844	Laboratory Course on Methods and Synthesis in Organic Chemistry	0	0	4	4	2
9	SEC	BOT1844	Herbal Technology	2	0	0	0	2
							Total Credit	23

Semester V								
S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
1	Core	BOT1851	Reproductive Biology of Angiosperms	4	0	0	4	4
2		BOT1852	Plant Physiology	4	0	0	4	4
3	SEC	BOT1855	Reproductive Biology of Angiosperms Practical	0	0	4	4	2
4		BOT1856	Plant Physiology Practical	0	0	4	4	2
5	DSE	BOT1853/ BOT1854	Horticultural Practices and Post-Harvest Technology/ Plant Breeding	4	0	0	4	4
6	SEC	BOT1857/ BOT1858	Horticultural Practices and Post-Harvest Technology Practical/ Plant Breeding Practical	0	0	4	4	2
							Total Credit	18

Semester VI								
S.No	Course Category	Course Code	Course Name	L	T	P	L+T+P	C
1	Core	BOT1861	Plant Metabolism	4	0	0	4	4
2		BOT1862	Plant Biotechnology and Bioinformatics	4	0	0	4	4
3	SEC	BOT1865	Plant Metabolism-Practical	0	0	4	4	2
4		BOT1866	Plant Biotechnology and Bioinformatics Practical	0	0	4	4	2
5	DSE	BOT1863/ BOT1864	Industrial and Environmental Microbiology/ Biostatistics	4	0	0	4	4
6	SEC	BOT1867/ BOT1868	Industrial and Environmental Microbiology Practical/ Biostatistics Practical	0	0	4	4	2
							Total Credit	18

<b>8. Program Articulation Matrix</b>											
<b>Course Name</b>	<b>Program Learning Outcomes</b>										
	Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
Microbiology and Phycology	H	-	M	-	-	M	-	M	-	H	H
Plant Morphology and Plant Systematics	H	H	H	-	-	M	-	M	-	H	H
Microbiology and Phycology Practical	H	H	H	-	M	M	H	H	-	H	H
Plant Morphology and Plant Systematics Practical	H	M	M	-	-	H	H	H	-	H	H
Mycology and Phytopathology	H	H	H	M	H	H	-	M	H	H	H
Archegoniate and Palaeobotany	H	-	H	H	M	H	M	M	-	H	H
Mycology and Phytopathology Practical	H	H	M	H	H	H	M	H	-	H	H
Archegoniate-Practical	H	H	M	-	H	H	H	H	-	H	H
Plant Anatomy	H	H	H	-	-	H	M	M	-	H	H
Economic Botany	H	H	-	-	M	H	-	M	H	H	H
Plant Genetics	H	H	M	H	-	H	M	M	-	H	H
Ethnobotany	H	H	-	-	M	H	-	M	H	H	H
Plant Anatomy-Practical	H	H	M	-	-	M	H	H	-	M	H
Economic Botany-Practical	H	M	M	-	M	-	M	M	H	H	H
Plant Genetics-Practical	H	H	M	-	-	H	H	M	-	H	H
Molecular Biology	H	H	H	M	-	H	-	M	-	H	H
Plant Ecology and Phytogeography	H	H	-	H	-	H	-	M	-	H	H
Biomolecules and Cell Biology	H	H	-	H	-	H	-	M	-	H	H
Herbal Technology	H	-	-	-	M	H	-	M	H	H	H
Molecular Biology Practical	H	H	M	-	-	H	H	M	-	H	H
Plant Ecology and Phytogeography Practical	H	H	M	-	-	H	H	M	-	H	H
Biomolecules and Cell Biology Practical	H	H	M	M	-	H	H	M	-	H	H
Reproductive Biology of Angiosperms	H	M	M	-	-	M	-	M	-	H	H
Plant Physiology	H	H	H	M	M	M	-	M	-	H	H
Horticultural Practices and Post-Harvest Technology	H	M	H	-	H	H	H	-	H	H	H
Plant Breeding	H	H	H	-	H	M	M	M	-	H	H
Reproductive Biology of Angiosperms Practical	H	H	M	-	-	H	H	H	-	H	H

Plant Physiology Practical	H	H	H	-	M	H	H	M	-	H	H
Horticultural Practices and Post-Harvest Technology Practical	H	M	M	-	H	H	H	M	H	H	H
Plant Breeding Practical	H	H	M	-	M	H	H	M	-	H	H
Plant Metabolism	H	M	-	M	-	H	-	M	-	H	H
Plant Biotechnology and Bioinformatics	H	H	H	M	H	H	-	M	-	H	H
Industrial and Environmental Microbiology	H	H	M	-	-	H	M	M	H	H	H
Biostatistics	H	H	M	H	-	H	-	M	-	H	-
Plant Metabolism-Practical	H	H	M	-	M	H	M	M	-	H	H
Plant Biotechnology and Bioinformatics Practical	H	H	H	-	H	H	M	M	H	H	M
Industrial and Environmental Microbiology Practical	H	M	H	-	H	H	M	H	H	H	H
Biostatistics Practical	H	M	H	-	H	H	M	H	H	H	M

# **Semester I**

Course Code	LAE18 11	Course Name	English I -LSRW	Course Category	AE CC	Ability Enhancement Compulsory Course	L	T	P	C
							2	1	0	3
Pre-requisite			Nil	Co-requisite		Nil				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Identify strategies to become appreciative and empathetic listeners.	3	H	-	-	-	-	H	H	H	-	H	-
CLO-2	Express facts, ideas and opinions with fluency, clarity and confidence.	3	H	-	-	-	-	H	H	H	-	H	-
CLO-3	Demonstrate critical understanding of written texts.	3	H	-	-	-	-	H	H	H	-	H	-
CLO-4	Compose an array of business correspondence with ease and elegance.	3	H	-	-	-	-	H	H	H	-	H	-
CLO-5	Articulate flawlessly in English Language.	3	H	-	-	-	-	H	H	H	-	H	-

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
Unit 1	<b>Listening Skills</b> Introduction to Communication-LSRW Active Listening Reasons for poor Listening Types of Listening Barriers to Listening Traits of a good Listener <i>Activity:</i> Listening to the news and making notes, listening to announcements, listening to speeches, listening to instructions and summarizing them, listening to and differentiating pronunciations.	9	CLO 1
Unit 2	<b>Speaking Skills</b> Importance of Speaking Skills Effective Speaking-Confidence, Clarity and Fluency Types of Speaking-Tasks Oriented-Interpersonal-Formal and Semi Formal Persuasive Speaking and Public Speaking Barriers to Speaking Guidelines for conducting a Group Discussion	9	CLO 2

	Guidelines for conducting a Meeting <i>Activity:</i> Peer Introduction, JAM, Public speech, Role play, Product description, debate, GD, panel discussion, Conducting Meeting		
<b>Unit 3</b>	<b>Reading Skills</b> Introduction to Reading skills Thesis, Evidence, Evaluation Topic sentence and its role Types of reading-Intensive-Extensive-Skimming-Scanning Reading and its purposes Reading for pleasure Reading for critical interpretation Reading for note making and summarizing <i>Activity:</i> Reading articles and short stories and verbally summarizing them, reading newspapers and magazines and highlighting the content, reading comprehensions, reading reviews, reading and interpreting the content, identifying the thesis-evidence-evaluation, reading novels (Abridged version).	9	CLO3
<b>Unit 4</b>	<b>Writing Skills</b> Introduction and Importance of Writing Writing a Sentence Writing a Paragraph-Topic Sentence, illustration Characteristics of Writing-Clarity-Accuracy-Correctness-Descriptiveness Language-Appropriateness-Conciseness-Flow Business Writing-Basic principles of Business Communication Letter writing-Thank you and follow-up letter, complaint letter, inquiry letter, invitation letter, letter to the editor Writing memo, notice, agenda and minutes of the meeting Report writing Interpretation of data (flow charts, figures and pictures) Essay and Article Writing Poster Making <i>Activity-</i> Writing a paragraph, writing different kinds of letters, framing notices and memos and agendas, jotting down minutes of the meeting, reporting an event or the work done, interpreting various pictures, figures and data.	9	CLO 4
<b>Unit 5</b>	<b>Basic Grammar</b> Tense and Articles Prepositions Direct and Indirect Speech Active and Passive Voice	9	CLO 5

Learning Resources	
Text Books	Raman Meenakshi, Sangeeta Sharma, "Technical Communication Principles and Practice". Ed Second. Oxford University Press, Delhi, 2013.
Ref. Books	1. Raman, Meenakshi, Prakash Singh, "Business Communication". 2 <sup>nd</sup> Edition. Oxford University Press, 2013 Taylor, Shirley, V. Chandra. "Communication for Business. 4 <sup>th</sup> Ed. Dorling Kindersly India pvt. Ltd., 2011 2. Dhanavel, S.P. "English and Communication Skills for Students of Science and Engineering", Orient Blackswan Ltd.,2009 3. Green, David. "Contemporary English Grammar Structures and Composition." Macmillian Publisher India Ltd, Delhi,2000

Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)				Final Examination (50 % weightage)
	CLA – 1 (Cycle Test)	CLA – 2 (Model Test)	CLA – 3 (Assignment)	CLA – 4 (Surprise Test/Quiz/)	
	10%	20%	10%	5%	

		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
1	Remember	30%		20%		20%		30%		30%	
2	Understand	30%		20%		20%		30%		20%	
3	Apply	10%		30%			30%	20%		20%	
4	Analyze	30%		20%		-		20%		10%	
5	Evaluate	-		10%		-				10%	
6	Create	-		-			30%			10%	
	Total	100%		100%		100%		100%		100%	

CLA – 5% for attendance will be taken from ERP

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	Dr. Pramila Chettri, Associate Professor, Tadong Govt College, Gangtok	Ms. Manisha Takuri, Assistant Professor, SRM University Sikkim

Course Code	BOT1812	Course Name	Microbiology and Phycology	Course Category	C	Core	L	T	P	C
							4	0	0	4
Pre-requisite			NIL	Co-requisite		BOT1814				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define basic concept on different forms of bacteria, viruses, cell structure, nutrition, genetics, metabolism and their economic use with reference the role in agriculture and industries	1	H	-	M	-	-	-	-	M	-	H	H
CLO-2	Classify structural morphology, diversity and reproduction of algae	2	H	-	M	-	-	M	-	M	-	H	H
CLO-3	Explain the concept on thallus organization, cell structure, reproduction, life cycle pattern of Cyanophyta and Xanthophyta	2	H	-	M	-	-	M	-	M	-	H	H
CLO-4	Develop the concept on vegetative and reproductive structures of Chlorophyta and Charophyta	3	H	-	M	-	-	M	-	M	-	H	H
CLO-5	Analyze the life cycle patterns of Phaeophyta and Rhodophyta	4	H	-	M	-	-	M	-	M	-	H	H
			H		M	-	-	M	-	M	-	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Microbes</b> Bacteria-Discovery, general characteristics and cell structure; Types-archaeobacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Microbial growth, nutrition and metabolism; Reproduction-vegetative, asexual and recombination (conjugation, transformation and	15	CLO 1

	transduction); Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine). Viruses: Discovery, General characteristics, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases.		
2	<b>Algae</b> General characteristics; Classification (system of Fritsch); Distribution; Range of thallus organization; Cell structure and components; Cell wall, pigments, reserve food, flagella; methods of reproduction; criteria; Evolutionary classification of Lee (only up to groups).	9	CLO 2
3	<b>Cyanophyta and Xanthophyta</b> Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and life-cycle of <i>Nostoc</i> and <i>Vaucheria</i> .	12	CLO 3
4	<b>Chlorophyta and Charophyta</b> General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of <i>Chlamydomonas</i> , <i>Volvox</i> , <i>Oedogonium</i> , <i>Coleochaete</i> , <i>Chara</i> . Evolutionary significance of <i>Prochloron</i> .	12	CLO 4
5	<b>Phaeophyta and Rhodophyta</b> Characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of <i>Ectocarpus</i> , <i>Fucus</i> and <i>Polysiphonia</i> .	12	CLO 5

### Learning Resources

<b>Text Books</b>	<ol style="list-style-type: none"> <li>1. Kumar, H.D. (1999). Introductory Phycology, 2<sup>nd</sup> Edition. Affiliated East-West Press Pvt. Ltd. Delhi.</li> <li>2. Dubey, R.C. and Maheshwari, D.K. (2009). A Text Book of Microbiology, 1<sup>st</sup> Edition. S. Chand Publication.</li> <li>3. Mitra, D., Guha, J. and Chowdhury, S.K. Studies in Botany: Volume I. Moulik Library.</li> <li>4. Gangulee, H.C. and Kar, A.K. (1989). College Botany: Volume II:3<sup>rd</sup> Reprint 2010, NCBA (P) Limited.</li> <li>5. Banerjee, A.K. and Banerjee, N. (2008). Fundamentals of Microbiology &amp; Immunology. NCBA (P) Limited.</li> </ol>
<b>Ref. Books</b>	<ol style="list-style-type: none"> <li>1. Lee, R.E. (2008). Phycology, 4<sup>th</sup> Edition. Cambridge University Press, Cambridge.</li> <li>2. Black, J.G. and Black, J.L. (2015). Microbiology: Principles and Explorations, 9<sup>th</sup> Edition.</li> <li>3. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. (2013) Prescott's Microbiology, 9<sup>th</sup> Edition. McGraw Hill International.</li> <li>4. Tortora, G.J., Funke, B.R. and Case, C.L. (2010). Microbiology: An Introduction, 10<sup>th</sup> Edition, Pearson Benjamin Cummings, U.S.A.</li> <li>5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V. and Jackson R.B. (2008). Biology, 8<sup>th</sup> Edition. Pearson Benjamin Cummings, USA.</li> <li>6. Pelczar, M.J. (2001). Microbiology, 5th Edition, Tata McGraw-Hill Co, New Delhi.</li> </ol>

Bloom's Level of Thinking		Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%
4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

### Course Designers

Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	<ol style="list-style-type: none"> <li>1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>2. Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1813	Course Name	Plant Morphology and Plant Systematics	Course Category	C	Core	L	T	P	C
							4	0	0	4
Pre-requisite			NIL	Co-requisite		BOT1815				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define the basic morphological terminology of flowering plants.	1	H	-	-	-	-	M	-	M	-	H	H
CLO-2	Explain identification and nomenclature of plants	2	H	-	-	-	-	M	-	M	-	H	H
CLO-3	Explain the different artificial, natural, and phylogenetic system of classification.	2	H	-	-	-	-	M	-	M	-	H	H
CLO-4	Develop a concept on cladistic and numerical taxonomy	3	H	-	H	-	-	M	-	M	-	H	H
CLO-5	Solve problems related to phylogeny of angiosperms	3	H	H	H	-	-	M	-	M	-	H	H
			H	H	H			M		M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Seed Plants and Angiosperm Morphology</b> Leaf: Morphology and phyllotaxy; Flower: Type and structure. Morphology of stamen and carpel; Pollination, Double fertilization; Inflorescence; Types and examples. Fruits and seeds: General concepts, type and dispersal. Seed Plants: Characteristics of seed plants with fruits (Angiosperm) and without fruits (Gymnosperms). Angiosperm: Origin and evolution. Some examples of primitive angiosperms.	16	CLO1
2	<b>Significance of Plant Systematics</b> Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access. Taxonomic hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary). Botanical nomenclature: Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.	16	CLO2
3	<b>Systems of Classification</b> Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (up to series) and Engler and Prantl (up to series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.	8	CLO3
4	<b>Biometrics, Numerical Taxonomy, Cladistics</b> Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).	8	CLO3, CLO 4

5	<b>Phylogeny of Angiosperms</b> Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).	12	CLO 3, CLO 4, CLO5
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Learning Resources	
Text Books	1. A.K Pandey and S. Kasana (2021) <i>Plant Systematics</i> . Jaya Publishing House, New Delhi.
Ref. Books	1. R.J. Henry (2005). <i>Plant Diversity and Evolution: Genotypic and Phenotypic Variation in Higher Plants</i> . CABI Publishing, CAB International, UK. 2. M.G. Simpson (2010). <i>Plant Systematics</i> . Elsevier Academic Press, Amsterdam.

Bloom's Level of Thinking	Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	Course Name	Animal Diversity	Course Category	GE	Generic Elective	L	T	P	C
ZOLA1831						3	0	0	3
Pre-requisite		NIL	Co-requisite		ZOLA1832				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
CLO-1	Define the general characters of Protista, Porifera, Aceolomates and Pseudocoelomates.	1	H	-	-	-	M	H	-	M		H	H
CLO-2	Explain the general characteristics of Coelomate, Arthropoda and Mollusca.	2	H	-	-	-	-	H	-	M	M	H	H

CLO-3	Define the salient features of Protochordata.	3	H	-	-	-	-	H	-	M		H	H
CLO-4	Describe diversity of Chordates with salient features.	3	H	-	-	-	-	H	-	M		H	H
CLO-5	Analyze the early evolution of Mammalia.	4	H	-	-	-	M	H	-	M		H	H
			H	-	-	-	M	H	-	M	M	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1.	<b>Protista, Porifera, Radiata, Aceolomates, Pseudocoelomates</b> General characters of Protozoa; Life cycle of <i>Plasmodium</i> General characters and canal system in Porifera General characters of Cnidarians and polymorphism General characters of Helminthes; Life cycle of <i>Taeniasolium</i> General characters of Nemetehelminthes; Parasitic adaptations	12	CLO 1
2.	<b>Coelomate Protostomes, Arthropoda, Mollusca, Coelomate, Deuterostomes</b> General characters of Annelida; Metamerism General characters. Social life in insects. General characters of mollusca; Pearl Formation General characters of Echinodermata, Water Vascular system in Starfish.	12	CLO 2
3.	<b>Protochordata</b> Salient features	12	CLO 3
4.	<b>Diversity of Chordates</b> Osmoregulation, Migration of Fishes General characters, Adaptations for terrestrial life, parental care in Amphibia. Amniotes; Origin of reptiles. Terrestrial adaptations in reptiles. The origin of birds; Flight adaptations	12	CLO 4
5.	<b>Mammalia</b> Early evolution of mammals; Primates; Dentition in mammals	12	CLO 5

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Learning Resources	
<b>Text Books</b>	1. Jordan, E.L. and Verma, P.S. <i>Invertebrate Zoology</i> . New edition Edition, S. Chand Publications. 2. Jordan, E.L. and Verma P.S. <i>Chordate Zoology</i> . New edition Edition, S. Chand Publications. 3. Kotpal, R.L. <i>Modern Textbook of Zoology-Invertebrates</i> , Rastogi Publications. 4. Kotpal, R.L. <i>Modern Textbook of Zoology-Vertebrates</i> , Rastogi Publications.
<b>Ref. Books</b>	1. Ruppert and Barnes, R.D. (2006). <i>Invertebrate Zoology</i> , VIII edition. Holt Saunders International Edition. 2. Barnes, R.S.K., Calow, P., Olive, P.I.W. and Spicer, J.I. (2002). <i>The Invertebrates: A New Synthesis</i> , III Edition, Blackwell Science.

Bloom's Level of Thinking	Internal Assessment for theory papers (40 % weightage)			Final Examination for theory papers (60 % weightage)
	Cycle test (10)	Assignment (10)	Model Test (20)	End Semester Theory Exam (60)
1 Remember	50%	5%	25%	25%
2 Understand	50%	20%	25%	25%
3 Apply	-	50%	25%	25%
4 Analyze	-	25%	25%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Code	BOT1814	Course Name	Microbiology and Phycology Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite	BOT1812			Co-requisite	NIL		0	0	4	2

<b>Program Learning Outcomes (PLO)</b>										
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Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Demonstrate life cycle of bacteria, viruses through charts and permanent slides	2	H	H	H	-	M	-	H	H	-	H	H
CLO-2	Apply basic working principle and applications of various instruments used in Microbiology and Phycology	3	H	H	H	-	M	-	H	H	-	H	H
CLO-3	Implement various microbiological techniques	3	H	H	H	-	-	-	H	H	-	H	H
CLO-4	Construct an idea around the concept, principle and types of sterilization methods	3	H	H	M	-	-	-	H	H	-	H	H
CLO-5	Categorize various groups of algae, their identification along with systematic position while working with fresh and preserved algal specimens	4	H	H	M	-	-	M	H	H	-	H	H
			H	H	H		M	M	H	H		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	T-Phage and TMV- Electron micrographs pictures only. Lytic and Lysogenic cycle- Line drawing only. Types of Bacteria to be observed from permanent slides and photographs.	9	CLO 1
2	Microscopy- handling of microscope, study on the functions of different parts of microscope.	12	CLO 1, CLO 2
3	Gram staining technique.	12	CLO 1, CLO 2, CLO 3
4	Endospore staining with malachite green using (endospores taken from soil bacteria).	12	CLO 1, CLO 2, CLO 3, CLO 4
5	Study of vegetative and reproductive structures and temporary slide preparation of fresh algal specimens of <i>Nostoc</i> , <i>Chlamydomonas</i> , <i>Volvox</i> , <i>Oedogonium</i> , <i>Coleochaete</i> , <i>Chara</i> , <i>Vaucheria</i> , <i>Ectocarpus</i> , <i>Fucus</i> , <i>Polysiphonia</i> and <i>Prochloron</i> . Study form permanent slide.	15	CLO 5

Learning Resources	
<b>Text Books</b>	1. Kumar, H.D. (1999). Introductory Phycology, 2 <sup>nd</sup> Edition. Affiliated East-West Press Pvt. Ltd. Delhi. 2. Dubey, R.C. and Maheshwari, D.K. (2009). A Text Book of Microbiology, 1 <sup>st</sup> Edition. S. Chand Publication.
<b>Ref. Books</b>	1. Lee, R.E. (2008). Phycology, 4 <sup>th</sup> Edition. Cambridge University Press, Cambridge. 2. Tortora, G.J., Funke, B.R. and Case, C.L. (2010). Microbiology: An Introduction, 10 <sup>th</sup> Edition, Pearson Benjamin Cummings, U.S.A. 3. Pelczar, M.J. (2001). Microbiology, 5 <sup>th</sup> Edition, Tata McGraw-Hill Co, New Delhi.

Bloom's Level of Thinking		Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
		Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1	Remember	25%	25%	25%	20%
2	Understand	25%	25%	25%	20%
3	Apply	25%	25%	25%	20%
4	Analyze	25%	25%	25%	20%
5	Evaluate	-	-	-	20%

6	Create	-	-	-	-
	Total	100%	100%	100%	100%

### Course Designers

Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1815	Course Name	Plant Morphology and Plant Systematics Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
							0	0	4	2
Pre-requisite		BOT1813		Co-requisite		NIL				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Identify the vegetative and floral characters of locally available flowering plants	3	H	H	M	-	-	H	H	H	-	H	H
CLO-2	Discover the local floral composition through a field visit	4	H	M	M	-	-	H	H	H	-	H	H
CLO-3	Categorize the local flora through Herbarium preparation	4	H	M	M	-	-	H	H	H	-	H	H
			H	M	M	-	-	H	H	H	-	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

### Summary of Course Content

S. No	Course Content	Hour	Alignment to CLO
1	Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham and Hooker's system of classification): Ranunculaceae, Brassicaceae, Myrtaceae, Umbelliferae, Asteraceae, Solanaceae, Lamiaceae, Euphorbiaceae, Liliaceae, Poaceae.	20	CLO1
2	Field visit (local)-Subject to grant of funds from the university.	20	CLO1, CLO2
3	Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in Central Herbarium room of University).	20	CLO1, CLO2, CLO3

### Learning Resources

<b>Text Books</b>	1. S.C. Santra (2015). Practical Botany. New Central Book Agency Pvt. Ltd., Kolkata.
<b>Ref. Books</b>	<ol style="list-style-type: none"> <li>Singh G. <i>Plant Systematics: Theory and Practice</i>. Publisher: Oxford and IBH-PUBS Company, New Delhi.</li> <li>Sinha, R.K. (2013). <i>Practical-Taxonomy of Angiosperms</i>.</li> </ol>

<b>Bloom's Level of Thinking</b>	<b>Internal Assessment for practical papers (40% weightage)</b>	<b>Final Examination for practical papers (60 % weightage)</b>
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		Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1	Remember	25%	25%	25%	20%
2	Understand	25%	25%	25%	20%
3	Apply	25%	25%	25%	20%
4	Analyze	25%	25%	25%	20%
5	Evaluate	-	-	-	20%
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	ZOLA1832	Course Name	Animal Diversity-Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
							0	0	4	2
Pre-requisite			ZOLA1831	Co-requisite		NIL				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Identify specimens from non-chordates.	3	H	-	-	-	-	-	-	-	-	H	-
CLO-2	Identify specimens from chordates	3	H	-	-	-	-	-	-	H	-	-	-
CLO-3	Analyze permanent slides	3	-	H	-	M	-	-	-	-	-	H	-
CLO-4	Demonstrate nephridia of earthworm and scales of fishes	4	-	H	-	M	-	-	-	H	-	-	-
CLO-5	Evaluate different systems of Cockroach and Rat	5	-	H	-	M	-	-	-	H	-	-	-

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1.	<b>Study of following specimens:</b> Non Chordates: <i>Euglena, Noctiluca, Paramecium, Sycon, Physalia, Tubipora, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, Hermitcrab, Daphnia, Millipede, Centipede, Beetle, Chiton, Dentalium, Octopus, Asterias, and Antedon.</i>	15	CLO1
2.	<b>Study of following specimens:</b> Chordates: <i>Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Ichthyophis/Uraeotyphlus, Salamander, Rhacophorus Draco, Uromastix, Naja, Viper, model of Archaeopteryx, any three common birds- (Crow, duck, Owl), Squirrel and Bat.</i>	15	CLO2

3.	Study of following Permanent Slides: Cross section of Sycon, Sea anemone and <i>Ascaris</i> (male and female). T.S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva.	15	CLO3
4.	Study of following Permanent Slides: Cross section of Sycon, Sea anemone and <i>Ascaris</i> (male and female). T.S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva.	15	CLO4
5.	Dissections of (a) Digestive and nervous system of Cockroach (b) Urinogenital system of Rat.		CLO5

Learning Resources	
<b>Text Books</b>	1. Verma, P.S. A Manual of Practical Zoology: Chordates, 10th Revised edition, Kindle Edition, S. Chand Publication.
<b>Ref. Books</b>	1. Verma, P.S. A Manual of Practical Zoology Invertebrates, Kindle Edition, S. Chand Publication.

Bloom's Level of Thinking		Internal Assessment for practical papers (40 % weightage)			Final Examination for practical papers (60% weightage)
		Internal Assessment Practical Exam (40)			End Semester Practical Exam (60)
		Experiments (20)	Lab record notebook (10)	Clarity/Viva voce (10)	
1	Remember	20%	20%	20%	20%
2	Understand	20%	20%	20%	20%
3	Apply	20%	20%	20%	20%
4	Analyze	20%	20%	20%	20%
5	Evaluate	20%	20%	20%	20%
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Code	EVS1817	Course Name	Environmental Studies	Course Category	SEC	Skill Enhancement Course	L	T	P	C
							2	0	0	2
<b>Pre-requisite</b>			NIL	<b>Co-requisite</b>		NIL				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
<b>CLO-1</b>	Define the structure, function, dynamics and mechanism of ecosystem	1	H	-	-	H	-	H	M	M	-	H	H
<b>CLO-2</b>	Explain the different types pollution, causative agents and their management	2	H	-	-	H	-	H	M	M	-	H	H
<b>CLO-3</b>	Develop concept on different national policies and programs pertaining to environment and wildlife protection	3	H	-	-	H	-	H	M	M	-	H	H
<b>CLO-4</b>	Build concept on different types of diversity, threats, conversation and management	3	H	-	-	H	-	H	M	M	-	H	H
<b>CLO-5</b>	Analyze the cause and the mitigation mechanism for natural and man-made disasters	4	H	H	-	H	-	H	M	M	-	H	H

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>ENVIRONMENTAL EDUCATION</b> Definition and objective. Structure and function of an ecosystem – ecological succession –primary and secondary succession-ecological pyramids– pyramid of number, pyramid of energy and pyramid of biomass.	6	CLO1
2	<b>POLLUTION</b> Air, water, soil –causes and effects and control measures. Specifically: acid rain, ozone layer depletion, greenhouse effect and global warming. Waste management: prevention and control measures of solid waste.	6	CLO2
3	<b>NATIONAL CONCERN FOR ENVIRONMENT</b> Important environmental protection Acts in India– water, air (prevention and control of pollution) act, wild life conservation and forest act. Functions of central and state pollution control boards. Issues involved in enforcement of environmental legislation.	6	CLO3
4	<b>BIODIVERSITY</b> Genetic, species and ecosystem diversity – bio diversity hot spots - values of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values - threats to biodiversity: habitat loss, poaching of wildlife – endangered and endemic species of India, Conservation of biodiversity: in-situ and ex-situ conservations.	6	CLO4
5	<b>NATURAL AND MAN-MADE DISASTERS</b> Natural and Man-made disasters -types, causes, onset, impacts. (viz. earthquake, flood, drought, cyclone, tsunamic, volcanics, landslide, industrial accidents.). Forecasting and managements	6	CLO5

Learning Resources	
Text Books	1. Jeyalakshmi.R, “Principles of Environmental Science”, 1st Edition, Devi Publications, Chennai, 2006.
Ref. Books	<ol style="list-style-type: none"> <li>De. A.K, “Environmental Chemistry”, New Age International, New Delhi, 1996.</li> <li>Sharma.B.K. and Kaur, “Environmental Chemistry”, Goel Publishing House, Meerut, 1994.</li> <li>Dara S.S., “A Text Book of Environmental Chemistry and pollution control”, S.Chand &amp; Company Ltd., New Delhi, 2004.</li> <li>Dr.Rahavan Nambiar, “Textbook of Environmental studies” SciTech Publication (India) Pvt.Ltd. Second edition.</li> </ol>

Bloom’s Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

# **Semester II**

Course Code	LAE1821	Course Name	ENGLISH – II (Communication skill)	Course Category	AE CC	Ability Enhancement Compulsory Course	L	T	P	C
Pre-requisite	NIL			Co-requisite	NIL		2	1	0	3

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Explain the nature and models of professional communication.	1	H	-	-	M	-	H	H	M	-	H	-
CLO-2	Employ technology ethically as an aid to communication.	2	H	-	-	M	-	H	H	M	-	H	-
CLO-3	Demonstrate a conscious practice of verbal and non-verbal communication	3	H	-	-	M	-	H	H	M	-	H	-
CLO-4	Incorporate effective tools and strategies for job interviews	4	H	-	-	M	-	H	H	M	-	H	-
CLO-5	Adapt in a multi-cultural professional scenario	4	H	-	-	M	-	H	H	M	-	H	-
			H	-	-	M	-	H	H	M	-	H	-

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
Unit 1	<b>Understanding Communication</b> Introduction to Communication Definition Communication process Methods of Communication- Internal and External communication Networks of communication- Vertical- horizontal- diagonal Barriers of Communication- Linguistic, Psychological, Interpersonal, cultural, physical and organizational (R.C Sharma and Krishna Mohan, <i>Business Correspondence</i> , pages 34-43)	9	CLO1
Unit 2	<b>Technology -Based Communication Aids</b> Telephone and voicemails Facsimile Machines Internet and computers Emails Conferencing Instant Messaging Groupware NETTIQUETTE Positive and Negative Impact of Technology enabled communication Effectiveness in Technology based communication	9	CLO2
Unit 3	<b>Verbal and Non-Verbal Communications</b> <i>Verbal Communication</i> Conversation- importance- essentials- conversation management- non-verbal cues in conversation- Oral Presentation Skills--- Technical aids in Visual Communication (Shirley Taylor, V. Chandra, <i>Communication for Business–A practical Approach</i> 4 <sup>th</sup> ed, page nos 378-397) Team Presentation <i>Non- verbal Communication</i> Definition and Significance Significance of Non-verbal Signals in organizations Types of Nonverbal communication- Kinesics- Paralinguistic- Proxemics and Chronemics	9	CLO3

<b>Unit 4</b>	<b>Interviews</b> Introduction- Objectives of Interviews Types of interviews Job Interviews- cover letter- Resume Writing- Preparation for interview- Interviewing Process- Mock Interview Medium of Interview- Telephonic interview- web interview (Meenakshi Raman, Sangeeta Sharma, <i>Technical Communication-Principles and practices</i> , pg no 180-203)	9	CLO4
<b>Unit 5</b>	<b>Cross Cultural Communication</b> Introduction Concept of Cross- Cultural Communication Ethnocentrism Cultural Variables and Communication Sensitivity Variables of National Culture Cross- Cultural Communication Strategies Potential Hot Spots in Cross- Cultural Communication	9	CLO5

<b>Learning Resources</b>	
<b>Text Books</b>	Raman Meenakshi, Prakash Singh, <i>Business Communication</i> , second edition, Oxford University Press, Delhi 2013.
<b>Ref. Books</b>	<ol style="list-style-type: none"> <li>Raman Meenakshi, Sangeeta Sharma, "Technical Communication Principles and Practice". Ed Second. Oxford University Press, Delhi, 2013.</li> <li>Shirley Taylor, V. Chandra, <i>Communication for Business – A practical Approach</i> 4<sup>th</sup> ed Pearson Education Ltd., 2013</li> <li>Nawal, Mallika, "Business Communication". CENGAGE Learning, 2012.</li> <li>Sharma R.C. Business Correspondence and Report Writing, McGraw Hill Education (India) Private limited, New Delhi, 2014</li> </ol>

Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50 % weightage)		
	CLA – 1 (Cycle Test)		CLA – 2 (Model Test)		CLA – 3 (Assignment)		CLA – 4 (Surprise Test/Quiz)		Theory	Practice	
	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice			
1	Remember	30%		20%		20%		30%		30%	
2	Understand	30%		20%		20%		30%		20%	
3	Apply	10%		30%			30%	20%		20%	
4	Analyze	30%		20%		-		20%		10%	
5	Evaluate	-		10%		-				10%	
6	Create	-		-			30%			10%	
	Total	100%		100%		100%		100%		100%	

<b>Course Designers</b>		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	Dr. Pramila Chettri, Associate Professor, Tadong Govt College, Gangtok	Ms. Manisha Takuri, Assistant Professor, SRM University Sikkim

<b>Course Code</b>	BOT1822	<b>Course Name</b>	<b>Mycology and Phytopathology</b>	<b>Course Category</b>	C	<b>Core</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Pre-requisite</b>	NIL			<b>Co-requisite</b>	BOT1824		4	0	0	4

<b>Course Learning Outcomes (CLO)</b>	At the end of this course, learners will be able to:	<b>Bloom's Learning (BL) Level</b>	<b>Program Learning Outcomes (PLO)</b>								
			<b>PLO-1</b>	<b>PLO-2</b>	<b>PLO-3</b>	<b>PLO-4</b>	<b>PLO-5</b>	<b>PLO-6</b>	<b>PLO-7</b>	<b>PLO-8</b>	<b>PLO-9</b>

			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define diversity, thallus organization and life cycle pattern of major classes of fungi	1	H	-	-	-	H	H	-	M	-	H	H
CLO-2	Explain the basic concept of classification and life cycle of allied fungi	2	H	-	-	-	H	H	-	M	-	H	H
CLO-3	Develop a concept on different symbiotic association of fungi	3	H	-	-	-	H	H	-	M	H	H	H
CLO-4	Analyze the role of fungi in biotechnology, food industry, agriculture and medicine	4	H	H	H	H	H	H	-	M	H	H	H
CLO-5	Analyze the general symptoms, causal organism, prevention and control measures of various plant disease	4	H	H	H	H	H	H	-	M	H	H	H
			H	H	H	M	H	H	-	M	H	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>General Account of Fungi</b> Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification; Chytridiomycetes: General account; Zygomycota: General characteristics; Ecology; Thallus organisation; Life cycle with reference to <i>Rhizopus</i> ; Ascomycota: General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to <i>Saccharomyces</i> , <i>Aspergillus</i> , <i>Penicillium</i> , <i>Alternaria</i> , <i>Neurospora</i> and <i>Peziza</i> ; Basidiomycota: General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat <i>Puccinia</i> (Physiological Specialization), loose and covered smut (symptoms only), <i>Agaricus</i> ; Bioluminescence, Fairy Rings and Mushroom Cultivation.	15	CLO 1
2	<b>Allied Fungi</b> General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.: <b>Oomycota</b> : General characteristic; Ecology; Life cycle and classification with reference to <i>Phytophthora</i> , <i>Albugo</i> .	9	CLO 2
3	<b>Symbiotic Associations</b> Lichen-Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction. Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.	9	CLO 3
4	<b>Applied Mycology</b> Role of fungi in biotechnology, Application in food industry (Flavour and texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.	12	CLO 4
5	<b>Phytopathology</b> Terms and concepts; General symptoms; Geographical distribution of diseases; etiology; symptomology; Host-Pathogen relationships; disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. Bacterial Diseases-Citrus canker and angular leaf spot disease of Cotton. Viral Diseases-Tobacco Mosaic viruses, vein clearing. Fungal Diseases-Early blight of potato, Black stem rust of wheat, white rust of crucifers.	15	CLO 5

Learning Resources	
<b>Text Books</b>	1. Aneja, K.R. (2015). An Introduction to Mycology, 2 <sup>nd</sup> Edition, New Age International (P) Limited. 2. Saxena, S. (2012). Textbook of Mycology, 5 <sup>th</sup> Edition, Sonali Publications. 3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd. 4. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.
<b>Ref. Books</b>	1. Agrios, G.N. (2005). Plant Pathology, 5 <sup>th</sup> Edition, Academic Press, U.K. 2. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). Introductory Mycology, 4 <sup>th</sup> Edition, John Wiley & Sons (Asia) Singapore. 3. Webster, J. and Weber, R. (2007). Introduction to Fungi, 3 <sup>rd</sup> Edition, Cambridge University Press, Cambridge.

Bloom's Level of Thinking		Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%
4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1823	Course Name	Archegoniate and Palaeobotany	Course Category	C	Core	L	T	P	C
							4	0	0	4
Pre-requisite			NIL	Co-requisite		BOT1825				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
CLO-1	Define the general characters and life cycle of archegoniate plants	1	H	-	-	-	M	H	M	M	-	H	H
CLO-2	Explain the vegetative, reproductive features and economic importance of bryophytes	2	H	-	-	-	M	H	M	M	-	H	H
CLO-3	Express the general morphology, classification and life cycle pattern of extant and extinct pteridophytes	2	H	-	-	-	M	H	M	M	-	H	H
CLO-4	Illustrate the morphology and economic importance of gymnosperms	2	H	-	-	-	M	H	M	M	-	H	H

CLO-5	Identify the different types of fossils and fossilization process through time	3	H	-	H	H	-	H	M	M	-	H	H
			H		H	H	M	H	M	M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Introduction</b> Unifying features of archegoniates; Transition to land habit; Alternation of generations.	8	CLO1
2	<b>Bryophytes</b> General characteristics; Adaptations to land habit; Classification; Range of thallus organization. Classification (up to family). <i>Riccia</i> , <i>Marchantia</i> , <i>Pellia</i> , <i>Porella</i> , <i>Anthoceros</i> , <i>Sphagnum</i> and <i>Funaria</i> ; Reproduction and evolutionary trends in <i>Riccia</i> , <i>Marchantia</i> , <i>Anthoceros</i> and <i>Funaria</i> (developmental stages not included). Ecological and economic importance of bryophytes with special reference to <i>Sphagnum</i> .	14	CLO2
3	<b>Pteridophytes</b> General characteristics, classification, early land plants ( <i>Cooksonia</i> and <i>Rhynia</i> ). Classification (up to family), morphology, anatomy and reproduction of <i>Psilotum</i> , <i>Selaginella</i> , <i>Equisetum</i> and <i>Pteris</i> (Developmental details not to be included). Apogamy and apospory, heterospory and seed habit, telome theory, stelar evolution. Ecological and economic importance.	14	CLO3
4	<b>Gymnosperms</b> General characteristics, classification (up to family), morphology, anatomy and reproduction of <i>Cycas</i> , <i>Pinus</i> and <i>Gnetum</i> (Developmental details not to be included). Ecological and economic importance.	14	CLO4
5	<b>Palaeobotany</b> Contributions of Birbal Sahni in Indian Palaeobotany. Introduction, importance of Paleobotany. Definition of fossil, process of fossilization, types of fossils on the basis of their preservation; concept of Form Genus, conditions for fossilization. Origin of life, Geologic Time Scale, major events of plant life through geologic time.	10	CLO5

Learning Resources	
<b>Text Books</b>	<ol style="list-style-type: none"> <li>Rashid, A. (2016). <i>An Introduction to Archigoniata Plants</i>. Vikas Publishing.</li> <li>Vashishta, P.C., Sinha, A.K. and Kumar, A. (2010). <i>Pteridophyta</i>, S. Chand Publication, Delhi, India.</li> <li>Mitra, D., Guha, J. and Chowdhury, S.K. <i>Studies in Botany: Volume I</i>. Moulik Library.</li> <li>Bhatnagar, S.P. and Moitra, A. (1996). <i>Gymnosperms</i>. New Age International (P) Ltd Publishers, New Delhi, India.</li> </ol>
<b>Ref. Books</b>	<ol style="list-style-type: none"> <li>Shaw, A.J. and Goffinet, B. (2000). <i>Bryophyte Biology</i>, Cambridge University Press.</li> <li>Santra, S.C., Chatterjee, T.P. and Das, A.P. (2010). <i>College Botany Practical, Volume I</i>. New Central Book Agency (P) Limited.</li> <li>Stewart, W.N. and Rathwell, G.W. (1993). <i>Paleobotany and the Evolution of Plants</i>. Cambridge University Press.</li> <li>Taylor Thomas N., Taylor E.L. and Michael, K. (2009). <i>Palaeobotany-The Biology and Evolution of Fossil Plants</i>. Academic Press, Elsevier.</li> </ol>

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director,</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu

Course Code	ZOLA1841	Course Name	Aquatic Biology	Course Category	GE	Generic Elective		L	3	T	0	P	0	C	3
Pre-requisite	NIL			Co-requisite	ZOLA1842										

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define aquatic biomes and different zones.	1	H	-	-	-	-	H	-	M	-	H	H
CLO-2	Describe the biology and parameters of lakes, and nutrient cycles and adaptation of hill-stream fishes	2	H	-	-	-	H	H	-	M	H	H	H
CLO-3	Express the aquatic biology of marine water and adaptations of deep-sea organisms.	2	H	-	-	-	-	H	-	M	-	H	H
CLO-4	Analyze the different processes of management of aquatic resources	3	H	M	-	-	H	H	H	M	H	H	H
			H	M	-	-	H	H	H	M	H	H	H

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1.	<b>Aquatic Biomes</b> Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.	15	CLO1
2.	<b>Freshwater Biology</b> Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous. Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.	15	CLO2
3.	<b>Marine Biology</b> Salinity and density of Sea water, Continental shelf, Adaptations of deep-sea organisms, Coral reefs, Sea weeds.	15	CLO3
4.	<b>Management of Aquatic Resources</b> Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, management and conservation (legislations), Sewage treatment, Water quality assessment-BOD and COD.	15	CLO4

Learning Resources	
<b>Text Books</b>	1. Odum and Barret. Fundamentals of Ecology, 5 <sup>th</sup> Edition. 2. Wetzel. Limnology, 3 <sup>rd</sup> Edition.

<b>Ref. Books</b>	1. Goldman. Limnology, 2 <sup>nd</sup> Edition. 2. Welch. Limnology Vols I-II.
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Bloom's Level of Thinking		Internal Assessment for theory papers (40 % weightage)			Final Examination for theory papers (60 % weightage)
		Cycle test (10)	Assignment (10)	Model Test (20)	End Semester Theory Exam (60)
1	Remember	50%	5%	25%	25%
2	Understand	50%	20%	25%	25%
3	Apply	-	50%	25%	25%
4	Analyze	-	25%	25%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

<b>Course Code</b>	BOT1824	<b>Course Name</b>	<b>Mycology and Phytopathology Practical</b>	<b>Course Category</b>	SEC	<b>Skill Enhancement Course</b>	L	T	P	C
<b>Pre-requisite</b>	BOT1822			<b>Co-requisite</b>	NIL		0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Dissect the vegetative and reproductive structure of fungi from fresh and preserved specimens	4	H	H	M	-	H	H	-	H	-	H	H
<b>CLO-2</b>	Analyze the different growth forms, reproductive structure of lichens and mycorrhiza	4	H	H	M	H	H	H	M	H	-	H	H
<b>CLO-3</b>	Evaluate the various plant disease caused by different micro-organism through fresh samples and permanent slides	5	H	H	M	H	H	H	M	H	-	H	H
			H	H	M	H	H	H	M	H		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	1. <i>Rhizopus</i> , <i>Aspergillus</i> and <i>Penicillium</i> - study of asexual stage from temporary mounts and sexual structures through permanent slides. 2. <i>Peziza</i> : sectioning through ascocarp and preparation of temporary mounts. 3. <i>Alternaria</i> : Specimens study from temporary mounts. 4. <i>Puccinia</i> : Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections and mounts of spores on wheat and permanent slides of both the hosts. 5. <i>Agaricus</i> : Specimens of button stage and full-grown mushroom; sectioning of gills of <i>Agaricus</i> . 6. Study of phanero plasmodium and sporangia of <i>Stemonitis</i> from photograph.	20	CLO 1

	7. <i>Albugo</i> : Study of symptoms of plants infected with <i>Albugo</i> ; asexual phase study through section and temporary mounts and sexual structures through permanent slides.		
2	Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates (field collection). Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs).	20	CLO 2
3	Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.	20	CLO 3

### Learning Resources

<b>Text Books</b>	1. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd. 2. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.
<b>Ref. Books</b>	1. Agrios, G.N. (2005). Plant Pathology, 5 <sup>th</sup> Edition, Academic Press, U.K. 2. Webster, J. and Weber, R. (2007). Introduction to Fungi, 3 <sup>rd</sup> Edition, Cambridge University Press, Cambridge.

Bloom's Level of Thinking		Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
		Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1	Remember	25%	25%	25%	20%
2	Understand	25%	25%	25%	20%
3	Apply	25%	25%	25%	20%
4	Analyze	25%	25%	25%	20%
5	Evaluate	-	-	-	20%
6	Create	-	-	-	-
Total		100%	100%	100%	100%

### Course Designers

Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1825	Course Name	Archegoniate Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			BOT1823	Co-requisite	NIL		0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
CLO-1	Examine the vegetative and reproductive structure of bryophytes, pteridophytes and gymnosperms from fresh specimens	4	H	H	M	-	H	H	H	H	-	H	H

<b>CLO-2</b>	Compare the life-cycle patterns of different archaegonites from permanent slide	4	H	H	M	-	H	H	H	H	-	H	H
<b>CLO-3</b>	Compile the diversity of archaegonites via field survey	6	H	H	-	-	-	H	H	H	-	H	H
			H	H	M		H	H	H	H		H	H

(Level of correlation: **3-High, 2-Medium, 1-Low** can be used)

<b>Summary of Course Content</b>			
<b>S. No</b>	<b>Course Content</b>	<b>Hour</b>	<b>Alignment to CLO</b>
1	<p><i>Riccia</i>-Morphology of thallus; <i>Marchantia</i>-Morphology of thallus, whole mount of rhizoids and Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides).</p> <p>2. <i>Anthoceros</i>-Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide).</p> <p>3. <i>Pellia</i>, <i>Porella</i>-Study through permanent slides; <i>Sphagnum</i>-Morphology of plant.</p> <p>4. <i>Funaria</i>-Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides).</p> <p>5. <i>Psilotum</i>-Study of specimen.</p> <p>6. <i>Selaginella</i>-Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides).</p> <p>7. <i>Equisetum</i>-Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide).</p> <p>7. <i>Pteris</i>-Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides).</p> <p>8. <i>Cycas</i>-Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides),</p> <p>9. <i>Pinus</i>-Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal/transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides).</p> <p>9. <i>Gnetum</i>-Morphology (stem, male and female cones), transverse section of stem.</p>	30	CLO1
2	<p>1. <i>Riccia</i>- vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).</p> <p>2. <i>Anthoceros</i>- vertical section of thallus (permanent slide).</p> <p>3. <i>Pellia</i>- whole mount of leaf (permanent slide only).</p> <p>4. <i>Funaria</i>- permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.</p> <p>5. <i>Psilotum</i>- transverse section of synangium (permanent slide).</p> <p>6. <i>Selaginella</i>- longitudinal section of strobilus (permanent slide).</p> <p>7. <i>Equisetum</i>- transverse section of rhizome (permanent slide).</p> <p>7. <i>Pteris</i>- transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).</p> <p>8. <i>Cycas</i>- longitudinal section of ovule, transverse section of root (permanent slide).</p> <p>9. <i>Pinus</i>- longitudinal section of female cone, tangential longitudinal section and radial longitudinal sections stem (permanent slide).</p> <p>9. <i>Gnetum</i>- vertical section of ovule (permanent slide).</p>	20	CLO2
3	Botanical Excursion-Special class on field tour, Survey, collection of plants, precautionary measures (Practical perspectives).	10	CLO3

Learning Resources	
<b>Text Books</b>	1. Santra, S.C., Chatterjee, T.P. and Das, A.P. (2010). <i>College Botany Practical: Volume II</i> . New Central Book Agency (P) Limited.
<b>Ref. Books</b>	1. Santra, S.C., Chatterjee, T.P. and Das, A.P. (2010). <i>College Botany Practical: Volume II</i> . New Central Book Agency (P) Limited.

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1 Remember	25%	25%	25%	20%
2 Understand	25%	25%	25%	20%
3 Apply	25%	25%	25%	20%
4 Analyze	25%	25%	25%	20%
5 Evaluate	-	-	-	20%
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	ZOLA1842	Course Name	Aquatic Biology-Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
							0	0	4	2
Pre-requisite		ZOLA1841		Co-requisite		NIL				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Apply the graphimetric and gravimetric method to calculate the area of a lake.	3	H	H	M	-	M	H	M	M	-	H	H
CLO-2	Analyze of phytoplanktons and zooplanktons	4	H	H	M	M	M	H	M	M	-	H	H
CLO-3	Examine the physical and physicochemical parameters of aquatic ecosystems.	4	H	H	M	H	M	H	M	M	M	H	H
CLO-4	Perceive the important instruments used in limnology	5	-	H	M	H	M	H	M	M	M	H	H
CLO-5	Elaborate the method of sewage treatment plant or fisheries and writing the report	6	H	H	M	H	M	H	M	M	M	H	H
			H	H	M	H	M	H	M	M	M	H	H

(Level of correlation: *3-High, 2-Medium, 1-Low* can be used)

<b>Summary of Course Content</b>			
<b>S. No</b>	<b>Course Content</b>	<b>Hour</b>	<b>Alignment to CLO</b>
1.	Determine the area of a lake using graphimetric and gravimetric method.	10	CLO 1
2.	Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.	14	CLO 2
3.	Determine the amount of Turbidity/transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates and bicarbonates) in water collected from a nearby lake/water body.	14	CLO 3
4.	Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.	12	CLO 4
5.	A Project Report on a visit to a Sewage treatment plant/Marine bio-reserve/Fisheries Institutes.	10	CLO 5

<b>Learning Resources</b>	
<b>Text Books</b>	1. Odum and Barret. Fundamentals of Ecology, 5 <sup>th</sup> Edition. 2. Wetzel. Limnology, 3 <sup>rd</sup> Edition.
<b>Ref. Books</b>	1. Goldman. Limnology, 2 <sup>nd</sup> Edition. 2. Welch. Limnology Vols I-II.

<b>Bloom's Level of Thinking</b>	<b>Internal Assessment for practical papers (40% weightage)</b>			<b>Final Examination for practical papers (60 % weightage)</b>
	<b>Experiment (20)</b>	<b>Lab record notebook (10)</b>	<b>Clarity/Viva voce (10)</b>	<b>End Semester Practical Exam (60)</b>
1 Remember	25%	25%	25%	20%
2 Understand	25%	25%	25%	20%
3 Apply	25%	25%	25%	20%
4 Analyze	25%	25%	25%	20%
5 Evaluate	-	-	-	20%
6 Create	-	-	-	-
Total	100%	100%	100%	100%

# **Semester III**

Course Code	BOT1831	Course Name	Plant Anatomy	Course Category	C	Core	L	T	P	C
							3	0	0	3
Pre-requisite			NIL	Co-requisite		BOT1835				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Write the basic concepts, theories, terminologies about the structure and development of plant body.	1	H	-	-	-	-	H	M	M	-	H	H
CLO-2	Explain scope and applications of plant anatomy in different scientific fields.	2	H	-	H	-	-	H	M	M	-	H	H
CLO-3	Identify the different growth patterns in plant and the underlying functions and structures of the cells and the tissues	3	H	-	M	-	-	H	M	M	-	H	H
CLO-4	Analyze the ecological adaptabilities exhibited by different plants in different habitats	4	H	H	M	-	-	H	M	M	-	H	H
CLO-5	Distinguish the various tissues and cells, their function based on their specific location	4	H	H	M	-	-	H	M	M	-	H	H
			H	H	H	-	-	H	M	M	-	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Scope of Plant Anatomy</b> Applications in systematics, forensics and pharmacognosy.	4	CLO 1
2	<b>Structure and Development of Plant Body</b> Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cytodifferentiation and organogenesis during embryogenic development. Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.	12	CLO 2
3	<b>Meristems and Anatomical Structures</b> Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structure of dicot and monocot stem. Origin, development, arrangement and diversity in size and shape of leaves; Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.	12	CLO 3
4	<b>Vascular Cambium and Wood</b> Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring	12	CLO 4

	and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels.		
5	<b>Adaptive and Protective Systems</b> Epidermal tissue system, cuticle, epicuticular waxes, trichomes (unicellular and multicellular, glandular and non-glandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.	5	CLO 5

Learning Resources	
Text Books	1. Pandey, B.P. (2012). Plant Anatomy. S. Chand Publication Pvt. Ltd.
Ref. Books	1. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA. 2. Cutler, D.F., Stevenson, D.W. and Botha, C.E.J. (2008). Plant Anatomy: An Applied Approach. John Wiley & Sons. Blackwell Publishing.

Bloom's Level of Thinking	Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmsu.edu.in

Course Code	BOT1832	Course Name	Economic Botany	Course Category	C	Core	L	T	P	C
							3	0	0	3
Pre-requisite			NIL	Co-requisite		BOT1836				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
CLO-1	Write the fundamental concept of the origin of cultivated plants.	1	H	-	-	-	-	H	-	M	H	H	H
CLO-2	Explain the various Indian agencies involved in plant introduction.	2	H	-	-	-	-	H	-	M	H	H	H

<b>CLO-3</b>	Identify economically important plants with special reference to the scientific name, family and morphology	3	H	-	-	-	M	H	-	M	H	H	H
<b>CLO-4</b>	Analyze the economic importance of spices, cereals, legumes, and sugar processing and its products	4	H	H	-	-	M	H	-	M	H	H	H
<b>CLO-5</b>	Evaluate the chemical constituents and drugs obtained from high valued medicinal plants	5	H	H	-	-	M	H	-	M	H	H	H
			H	H			M	H		M	H	H	H

### Summary of Course Content

S. No	Course Content	Hour	Alignment to CLO
1	<b>Origin of Cultivated Plants</b> Concept of centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity	9	CLO1
2	<b>Cereals, Legumes, Sugars and Starches</b> Wheat and Rice (origin, morphology, processing and uses), brief account of millets. General account of legumes, its importance to man and ecosystem. Sugars and Starches: Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato-morphology, propagation and uses.	9	CLO2
3	<b>Spices</b> Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper.	9	CLO1, CLO2, CLO3
4	<b>Oils, Fats and essential oils</b> General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and <i>Brassica</i> and Coconut (Botanical name, family and uses). Essential Oils: General account, extraction methods, comparison with fatty oils and their uses.	9	CLO1, CLO2, CLO3, CLO4
5	<b>Other Economically Important Plants</b> Beverages: Tea, Coffee (morphology, processing and uses). Natural Rubber: Para-rubber: tapping, processing and uses. Drug-yielding plants: Therapeutic and habit-forming drugs with special reference to Cinchona, <i>Digitalis</i> , <i>Papaver</i> and <i>Cannabis</i> . Tobacco: Tobacco (Morphology, processing, uses and health hazards). Timber plants: General account with special reference to teak and pine. Fibres: Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses).	9	CLO5

### Learning Resources

<b>Text Books</b>	1. Kochhar, S.L. (2012). <i>Economic Botany in Tropics</i> , MacMillan & Co. New Delhi, India. Sambamurthy, A.V.S.S. (2008). <i>A Textbook of Modern Economic Botany</i> , 1 <sup>st</sup> Edition, CBS Publication.
<b>Ref. Books</b>	2. Umrani, R. (2009). <i>Basics of Economic Botany</i> , Anmol Publication. 1. Wickens, G.E. (2001). <i>Economic Botany: Principles and Practices</i> . Kluwer Academic Publishers, The Netherlands.

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

### Course Designers

Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
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NA	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in
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Course Code	BOT1833	Course Name	Plant Genetics	Course Category	C	Core		L	3	T	0	P	0	C	3
Pre-requisite			NIL	Co-requisite		BOT1837									

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)											
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11	
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability	
CLO-1	Define the principles of Mendelian and non-Mendelian inheritance in plants, gene interaction through probability and pedigree studies.	1	H	H	M	H	-	H	M	M	-	H	H	
CLO-2	Express the patterns of extra chromosomal inheritance with examples.	2	H	H	M	M	-	H	M	M	-	H	H	
CLO-3	Demonstrate the cytological basis of crossing over and genetic linkage through numerical.	2	H	H	H	M	-	H	M	M	-	H	H	
CLO-4	Build a concept of chromosomal mutations, point mutations, DNA damage and repair mechanisms.	3	H	H	H	H	-	H	M	M	-	H	H	
CLO-5	Analyze allele frequencies, Genotype frequencies, and express Hardy-Weinberg Law and factors affecting allele frequencies in natural populations	4	H	H	M	H	-	H	M	M	-	H	H	
			H	H	M	H	-	H	M	M	-	H	H	

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Extension of Mendelian Genetics</b> Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance	9	CLO1
2	<b>Extrachromosomal Inheritance</b> Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective Heredity-Kappa particles in <i>Paramecium</i> .	9	CLO2
3	<b>Linkage, Crossing over and Chromosome mapping</b> Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.	9	CLO3



			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Explain the knowledge about fundamentals of atomic structure	2	H	H	-	H	-	H	M	M	-	H	-
<b>CLO-2</b>	Illustrate atomic structure knowledge to construct arrangement of elements in the periodic table and periodic properties	2	H	H	-	M	-	H	M	M	-	H	-
<b>CLO-3</b>	Apply the basics to construct ionic crystals and metallic bonding	3	H	H	-	H	-	H	M	M	-	H	-
<b>CLO-4</b>	Examine covalent structures and bonding in molecules	4	H	H	-	H	-	H	M	M	-	H	-
<b>CLO-5</b>	Analyze the fundamentals of bonding theory to evaluate redox reactions.	4	H	H	-	H	-	H	M	M	-	H	-
			H	H		H	-	H	M	M	-	H	

(Level of correlation: **3-High, 2-Medium, 1-Low** can be used)

### Summary of Course Content

S. No	Course Content	Hour	Alignment to CLO
1	<b>Atomic Structure</b> Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of $\psi$ and $\psi^2$ . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wavefunctions for hydrogen atom. Radial and angular distribution curves. Shapes of <i>s</i> , <i>p</i> , <i>d</i> and <i>f</i> orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.	14	CLO1
2	<b>Periodicity of Elements</b> <i>s</i> , <i>p</i> , <i>d</i> , <i>f</i> block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to <i>s</i> & <i>p</i> -block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.	16	CLO2
3	<b>Ionic and Metallic Chemical Bonding</b> (i) <i>Ionic bond</i> : General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) <i>Metallic Bond</i> : Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids	13	CLO3
4	<b>Covalent and Weak Chemical Bonding</b> (i) <i>Covalent bond</i> : Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory.	13	CLO4

	<p>Molecular orbital diagrams of diatomic and simple polyatomic molecules N<sub>2</sub>, O<sub>2</sub>, C<sub>2</sub>, B<sub>2</sub>, F<sub>2</sub>, CO, NO, and their ions; HCl, BeF<sub>2</sub>, CO<sub>2</sub>, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (<math>\sigma</math> and <math>\pi</math> bond approach) and bond lengths.</p> <p>Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.</p> <p>(ii) <i>Weak Chemical Forces</i>: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment)</p> <p>Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.</p>		
5	<p><b>Oxidation-Reduction</b></p> <p>Redox equations, Standard Electrode Potential and its application to inorganic reactions.</p> <p>Principles involved in volumetric analysis to be carried out in class</p>	4	CLO5

Learning Resources	
Text Books	<ol style="list-style-type: none"> <li>1. D. F Shriver, P. W Atkins and C. H. Langford, Inorganic Chemistry, 3rd Ed., Oxford University Press, London, 2001</li> <li>2. B. Douglas, D. McDaniel, and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd ed., John Wiley, 1994.</li> <li>3. J. D. Lee, Concise Inorganic Chemistry, 5th ed., Wiley, 2008.</li> <li>4. P.W. Atkins, J.D. Paula, Physical chemistry, 9th Oxford university press, 2009.</li> </ol>
Ref. Books	<ol style="list-style-type: none"> <li>1. K. F Purcell and J. C. Kotz, Inorganic Chemistry, Saunders, Philadelphia, 1976.</li> <li>2. T. Moeller, Inorganic Chemistry: A Modern Introduction, Wiley, New York, 1990.</li> <li>3. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Shoban Lal Nagin Chand and Co, 1996.</li> <li>4. J. E. Huheey, E. A. Keiter, and Keiter, R. L., Inorganic Chemistry, 4th Ed., Harper and Row, New York, 1983.</li> <li>5. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.</li> </ol>

Bloom's Level of Thinking		Continuous Learning Assessment (40% weightage)			Final Examination (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	
1	Remember	40%	15%	20%	20%
2	Understand	40%	15%	20%	20%
3	Apply	-	20%	20%	20%
4	Analyze	20%	20%	20%	20%
5	Evaluate	-	15%	20%	20%
6	Create	-	15%	-	-
<b>Total</b>		<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

\*CLA: 5% is based on Attendance

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
Name: K. Anil Kumar Designation: Chief Scientific Officer- Arna Immuno ingredients Pvt. Ltd. , Email: Anil.kumar@arnaimmuno.com	Name: Dr. Somendra Nath Chakraborty Designation: Assistant Professor, Sikkim University Email: snchakraborty@cus.ac.in	Name: Dr. Govind Pratap Singh Designation: Associate Professor, Email: govindpratapsingh.v@srmus.edu.in

Course Code	BOT1834	Course Name	Ethnobotany	Course Category	SEC	Skill Enhancement Courses	L	T	P	C
Pre-requisite	NIL			Co-requisite	NIL		2	0	0	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define the basic concept, scope and objectives of Ethnobotany	1	H	-	-	-	M	H	-	M	H	H	H
CLO-2	Explain different methodologies used in Ethnobotanical studies	2	H	-	-	-	M	H	-	M	H	H	H
CLO-3	Construct a database of medicinal plants, their habitat and morphology.	3	H	-	-	-	M	H	-	M	H	H	H
CLO-4	Plan the conservation of genetic plant resources	3	H	-	-	-	M	H	-	M	H	H	H
CLO-5	Analyze legal and ethical aspects of Ethnobotany like patents, Intellectual property rights, bio piracy, bioprospecting etc.	4	H	H	-	-	M	H	-	M	H	H	H
			H	H			M	H		M	H	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Ethnobotany</b> Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses.	6	CLO 1
2	<b>Methodology of Ethnobotanical studies</b> a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.	6	CLO 2
3	<b>Role of Ethnobotany in Modern Medicine</b> Medico-ethnobotanical sources in India; Significance of the following plants in ethnobotanical practices (along with their habitat and morphology) a) <i>Azadirachta indica</i> b) <i>Ocimum sanctum</i> c) <i>Vitex negundo</i> d) <i>Gloriosa superba</i> e) <i>Tribulus terrestris</i> f) <i>Pongamia pinnata</i> g) <i>Cassia auriculata</i> h) <i>Indigofera tinctoria</i> .	6	CLO 3
4	<b>Conservation of Plant Genetic Resources</b> Role of ethnobotany in modern medicine with special example <i>Rauvolfia serpentina</i> , <i>Trichopus zeylanicus</i> , <i>Artemisia</i> , <i>Withania</i> . Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).	6	CLO 4
5	<b>Ethnobotany and Legal Aspects</b> Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.	6	CLO 5

Learning Resources	
Text Books	1. Ashok Kumar Awasthi (2021). Concepts of Ethnobotany. Ane books Pvt. Ltd., New Delhi.

<b>Ref. Books</b>	S. K. Jain (2010). Manual of Ethnobotany 2 <sup>nd</sup> Edition. Scientific Publishers
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Bloom's Level of Thinking		Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%
4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1835	Course Name	Plant Anatomy Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C			
							0	0	4	2			
<b>Pre-requisite</b>			BOT1831	<b>Co-requisite</b>		NIL							
<b>Course Learning Outcomes (CLO)</b>	At the end of this course, learners will be able to:	<b>Bloom's Learning (BL) Level</b>	<b>Program Learning Outcomes (PLO)</b>										
			<b>PLO-1</b>	<b>PLO-2</b>	<b>PLO-3</b>	<b>PLO-4</b>	<b>PLO-5</b>	<b>PLO-6</b>	<b>PLO-7</b>	<b>PLO-8</b>	<b>PLO-9</b>	<b>PLO-10</b>	<b>PLO-11</b>
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Analyze the anatomical differences between monocot and dicot root and stem.	4	H	H	M	-	-	M	H	H	-	M	H
<b>CLO-2</b>	Distinguish different tissues and cells, primary structure, secondary structure and anomalous secondary structure	4	H	H	M	-	-	M	H	H	-	M	H
<b>CLO-3</b>	Appraise the skill of observing different microscopic internal structures of plant	5	H	H	M	-	-	H	H	H	-	H	H
<b>CLO-4</b>	Evaluate the ecological adaptations of different plant	5	H	H	M	-	-	M	H	H	-	M	H
<b>CLO-5</b>	Assess different ergastic substances	5	H	H	M	-	-	M	H	H	-	M	H
			H	H	M	-	-	M	H	H	-	M	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Study of anatomical details of root, stem and leaves through permanent slides.	12	CLO 1
2	Study of the anomalous structures of stems of the following genera: <i>Bignonia</i> , <i>Dracaena</i> , <i>Boerhaavia</i> and <i>Strychnos</i> . Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.	12	CLO 2

	Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.		
3	Microscopic identification of the followings: Primary structure of Sunflower and maize stem and gram and Canna root, Bulliform cells, stomatal types, lenticels, raphides (acicular and sphaeraphides), cystolith. Maceration of wood elements of <i>Cucurbita</i> and <i>Pinus</i> stem and their microscopic examination. Root: monocot, dicot, secondary growth. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels. Leaf: isobilateral, dorsiventral, C <sub>4</sub> leaves (Kranz anatomy).	12	CLO 3
4	Adaptive Anatomy: xerophytes, hydrophytes.	12	CLO 4
5	Secretory tissues: cavities, lithocysts and laticifers.	12	CLO 5

### Learning Resources

<b>Text Books</b>	1. Rajan, S.S. (2003). Practical Manual of Plant Anatomy and Embryology. Anmol Publication.
<b>Ref. Books</b>	2. Rajan, S.S. (2003). Practical Manual of Plant Anatomy and Embryology. Anmol Publication.

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1 Remember	25%	25%	25%	20%
2 Understand	25%	25%	25%	20%
3 Apply	25%	25%	25%	20%
4 Analyze	25%	25%	25%	20%
5 Evaluate	0	0	0	20%
6 Create	0	0	0	0
Total	100%	100%	100%	100%

### Course Designers

Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1836	Course Name	Economic Botany Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			BOT1832	Co-requisite		NIL	0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Examine the internal and external structures of cereals and legumes	3	H	M	M	-	-	-	M	M	H	H	H

CLO-2	Experiment with the economically important plants containing starch and sugar	3	H	M	-	-	-	-	M	M	H	H	H
CLO-3	Dissection of different plants yielding spices, oils, fats, drugs, rubber and woods	4	H	M	M	-	-	-	M	M	H	H	H
CLO-4	Evaluate the processing of tea, coffee and other beverages.	5	H	M	-	-	M	-	M	M	H	H	H
CLO-5	Assess the micro chemical test of fibre yielding plants	5	H	M	-	-	M	-	M	M	H	H	H
			H	M	M		M		M	M	H	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Cereals: Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests) Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests). Legumes: Soya bean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).	10	CLO1
2	Sugars and Starches: Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).	10	CLO2
3	Spices: Black pepper, Fennel and Clove (habit and sections).	10	CLO3
4	Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).	10	CLO4
5	Oils and Fats: Coconut-T.S. nut, Mustard-plant specimen, seeds; tests for fats in crushed seeds. Essential oil-yielding plants: Habit sketch of <i>Rosa</i> , <i>Vetiveria</i> , <i>Santalum</i> and, Eucalyptus (photographs). Rubber: specimen, photograph/model of tapping, samples of rubber products. Drug-yielding plants: Specimens of <i>Digitalis</i> , <i>Papaver</i> and <i>Cannabis</i> . Tobacco: specimen and products of Tobacco. Woods: <i>Tectona</i> , <i>Pinus</i> : Specimen, Section of young stem. Fibre-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; wholemount of fibre and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fibre).	20	CLO5

Learning Resources	
<b>Text Books</b>	1. Pandey, S.N and Chadha, A. (1993). <i>A Text Book of Botany: Plant Anatomy and Economic Botany</i> , Volume 3. Vikash Publishing House Pvt Ltd. Mitra, D., Ghua, J. and Mitra, J.N. <i>Studies in Botany: Volume II</i> , Moulik Library, Calcutta.
<b>Ref. Books</b>	2. Wickens G.E. <i>Economic Botany-Practical</i> . (2004) Springer-Verlag New York Inc. PP 535

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1 Remember	25%	25%	25%	20%
2 Understand	25%	25%	25%	20%
3 Apply	25%	25%	25%	20%
4 Analyze	25%	25%	25%	20%
5 Evaluate	0	0	0	20%
6 Create	0	0	0	0
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim.

	2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	anandsharma.a@srmus.edu .in
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Course Code	BOT1837	Course Name	Plant Genetics Practical	Course Category	SEC	Skill Enhancement Course		L	0	T	0	P	4	C	2
<b>Pre-requisite</b>			BOT1833	<b>Co-requisite</b>		NIL									

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)											
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11	
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability	
<b>CLO-1</b>	Develop the skills on the preparation, staining and identification of cell division stages.	3	H	H	M	-	-	H	H	M	-	H	H	
<b>CLO-2</b>	Analyze Mendelian and non-Mendelian inheritance pattern through probability and chi-square test.	4	H	H	M	-	-	H	H	M	-	H	H	
<b>CLO-3</b>	Analyze the pedigree and chromosomal mapping.	4	H	H	M	-	-	H	H	M	-	H	H	
<b>CLO-4</b>	Evaluate blood typing and identify genetic disorders in human.	5	H	H	H	-	-	H	H	M	-	H	H	
<b>CLO-5</b>	Assess chromosomal abnormalities like Translocation Ring, Laggards and Inversion Bridge.	5	H	H	H	-	-	H	H	M	-	H	H	
			H	H	M			H	H	M		H	H	

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Meiosis through temporary squash preparation.	12	CLO 1
2	1. Mendel's laws through seed ratios. 2. Laboratory exercises in probability and chi-square. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).	12	CLO 2
3	Chromosome mapping using point test cross data. Pedigree analysis for dominant and recessive autosomal and sex linked traits.	12	CLO 3
4	1. Blood Typing: ABO groups & Rh factor. 2. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.	12	CLO 4
5	Photographs showing Translocation Ring, Laggards and Inversion Bridge. Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobe.	12	CLO 5

Learning Resources	
<b>Text Books</b>	1. Santra, S.C. (2015). <i>Practical Botany-Volume I</i> . New Central Book Agency (P) Limited.
<b>Ref. Books</b>	1. Wallis, C.J. (1966). <i>Practical Botany: For Advanced Level and Intermediate Students</i> . 5 <sup>th</sup> Edition. Imprint: Butterworth-Heinemann.

Bloom's Level of Thinking		Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
		Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1	Remember	25%	25%	25%	20%
2	Understand	25%	25%	25%	20%
3	Apply	25%	25%	25%	20%
4	Analyze	25%	25%	25%	20%
5	Evaluate	0	0	0	20%
6	Create	0	0	0	0
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	CHM1814	Course Name	Inorganic Qualitative Analysis-I	Course Category	SEC	Skill Enhancement Course	L	T	P	C
							0	0	4	2
Pre-requisite				Co-requisite						

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Identify various anions and cations through dry and wet experiments.	3	H	H	H	-	-	H	M	M	H	H	-
CLO-2	Analyze the presence of cations and anions qualitatively in the mixture of two salts.	4	H	H	H	-	-	H	M	M	H	H	-
CLO-3	Evaluate the interfering ions and its separation towards analysis of ions in salt mixture.	3	H	H	H	-	-	H	M	M	H	H	-
			H	H	H			H	M	M	H	H	-

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Qualitative analysis of a mixture containing <b>two anions</b> and <b>two cations</b> .	20	CLO1
2	Analysis of a mixture containing <b>two cations</b> and <b>two anions</b> of which one will be an interfering ion. <b>Anions:</b> Carbonate, sulphate, chloride, bromide, acetate, nitrite, nitrate, borate, chromate, oxalate, tartrate, and phosphate. <b>Cations:</b> Lead, bismuth, copper, cadmium, antimony, iron, zinc, cobalt, nickel, manganese, calcium, strontium, barium, & ammonium, silver, magnesium, mercury.	40	CLO2, CLO3

Learning Resources	
Text Books	1. 1. V.V. Ramanujam, Inorganic Semi Micro Qualitative Analysis, 3rd edition, The National Publishing Company, Chennai, 1974. 2. 2. Vogel's Text Book of Inorganic Qualitative Analysis, 4th edition, ELBS, London, 1974. 3. 3. V.Venkateswaran, R.Veerasingam and A.R. Kulandaivelu, Basic principles of Practical Chemistry, 2nd edition, Sultan Chand & Sons, New Delhi, 1997. 4. 4. J. N. Gurtu and R. Kapoor, Advanced Experimental Chemistry, S. Chand and Co. 6th edition, 2010.
Ref. Books	---

Bloom's Level of Thinking		Continuous Learning Assessment (40% weightage)			Final Examination (60 % weightage)
		Cycle Test(10)	Model Examination (20)	Assignment (10)	
1	Remember	40%	15%	20%	20%
2	Understand	40%	15%	20%	20%
3	Apply	0	20%	20%	20%
4	Analyze	20%	20%	20%	20%
5	Evaluate	0	15%	20%	20%
6	Create	0	15%	0	0
Total		100%	100%	100%	100%

\*CLA: 5% is based on Attendance

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
Name: K. Anil Kumar Designation: Chief Scientific Officer- Arna Immuno ingredients Pvt. Ltd. , Email: Anil.kumar@arnaimmuno.com	Name: Dr. Somendra Nath Chakraborty Designation: Assistant Professor, Sikkim University Email: snchakraborty@cus.ac.in	Name: Dr. Govind Pratap Singh Designation: Associate Professor, Email: govindpratapsingh.v@srmus.edu.in

# **Semester IV**

Course Code	BOT1841	Course Name	Molecular Biology	Course Category	C	Core	L	T	P	C
Pre-requisite	NIL			Co-requisite	BOT1845		3	0	0	3

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define the fundamental theories, terminologies and inventions in the field of molecular biology.	1	H	-	-	M	-	H	-	M	-	H	H
CLO-2	Explain the mode of replication in Prokaryotes and Eukaryotes	2	H	-	H	-	-	H	-	M	-	H	H
CLO-3	Develop concept on the mechanism of central dogma and genetic code	3	H	-	H	M	-	H	-	M	-	H	H
CLO-4	Analyze transcription mechanism in eukaryotes and prokaryotes.	4	H	H	H	H	-	H	-	M	-	H	H
CLO-5	Evaluate the processing, modification of RNA and translation	5	H	H	H	M	-	H	-	M	-	H	H
			H	H	H	M		H		M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Nucleic Acids: Carriers of Genetic Information</b> Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey and Chase, Avery, McLeod and McCarty, Fraenkel-Conrat's experiment). The Structures of DNA and RNA/Genetic Material: DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA-Prokaryotes, Viruses, Eukaryotes. RNA Structure; Organelle DNA-mitochondria and chloroplast DNA. The Nucleosome; Chromatin structure-Euchromatin, Heterochromatin-Constitutive and Facultative heterochromatin.	12	CLO 1
2	<b>Replication of DNA</b> Chemistry of DNA synthesis (Kornberg's discovery); General principles-bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle, $\theta$ (theta) mode of replication, replication of linear ds-DNA, replication of the 5'end of linear chromosome; Enzymes involved in DNA replication.	12	CLO 2
3	<b>Central Dogma and Genetic Code</b> Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering and salient features).	4	CLO 3
4	<b>Transcription</b> Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in <i>E.coli</i> . Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.	8	CLO 4
5	<b>Processing and Modification of RNA and Translation</b> Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative	9	CLO 5

splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport. Translation: Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.		
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Learning Resources	
<b>Text Books</b>	1. Malacinski, G.M. (2015). Freifelder's Essentials of Molecular Biology, 4th edition. Jones and Bartlett India Private Limited
<b>Ref. Books</b>	Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2007). Molecular Biology of the Gene, 6th edition, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, 5th edition, John Wiley and Sons Inc., U.S.A.

Bloom's Level of Thinking		Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60% weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1	Remember	50%	15%	20%	20%
2	Understand	50%	15%	20%	20%
3	Apply	-	20%	20%	20%
4	Analyze	-	20%	20%	20%
5	Evaluate	-	15%	20%	20%
6	Create	-	15%	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1842	Course Name	Plant Ecology and Phytogeography	Course Category	C	Core	L	T	P	C
Pre-requisite		NIL		Co-requisite	BOT1846		3	0	0	3

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
CLO-1	Define the different level of ecosystem organization and its components	1	H	-	-	H	-	H	-	M	-	H	H
CLO-2	Explain the different abiotic and biotic components of ecosystem, their dynamics and adaptations of the plants to variation	2	H	-	-	H	-	H	-	M	-	H	H

<b>CLO-3</b>	Interpret the different Biotic interactions, speciation and succession	2	H	-	-	H	-	H	-	M	-	H	H
<b>CLO-4</b>	Develop concept on the structure and function of ecosystem, food chains, trophic level and biogeochemical cycle	3	H	-	-	H	-	H	-	M	-	H	H
<b>CLO-5</b>	Analyze the fundamental concepts and theory of Phytogeography	4	H	H	-	H	-	H	-	M	-	H	H
			H	H		H		H		M		H	H

(Level of correlation: *3-High, 2-Medium, 1-Low* can be used)

<b>Summary of Course Content</b>			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Introduction</b> Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.	5	CLO 1
2	<b>Environmental Components</b> Soil: Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development. Water: Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table. Light, temperature, wind and fire: Variations; adaptations of plants to their variation.	13	CLO 2
3	<b>Biotic Interactions</b> Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standing crop. Population ecology: Characteristics and Dynamics. Ecological Speciation. Plant communities: Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession-processes, types; climax concepts.	12	CLO 3
4	<b>Ecosystems</b> Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids. Functional aspects of ecosystem: Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.	6	CLO 4
5	<b>Phytogeography</b> Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate and tundra); Phytogeographical division of India; Local Vegetation.	9	CLO 5

<b>Learning Resources</b>	
<b>Text Books</b>	1.Sharma, P.D. (2010). Ecology and Environment, 8th edition, Rastogi Publications, Meerut, India 2. Singh, J.S., Singh, S.P. and Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
<b>Ref. Books</b>	1. Odum, E.P. (2005). Fundamentals of Ecology, 5th edition. Cengage Learning India Pvt. Ltd., New Delhi. 2. Singh, J.S., Singh, S.P. and Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.

Bloom's Level of Thinking	Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

<b>Course Designers</b>		
Experts from Industry:	Experts from Higher Education Institutions:	Internal Experts:

Name, Designation with official mail id	Name, Designation with official mail id	Name, Designation with official id
NA	<ol style="list-style-type: none"> <li>1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>2. Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

<b>Course Code</b>	<b>BOT1843</b>	<b>Course Name</b>	<b>Biomolecules and Cell Biology</b>	<b>Course Category</b>	<b>C</b>	<b>Core</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
							<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>Pre-requisite</b>	NIL			<b>Co-requisite</b>	BOT1847					

<b>Course Learning Outcomes (CLO)</b>	<i>At the end of this course, learners will be able to:</i>	<b>Bloom's Learning (BL) Level</b>	<b>Program Learning Outcomes (PLO)</b>										
			<b>PLO-1</b>	<b>PLO-2</b>	<b>PLO-3</b>	<b>PLO-4</b>	<b>PLO-5</b>	<b>PLO-6</b>	<b>PLO-7</b>	<b>PLO-8</b>	<b>PLO-9</b>	<b>PLO-10</b>	<b>PLO-11</b>
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Define the structure and biological roles of different biomolecules	1	H	H	-	H	-	H	-	M	-	H	H
<b>CLO-2</b>	Express how cell transforms energy and the thermodynamic laws behind it	2	H	H	-	H	-	H	-	M	-	H	H
<b>CLO-3</b>	Explain the structure, function and working principles of different bio-enzymes	2	H	H	-	H	-	H	-	M	-	H	H
<b>CLO-4</b>	Identify cytological, biochemical and physiological aspects of the cell, including cell division	3	H	H	-	H	-	H	-	M	-	H	H
<b>CLO-5</b>	Analyze the intricate relationship between various cell organelles present in plant cell and their corresponding functions	4	H	H	-	H	-	H	-	M	-	H	H
			H	H		H		H		M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

<b>Summary of Course Content</b>			
<b>S. No</b>	<b>Course Content</b>	<b>Hour</b>	<b>Alignment to CLO</b>
1	<b>Biomolecules</b> Types of chemical bonds; Structure and properties of water; pH and buffers. Nomenclature and classification of carbohydrates. Major classes of structural and storage lipids; Fatty acids structure and functions; Essential fatty acids; Triacylglycerols structure, functions and properties; Phosphoglycerides. Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins. Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.	10	CLO 1
2	<b>Bioenergetics</b> Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule.	4	CLO 2
3	<b>Enzymes</b>	7	CLO 3

	Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced-fit theory), Michaelis-Menten equation, enzyme inhibition and factors affecting enzyme activity.		
4	<b>The Plant Cell</b> Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory). Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport- Passive, active and facilitated transport, endocytosis and exocytosis.	11	CLO 4
5	<b>Cell Organelles</b> Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament. Chloroplast, mitochondria and peroxisomes: structural organization; Function; Semiautonomous nature of mitochondria and chloroplast. Endoplasmic Reticulum-Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus-organization, protein glycosylation, protein sorting and export from Golgi apparatus; Lysosomes. <b>Cell Division:</b> Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, role of protein kinases.	13	CLO 5

### Learning Resources

Text Books	1. Mali, N.S., Tembhurne, R.R., Shinde, S.S., Bhise, D.S. and Satpute, S.M. <i>Biomolecules and Cell Biology</i>
Ref. Books	1. Cooper, G.M. and Hausman, R.E. (2009). <i>The Cell: A Molecular Approach</i> . 5 <sup>th</sup> edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA. 2. Karp, G. (2010). <i>Cell Biology</i> , 6 <sup>th</sup> edition, John Wiley & Sons, U.S.A. 3. Nelson, D.L. and Cox, M.M. (2008). <i>Lehninger-Principles of Biochemistry</i> , 5 <sup>th</sup> Edition, W.H. Freeman and Company

Bloom's Level of Thinking	Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

### Course Designers

Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	CHM1823	Course Name	Basic Concepts of Organic Chemistry	Course Category	GE	Generic Elective	L	T	P	C
Pre-requisite			NIL	Co-requisite	NIL		4	0	0	4

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Express the basic concepts in organic chemistry.	2	H	H	-	-	-	H	-	M	-	H	-
CLO-2	Explain the importance of isomerism and incorporate in understanding stereochemistry.	2	H	H	-	-	-	H	-	M	-	H	-
CLO-3	Apply the basic knowledge of bonding in chemistry to aliphatic hydrocarbons	3	H	H	-	-	-	H	-	M	-	H	-
CLO-4	Examine the knowledge of general organic chemistry to construct cycloalkanes and conformational Analysis	4	H	H	-	-	-	H	-	M	-	H	-
CLO-5	Evaluate organic reactions and reaction intermediate in aromatic Hydrocarbons	5	H	H	-	-	-	H	-	M	-	H	-
			H	H				H		M		H	

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Basics of Organic Chemistry</b> Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electrometric, resonance and mesomeric effects, hyper conjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocation's, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.	10	CLO1
2	<b>Stereochemistry</b> Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis-trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations	14	CLO2
3	<b>Chemistry of Aliphatic Hydrocarbons</b> A. Carbon-Carbon sigma bonds Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity. B. Carbon-Carbon pi bonds:	18	CLO2, CLO3

	Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes		
4	<b>Cycloalkanes and Conformational Analysis</b> Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams	6	CLO4
5	<b>Aromatic Hydrocarbons</b> Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups	12	CLO5

### Learning Resources

Text Books	<ol style="list-style-type: none"> <li>1. T. W. Graham Solomons, Organic Chemistry, 6th edition, John Wiley and Sons, New York, 1996.</li> <li>2. L. G. Wade, Organic Chemistry, 8th edition, Pearson, 2016.</li> <li>3. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.</li> <li>4. Eliel, E. L. &amp; Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.</li> </ol>
Ref. Books	<ol style="list-style-type: none"> <li>1. S.H Pine, Organic Chemistry, 5th edition, McGraw Hill, New York, 1987.</li> <li>2. S.N. Ege, Organic Chemistry Structure and Reactivity, 3rd edition: A.I.T.B.S., New Delhi, 1998.</li> <li>3. F.A .Carey, Organic Chemistry, 3rd edition, Tata-McGraw Hill Publications, New Delhi, 1999.</li> <li>4. B.Y. Paula, Organic Chemistry, 3rd edition, Pearson Education Inc., Singapore, 2002.</li> <li>5. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd edition, Oxford, 2014.</li> </ol>

Bloom's Level of Thinking	Continuous Learning Assessment (40% weightage)			Final Examination (60 % weightage)	
	Cycle Test (10)	Model Examination (20)	Assignment (10)		
1	Remember	40%	15%	20%	20%
2	Understand	40%	15%	20%	20%
3	Apply	0	20%	20%	20%
4	Analyze	20%	20%	20%	20%
5	Evaluate	0	15%	20%	20%
6	Create	0	15%	0	0
	<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

### Course Designers

Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
Name: K. Anil Kumar Designation: Chief Scientific Officer- Arna Immuno ingredients Pvt. Ltd. , Email: Anil.kumar@arnaimmuno.com	Name: Dr. Somendra Nath Chakraborty Designation: Assistant Professor, Sikkim University Email: snchakraborty@cus.ac.in	Name: Dr. Govind Pratap Singh Designation: Associate Professor, Email: govindpratapsingh.v@srmus.edu.in

Course Code	BOTA1844	Course Name	Herbal Technology	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			NIL	Co-requisite		NIL	2	0	0	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Illustrate skill regarding cultivation, harvesting, processing, storage, marketing of medicinal plants	2	H	-	-	-	M	H	-	M	H	H	H
CLO-2	Summarise the information of medicinal herbs in curing various ailments.	2	H	-	-	-	M	H	-	M	H	H	H
CLO-3	Identify the active principles and methods of their testing and utilization of the medicinal herbs.	3	H	-	-	-	M	H	-	M	H	H	H
CLO-4	Analyze the information on drug adulteration, evaluation and phytochemical screening tests for secondary metabolites.	4	H	-	-	-	M	H	-	M	H	H	H
CLO-5	Examine the significance of medicinal plant and micro propagation techniques.	4	H	-	-	-	M	H	-	M	H	H	H
			H				M	H		M	H	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Herbal Medicines</b> History and scope-definition of medical terms - role of medicinal plants in Siddha systems of medicine; cultivation-harvesting-processing-storage-marketing and utilization of medicinal plants.	4	CLO1
2	<b>Pharmacognosy</b> Systematic position medicinal uses of following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka.	8	CLO2
3	<b>Phytochemistry</b> Active principles and methods of their testing-identification and utilization of the medicinal herbs; <i>Catharanthus roseus</i> (cardiotonic), <i>Withania somnifera</i> (drugs acting on nervous system), <i>Clerodendron phlomoides</i> (anti-rheumatic) and <i>Centella asiatica</i> (memory booster).	8	CLO3
4	<b>Analytical Pharmacognosy</b> Drug adulteration-types, methods of drug evaluation-Biological testing of herbal drugs-Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds).	6	CLO4
5	<b>Micropropagation of Medicinal Plants</b> Medicinal plant banks micro propagation of important species ( <i>Withania somnifera</i> , neem and tulsi- Herbal foods-future of pharmacognosy).	4	CLO5

Learning Resources	
<b>Text Books</b>	1. Kokate, C.K., Purohit, A.P. and Gokhle, S.B. (1999). <i>Pharmacognosy</i> , Nirali Prakashan. 2. Arber, A. (1999). <i>Herbal Plants and Drugs</i> . Mangal Deep Publications.
<b>Ref. Books</b>	1. Chopra, R.N., Nayar, S.L. and Chopra, I.C. (1956). <i>Glossary of Indian Medicinal Plants</i> . C.S.I.R., New Delhi.

Bloom's Level of Thinking		Internal Assessment for practical papers (40% weightage)			Final Examination for theory papers (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%
4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1845	Course Name	Molecular Biology Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			BOT1841	Co-requisite	NIL		0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Experiment with LB medium and raising <i>E. coli</i> .	3	H	H	M	-	-	H	H	M	-	H	H
CLO-2	Examine the genomic DNA from <i>E. coli</i> and cauliflower head.	4	H	H	M	-	-	H	H	M	-	H	H
CLO-3	Analyze the DNA replication and transcription mechanisms.	4	H	H	M	-	-	H	H	M	-	H	H
CLO-4	Deduce methods establishing nucleic acid as genetic material.	5	H	H	M	-	-	H	H	M	-	H	H
CLO-5	Evaluate different types of post transcriptional modifications.	5	H	H	M	-	-	H	H	M	-	H	H
			H	H	M			H	H	M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Preparation of LB medium and raising <i>E. coli</i> .	12	CLO 1
2	Isolation of genomic DNA from <i>E. coli</i> . DNA isolation from cauliflower head.	12	CLO 2
3	DNA estimation by diphenylamine reagent/UV Spectrophotometry. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication). Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.	12	CLO 3

4	Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)	12	CLO 4
5	Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.	12	CLO 5

Learning Resources	
<b>Text Books</b>	1. Santra, S.C. (2015). <i>Practical Botany-Volume I</i> . New Central Book Agency (P) Limited.
<b>Ref. Books</b>	1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2007). <i>Molecular Biology of the Gene</i> , Pearson Benjamin Cummings, 6th edition, CSHL Press, New York, U.S.A. 2. Snustad, D.P. and Simmons, M.J. (2010). <i>Principles of Genetics</i> , 5th edition, John Wiley and Sons Inc., U.S.A. 3. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2009). <i>Concepts of Genetics</i> , 9th edition. Benjamin Cummings. U.S.A. 4. Russell, P.J. (2010). <i>i-Genetics- A Molecular Approach</i> , 3rd edition, Benjamin Cummings, U.S.A. 5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B. and Doebley, J. (2010). <i>Introduction to Genetic Analysis</i> , 10th edition, W. H. Freeman and Co., U.S.A.

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1 Remember	25%	25%	25%	20%
2 Understand	25%	25%	25%	20%
3 Apply	25%	25%	25%	20%
4 Analyze	25%	25%	25%	20%
5 Evaluate	-	-	-	20%
6 Create	-	-	-	-
Total	100%	100%	100%	100%

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1846	Course Name	Plant Ecology and Phytogeography Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			BOT1842	Co-requisite		NIL	0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Identify the various instrument used in ecological studies	3	H	H	M	-	-	H	H	M	-	H	H

<b>CLO-2</b>	Analyze nutrient analysis of carbonates, chlorides, nitrates, sulphates of two soil samples.	4	H	H	M	-	-	H	H	M	-	H	H
<b>CLO-3</b>	Evaluate and monitor water quality by using BOD, COD etc.	5	H	H	M	-	-	H	H	M	-	H	H
<b>CLO-4</b>	Assess herbaceous vegetation and prepare species area curve through quadrat sampling method	5	H	H	M	-	-	H	H	M	-	H	H
<b>CLO-5</b>	Estimate density, frequency, abundance, dominance and IVI of herbaceous vegetation	5	H	H	M	-	-	H	H	M	-	H	H
			H	H	M			H	H	M		H	H

(Level of correlation: **3-High, 2-Medium, 1-Low** can be used)

<b>Summary of Course Content</b>			
S. No	Course Content	Hour	Alignment to CLO
1	Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter. Deamination of pH of various soil and water samples (pH meter, universal indicator and pH paper)	12	CLO1
2	Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests. Determination of organic matter of different soil samples by Walkley& Black rapid titration method. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.	12	CLO2
3	Determination of dissolved oxygen of water samples from polluted and unpolluted sources.	12	CLO3
4	Study of morphological adaptations of hydrophytes and xerophytes (four each). Study of biotic interactions of the following: Stem parasite ( <i>Cuscuta</i> ), Root parasite ( <i>Orobanch</i> ) Epiphytes, Predation (Insectivorous plants).	12	CLO4
5	Determination of minimal quadrat size for the study of herbaceous vegetation in the University campus, by species area curve method (species to be listed). Quantitative analysis of herbaceous vegetation in the University campus for frequency and comparison with Raunkiaer's frequency distribution law. Quantitative analysis of herbaceous vegetation for density and abundance in the University campus. Field visit to familiarize students with ecology of different sites.	12	CLO5

<b>Learning Resources</b>	
<b>Text Books</b>	1.Singh, J.S., Singh, S.P. and Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India. 2.Sharma, P.D. (2010). Ecology and Environment, 8th edition, Rastogi Publications, Meerut, India.
<b>Ref. Books</b>	Kormondy, E.J. (1996). Concepts of Ecology, 4th edition, PHI Learning Pvt. Ltd., Delhi, India

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1 Remember	25%	25%	25%	20%
2 Understand	25%	25%	25%	20%
3 Apply	25%	25%	25%	20%
4 Analyze	25%	25%	25%	20%
5 Evaluate	-	-	-	20%
6 Create	-	-	-	-
Total	100%	100%	100%	100%

<b>Course Designers</b>		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim.

	2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	anandsharma.a@srmus.edu .in
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Course Code	BOT1847	Course Name	Biomolecules and Cell Biology Practical	Course Category	SEC	Skill Enhancement Course				L	T	P	C		
<b>Pre-requisite</b>				BOT1843		<b>Co-requisite</b>		NIL				0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Apply the theoretical knowledge to identify different biomolecules in the laboratory	3	H	H	M	M	-	H	H	M	-	H	H
<b>CLO-2</b>	Analyze the structure and size of plant cell and its organelles through different techniques	4	H	H	M	M	-	H	H	M	-	H	H
<b>CLO-3</b>	Evaluate the effect of different physiological factors on cell membrane permeability	5	H	H	M	M	-	H	H	M	-	H	H
<b>CLO-4</b>	Appraise the skill to use different modern instruments for measuring and counting of cells	5	H	H	M	M	-	H	H	M	-	H	H
<b>CLO-5</b>	Compare different stages of cell divisions	5	H	H	M	M	-	H	H	M	-	H	H
			H	H	M	M		H	H	M		H	H

#### Summary of Course Content

S. No	Course Content	Hour	Alignment to CLO
1	Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.	12	CLO 1
2	Study of plant cell structure with the help of epidermal peel mount of onion ( <i>Allium cepa</i> ). Demonstration of the phenomenon of protoplasmic streaming in <i>Hydrilla</i> leaf. Measurement of cell size by the technique of micrometry.	12	CLO 2
3	Study of cell and its organelles with the help of electron micrographs photographs. Study the phenomenon of plasmolysis and deplasmolysis. Study the effect of organic solvent and temperature on membrane permeability.	12	CLO 3
4	Counting the cells per unit volume with the help of haemocytometer using bacterial cell.	12	CLO 4
5	Study of different stages of mitosis and meiosis from root tip and flower bud of <i>Allium cepa</i> .	12	CLO 5

#### Learning Resources

<b>Text Books</b>	2. Santra, S.C. (2015). <i>Practical Botany-Volume I</i> . New Central Book Agency (P) Limited.
<b>Ref. Books</b>	2. Wallis, C.J. (1966). <i>Practical Botany: For Advanced Level and Intermediate Students</i> . 5 <sup>th</sup> Edition. Imprint: Butterworth-Heinemann.

<b>Bloom's Level of Thinking</b>	<b>Internal Assessment for practical papers (40% weightage)</b>	<b>Final Examination for practical papers (60 % weightage)</b>
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		Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1	Remember	25%	25%	25%	20%
2	Understand	25%	25%	25%	20%
3	Apply	25%	25%	25%	20%
4	Analyze	25%	25%	25%	20%
5	Evaluate	-	-	-	20%
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NA	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	CHM1844	Course Name	Laboratory course on methods and synthesis in organic chemistry	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			CHM1823	Co-requisite		NIL	0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Develop the methodology for analysis of functional groups.	3	H	H	M	-	-	H	M	M	-	H	-
CLO-2	Apply the basic knowledge of acid base chemistry, solubility and polarity knowledge for purification of organic molecules.	3	H	H	M	-	-	H	M	M	-	H	-
CLO-3	Incorporate the theoretical knowledge of organic chemistry to organic synthesis.	4	H	H	M	-	-	H	M	M	-	H	-
CLO-4	Evaluate molecular models and their three-dimensional nature.	5	H	H	M	-	-	H	M	M	-	H	-
CLO-1	Appraise the methodology for analysis of functional groups.	5	H	H	M	-	-	H	M	M	-	H	-
			H	H	M			H	M	M		H	

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Functional group Analysis Qualitative organic functional group analysis - tests for alcohols, phenols, amines, carbonyls, carboxylic acids and nitro compounds.	10	CLO1
2	Separation and purification techniques Purification techniques: recrystallization, sublimation, distillation and steam distillation. Thin layer chromatography, column chromatography & paper chromatography.	12	CLO1, CLO2

	Specific rotation of chiral compounds (sugars) using a polarimeter. Plotting of molecular orbitals of aromatic compounds and conjugated systems. Conformational analysis – butane and substituted butanes, cyclohexane and di-substituted cyclohexane with stress on cis and trans isomerism. Molecular modelling: a) Stereo-chemistry: R-S configuration. b) Modeling on hybridization, geometry of some organic & inorganic compounds		
3	Organic synthesis Preparation of organic compounds: Dibenzylidene acetone, Aromatic sulphonation, Nitration of acetanilide, Bromination of acetanilide (Green Synthesis) Preparation of soap - saponification. Preparation of methyl orange and aspirin.	10	CLO2, CLO3, CLO4

### Learning Resources

Text Books	1. Ault, Allyn and Bacon, Techniques and experiments for organic chemistry Inc., 4th Ed., 1983. 2. Laurence M Harwood and Christopher Moody, Experimental organic chemistry, Principles and Practice, Blackwell Scientific Publications, 1989. 3. Donald Pavia, Gary M. Lampman and George S. Kriz Jr. Introduction to organic laboratory techniques a Contemporary Approach, 2nd Ed., 1982.
Ref. Books	1. L.F. Tietze and T H. Eicher, Reactions and synthesis in the Organic Chemistry Laboratory, University Science Books, 1989. 2. Koichi Tanaka, Solvent –free Organic Synthesis, Wiley-VCH, 2003. 3. Raphael Ikan, Natural Products -A Laboratory Guide, 2nd Ed., Academic Press Inc., 1991. 4. Plummer, David. T. Introduction to Practical Biochemistry, Tata McGraw-Hill Publishing Co., 2006. 5. Pushpa Sundararaj and AnupamaSiddhu, Qualitative tests and quantitative procedures in biochemistry, 2nd Ed., Phoenix publishing House Pvt Ltd., 2002. 6. B Sashidhar Rao and V. Deshpande, Experimental biochemistry-A student companion, 2nd Ed., Phoenix publishing House Pvt Ltd., 2002. 7. S. Sadasivam and A. Manickam, Biochemical methods, 2nd Ed., New Age International Pvt Ltd., 2005.

Bloom's Level of Thinking		Continuous Learning Assessment (40% weightage)			Final Examination (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	
1	Remember	40%	15%	20%	20%
2	Understand	40%	15%	20%	20%
3	Apply	-	20%	20%	20%
4	Analyze	20%	20%	20%	20%
5	Evaluate	-	15%	20%	20%
6	Create	-	15%	-	-
	Total	100%	100%	100%	100%

\*CLA: 5% is based on Attendance

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
Name: K. Anil Kumar Designation: Chief Scientific Officer- Arna Immuno ingredients Pvt. Ltd., Email: <a href="mailto:Anil.kumar@arnaimmuno.com">Anil.kumar@arnaimmuno.com</a>	Name: Dr. Somendra Nath Chakraborty Designation: Assistant Professor, Sikkim University Email: <a href="mailto:snchakraborty@cus.ac.in">snchakraborty@cus.ac.in</a>	Name: Dr. Govind Pratap Singh Designation: Associate Professor, Email: <a href="mailto:govindpratapsingh.v@srmus.edu.in">govindpratapsingh.v@srmus.edu.in</a>

# **Semester V**

Course Code	BOT1851	Course Name	Reproductive Biology of Angiosperms	Course Category	C	Core	L	T	P	C
Pre-requisite	NIL			Co-requisite	BOT1855		4	0	0	4

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Write the historical contribution of eminent scientist in the field of reproductive biology of angiosperms	1	H	M	-	-	-	M	-	M	-	H	H
CLO-2	Explain the floral development, micro/megasporogenesis, palynology, ultra-structure of male and female gametophyte	2	H	M	M	-	-	M	-	M	-	H	H
CLO-3	Outline the different types of pollination and fertilization and their significance	2	H	M	M	-	-	M	-	M	-	H	H
CLO-4	Illustrate the structure, types and pattern of development of monocot and dicot embryo and endosperm	2	H	M	-	-	-	M	-	M	-	H	H
CLO-5	Develop the concept polyembryology and apomixis	3	H	M	H	-	-	M	-	M	-	H	H
			H	M	M			M		M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Introduction</b> History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and its scope.	9	CLO 1
2	<b>Reproductive Development</b> Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects. Anther and pollen biology: Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia. Ovule: Structure; Types; Special structures—endothelium, obturator, aril, caruncle and hypostase; Female gametophyte-megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of <i>Polygonum</i> type); Organization and ultrastructure of mature embryo sac.	14	CLO 2
3	<b>Pollination and Fertilization</b> Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization. Self-incompatibility: Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and <i>in vitro</i> pollination; Modification of stigma surface, parasexual hybridization; Cybrids, <i>in vitro</i> fertilization.	12	CLO 3
4	<b>Embryo, Endosperm and Seed</b> Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in <i>Paonia</i> . Seed structure, importance and dispersal mechanisms	12	CLO 4

5	<b>Polyembryony and Apomixis</b> Introduction; Classification; Causes and applications.	12	CLO 5
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### Learning Resources

Text Books	1.Bhojwani, S.S. and Bhatnagar, S.P. (2011). Embryology of Angiosperms. 5th edition. Vikas Publication House Pvt. Ltd., New Delhi.
Ref. Books	1.Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi. 2.Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.

Bloom's Level of Thinking		Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%
4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

### Course Designers

Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1852	Course Name	Plant Physiology	Course Category	C	Core	L	T	P	C
Pre-requisite			NIL	Co-requisite		BOT1856	4	0	0	4

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define the process of absorption and transportation of water by plants	1	H	H	M	M	-	M	-	M	-	H	H
CLO-2	Explain process of translocation of minerals and nutrients by plants	2	H	H	H	M	-	M	-	M	-	H	H
CLO-3	Express the process of translocation and storage of food in plants	2	H	H	H	M	-	M	-	M	-	H	H
CLO-4	Identify the roles of hormones in plant growth and development	3	H	H	H	-	M	M	-	M	-	H	H
CLO-5	Analyze the effect of light perception and other parameters on the physiological of flowering	4	H	H	H	-	M	M	-	M	-	H	H

				<b>H</b>	<b>H</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>
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(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

<b>Summary of Course Content</b>			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Plant-water Relations</b> Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap-cohesion-tension theory. Transpiration and factors affecting transpiration, anti-transpirants, mechanism of stomatal movement.	13	CLO 1
2	<b>Mineral Nutrition and Nutrient Uptake by Plants</b> Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents. Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.	17	CLO 2
3	<b>Translocation in the Phloem</b> Experimental evidence in support of phloem as the site of sugar translocation. Pressure-Flow Model; Phloem loading and unloading; Source-sink relationship.	8	CLO 3
4	<b>Plant Growth Regulators</b> Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.	10	CLO 4
5	<b>Physiology of Flowering</b> Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy. Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action	12	CLO 5

<b>Learning Resources</b>	
<b>Text Books</b>	<ol style="list-style-type: none"> <li>Salisbury and Ross (2006). <i>Plant Physiology</i>, 1<sup>st</sup> edition, Cbs Publication.</li> <li>Pandey, S.N. and Sinha, B.K. (2005). <i>Plant Physiology</i>, 4<sup>th</sup> edition, S. Chand Publication.</li> </ol>
<b>Ref. Books</b>	<ol style="list-style-type: none"> <li>Hopkins, W.G. and Huner, A. (2008). <i>Introduction to Plant Physiology</i>, 4<sup>th</sup> edition. John Wiley and Sons, U.S.A.</li> <li>Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A. (2015). <i>Plant Physiology and Development</i>, 6<sup>th</sup> edition Sinauer Associates Inc., USA.</li> </ol>

Bloom's Level of Thinking	Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

<b>Course Designers</b>		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1853	Course Name	Horticultural Practices and Post-Harvest Technology	Course Category	DSE	Discipline-Specific Electives	L	T	P	C
Pre-requisite	NIL			Co-requisite	BOT1857		4	0	0	4

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define identification of horticultural and ornamental plants	1	H	M	H	-	H	H	H		H	H	H
CLO-2	Explain basic concept on the production, distribution, management and marketing of vegetable, flowers and fruit crops	2	H	M	H	-	H	H	H		H	H	H
CLO-3	Apply various horticultural techniques relating to the study of application of manure, fertilizers, nutrients, PGRs, weed control, biofertilizers, biopesticides, irrigation methods.	3	H	M	H	-	H	H	H		H	H	H
CLO-4	Analyze the importance of post-harvest technology for preservation, processing, storage and transportation of horticultural crops	4	H	M	H	-	H	H	H		H	H	H
CLO-5	Assess skills on disease control, management and identification of deficiency symptoms of post-harvest diseases along with IPM strategies of horticultural crops	5	H	M	H	-	H	H	H		H	H	H
			H	M	H	-	H	H	H		H	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Introduction Horticultural Plants</b> Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism. Ornamental plants:Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plants [rose, marigold, gladiolus, carnations, orchids, poppies, gerberas, tuberose, sages, cacti and succulents ( <i>Opuntia</i> , <i>Agave</i> and <i>Spurges</i> )] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail and areca palms, semul, coral tree).	12	CLO 1
2	<b>Fruit and Vegetable Crops and Flowering Plants</b> Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, chillies and cucurbits). Floriculture: Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows and exhibitions.	12	CLO 2
3	<b>Horticultural Techniques</b> Application of manure, fertilizers, nutrients and PGRs; Weed control; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Scope and limitations. Landscaping and garden design: Planning and layout (parks and avenues); gardening traditions- Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.	12	CLO 3



			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Recall the history and importance of plant breeding	1	H	-	-	-	H	M	M	M	-	H	H
<b>CLO-2</b>	Explain the process of crop domestication and methods of crop improvement through breeding and selection.	2	H	H	M	-	H	M	M	M	-	H	H
<b>CLO-3</b>	Interpret Quantitative Inheritance with examples.	2	H	H	M	-	H	M	M	M	-	H	H
<b>CLO-4</b>	Develop a concept on Inbreeding Depression and Heterosis and describe its applications in plant breeding.	3	H	H	H	-	H	M	M	M	-	H	H
<b>CLO-5</b>	Analyze the role of mutations; Polyploidy; Distant hybridization and biotechnology in crop improvement.	4	H	H	H	-	H	M	M	M	-	H	H
			H	H	H		H	M	M	M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

### Summary of Course Content

S. No	Course Content	Hour	Alignment to CLO
1	<b>Plant Breeding</b> Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.	12	CLO 1
2	<b>Methods of Crop Improvement</b> Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants-Procedure, advantages and limitations.	12	CLO 2
3	<b>Quantitative Inheritance</b> Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance.	12	CLO 3
4	<b>Inbreeding Depression and Heterosis</b> History, genetic basis of inbreeding depression and heterosis; Applications.	10	CLO 4
5	<b>Crop Improvement and Breeding</b> Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.	14	CLO 5

### Learning Resources

<b>Text Books</b>	1. Singh, B.D. (2005). <i>Plant Breeding: Principles and Methods</i> , 7 <sup>th</sup> edition, Kalyani Publishers. 2. Chahal, G.S. and Gosal, S.S. (2002). <i>Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches</i> . Alpha Science International Limited.
<b>Ref. Books</b>	1. Singh, B.D. (2005). <i>Plant Breeding: Principles and Methods</i> , 7 <sup>th</sup> edition, Kalyani Publishers. 2. Chaudhari, H.K. (1984). <i>Elementary Principles of Plant Breeding</i> , 2 <sup>nd</sup> edition, Oxford-IBH. 3. Acquaah, G. (2007). <i>Principles of Plant Genetics &amp; Breeding</i> . Blackwell Publishing.

Bloom's Level of Thinking	Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
	Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1 Remember	50%	25%	10%	25%
2 Understand	50%	25%	30%	25%
3 Apply	-	25%	30%	25%
4 Analyze	-	25%	30%	25%
5 Evaluate	-	-	-	-
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1855	Course Name	Reproductive Biology of Angiosperms Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			BOT1851	Co-requisite	NIL		0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Analyze the ornamentation, aperture, ultrastructure of pollen wall, MGU, Pollinia, Tapetum, Pollen viability and germination	4	H	H	M	-	-	H	H	H	-	H	H
CLO-2	Examine different types of ovule, special features and female gametophyte	4	H	H	M	-	-	H	H	H	-	H	H
CLO-3	Evaluate the intraovarian pollination	5	H	H	M	-	-	H	H	H	-	H	H
CLO-4	Compare the different types of endosperms by dissecting fresh specimens	5	H	H	M	-	-	H	H	H	-	H	H
CLO-5	Explain the different stages of embryo during embryogenesis	5	H	H	M	-	-	H	H	H	-	H	H
			H	H	M			H	H	H		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation. 2. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, psuedomonads, polyads, pollinia (photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test. germination: Calculation of percentage germination in different media using hanging drop method.	12	CLO 1
2	1. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs). 2. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.	12	CLO 2
3	Intra-ovarian pollination; Test tube pollination through photographs.	12	CLO 3

4	Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.	12	CLO 4
5	Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.	12	CLO 5

Learning Resources	
Text Books	1.Bhojwani, S.S. and Bhatnagar, S.P. (2011). Embryology of Angiosperms. 5th edition. Vikas Publication House Pvt. Ltd., New Delhi.
Ref. Books	1. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi. 2. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1 Remember	25%	25%	25%	20%
2 Understand	25%	25%	25%	20%
3 Apply	25%	25%	25%	20%
4 Analyze	25%	25%	25%	20%
5 Evaluate	-	-	-	20%
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	<ol style="list-style-type: none"> <li>Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1856	Course Name	Plant Physiology Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			BOT1852	Co-requisite	NIL		0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Analyze the osmotic and water potential of plant cells in the laboratory	4	H	H	H	-	-	H	H	M	-	H	H
CLO-2	Evaluate the effects of different physiological parameters on transpiration rate	5	H	H	H	-	-	H	H	M	-	H	H
CLO-3	Estimate the stomatal index, area and frequency of plants growing in extreme ecological conditions	5	H	H	H	-	-	H	H	M	-	H	H

<b>CLO-4</b>	Measure the effect of light and enzymes on germinating seeds	5	H	H	H	-	M	H	H	M	-	H	H
<b>CLO-5</b>	Evaluate the effect of plant hormones in different physiological functions	5	H	H	H	-	M	H	H	M	-	H	H
			H	H	H		M	H	H	M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

<b>Summary of Course Content</b>			
S. No	Course Content	Hour	Alignment to CLO
1	1. Determination of osmotic potential of plant cell sap by plasmolytic method. 2. Determination of water potential of given tissue (potato tuber) by weight method.	12	CLO 1
2	1. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.	12	CLO 2
3	1. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte. 2. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).	12	CLO 3
4	To study the phenomenon of seed germination (effect of light).	12	CLO 4
5	1. To study the effect of different concentrations of IAA on Avena coleoptile elongation (IAA Bioassay). 2. To study the induction of amylase activity in germinating barley grains. 3. Demonstration experiments a) To demonstrate suction due to transpiration. b) Fruit ripening/Rooting from cuttings (Demonstration). c) Bolting experiment/Avenacoleoptile bioassay (demonstration).	12	CLO 5

<b>Learning Resources</b>	
<b>Text Books</b>	2. Bajracharya, D. (1999). <i>Experiments in Plant Physiology-A Laboratory Manual</i> . Narosa Publishing House, New Delhi.
<b>Ref. Books</b>	1. Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A. (2015). <i>Plant Physiology and Development</i> , 6 <sup>th</sup> edition Sinauer Associates Inc., USA.

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1 Remember	25%	25%	25%	20%
2 Understand	25%	25%	25%	20%
3 Apply	25%	25%	25%	20%
4 Analyze	25%	25%	25%	20%
5 Evaluate	-	-	-	20%
6 Create	-	-	-	-
Total	100%	100%	100%	100%

<b>Course Designers</b>		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1857	Course Name	Horticultural Practices and Post-Harvest Technology-Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite	BOT1853			Co-requisite	NIL		0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Survey to gardens, nurseries, horticultural fields and other suitable locations	4	H	M	M	-	H	H	M	M	H	H	H
CLO-2	Evaluate Nursery and field management techniques.	5	H	M	M	-	H	H	M	M	H	H	H
CLO-3	Formulate different manures: like EM compost, green manure and vermin-compost.	6	H	M	M	-	H	H	H	M	H	H	H
			H	M	M		H	H	H	M	H	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Field trip: Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.	12	CLO1
2	Nursery and field management techniques.	12	CLO2
3	Preparation of different manures: Preparation of EM compost, green manure, vermin-compost.	12	CLO3

Learning Resources	
Text Books	1. Auxcilia J, Shabha N (2009). Horticultural Practices and Post-Harvest Technology-Practical. New India Publishing Agency Pp 345
Ref. Books	1. Mandal D, Shukla A.C. 2021. Siddiqui M.W Sustainable Horticulture, Volume 1: Diversity, Production, and Crop Improvement (Innovations in Horticultural Science), CRC Press, Taylor Francis Group

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)	
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)	
1	Remember	25%	25%	25%	20%
2	Understand	25%	25%	25%	20%
3	Apply	25%	25%	25%	20%
4	Analyze	25%	25%	25%	20%
5	Evaluate	-	-	-	20%
6	Create	-	-	-	-
	Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director,	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu

<b>Course Code</b>	<b>BOT1858</b>	<b>Course Name</b>	<b>Plant Breeding Practical</b>	<b>Course Category</b>	<b>SEC</b>	<b>Skill Enhancement Course</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Pre-requisite</b>	BOT1854			<b>Co-requisite</b>	NIL		<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Identify the germplasm during local expedition.	3	H	H	M	-	-	H	H	M	-	H	H
<b>CLO-2</b>	Analyze the floral structure of self-pollinated and cross-pollinated crops.	4	H	H	M	-	-	H	H	M	-	H	H
<b>CLO-3</b>	Compare the emasculation and hybridization techniques in self and cross pollinated crops.	4	H	H	M	-	M	H	H	M	-	H	H
<b>CLO-4</b>	Determine artificial pollination in self-pollinated crop (any one crop).	5	H	H	M	-	-	H	H	M	-	H	H
<b>CLO-5</b>	Compile the data on epistatic interactions, probability and Chi-square test and heritability analysis.	6	H	H	M	-	M	H	H	M	-	H	H
			H	H	M		M	H	H	M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Study of germplasm.	12	CLO 1
2	Study of floral structure of self-pollinated and cross pollinated crops.	12	CLO 2
3	Emasculation and hybridization techniques in self and cross pollinated crops.	12	CLO 3
4	Artificial pollination in self-pollinated crop (any one crop).	12	CLO 4
5	Experiments on epistatic interactions and data analysis. Study on probability and Chi-square test and heritability analysis.	12	CLO 5

Learning Resources	
<b>Text Books</b>	1. Singh, B.D. (2005). <i>Plant Breeding: Principles and Methods</i> , 7 <sup>th</sup> edition, Kalyani Publishers. 2. Chahal, G.S. and Gosal, S.S. (2002). <i>Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches</i> . Alpha Science International Limited.
<b>Ref. Books</b>	1. Singh, B.D. (2005). <i>Plant Breeding: Principles and Methods</i> , 7 <sup>th</sup> edition, Kalyani Publishers. 2. Chaudhari, H.K. (1984). <i>Elementary Principles of Plant Breeding</i> , 2 <sup>nd</sup> edition, Oxford-IBH. 3. Acquaah, G. (2007). <i>Principles of Plant Genetics &amp; Breeding</i> . Blackwell Publishing.

Bloom's Level of Thinking		Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
		Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1	Remember	25%	25%	25%	20%
2	Understand	25%	25%	25%	20%
3	Apply	25%	25%	25%	20%
4	Analyze	25%	25%	25%	20%
5	Evaluate	-	-	-	20%
6	Create	-	-	-	-
Total		100%	100%	100%	100%

<b>Course Designers</b>		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
<b>NIL</b>	<ol style="list-style-type: none"> <li>1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in</li> <li>2. Dr. B. C. Basistha, Additional Director, Science &amp; Technology, Govt. of Sikkim. basisthabharat@gmail.com</li> </ol>	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

# **SEMESTER - VI**

Course Code	BOT1861	Course Name	Plant metabolism	Course Category	C	Core	L	T	P	C
Pre-requisite	NIL			Co-requisite	BOT1865		4	0	0	4

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define the types of metabolism occurring in plants	1	H	-	-	-	-	H	-	M	-	H	H
CLO-2	Explain the biochemical pathways behind carbon assimilation in plants	2	H	-	-	-	-	H	-	M	-	H	H
CLO-3	Identify the interrelated metabolic pathways responsible for energy production in plants	3	H	-	-	-	-	H	-	M	-	H	H
CLO-4	Analyze the uptake and assimilation of nitrogen by plants	4	H	-	-	-	-	H	-	M	-	H	H
CLO-5	Examine the different components of signal transduction pathways and the basic principles behind its mechanism	4	H	M	-	M	-	H	-	M	-	H	H
			H	M		M		H		M		H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Concept of Metabolism</b> Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).	6	CLO 1
2	<b>Carbon Assimilation</b> Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO <sub>2</sub> reduction, photorespiration, C <sub>4</sub> pathways; Crassulacean acid metabolism; Factors affecting CO <sub>2</sub> reduction.	16	CLO 2
3	<b>Carbohydrate Metabolism and Lipid Metabolism</b> Synthesis and catabolism of sucrose and starch. Carbon Oxidation: Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration. ATP-Synthesis: Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers. Lipid metabolism: Synthesis and breakdown of triglycerides, $\beta$ -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination, $\alpha$ oxidation.	20	CLO 3
4	<b>Nitrogen Metabolism</b> Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.	10	CLO 4
5	<b>Mechanisms of Signal Transduction</b>	8	CLO 5

Receptor-ligand interactions; Second messenger concept, Calcium calmodulin, MAP kinase cascade.		
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Learning Resources	
<b>Text Books</b>	1. Mitra, D., Ghua, J. and Mitra, J.N. <i>Studies in Botany: Volume II</i> , Moulik Library, Calcutta.
<b>Ref. Books</b>	1. Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A. (2015). <i>Plant Physiology and Development</i> , 6 <sup>th</sup> edition Sinauer Associates Inc., USA. 2. Hopkins, W.G. and Huner, A. (2008). <i>Introduction to Plant Physiology</i> , 4 <sup>th</sup> edition. John Wiley and Sons, U.S.A.

Bloom's Level of Thinking		Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%
4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1862	Course Name	Plant Biotechnology and Bioinformatics	Course Category	C	Core	L	T	P	C
							4	0	0	4
Pre-requisite				Co-requisite		BOT1866				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define the concept of totipotency, organogenesis, embryogenesis, and define the process of protoplast isolation, culture, fusion and cryopreservation.	1	H	H	H	-	H	H	-	M	-	H	H
CLO-2	Explain restriction endonucleases, cloning vectors and different recombinant gene transfer methods in plants.	2	H	H	H	-	H	H	-	M	-	H	H
CLO-3	Build a concept on the application of recombinant DNA technology in improved plant varieties, bioremediation, edible	3	H	H	H	-	H	H	-	M	-	H	H

	vaccines, industrial enzymes, and genetically engineered products for human welfare.												
<b>CLO-4</b>	Apply bioinformatics tools and databases for nucleotide and protein analysis in silico.	4	H	H	H	-	H	H	-	M	-	H	H
<b>CLO-5</b>	Analyze sequence alignments for phylogenetic relations and demonstrate drug designing using computational tools.	4	H	H	H	M	H	H	-	M	-	H	H
			H	H	H	M	H	H		M		H	H

(Level of correlation: **3-High, 2-Medium, 1-Low** can be used)

<b>Summary of Course Content</b>			
<b>S. No</b>	<b>Course Content</b>	<b>Hour</b>	<b>Alignment to CLO</b>
1	<b>Plant Tissue Culture</b> Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).	12	CLO 1
2	<b>Recombinant DNA technology</b> Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC). Gene Cloning: Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR. Methods of gene transfer: Agrobacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics-selectable marker and reporter genes (Luciferase, GUS, GFP).	20	CLO 2
3	<b>Applications of Biotechnology</b> Pest resistant (Bt-cotton); herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Improved horticultural varieties (Moon dust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products-Human Growth Hormone; Humulin; Biosafety concerns.	12	CLO1, CLO 2, CLO 3
4	<b>Bioinformatics</b> Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics. Databases: Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System. Biological Sequence Databases: National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database. Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.	10	CLO 4
5	<b>Sequence Alignments</b> Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM). Molecular Phylogeny and Application of Bioinformatics: Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.	6	CLO 5

Learning Resources	
<b>Text Books</b>	1. Satyavathi, C.T, Bharadwaj, C., Srivastava, SK, Anand, G.R. and Prasad, S.V. S. (2014). <i>Biotechnology</i> , 2 <sup>nd</sup> edition, New Vishal Publication. 2. Chawla, H.S. (2008). <i>Introduction to Plant Biotechnology</i> , 3 <sup>rd</sup> edition, Oxibh Publication. 3. Umesh, S., (2005). <i>Plant Biotechnology</i> . The Energy and Resources Institute Publication.
<b>Ref. Books</b>	1. Bhojwani, S.S. and Razdan, M.K., (1996). <i>Plant Tissue Culture: Theory and Practice</i> . Elsevier Science Amsterdam. The Netherlands. 2. Glick, B.R. and Pasternak, J.J. (2003). <i>Molecular Biotechnology-Principles and Applications of Recombinant DNA</i> . ASM Press, Washington. 3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). <i>The Embryology of Angiosperms</i> . Vikas Publication House Pvt. Ltd., New Delhi. 5th edition. 4. Snustad, D.P. and Simmons, M.J. (2010). <i>Principles of Genetics</i> . John Wiley and Sons, U.K. 5th edition. 5. Stewart, C.N. Jr. (2008). <i>Plant Biotechnology &amp; Genetics: Principles, Techniques and Applications</i> . John Wiley & Sons Inc. U.S.A.

Bloom's Level of Thinking		Internal Assessment for theory papers (40% weightage)			Final Examination for theory papers (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	End Semester Theory Exam (60)
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%
4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1863	Course Name	Industrial and Environmental Microbiology	Course Category	DSE 1	Discipline Specific Elective	L	T	P	C
Pre-requisite			NIL	Co-requisite		BOT1867	4	0	0	4

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
CLO-1	Understand different equipment used in microbial fermentation processes.	2	H	-	M	-	-	H	M	M	H	H	H

<b>CLO-2</b>	Demonstrate skill on microbiological culture media preparation and microbial quality control	2	<b>H</b>	-	<b>M</b>	-	<b>H</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>	<b>H</b>
<b>CLO-3</b>	Build a concept on industrial application of microorganism	3	<b>H</b>	-	<b>M</b>	-	-	<b>H</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>	<b>H</b>
<b>CLO-4</b>	Analyze the role of microorganism in checking the quality of the environment	4	<b>H</b>	<b>H</b>	<b>M</b>	-	<b>H</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>	<b>H</b>
<b>CLO-5</b>	Evaluate the concept on bioremediation and role of mycorrhizae in biological fixation.	5	<b>H</b>	<b>H</b>	<b>M</b>	-	<b>H</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>	<b>H</b>
			<b>H</b>	<b>H</b>	<b>M</b>	-	-	<b>H</b>	<b>M</b>	<b>M</b>	<b>H</b>	<b>H</b>	<b>H</b>

(Level of correlation: **3-High, 2-Medium, 1-Low** can be used)

### Summary of Course Content

S. No	Course Content	Hour	Alignment to CLO
1	<b>Scope of Microbes in Industry and Environment</b> Bioreactors/Fermenters and fermentation processes: Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.	12	CLO1
2	<b>Microbial Production of Industrial Products</b> Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)	14	CLO 2
3	<b>Microbial Enzymes of Industrial Interest and Enzyme Immobilization</b> Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).	12	CLO 3
4	<b>Microbes and Quality of Environment</b> Distribution of microbes in air; Isolation of microorganisms from soil, air and water. Microbial flora of water: Water pollution, role of microbes in sewage and domestic waste water treatment Systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.	12	CLO 4
5	<b>Microbes in Agriculture and Remediation of Contaminated soils</b> Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.	10	CLO 5

### Learning Resources

<b>Text Books</b>	1. Dubey, R.C. and Maheshwari, D.K. (2009). A Text Book of Microbiology, 1 <sup>st</sup> Edition. S. Chand Publication. 2. Banerjee, A.K. and Banerjee, N. (2008). Fundamentals of Microbiology & Immunology. NCBA (P) Limited.
<b>Ref. Books</b>	1. Pelzar, M.J. Jr., Chen E.C. S. and Krieg, N.R. (2010). Microbiology: An Application Based Approach. Tata McGraw Hill Education Pvt. Ltd., Delhi. 2. Tortora, G.J., Funke, B.R. and Case. C.L. (2007). Microbiology, 9th. Pearson Benjamin Cummings, edition San Francisco, U.S.A.

Bloom's Level of Thinking	Continuous Learning Assessment (40% weightage)			Final Examination (60 % weightage)	
	Cycle Test (10)	Model Examination (20)	Assignment (10)		
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%

4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
	Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1864	Course Name	Biostatistics	Course Category	DSE 2	Discipline Specific Elective	L	T	P	C
Pre-requisite			NIL	Co-requisite		BOT1864	4	0	0	4

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Define the basic principles. limitations and uses of statistics.	1	H	H	M	H	-	H	-	M	-	H	-
CLO-2	Explain the types, methods and presentation of data collection procedures and its merits and demerits.	2	H	H	M	H	-	H	-	M	-	H	-
CLO-3	Develop a concept about the mean, median, mode and measures of dispersions.	3	H	H	M	H	-	H	-	M	-	H	-
CLO-4	Analyze the types and methods of correlation and regression.	4	H	H	M	H	-	H	-	M	-	H	-
CLO-5	Determine the various numericals about hypothesis testing using statistical methods.	5	H	H	M	H	-	H	-	M	-	H	-
			H	H	M	H	-	H	-	M	-	H	-

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	<b>Biostatistics</b> Definition-statistical methods-basic principles. Variables-measurements, functions, limitations and uses of statistics.	12	CLO1
2	<b>Collection of Data Primary and Secondary</b> Types and methods of data collection procedures-merits and demerits. Classification-tabulation and presentation of data-sampling methods.	12	CLO 2
3	<b>Measures of Central Tendency</b> Mean, median, mode, geometric mean - merits and demerits. Measures of dispersion -range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co-efficient of variations.	12	CLO 3
4	<b>Correlation</b>	12	CLO 4

	Types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.		
5	<b>Statistical Inference</b> Hypothesis-simple hypothesis-student 't' test-chi square test. ( <b>Practical based</b> ):1. Calculation of mean, standard deviation and standard error. 2. Calculation of correlation coefficient values and finding out the probability. 3. Calculation of 'F' value and finding out the probability value for the F value.	12	CLO 5

Learning Resources	
<b>Text Books</b>	1. Danniel, W.W. (1987). Biostatistics, New York, John Wiley Sons. 2. Sundarrao, P.S.S and Richards, J. Christian. An introduction to Biostatistics, 3rd edition, Medical College, Vellore.
<b>Ref. Books</b>	1. Selvin, S. (1991). Statistical Analysis of Epidemiological data, New York University Press. 2. Freedman, P. The Principles of scientific research, Pergamon Press, New York. 3. Campbell, R.C. (1998). Statistics for Biologists. Cambridge University Press.

Bloom's Level of Thinking		Continuous Learning Assessment (40% weightage)			Final Examination (60 % weightage)
		Cycle Test (10)	Model Examination (20)	Assignment (10)	
1	Remember	50%	25%	10%	25%
2	Understand	50%	25%	30%	25%
3	Apply	-	25%	30%	25%
4	Analyze	-	25%	30%	25%
5	Evaluate	-	-	-	-
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1865	Course Name	Plant metabolism Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
							0	0	4	2
Pre-requisite			BOT1861	Co-requisite		NIL				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Analyze the separation of different photosynthetic pigments with the help of chemicals	4	H	H	M	-	-	H	M	M	-	H	H
CLO-2	Estimate the amount of different photosynthetic pigments present in the leaf	5	H	H	M	-	-	H	M	M	-	H	H



			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Demonstrate preparation of culture medium, sterilization, inoculation and micro-propagation in plant tissue culture.	2	H	H	H	-	-	H	M	M	H	H	M
<b>CLO-2</b>	Construct restriction map of circular and linear DNA from the data provided.	3	H	H	H	-	H	H	M	M	H	H	M
<b>CLO-3</b>	Analyze isolated protoplasts from plant tissue, and demonstrate isolation of plasmid DNA; Restriction digestion and gel electrophoresis of plasmid DNA.	4	H	H	H	-	-	H	M	M	H	H	M
<b>CLO-4</b>	Compare and identify photographs of <i>Agrobacterium</i> -mediated or direct gene transfer, steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato.	5	H	H	H	-	H	H	M	M	H	H	M
<b>CLO-5</b>	Create sequence alignment, sequence homology, phylogenetic trees and gene annotation by sequence retrieval from nucleic acid and protein databases.	6	H	H	H	-	H	H	M	M	H	H	M
			H	H	H		H	H	M	M	H	H	M

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

<b>Summary of Course Content</b>			
S. No	Course Content	Hour	Alignment to CLO
1	1. (a) Preparation of MS medium (b) Demonstration of <i>in vitro</i> sterilization and inoculation methods using leaf and nodal explants of tobacco, <i>Datura</i> , <i>Brassica</i> etc. 2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis and artificial seeds through photographs.	12	CLO 1
2	1. Construction of restriction map of circular and linear DNA from the data provided. 2. Isolation of plasmid DNA; Restriction digestion and gel electrophoresis of plasmid DNA.	12	CLO 2
3	Isolation of protoplasts.	12	CLO 3
4	1. Study of methods of gene transfer through photographs: <i>Agrobacterium</i> -mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment. 2. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.	12	CLO 4
5	1. Nucleic acid and protein databases; Sequence retrieval from databases. 2. Sequence alignment; Sequence homology and Gene annotation. 3. Construction of phylogenetic tree	12	CLO 5

<b>Learning Resources</b>	
<b>Text Books</b>	1. Giri, CC. and Giri, A. (2007). Plant Biotechnology: Practical Manual. I.K. International Publication. 2. Plant Biotechnology Practical Manual, SRM University.
<b>Ref. Books</b>	1. Satyavathi, C.T, Bharadwaj, C., Srivastava, SK, Anand, G.R. and Prasad, S.V. S. (2014). <i>Biotechnology</i> , 2 <sup>nd</sup> edition, New Vishal Publication. 2. Chawla, H.S. (2008). <i>Introduction to Plant Biotechnology</i> , 3 <sup>rd</sup> edition, Oxibh Publication. 3. Umesh, S., (2005). <i>Plant Biotechnology</i> . The Energy and Resources Institute Publication.

Bloom's Level of Thinking		Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
		Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1	Remember	10%	20%	25%	10%
2	Understand	20%	20%	25%	20%
3	Apply	20%	20%	25%	20%
4	Analyze	20%	20%	25%	20%
5	Evaluate	20%	20%	-	20%
6	Create	10%	-	-	10%
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1867	Course Name	Industrial and Environmental Microbiology Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			BOT1863	Co-requisite	NIL		0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
CLO-1	Inspect the basic instruments used in microbiology laboratory	4	H	M	H	-	H	H	M	H	H	H	H
CLO-2	Examine the skill on sterilization techniques and preparation of culture media.	4	H	M	H	-	H	H	M	H	H	H	H
CLO-3	Evaluate the downstream and fermentation process through industrial visit	5	H	M	H	-	H	H	M	H	H	H	H
			H	M	H		H	H	M	H	H	H	H

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Principles and functioning of instruments in microbiology laboratory	20	CLO 1
2	Hands on sterilization techniques and preparation of culture media.	20	CLO 2
3	A visit to any educational institute/ industry to see an industrial fermenter, and other downstream	20	CLO 3

Learning Resources	
<b>Text Books</b>	1. Dubey, R.C. and Maheshwari, D.K. (2009). A Text Book of Microbiology, 1st Edition. S. Chand Publication. 2. Banerjee, A.K. and Banerjee, N. (2008). Fundamentals of Microbiology & Immunology. NCBA (P) Limited.
<b>Ref. Books</b>	1. Pelzar, M.J. Jr., Chen E.C. S. and Krieg, N.R. (2010). Microbiology: An Application Based Approach. Tata McGraw Hill Education Pvt. Ltd., Delhi. Tortora, G.J., Funke, B.R. and Case. C.L. (2007). Microbiology, 9th. Pearson Benjamin Cummings, edition San Francisco, U.S.A.

Bloom's Level of Thinking		Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
		Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1	Remember	20%	25%	25%	20%
2	Understand	20%	25%	25%	20%
3	Apply	20%	25%	25%	20%
4	Analyze	20%	25%	25%	20%
5	Evaluate	20%	-	-	20%
6	Create	-	-	-	-
Total		100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in

Course Code	BOT1868	Course Name	Biostatistics Practical	Course Category	SEC	Skill Enhancement Course	L	T	P	C
Pre-requisite			BOT1864	Co-requisite		NIL	0	0	4	2

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6	PLO-7	PLO-8	PLO-9	PLO-10	PLO-11
			Profession Knowledge	Problem Analysis	Modern Usage tools	Inter and Trans disciplinary Development	Innovation and Entrepreneurship	Ethics	Individual and Team Work	Communications	Vocational and Industry Exposure	Life-long learning	Environment and sustainability
<b>CLO-1</b>	Analyze the mean, standard deviation and standard error	4	H	M	H	-	H	H	M	H	H	H	M
<b>CLO-2</b>	Determine the correlation coefficient values and finding out the probability	5	H	M	H	-	H	H	M	H	H	H	M
<b>CLO-3</b>	Estimate the 'F' value and finding out the probability value for the F value	5	H	M	H	-	H	H	M	H	H	H	M
			H	M	H		H	H	M	H	H	H	M

(Level of correlation: 3-High, 2-Medium, 1-Low can be used)

Summary of Course Content			
S. No	Course Content	Hour	Alignment to CLO
1	Calculation of mean, standard deviation and standard error	20	CLO 1
2	Calculation of correlation coefficient values and finding out the probability	20	CLO 2
3	Calculation of 'F' value and finding out the probability value for the F value	20	CLO 3

Learning Resources	
<b>Text Books</b>	1. Danniel, W.W. (1987). Biostatistics, New York, John Wiley Sons. 2. Sundarrao, P.S.S and Richards, J. Christian. An introduction to Biostatistics, 3rd edition, Medical College, Vellore.
<b>Ref. Books</b>	1. Selvin, S. (1991). Statistical Analysis of Epidemiological data, New York University Press. 2. Freedman, P. The Principles of scientific research, Pergamon Press, New York. 3. Campbell, R.C. (1998). Statistics for Biologists. Cambridge University Press.

Bloom's Level of Thinking	Internal Assessment for practical papers (40% weightage)			Final Examination for practical papers (60 % weightage)
	Experiment (20)	Lab record notebook (10)	Clarity/Viva voce (10)	End Semester Practical Exam (60)
1 Remember	20%	25%	25%	20%
2 Understand	20%	25%	25%	20%
3 Apply	20%	25%	25%	20%
4 Analyze	20%	25%	25%	20%
5 Evaluate	20%	-	-	20%
6 Create	-	-	-	-
Total	100%	100%	100%	100%

Course Designers		
Experts from Industry: Name, Designation with official mail id	Experts from Higher Education Institutions: Name, Designation with official mail id	Internal Experts: Name, Designation with official id
NIL	1. Dr. Dhani raj Chhetri, Associate Professor, Sikkim University. drchhetri@cus.ac.in 2. Dr. B. C. Basistha, Additional Director, Science & Technology, Govt. of Sikkim. basisthabharat@gmail.com	Dr. Anand Sharma, Assistant Professor, SRM University Sikkim. anandsharma.a@srmus.edu.in



**BACHELOR OF SCIENCE (HONOURS)-BOTANY  
CURRICULUM AND SYLLABI**

**(For students admitted for the academic year 2019-20)**

**Sri Ramasamy Memorial University, Sikkim  
5th Mile, Tadong, Gangtok, Sikkim 737102**

Semester	Discipline specific core course (DSC)	Ability Enhancement Compulsory Course (AECC)	Skill Enhancement Course (SEC)	Discipline specific elective course (DSE)	Ancillary
I	1. Microbiology and Phycology	English-I (LSRW)			Zoology
	2. Plant Morphology and Plant Systematics				
II	3. Mycology and Phytopathology	English-II Communication			Zoology
	4. Archegoniate and Palaeobotany				
III	5. Plant Anatomy		Ethnobotany		Chemistry
	6. Economic Botany				
	7. Plant Genetics				
IV	8. Molecular Biology		Herbal Technology		Chemistry
	9. Plant Ecology and Phytogeography				
	10. Biomolecules and Cell Biology				
V	11. Reproductive Biology of Angiosperms			1. Horticultural Practices and Post-Harvest Technology OR 2. Plant Breeding	
	12. Plant Physiology				
VI	13. Plant Metabolism			1. Industrial and Environmental Microbiology OR 2. Biostatistics	
	14. Plant Biotechnology and Bioinformatics				

### B.Sc. (Honours) Botany Curriculum

Course category	Course code	Course Name	L	T	P	C
<b>SEMESTER-I</b>						
AECC	LAE1811	English-I(LSRW)	2	1	0	3
C	BOT1812	Microbiology and Phycology	4	0	0	4
C	BOT1813	Plant Morphology and Plant Systematics	4	0	0	4
GE	ZOLA1831	Animal Diversity	3	0	0	3
SEC	BOT1814	Microbiology and Phycology Practical	0	0	4	2
SEC	BOT1815	Plant Morphology and Plant Systematics Practical	0	0	4	2
SEC	ZOLA1832	Animal Diversity Practical	0	0	4	2
*SWAYAM	EVS1817	Environmental Studies (Internal Evaluation)	2	0	0	2
		<b>TOTAL</b>			<b>12</b>	<b>22</b>
<b>SEMESTER-II</b>						
Course category	Course code	Course Name	L	T	P	C
AECC	LAE1821	English-II (Communication Skill)	2	1	0	3
C	BOT1822	Mycology and Phytopathology	4	0	0	4
C	BOT1823	Archegoniate and Palaeobotany	4	0	0	4
GE	ZOLA1841	Aquatic Biology	3	0	0	3
SEC	BOT1824	Mycology and Phytopathology Practical	0	0	4	2
SEC	BOT1825	Archegoniate-Practical	0	0	4	2
SEC	ZOLA1842	Aquatic Biology Practical	0	0	4	2
Extension	EX*will be S/C/Y	NSS / NCC /Yoga (Internal Evaluation)				
		<b>TOTAL</b>			<b>12</b>	<b>20</b>
<b>SEMESTER-III</b>						
Course category	Course code	Course Name	L	T	P	C
C	BOT1831	Plant Anatomy	3	0	0	3
C	BOT1832	Economic Botany	3	0	0	3
C	BOT1833	Plant Genetics	3	0	0	3
GE	CHM1812	Structure and Bonding in Chemistry	4	0	0	4
SEC	BOT1834	Ethnobotany	2	0	0	2
SEC	BOT1835	Plant Anatomy-Practical	0	0	4	2
SEC	BOT1836	Economic Botany-Practical	0	0	4	2
SEC	BOT1837	Plant Genetics-Practical	0	0	4	2
SEC	CHM1814	Inorganic Qualitative Analysis-I	0	0	4	2
		<b>TOTAL</b>			<b>16</b>	<b>23</b>
<b>SEMESTER-IV</b>						
Course category	Course code	Course Name	L	T	P	C
C	BOT1841	Molecular Biology	3	0	0	3
C	BOT1842	Plant Ecology and Phytogeography	3	0	0	3
C	BOT1843	Biomolecules and Cell Biology	3	0	0	3
GE	CHM1823	Basic Concepts of Organic Chemistry	4	0	0	4
SEC	BOT1844	Herbal Technology	2	0	0	2
SEC	BOT1845	Molecular Biology Practical	0	0	4	2
SEC	BOT1846	Plant Ecology and Phytogeography Practical	0	0	4	2
SEC	BOT1847	Biomolecules and Cell Biology Practical	0	0	4	2
SEC	CHM1844	Laboratory Course on Methods and Synthesis in Organic Chemistry	0	0	4	2
		<b>TOTAL</b>			<b>16</b>	<b>23</b>
<b>SEMESTER-V</b>						
Course category	Course code	Course Name	L	T	P	C
C	BOT1851	Reproductive Biology of Angiosperms	4	0	0	4
C	BOT1852	Plant Physiology	4	0	0	4
DSE	BOT1853	Horticultural Practices and Post-Harvest Technology	4	0	0	4

DSE	BOT1854	Plant Breeding				
SEC	BOT1855	Reproductive Biology of Angiosperms Practical	0	0	4	2
SEC	BOT1856	Plant Physiology Practical	0	0	4	2
SEC	BOT1857	Horticultural Practices and Post-Harvest Technology Practical	0	0	4	2
SEC	BOT1858	Plant Breeding Practical				
		<b>TOTAL</b>			<b>12</b>	<b>18</b>
<b>SEMESTER-VI</b>						
<b>Course category</b>	<b>Course code</b>	<b>Course Name</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
C	BOT1861	Plant Metabolism	4	0	0	4
C	BOT1862	Plant Biotechnology and Bioinformatics	4	0	0	4
DSE	BOT1863	Industrial and Environmental Microbiology	4	0	0	4
DSE	BOT1864	Biostatistics				
SEC	BOT1865	Plant Metabolism-Practical	0	0	4	2
SEC	BOT1866	Plant Biotechnology and Bioinformatics Practical	0	0	4	2
SEC	BOT1867	Industrial and Environmental Microbiology Practical	0	0	4	2
SEC	BOT1868	Biostatistics Practical				
		<b>TOTAL</b>			<b>12</b>	<b>18</b>

C-Core

SEC-Skill Enhancement Course

DSE-Discipline Specific Elective Course

AECC- Ability Enhancement Compulsory Courses

\*These courses are suggested to complete through online SWAYAM and credit will be displayed on the mark sheet.

# **SEMESTER-I**

Course Category	Course code	Course Name	L	T	P	C
AECC	LAE1811	English-I (LSRW)	2	1	0	3

### UNIT I: Listening Skills

Introduction to Communication-LSRW

Active Listening

Reasons for poor Listening

Types of Listening

Barriers to Listening

Traits of a good Listener

*Activity:* Listening to the news and making notes, listening to announcements, listening to speeches, listening to instructions and summarizing them, listening to and differentiating pronunciations.

### UNIT II: Speaking Skills

Importance of Speaking Skills

Effective Speaking-Confidence, Clarity and Fluency

Types of Speaking-Task Oriented-Interpersonal-Formal and Semi Formal

Persuasive Speaking and Public Speaking

Barriers to Speaking

Guidelines for conducting a Group Discussion

Guidelines for conducting a Meeting

*Activity:* Peer Introduction, JAM, Public speech, Role play, Product description, debate, GD, panel discussion, Conducting Meeting

### UNIT III: Reading Skills

Introduction to Reading skills

Thesis, Evidence, Evaluation

Topic sentence and its role

Types of reading-Intensive-Extensive-Skimming-Scanning Reading and its purposes

Reading for pleasure

Reading for critical interpretation

Reading for note making and summarizing

*Activity:* Reading articles and short stories and verbally summarizing them, reading newspapers and magazines and highlighting the content, reading comprehensions, reading reviews, reading and interpreting the content, identifying the thesis-evidence-evaluation, reading novels (Abridged version).

### UNIT IV: Writing Skills

Introduction and Importance of Writing

Writing a Sentence

Writing a Paragraph-Topic Sentence, illustration

Characteristics of Writing-Clarity-Accuracy-Correctness-Descriptiveness

Language-Appropriateness-Conciseness-Flow

Business Writing-Basic principles of Business Communication

Letter writing-Thank you and follow-up letter, complaint letter, inquiry letter, invitation letter, letter to the editor

Writing memo, notice, agenda and minutes of the meeting

Report writing

Interpretation of data (flow charts, figures and pictures)

Essay and Article Writing

## Poster Making

*Activity-* Writing a paragraph, Writing different kinds of letters, framing notices and memos and agendas, jotting down minutes of the meeting, reporting an event or the work done, interpreting various pictures, figures and data.

## UNIT V: Basic Grammar

Tense and Articles

Prepositions

Direct and Indirect Speech

Active and Passive Voice

Course category	Course code	Course Name	L	T	P	C
C	BOT1812	Microbiology and Phycology	4	0	0	4

## UNIT I: Microbes

Bacteria-Discovery, general characteristics and cell structure; Types-archaeobacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Microbial growth, nutrition and metabolism; Reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance of bacteria with reference to their role in agriculture and industry (fermentation and medicine). Viruses: Discovery, General characteristics, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of plant diseases.

## UNIT II: Algae

General characteristics; Classification (system of Fritsch); Distribution; Range of thallus organization; Cell structure and components; Cell wall, pigments, reserve food, flagella; methods of reproduction; criteria; Evolutionary classification of Lee (only up to groups).

## UNIT III: Cyanophyta and Xanthophyta

Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and life-cycle of *Nostoc* and *Vaucheria*.

## UNIT IV: Chlorophyta and Charophyta

General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Chlamydomonas*, *Volvox*, *Oedogonium*, *Coleochaete*, *Chara*. Evolutionary significance of *Prochloron*.

## UNIT V: Phaeophyta and Rhodophyta

Characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Ectocarpus*, *Fucus* and *Polysiphonia*.

## Text Books

1. Kumar, H.D. (1999). *Introductory Phycology*, 2<sup>nd</sup> edition. Affiliated East-West Press Pvt. Ltd. Delhi.
2. Dubey, R.C. and Maheshwari, D.K. (2009). *A Text Book of Microbiology*, 1<sup>st</sup> Edition. S. Chand Publication.
3. Mitra, D., Guha, J. and Chowdhury, S.K. *Studies in Botany: Volume I*. Moulik Library.
4. Gangulee, H.C. and Kar, A.K. (1989). *College Botany: Volume II*: 3<sup>rd</sup> Reprint 2010, New Central Book Agency (P) Limited.
5. Banerjee, A.K. and Banerjee, N. (2008). *Fundamentals of Microbiology & Immunology*. New Central Book Agency (P) Limited.

## Reference Books

1. Lee, R.E. (2008). *Phycology*, 4<sup>th</sup> edition. Cambridge University Press, Cambridge.
2. Black, J.G. and Black, J.L. (2015). *Microbiology: Principles and Explorations*, 9<sup>th</sup> Edition.

3. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. (2013) *Prescott's Microbiology*, 9<sup>th</sup> Edition. McGrawHill International.
4. Tortora, G.J., Funke, B.R. and Case, C.L. (2010). *Microbiology: An Introduction*, 10<sup>th</sup> edition, Pearson Benjamin Cummings, U.S.A.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V. and Jackson R.B. (2008). *Biology*, 8<sup>th</sup> edition. Pearson Benjamin Cummings, USA.
6. Pelczar, M.J. (2001). *Microbiology*, 5<sup>th</sup> edition, Tata McGraw-Hill Co, New Delhi.

Course category	Course code	Course Name	L	T	P	C
C	BOT1813	Plant Morphology and Plant Systematics	4	0	0	4

### UNIT I: Seed Plants and Angiosperm Morphology

Leaf: Morphology and phyllotaxy; Flower: Type and structure. Morphology of stamen and carpel; Pollination, Double fertilization; Inflorescence; Types and examples. Fruits and seeds: General concepts, type and dispersal. Seed Plants: Characteristics of seed plants with fruits (Angiosperm) and without fruits (Gymnosperms). Angiosperm: Origin and evolution. Some examples of primitive angiosperms.

### UNIT II: Significance of Plant Systematics

Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry and molecular data. Field inventory; Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Keys: Single access and Multi-access. Taxonomic hierarchy: Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary). Botanical nomenclature: Principles and rules (ICN); Ranks and names; Typification, author citation, valid publication, rejection of names, principle of priority and its limitations; Names of hybrids.

### UNIT III: Systems of Classification

Major contributions of Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan and Cronquist; Classification systems of Bentham and Hooker (upto series) and Engler and Prantl (upto series); Brief reference of Angiosperm Phylogeny Group (APG III) classification.

### UNIT IV: Biometrics, Numerical Taxonomy, Cladistics

Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).

### UNIT V: Phylogeny of Angiosperms

Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms; Co-evolution of angiosperms and animals; Methods of illustrating evolutionary relationship (phylogenetic tree, cladogram).

### Text Books

1. Sharan, S. (2011). *Plant Morphology*.
2. Singh, B.D. *Concept in Plant Morphology*, Anmol Publication (P) Limited.

### Reference Books

1. Singh (2012). *Plant Systematics: Theory and Practice*, 3<sup>rd</sup> edition, Oxford & IBH Pvt. Ltd., New Delhi.
2. Jeffrey, C. (1982). *An Introduction to Plant Taxonomy*. Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A. and Stevens, P.F. (2002). *Plant Systematics-A Phylogenetic Approach*, 2<sup>nd</sup> edition, Sinauer Associates Inc., U.S.A.
4. Radford, A.E. (1986). *Fundamentals of Plant Systematics*. Harper and Row, New York.

Course category	Course code	Course Name	L	T	P	C
GE	ZOLA1831	Animal Diversity	3	0	0	3

### UNIT I: Protista, Porifera, Radiata, Aceolomates, Pseudocoelomates

General characters of Protozoa; Life cycle of *Plasmodium*

General characters and canal system in Porifera

General characters of Cnidarians and polymorphism

General characters of Helminthes; Life cycle of *Taeniasolium*

General characters of Nemethehelminthes; Parasitic adaptations

### UNIT II: Coelomate Protostomes, Arthropoda, Mollusca, Coelomate, Deuterostomes

General characters of Annelida; Metamerism

General characters. Social life in insects.

General characters of mollusca; Pearl Formation

General characters of Echinodermata, Water Vascular system in Starfish.

### UNIT III: Protochordata

Salient features

### UNIT IV: Diversity of Chordates

Osmoregulation, Migration of Fishes

General characters, Adaptations for terrestrial life, parental care in Amphibia.

Amniotes; Origin of reptiles. Terrestrial adaptations in reptiles.

The origin of birds; Flight adaptations

### UNIT V: Mammalia

Early evolution of mammals; Primates; Dentition in mammals

### Text book

1. Jordan, E.L. and Verma, P.S. *Invertebrate Zoology*. New edition Edition, S. Chand Publications.
2. Jordan, E.L. and Verma P.S. *Chordate Zoology*. New edition Edition, S. Chand Publications.
3. Kotpal, R.L. *Modern Textbook of Zoology-Invertebrates*, Rastogi Publications.
4. Kotpal, R.L. *Modern Textbook of Zoology-Vertebrates*, Rastogi Publications.

### Reference book

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.I.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1814	Microbiology and Phycology Practical	0	0	4	2

1. Microscopy- handling of microscope, study on the functions of different parts of microscope.
2. T-Phage and TMV- Electron micrographs pictures only.
3. Lytic and Lysogenic cycle- Line drawing only.
4. Types of Bacteria to be observed from permanent slides and photographs.
5. Study of bacterial binary fission, endospore formation, conjugation, root nodule by electron micrographs photograph.
6. Gram staining technique.
7. Endospore staining with malachite green using (endospores taken from soil bacteria).

8. Study of vegetative and reproductive structures and temporary slide preparation of fresh algal specimens of *Nostoc*, *Chlamydomonas*, *Volvox*, *Oedogonium*, *Coleochaete*, *Chara*, *Vaucheria*, *Ectocarpus*, *Fucus*, *Polysiphonia* and *Prochloron*. Study form permanent slide.

### Practical Text Books

1. [Santra](#), S.C., Chatterjee, T.P. and [Das, A.P. \(2010\)](#). *College Botany Practical, Volume I*. New Central Book Agency (P) Limited.
2. [Santra](#), S.C., Chatterjee, T.P. and [Das, A.P. \(2010\)](#). *College Botany Practical: Volume II*. New Central Book Agency (P) Limited.
3. Santra, S.C. (2015). *Practical Botany-Volume II*. New Central Book Agency (P) Limited.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1815	Plant Morphology and Plant Systematics Practical	0	0	4	2

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham and Hooker's system of classification): Ranunculaceae, Brassicaceae, Myrtaceae, Umbelliferae, Asteraceae, Solanaceae, Lamiaceae, Euphorbiaceae, Liliaceae, Poaceae.
2. Field visit (local)-Subject to grant of funds from the university.
3. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in Central Herbarium room of University).

### Practical Books

1. [Singh G.](#) *Plant Systematics: Theory and Practice*. Publisher: Oxford and IBH-PUBS Company, New Delhi.
2. Sinha, R.K. (2013). *Practical-Taxonomy of Angiosperms*.
4. Gurtu, J.N. and Kapoor, R. (2010). *Advanced Experimental Chemistry*, 6<sup>th</sup> edition, S. Chand and Co.

Course category	Course code	Course Name	L	T	P	C
SEC	ZOLA1832	Animal Diversity Practical	0	0	4	2

1. Study of following specimens:

Non Chordates: *Euglena*, *Noctiluca*, *Paramecium*, *Sycon*, *Physalia*, *Tubipora*, *Metridium*, *Taenia*, *Ascaris*, *Nereis*, *Aphrodite*, *Leech*, *Peripatus*, *Limulus*, Hermit crab, *Daphnia*, Millipede, Centipede, Beetle, *Chiton*, *Dentalium*, *Octopus*, *Asterias*, and *Antedon*.

Chordates: *Balanoglossus*, *Amphioxus*, *Petromyzon*, *Pristis*, *Hippocampus*, *Labeo*, *Ichthyophis/Uraeotyphlus*, *Salamander*, *Rhacophorus Draco*, *Uromastix*, *Naja*, *Viper*, model of *Archaeopteryx*, any three common birds- (Crow, duck, Owl), Squirrel and Bat.

2. Study of following Permanent Slides: Cross section of *Sycon*, Sea anemone and *Ascaris* (male and female). T.S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva.
3. Temporary mounts of (a) Septal and pharyngeal nephridia of earthworm (b) Unstained mounts of Placoid, cycloid and ctenoid scales.
4. Dissections of (a) Digestive and nervous system of Cockroach (b) Urinogenital system of Rat.

### Practical Books

1. Verma, P.S. *A Manual of Practical Zoology: Chordates*, 10<sup>th</sup> Revised edition, Kindle Edition, S. Chand Publication.
2. Verma, P.S. *A Manual of Practical Zoology Invertebrates*, Kindle Edition, S. Chand Publication.

# **SEMESTER-II**

Course category	Course code	Course Name	L	T	P	C
AECC	LAE1821	English-II (Communication Skill)	2	1	0	3

### **UNIT I: Understanding Communication**

Introduction to Communication

Definition

Communication process

Methods of Communication-Internal and External communication

Networks of communication-Vertical horizontal- diagonal

Barriers of Communication-Linguistic, Psychological, Interpersonal, cultural, physical and organizational.

(R.C. Sharma and Krishna Mohan, *Business Correspondence*, pages 34-43)

### **UNIT II: Technology-based Communication Aids**

Telephone and voicemails

Facsimile Machines

Internet and computers

Emails

Conferencing

Instant Messaging

Groupware

NETTIQUETTE

Positive and Negative Impact of Technology enabled communication

Effectiveness in Technology based communication

### **UNIT III: Verbal and Non-Verbal Communication**

*Verbal Communication*

Conversation-importance-essentials-conversation management-non-verbal cues in conversation-Oral

Presentation Skills-Technical aids in Visual Communication

(Shirley Taylor, V. Chandra, *Communication for Business—A practical Approach*, 4<sup>th</sup> edition, page no. 378-397)

Team Presentation

*Non-verbal Communication*

Definition and Significance

Significance of Non-verbal Signals in organizations

Types of Non-verbal communication- Kinesics- Paralinguistic- Proxemics and Chronemics

### **UNIT IV: Interviews**

Introduction- Objectives of Interviews

Types of interviews

Job Interviews-cover Letter-Resume Writing-Preparation for Interview-Interviewing Process-Mock Interview

Medium of Interview-Telephonic interview-web interview

(Meenakshi Raman, Sangeeta Sharma, *Technical Communication-Principles and practices*, pg. no 180-203).

### **UNIT V: Cross Cultural Communication**

Introduction

Concept of Cross-Cultural Communication

Ethnocentrism

Cultural Variables and Communication Sensitivity

Variables of National Culture

Cross- Cultural Communication Strategies  
 Potential Hot Spots in Cross-Cultural Communication  
 Cross-Cultural Communication Skills-Basic Tips

Course category	Course code	Course Name	L	T	P	C
C	BOT1822	Mycology and Phytopathology	4	0	0	4

### UNIT I: General Account of Fungi

Definition, General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification; Chytridiomycetes: General account; Zygomycota: General characteristics; Ecology; Thallus organisation; Life cycle with reference to *Rhizopus*; Ascomycota: General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle, Heterokaryosis and parasexuality; life cycle and classification with reference to *Saccharomyces*, *Aspergillus*, *Penicillium*, *Alternaria*, *Neurospora* and *Peziza*; Basidiomycota: General characteristics; Ecology; Life cycle and Classification with reference to black stem rust on wheat *Puccinia* (Physiological Specialization), loose and covered smut (symptoms only), *Agaricus*; Bioluminescence, Fairy Rings and Mushroom Cultivation.

### UNIT II: Allied Fungi

General characteristics; Status of Slime molds, Classification; Occurrence; Types of plasmodia; Types of fruiting bodies.: **Oomycota**: General characteristic; Ecology; Life cycle and classification with reference to *Phytophthora*, *Albugo*.

### UNIT III: Symbiotic Associations

Lichen-Occurrence; General characteristics; Growth forms and range of thallus organization; Nature of associations of algal and fungal partners; Reproduction. Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance.

### UNIT IV: Applied Mycology

Role of fungi in biotechnology, Application in food industry (Flavour and texture, Fermentation, Baking, Organic acids, Enzymes, Mycoproteins); Secondary metabolites (Pharmaceutical preparations); Agriculture (Biofertilizers); Mycotoxins; Biological control (Mycofungicides, Mycoherbicides, Mycoinsecticides, Myconematicides); Medical mycology.

### UNIT V: Phytopathology

Terms and concepts; General symptoms; Geographical distribution of diseases; etiology; symptomology; Host-Pathogen relationships; disease cycle and environmental relation; prevention and control of plant diseases, and role of quarantine. Bacterial Diseases-Citrus canker and angular leaf spot disease of Cotton. Viral Diseases-Tobacco Mosaic viruses, vein clearing. Fungal Diseases-Early blight of potato, Black stem rust of wheat, white rust of crucifers.

### Text Books

1. Aneja, K.R. (2015). *An Introduction to Mycology*, 2<sup>nd</sup> edition, New Age International (P) Limited.
2. Saxena, S. (2012). *Textbook of Mycology*, 5<sup>th</sup> edition, Sonali Publications.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). *Introductory Mycology*, 4<sup>th</sup> edition, John Wiley & Sons (Asia) Singapore.
4. Sethi, I.K. and Walia, S.K. (2011). *Text book of Fungi and Their Allies*, Macmillan Publishers India Ltd.
5. Sharma, P.D. (2011). *Plant Pathology*, Rastogi Publication, Meerut, India.

## Reference Books

1. Agrios, G.N. (2005). *Plant Pathology*, 5<sup>th</sup> edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). *Introductory Mycology*, 4<sup>th</sup> edition, John Wiley & Sons (Asia) Singapore.
3. Webster, J. and Weber, R. (2007). *Introduction to Fungi*, 3<sup>rd</sup> edition, Cambridge University Press, Cambridge.

Course category	Course code	Course Name	L	T	P	C
C	BOT1823	Archegoniate and Palaeobotany	4	0	0	4

## UNIT I: Introduction

Unifying features of archegoniates; Transition to land habit; Alternation of generations.

## UNIT II: Bryophytes

General characteristics; Adaptations to land habit; Classification; Range of thallus organization. Classification (up to family). *Riccia*, *Marchantia*, *Pellia*, *Porella*, *Anthoceros*, *Sphagnum* and *Funaria*; Reproduction and evolutionary trends in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* (developmental stages not included). Ecological and economic importance of bryophytes with special reference to *Sphagnum*.

## UNIT III: Pteridophytes

General characteristics, classification, early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Psilotum*, *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included). Apogamy and apospory, heterospory and seed habit, telome theory, stelar evolution. Ecological and economic importance.

## UNITIV: Gymnosperms

General characteristics, classification (up to family), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (Developmental details not to be included). Ecological and economic importance.

## UNIT V: Palaeobotany

Contributions of Birbal Sahni in Indian Palaeobotany. Introduction, importance of Paleobotany. Definition of fossil, process of fossilization, types of fossils on the basis of their preservation; concept of Form Genus, conditions for fossilization. Origin of life, Geologic Time Scale, major events of plant life through geologic time.

## Text Books

1. Rashid, A. (2016). *An Introduction to Archigoniate Plants*. Vikas Publishing.
2. Vashishta, P.C., Sinha, A.K. and Kumar, A. (2010). *Pteridophyta*, S. Chand Publication, Delhi, India.
3. Mitra, D., Guha, J. and Chowdhury, S.K. *Studies in Botany: Volume I*. Moulik Library.
4. Bhatnagar, S.P. and Moitra, A. (1996). *Gymnosperms*. New Age International (P) Ltd Publishers, New Delhi, India.

## Reference Book

1. Shaw, A.J. and Goffinet, B. (2000). *Bryophyte Biology*, Cambridge University Press.
2. [Santra, S.C.](#), Chatterjee, T.P. and [Das, A.P. \(2010\)](#). *College Botany Practical, Volume I*. New Central Book Agency (P) Limited.
3. Stewart, W.N. and Rathwell, G.W. (1993). *Paleobotany and the Evolution of Plants*. Cambridge University Press.

4. Taylor Thomas N., Taylor E.L. and Michael, K. (2009). *Palaeobotany-The Biology and Evolution of Fossil Plants*. Academic Press, Elsevier.

Course category	Course code	Course Name	L	T	P	C
GE	ZOLA1841	Aquatic Biology	3	0	0	3

### UNIT I: Aquatic Biomes

Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.

### UNIT II: Freshwater Biology

Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous. Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes.

### UNIT III: Marine Biology

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.

### UNIT IV: Management of Aquatic Resources

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, management and conservation (legislations), Sewage treatment, Water quality assessment-BOD and COD.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1824	Mycology and Phytopathology Practical	0	0	4	2

1. *Rhizopus*, *Aspergillus* and *Penicillium*- study of asexual stage from temporary mounts and sexual structures through permanent slides.
  2. *Peziza*: sectioning through ascocarp and preparation of temporary mounts.
  3. *Alternaria*: Specimens study from temporary mounts.
  4. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections and mounts of spores on wheat and permanent slides of both the hosts.
  5. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*.
  6. Study of phanero plasmodium and sporangia of *Stemonitis* from photograph.
  7. *Albugo*: Study of symptoms of plants infected with *Albugo*; asexual phase study through section and temporary mounts and sexual structures through permanent slides.
  8. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates (field collection). Study of thallus and reproductive structures (soredia and apothecium) through permanent slides.
- Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs).
9. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1825	Archegoniate Practical	0	0	4	2

1. *Riccia*-Morphology of thallus; *Marchantia*-Morphology of thallus, whole mount of rhizoids and Scales, vertical section of thallus through Gemma cup, whole mount of Gemmae (all temporary slides), vertical section of Antheridiophore, Archegoniophore, longitudinal section of Sporophyte (all permanent slides).

2. *Anthoceros*-Morphology of thallus, dissection of sporophyte (to show stomata, spores, pseudoelaters, columella) (temporary slide), vertical section of thallus (permanent slide).
  3. *Pellia*, *Porella*-Study through permanent slides; *Sphagnum*-Morphology of plant, whole mount of leaf (permanent slide only).
  4. *Funaria*-Morphology, whole mount of leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, longitudinal section of capsule and protonema.
  5. *Psilotum*-Study of specimen, transverse section of synangium (permanent slide).
  6. *Selaginella*-Morphology, whole mount of leaf with ligule, transverse section of stem, whole mount of strobilus, whole mount of microsporophyll and megasporophyll (temporary slides), longitudinal section of strobilus (permanent slide); *Equisetum*-Morphology, transverse section of internode, longitudinal section of strobilus, transverse section of strobilus, whole mount of sporangiophore, whole mount of spores (wet and dry) (temporary slide), transverse section of rhizome (permanent slide).
  7. *Pteris*-Morphology, transverse section of rachis, vertical section of sporophyll, whole mount of sporangium, whole mount of spores (temporary slides), transverse section of rhizome, whole mount of prothallus with sex organs and young sporophyte (permanent slide).
  8. *Cycas*-Morphology (coralloid roots, bulbil, leaf), whole mount of microsporophyll, transverse section of coralloid root, transverse section of rachis, vertical section of leaflet, vertical section of microsporophyll, whole mount of spores (temporary slides), longitudinal section of ovule, transverse section of root (permanent slide); *Pinus*-Morphology (long and dwarf shoots, whole mount of dwarf shoot, male and female cones), transverse section of Needle, transverse section of stem, longitudinal/transverse section of male cone, whole mount of microsporophyll, whole mount of Microspores (temporary slides), longitudinal section of female cone, tangential longitudinal section and radial longitudinal sections stem (permanent slide).
  9. *Gnetum*-Morphology (stem, male and female cones), transverse section of stem, vertical section of ovule (permanent slide).
- Botanical Excursion-Special class on field tour, Survey, collection of plants, precautionary measures (Practical perspectives).

### Practical Text Book

[Santra, S.C.](#), [Chatterjee, T.P.](#) and [Das, A.P. \(2010\)](#). *College Botany Practical: Volume II*. New Central Book Agency (P) Limited.

Course category	Course code	Course Name	L	T	P	C
SEC	ZOLA1842	Aquatic Biology Practical	0	0	4	2

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in a lake ecosystem.
3. Determine the amount of Turbidity/transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates and bicarbonates) in water collected from a nearby lake/water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/Marine bio-reserve/Fisheries Institutes.

# **SEMESTER-III**

Course category	Course code	Course Name	L	T	P	C
C	BOT1831	Plant Anatomy	3	0	0	3

### UNIT I: Scope of Plant Anatomy

Applications in systematics, forensics and pharmacognosy.

### UNIT II: Structure and Development of Plant Body

Internal organization of plant body: The three tissue systems, types of cells and tissues. Development of plant body: Polarity, Cytodifferentiation and organogenesis during embryogenic development. Classification of tissues; Simple and complex tissues (no phylogeny); cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Wall ingrowths and transfer cells, adcrustation and incrustation, Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

### UNIT III: Meristems and Anatomical Structures

Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory, continuing meristematic residue, cytohistological zonation); Types of vascular bundles; Structure of dicot and monocot stem. Origin, development, arrangement and diversity in size and shape of leaves; Structure of dicot and monocot leaf, Kranz anatomy. Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

### UNIT IV: Vascular Cambium and Wood

Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Axially and radially oriented elements; Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Dendrochronology. Development and composition of periderm, rhytidome and lenticels.

### UNIT V: Adaptive and Protective Systems

Epidermal tissue system, cuticle, epicuticular waxes, trichomes (unicellular and multicellular, glandular and non-glandular, two examples of each), stomata (classification); Adcrustation and incrustation; Anatomical adaptations of xerophytes and hydrophytes.

### Text Books

1. Pandey, B.P. (2012). *Plant Anatomy*. S. Chand Publication Pvt. Ltd.
2. Mitra, D., Guha, J. and Chowdhury, S.K. *Studies in Botany: Volume I*. Moulik Library.

### Reference Books

1. Mauseth, J.D. (1988). *Plant Anatomy*. The Benjamin/Cummings Publisher, USA.
2. Cutler, D.F., Stevenson, D.W. and Botha, C.E.J. (2008). *Plant Anatomy: An Applied Approach*. John Wiley & Sons. Blackwell Publishing.

Course category	Course code	Course Name	L	T	P	C
C	BOT1832	Economic Botany	3	0	0	3

### UNIT I: Origin of Cultivated Plants

Concept of centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

## **UNIT II: Cereals, Legumes, Sugars and Starches**

Wheat and Rice (origin, morphology, processing and uses), brief account of millets. General account of legumes, its importance to man and ecosystem. Sugars and Starches: Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato-morphology, propagation and uses.

## **UNIT III: Spices**

Listing of important spices, their family and part used, economic importance with special reference to fennel, saffron, clove and black pepper.

## **UNIT IV: Oils, Fats and essential oils**

General description, classification, extraction, their uses and health implications groundnut, coconut, linseed and *Brassica* and Coconut (Botanical name, family and uses). Essential Oils: General account, extraction methods, comparison with fatty oils and their uses.

## **UNIT V: Other Economically Important Plants**

Beverages: Tea, Coffee (morphology, processing and uses). Natural Rubber: Para-rubber: tapping, processing and uses. Drug-yielding plants: Therapeutic and habit-forming drugs with special reference to *Cinchona*, *Digitalis*, *Papaver* and *Cannabis*. Tobacco: Tobacco (Morphology, processing, uses and health hazards). Timber plants: General account with special reference to teak and pine. Fibres: Classification based on the origin of fibres, Cotton and Jute (morphology, extraction and uses).

## **Text Books**

1. Kochhar, S.L. (2012). *Economic Botany in Tropics*, MacMillan & Co. New Delhi, India.
2. [Sambamurty](#), A.V.S.S. (2008). *A Textbook of Modern Economic Botany*, 1<sup>st</sup> Edition, CBS Publication.
3. [Umrani](#), R. (2009). *Basics of Economic Botany*, Anmol Publication.

## **Reference Book**

Wickens, G.E. (2001). *Economic Botany: Principles and Practices*. Kluwer Academic Publishers, The Netherlands.

Course category	Course code	Course Name	L	T	P	C
C	BOT1833	Plant Genetics	3	0	0	3

## **UNIT I: Extension of Mendelian Genetics**

Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Numericals; Polygenic inheritance.

## **UNIT II: Extrachromosomal Inheritance**

Chloroplast mutation: Variegation in Four o'clock plant; Mitochondrial mutations in yeast; Maternal effects-shell coiling in snail; Infective Heredity-Kappa particles in *Paramecium*.

## **UNIT III: Linkage, Crossing over and Chromosome mapping**

Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

#### UNIT IV: Variation in Chromosome Number and Structure

Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy. Gene Mutations and Fine Structure of Gene: Types of mutations; Molecular basis of Mutations; Mutagens-physical and chemical (Baseanalog, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method. Role of Transposons in mutation. DNA repair mechanisms. Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism; Structure of Phage T4, rII Locus.

#### UNIT V. Population and Evolutionary Genetics

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection mutation, genetic drift. Genetic variation and Speciation.

#### Text Books

1. Mahabal, R. (2010). *Fundamentals of Cytogenetics and Genetics*, 1<sup>st</sup> edition, PHI learning Pvt. Limited, New Delhi.
2. Mitra, D., Guha, J. and Chowdhury, S.K. *Studies in Botany* Volume I. Moulik Library.

#### Reference Books

1. Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*, 5<sup>th</sup> edition, John Wiley & Sons Inc., India
2. Gardner, E.J., Simmons, M.J. and Snustad, D.P. (1991). *Principles of Genetics*, 8<sup>th</sup> edition, John Wiley & sons, India.
3. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2009). *Concepts of Genetics*, 9<sup>th</sup> edition, Benjamin Cummings, U.S.A.
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B. and Doebley, J. (2010). *Introduction to Genetic Analysis*, 10<sup>th</sup> edition, W. H. Freeman and Co., U.S.A.

Course category	Course code	Course Name	L	T	P	C
GE	CHM1812	Structure and Bonding in Chemistry	4	0	0	4

#### UNIT I: Atomic Structure

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of  $\psi$  and  $\psi^2$ . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wavefunctions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. (14 Lectures)

#### UNIT II: Periodicity of Elements

*s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* & *p*-block.

- (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
- (b) Atomic radii (van der Waals)
- (c) Ionic and crystal radii.
- (d) Covalent radii (octahedral and tetrahedral)
- (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
- (f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio. (16 Lectures)

### UNITIII: Chemical Bonding

(i) *Ionic bond*: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) *Covalent bond*: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N<sub>2</sub>, O<sub>2</sub>, C<sub>2</sub>, B<sub>2</sub>, F<sub>2</sub>, CO, NO, and their ions; HCl, BeF<sub>2</sub>, CO<sub>2</sub>, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding ( $\sigma$  and  $\pi$  bond approach) and bond lengths.

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

(iii) *Metallic Bond*: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

(iv) *Weak Chemical Forces*: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment)

Effects of chemical force, melting and boiling points, solubility energetics of dissolution process. (26 Lectures)

### UNITIV: Oxidation-Reduction

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class. (4 Lectures)

### Text Books

1. Shriver, D.F., Atkins, P.W. and Langford, C.H. (2001). *Inorganic Chemistry*, 3<sup>rd</sup> edition, Oxford University Press, London.
2. Douglas, B., McDaniel, D. and Alexander, J. (1994). *Concepts and Models of Inorganic Chemistry*, 3<sup>rd</sup> edition, John Wiley.
3. Lee, J.D. (2008). *Concise Inorganic Chemistry*, 5<sup>th</sup> edition, Wiley.
4. Atkins, P.W and Paula, J. D. (2009). *Physical chemistry*, 9<sup>th</sup> Oxford University Press.

### Reference Books

1. Purcell, K.F and Kotz, J.C. (1976). *Inorganic Chemistry*, Saunders, Philadelphia.
2. Moeller, T. (1990). *Inorganic Chemistry: A Modern Introduction*, Wiley, New York.
3. Puri, B.R., Sharma, L.R. and Kalia, K.C. (1996). *Principles of Inorganic Chemistry*, Shoban Lal Nagin Chand and Co.
4. Huheey, J.E., Keiter, E.A. and Keiter, R.L. (1983). *Inorganic Chemistry*, 4<sup>th</sup> edition, Harper and Row, New York.
5. Day, M.C. and Selbin, J. (1962). *Theoretical Inorganic Chemistry*, ACS Publications.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1834	Ethnobotany	2	0	0	2

## UNIT I: Ethnobotany

Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of ethnobotany in the present context; Major and minor ethnic groups or Tribals of India, and their life styles. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses.

## UNIT II: Methodology of Ethnobotanical studies

a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.

## UNIT III: Role of Ethnobotany in Modern Medicine

Medico-ethnobotanical sources in India; Significance of the following plants in ethnobotanical practices (along with their habitat and morphology) a) *Azadiractha indica* b) *Ocimum sanctum* c) *Vitex negundo* d) *Gloriosa superba* e) *Tribulus terrestris* f) *Pongamia pinnata* g) *Cassia auriculata* h) *Indigofera tinctoria*.

## UNIT IV: Conservation of Plant Genetic Resources

Role of ethnobotany in modern medicine with special example *Rauwolfia serpentina*, *Trichopus zeylanicus*, *Artemisia*, *Withania*. Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).

## UNIT V: Ethnobotany and Legal Aspects

Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy, Intellectual Property Rights and Traditional Knowledge.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1835	Plant Anatomy Practical	0	0	4	2

1. Study of anatomical details of root, stem and leaves through permanent slides.
2. Study of the anomalous structures of stems of the following genera: *Bignonia*, *Dracaena*, *Boerhaavia* and *Strychnos*.
3. Xylem: Tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
4. Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
5. Microscopic identification of the followings: Primary structure of Sunflower and maize stem and gram and Canna root, Bulliform cells, stomatal types, lenticels, raphides (acicular and sphaeraphides), cystolith.
6. Maceration of wood elements of *Cucurbita* and *Pinus* stem and their microscopic examination.
7. Root: monocot, dicot, secondary growth.
8. Stem: monocot, dicot - primary and secondary growth; periderm; lenticels.
9. Leaf: isobilateral, dorsiventral, C<sub>4</sub> leaves (Kranz anatomy).
10. Adaptive Anatomy: xerophytes, hydrophytes.
11. Secretory tissues: cavities, lithocysts and laticifers.

## Practical Book

1. [Rajan](#), S.S. (2003). Practical Manual of Plant Anatomy and Embryology. Anmol Publication.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1836	Economic Botany Practical	0	0	4	2

1. Cereals: Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests) Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. Legumes: Soya bean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).

- Sugars and Starches: Sugarcane (habit sketch; cane juice- micro-chemical tests), Potato (habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).
- Spices: Black pepper, Fennel and Clove (habit and sections).
- Beverages: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).
- Oils and Fats: Coconut-T.S. nut, Mustard-plant specimen, seeds; tests for fats in crushed seeds.
- Essential oil-yielding plants: Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and, Eucalyptus (photographs).
- Rubber: specimen, photograph/model of tapping, samples of rubber products.
- Drug-yielding plants: Specimens of *Digitalis*, *Papaver* and *Cannabis*.
- Tobacco: specimen and products of Tobacco.
- Woods: *Tectona*, *Pinus*: Specimen, Section of young stem.
- Fibre-yielding plants: Cotton (specimen, whole mount of seed to show lint and fuzz; wholemount of fibre and test for cellulose), Jute (specimen, transverse section of stem, test for lignin on transverse section of stem and fibre).

### Practical Book

- Pandey, S.N and Chadha, A. (1993). *A Text Book of Botany: Plant Anatomy and Economic Botany*, Volume 3. Vikash Publishing House Pvt Ltd.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1837	Plant Genetics Practical	0	0	4	2

- Meiosis through temporary squash preparation.
- Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
- Chromosome mapping using point test cross data.
- Pedigree analysis for dominant and recessive autosomal and sex linked traits.
- Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
- Blood Typing: ABO groups & Rh factor.
- Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes.
- Photographs showing Translocation Ring, Laggards and Inversion Bridge.
- Study of human genetic traits: Sickle cell anemia, Xeroderma Pigmentosum, Albinism, red-green Colour blindness, Widow's peak, Rolling of tongue, Hitchhiker's thumb and Attached ear lobe.

### Reference Books

- Gardner, E.J., Simmons, M.J. and Snustad, D.P. (1991). *Principles of Genetics*, 8<sup>th</sup> edition, John Wiley & Sons, India.
- Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*, 5<sup>th</sup> edition, John Wiley & Sons Inc., India.
- Klug, W.S., Cummings, M.R. and Spencer, C.A. (2009). *Concepts of Genetics*, 9<sup>th</sup> edition, Benjamin Cummings, U.S.A.
- Griffiths, A.J.F., Wessler, S.R., Carroll, S.B. and Doebley, J. (2010). *Introduction to Genetic Analysis*, 10<sup>th</sup> edition, W. H. Freeman and Co., U.S.A.

Course category	Course code	Course Name	L	T	P	C
SEC	CHM1814	Inorganic Qualitative Analysis-I	0	0	4	2

### Semi micro qualitative analysis

Qualitative analysis of a mixture containing **two anions** and **two cations**.

Analysis of a mixture containing **two cations** and **two anions** of which one will be an interfering ion.

**Anions:** Carbonate, sulphate, chloride, bromide, acetate, nitrite, nitrate, borate, chromate, oxalate, tartrate, and phosphate.

**Cations:** Lead, bismuth, copper, cadmium, antimony, iron, zinc, cobalt, nickel, manganese, calcium, strontium, barium, & ammonium, silver, magnesium, mercury.

### **Reference Books**

1. Ramanujam, V.V. (1974). *Inorganic Semi Micro Qualitative Analysis*, 3<sup>rd</sup> edition, The National Publishing Company, Chennai.
2. Vogel's *Text Book of Inorganic Qualitative Analysis*, 4<sup>th</sup> edition (1974), ELBS, London.
3. Venkateswaran, V., Veerasamy, R. and Kulandaivelu, A.R. (1997). *Basic Principles of Practical Chemistry*, 2<sup>nd</sup> edition, S. Chand & Sons, New Delhi.

# **SEMESTER IV**

Course category	Course code	Course Name	L	T	P	C
C	BOT1841	Molecular Biology	3	0	0	3

### UNIT I: Nucleic Acids: Carriers of Genetic Information

Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey and Chase, Avery, McLeod and McCarty, Fraenkel-Conrat's experiment). The Structures of DNA and RNA/Genetic Material: DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; Organization of DNA-Prokaryotes, Viruses, Eukaryotes. RNA Structure; Organelle DNA-mitochondria and chloroplast DNA. The Nucleosome; Chromatin structure-Euchromatin, Heterochromatin-Constitutive and Facultative heterochromatin.

### UNIT II: Replication of DNA

Chemistry of DNA synthesis (Kornberg's discovery); General principles-bidirectional, semiconservative and semi discontinuous replication, RNA priming; Various models of DNA replication, including rolling circle,  $\theta$  (theta) mode of replication, replication of linear ds-DNA, replication of the 5' end of linear chromosome; Enzymes involved in DNA replication.

### UNIT III: Central Dogma and Genetic Code

Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering and salient features).

### UNIT IV: Transcription

Transcription in prokaryotes and eukaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli*. Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones; Gene silencing.

### UNIT V: Processing and Modification of RNA and Translation

Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes; RNA editing and mRNA transport. Translation: Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Post-translational modifications of proteins.

### Text Books

1. Malacinski, G.M. (2015). *Freifelder's Essentials of Molecular Biology*, 4<sup>th</sup> edition. Jones and Bartlett India Private Limited.
2. Powar, C.B. (2010). *Cell Biology*, Himalaya Publishing House.
3. Arumugam, N. (2014). *Molecular Biology*.

### Reference Books

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2007). *Molecular Biology of the Gene*, 6<sup>th</sup> edition, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A.
2. Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*, 5<sup>th</sup> edition, John Wiley and Sons Inc., U.S.A.

- Klug, W.S., Cummings, M.R. and Spencer, C.A. (2009). *Concepts of Genetics*, 9<sup>th</sup> edition Benjamin Cummings. U.S.A.
- Russell, P.J. (2010). *i-Genetics- A Molecular Approach*, 3<sup>rd</sup> edition, Benjamin Cummings, U.S.A.
- Griffiths, A.J.F., Wessler, S.R., Carroll, S.B. and Doebley, J. (2010). *Introduction to Genetic Analysis*, 10<sup>th</sup> edition, W. H. Freeman and Co., U.S.A.

Course category	Course code	Course Name	L	T	P	C
C	BOT1842	Plant Ecology and Phytogeography	3	0	0	3

### UNIT I: Introduction

Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.

### UNIT II: Environmental Components

Soil: Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development. Water: Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Water in soil; Water table. Light, temperature, wind and fire: Variations; adaptations of plants to their variation.

### UNIT III: Biotic Interactions

Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standing crop. Population ecology: Characteristics and Dynamics. Ecological Speciation. Plant communities: Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession-processes, types; climax concepts.

### UNIT IV: Ecosystems

Structure; Processes; Trophic organisation; Food chains and Food webs; Ecological pyramids. Functional aspects of ecosystem: Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

### UNIT V: Phytogeography

Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate and tundra); Phytogeographical division of India; Local Vegetation.

### Text Books

- Sharma, P.D. (2010). *Ecology and Environment*, 8<sup>th</sup> edition, Rastogi Publications, Meerut, India.
- Singh, J.S., Singh, S.P. and Gupta, S. (2006). *Ecology Environment and Resource Conservation*. Anamaya Publications, New Delhi, India.
- Kormondy, E.J. (1996). *Concepts of Ecology*, 4<sup>th</sup> edition, PHI Learning Pvt. Ltd., Delhi, India.

### Reference Books

- Odum, E.P. (2005). *Fundamentals of Ecology*, 5<sup>th</sup> edition. Cengage Learning India Pvt. Ltd., New Delhi.
- Singh, J.S., Singh, S.P. and Gupta, S. (2006). *Ecology Environment and Resource Conservation*. Anamaya Publications, New Delhi, India.
- Sharma, P.D. (2010). *Ecology and Environment*, 8<sup>th</sup> edition. Rastogi Publications, Meerut, India.
- Wilkinson, D.M. (2007). *Fundamental Processes in Ecology: An Earth Systems Approach*. Oxford University Press. U.S.A.
- Kormondy, E.J. (1996). *Concepts of Ecology*, 4<sup>th</sup> edition, PHI Learning Pvt. Ltd., Delhi, India.

Course category	Course code	Course Name	L	T	P	C
C	BOT1843	Biomolecules and Cell Biology	3	0	0	3

### UNIT I: Biomolecules

Types of chemical bonds; Structure and properties of water; pH and buffers. Nomenclature and classification of carbohydrates. Major classes of structural and storage lipids; Fatty acids structure and functions; Essential fatty acids; Triacylglycerols structure, functions and properties; Phosphoglycerides. Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins. Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

### UNIT II: Bioenergetics

Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as an energy currency molecule.

### UNIT III: Enzymes

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced-fit theory), Michaelis-Menten equation, enzyme inhibition and factors affecting enzyme activity.

### UNIT IV: The Plant Cell

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory). Chemistry, structure and function of Plant cell wall. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport- Passive, active and facilitated transport, endocytosis and exocytosis.

### UNIT V: Cell Organelles

Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament. Chloroplast, mitochondria and peroxisomes: structural organization; Function; Semiautonomous nature of mitochondria and chloroplast. Endoplasmic Reticulum-Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus-organization, protein glycosylation, protein sorting and export from Golgi apparatus; Lysosomes. **Cell Division:** Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, role of protein kinases.

### Text Books

1. Mali, N.S., Tembhurne, R.R., Shinde, S.S., Bhise, D.S. and Satpute, S.M. *Biomolecules and Cell Biology*.
2. Mitra, D., Guha, J. and Chowdhury, S.K. *Studies in Botany: Volume II*. Moulik Library.
3. Rastogi, S.C. (2005). *Cell Biology*. New Age International Publication.

### Reference Books

1. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. 5<sup>th</sup> edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
2. Karp, G. (2010). *Cell Biology*, 6<sup>th</sup> edition, John Wiley & Sons, U.S.A.
3. Nelson, D.L. and Cox, M.M. (2008). *Lehninger-Principles of Biochemistry*, 5<sup>th</sup> Edition, W.H. Freeman and Company.

4. Hardin, J., Becker, G. and Skliensmith, L.J. (2012). *Becker's World of the Cell*, 8<sup>th</sup> edition. Pearson Education Inc. U.S.A.

5. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2011). *Biochemistry*, W.H. Freeman and Company.

Course category	Course code	Course Name	L	T	P	C
GE	CHM1823	Basic Concepts of Organic Chemistry	4	0	0	4

### UNIT I: Basics of Organic Chemistry

*Organic Compounds:* Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

*Electronic Displacements:* Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. (6 Lectures)

### UNIT II: Stereochemistry

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis-trans and, syn-anti isomerism E/Z notations with C.I.P rules.

*Optical Isomerism:* Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations. (18 Lectures)

### UNIT III: Chemistry of Aliphatic Hydrocarbons

#### A. Carbon-Carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

#### B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1c<sub>b</sub> reactions. Saytzeff and Hofmann eliminations.

*Reactions of alkenes:* Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2- and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

*Reactions of alkynes:* Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

#### C. Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams. (24 Lectures)

### UNIT IV: Aromatic Hydrocarbons

*Aromaticity:* Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups. (12 Lectures)

## Text Books

1. Graham Solomons, T.W. (1996). *Organic Chemistry*, 6<sup>th</sup> edition, John Wiley and Sons, New York.
2. Wade, L.G. (2016). *Organic Chemistry*, 8<sup>th</sup> edition, Pearson.
3. Kalsi, P.S (2005). *Stereochemistry Conformation and Mechanism*; New Age International.
4. Eliel, E.L. and Wilen, S.H. (1994). *Stereochemistry of Organic Compounds*; Wiley: London.

## Reference Books

1. Pine, S.H.(1987). *Organic Chemistry*, 5<sup>th</sup> edition, McGraw Hill, New York.
2. Ege, S.N. (1998). *Organic Chemistry Structure and Reactivity*, 3<sup>rd</sup> edition, A.I.T.B.S., New Delhi.
3. Carey, F.A. (1999). *Organic Chemistry*, 3<sup>rd</sup> edition, Tata-McGraw Hill Publications, New Delhi.
4. Paula, B.Y. (2002). *Organic Chemistry*, 3<sup>rd</sup> edition, Pearson Education Inc., Singapore.
5. Clayden, J., Greeves, N. and Warren, S. (2014). *Organic Chemistry*, 2<sup>nd</sup> edition, Oxford.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1844	Herbal Technology	2	0	0	2

## UNIT I: Herbal Medicines

History and scope-definition of medical terms - role of medicinal plants in Siddha systems of medicine; cultivation-harvesting-processing-storage-marketing and utilization of medicinal plants.

## UNIT II: Pharmacognosy

Systematic position medicinal uses of following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka.

## UNIT III: Phytochemistry

Active principles and methods of their testing-identification and utilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendron phlomoides* (anti-rheumatic) and *Centella asiatica* (memory booster).

## UNIT IV: Analytical Pharmacognosy

Drug adulteration-types, methods of drug evaluation-Biological testing of herbal drugs-Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds).

## UNIT V: Micropropagation of Medicinal Plants

Medicinal plant banks micro propagation of important species (*Withania somnifera*, neem and tulsi- Herbal foods-future of pharmacognosy).

## Text Books

1. Kokate, C.K., Purohit, A.P. and Gokhle, S.B. (1999). *Pharmacognosy*, NiraliPrakashan.
2. Arber, A. (1999). *Herbal Plants and Drugs*. Mangal Deep Publications.

## Reference Books

1. Chopra, R.N., Nayar, S.L. and Chopra, I.C. (1956). *Glossary of Indian Medicinal Plants*. C.S.I.R, New Delhi.
2. Kanny, Lall, Dey and Raj Bahadur (1984). *The Indigenous Drugs of India*. International Book Distributors.
3. Arber, A. (1999). *Herbal Plants and Drugs*. Mangal Deep Publications.
4. Sivarajan, V.V. and Indra, B. (1994). *Ayurvedic Drugs and Their Plant Source*. Oxford IBH publishing Co.
5. Light, M. and Bryan, M. (1998). *Ayurveda and Aromatherapy*. Banarsidass, Delhi.
6. Green, A. (2000). *Principles of Ayurveda*, Thomsons, London.
7. Kokate, C.K., Purohit, A.P. and Gokhle, S.B. (1999). *Pharmacognosy*, NiraliPrakashan.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1845	Molecular Biology Practical	0	0	4	2

1. Preparation of LB medium and raising *E. coli*.
2. Isolation of genomic DNA from *E. coli*.
3. DNA isolation from cauliflower head.
4. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
5. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).
6. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
7. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel&Conrat's experiments)
8. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

### Practical Books

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2007). *Molecular Biology of the Gene*, Pearson Benjamin Cummings, 6<sup>th</sup> edition, CSHL Press, New York, U.S.A.
2. Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*, 5<sup>th</sup> edition, John Wiley and Sons Inc., U.S.A.
3. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2009). *Concepts of Genetics*, 9<sup>th</sup> edition. Benjamin Cummings. U.S.A.
4. Russell, P.J. (2010). *i-Genetics- A Molecular Approach*, 3<sup>rd</sup> edition, Benjamin Cummings, U.S.A.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B. and Doebley, J. (2010). *Introduction to Genetic Analysis*, 10<sup>th</sup> edition, W. H. Freeman and Co., U.S.A.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1846	Plant Ecology and Phytogeography Practical	0	0	4	2

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (pH meter, universal indicator and pH paper)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid titration method.
5. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
6. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
7. (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).  
(b) Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobancha*) Epiphytes, Predation (Insectivorous plants).
8. Determination of minimal quadrat size for the study of herbaceous vegetation in the University campus, by species area curve method (species to be listed).
9. Quantitative analysis of herbaceous vegetation in the University campus for frequency and comparison with Raunkiaer's frequency distribution law.
10. Quantitative analysis of herbaceous vegetation for density and abundance in the University campus.
11. Field visit to familiarize students with ecology of different sites.

## Reference Books

1. Odum, E.P. (2005). *Fundamentals of ecology*, 5<sup>th</sup> edition. Cengage Learning India Pvt. Ltd., New Delhi.
2. Singh, J.S., Singh, S.P. and Gupta, S. (2006). *Ecology Environment and Resource Conservation*. Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). *Ecology and Environment*, 8<sup>th</sup> edition, Rastogi Publications, Meerut, India.
4. Wilkinson, D.M. (2007). *Fundamental Processes in Ecology: An Earth Systems Approach*. Oxford University Press. U.S.A.
5. Kormondy, E.J. (1996). *Concepts of Ecology*, 4<sup>th</sup> edition, PHI Learning Pvt. Ltd., Delhi, India.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1847	Biomolecules and Cell Biology Practical	0	0	4	2

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of onion (*Allium cepa*).
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Measurement of cell size by the technique of micrometry.
5. Counting the cells per unit volume with the help of haemocytometer using bacterial cell.
6. Study of cell and its organelles with the help of electron micrographs photographs.
7. Study the phenomenon of plasmolysis and deplasmolysis.
8. Study the effect of organic solvent and temperature on membrane permeability.
9. Study of different stages of mitosis and meiosis from root tip and flower bud of *Allium cepa*.

## Practical Text Books

1. [Santra, S.C.](#), Chatterjee, T.P. and [Das, A.P. \(2010\)](#). *College Botany Practical, volume I*. New Central Book Agency (P) Limited.
2. Santra, S.C. (2015). *Practical Botany-Volume I*. New Central Book Agency (P) Limited.
3. Pandey, B.P. (2005). *Modern Practical Botany-Volume-I*, S. Chand Publication.

## Practical Reference Book

1. Wallis, C.J. (1966). *Practical Botany: For Advanced Level and Intermediate Students*. 5<sup>th</sup> Edition. Imprint: Butterworth-Heinemann.

Course category	Course code	Course Name	L	T	P	C
SEC	CHM1844	Laboratory Course on Methods and Synthesis in Organic Chemistry	0	0	4	2

1. Qualitative organic functional group analysis-tests for alcohols, phenols, amines, carbonyls, carboxylic acids and nitro compounds.
2. Preparation of organic compounds: Dibenzylidene acetone, Aromatic sulphonation, Nitration of acetanilide, Bromination of acetanilide (Green Synthesis)
3. Purification techniques: recrystallization, sublimation, distillation and steam distillation.
4. Thin layer chromatography, column chromatography & paper chromatography.
5. Preparation of soap - saponification.
6. Preparation of methyl orange and aspirin.
7. Specific rotation of chiral compounds (sugars) using a polarimeter.
8. Plotting of molecular orbitals of aromatic compounds and conjugated systems.

9. Conformational analysis-butane and substituted butanes, cyclohexane and di-substituted cyclohexane with stress on *cis* and *trans* isomerism.

10. Molecular modelling:

a) Stereo-chemistry: R-S configuration.

b) Modeling on hybridization, geometry of some organic & inorganic compounds.

### **Reference Books**

1. Pavia, D.L., Lampman, G.M. and Kriz, G.S. (1982). *Introduction to Organic Laboratory Techniques*, 2<sup>nd</sup> edition, Saunders College Publishing.
2. Singh, P.R., Gupta, D.S. and Bajpai, K.S. (1980). *Experimental Organic Chemistry: Volume I and II*, Tata McGraw Hill.
3. *Vogel's Text Book of Qualitative Organic Analysis* (1994), 5<sup>th</sup> edition, ELBS.
4. Athawale, V.D and Mathur, P. (2001). *Experimental Physical Chemistry*, New Age International Publishers.

# **SEMESTER-V**

Course category	Course code	Course Name	L	T	P	C
C	BOT1851	Reproductive Biology of Angiosperms	4	0	0	4

### UNIT I: Introduction

History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P.Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison) and its scope.

### UNIT II: Reproductive Development

Induction of flowering; flower as a modified determinate shoot. Flower development: genetic and molecular aspects. Anther and pollen biology: Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen wall proteins; Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia. Ovule: Structure; Types; Special structures—endothelium, obturator, aril, caruncle and hypostase; Female gametophyte-megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac.

### UNIT III: Pollination and Fertilization

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization. Self-incompatibility: Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self-incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.

### UNIT IV: Embryo, Endosperm and Seed

Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*. Seed structure, importance and dispersal mechanisms

### UNIT V: Polyembryony and Apomixis

Introduction; Classification; Causes and applications.

### Text Books

- Johri, B.M. and Srivastava, P.S. (2001). *Reproductive Biology of Plants*, 1<sup>st</sup> edition, Narosa Publishing House.
- Bhojwani, S.S. and Bhatnagar, S.P. (2011). *The Embryology of Angiosperms*, 5<sup>th</sup> edition, Vikas Publishing House, Delhi.

### Reference Books

- Shivanna, K.R. (2003). *Pollen Biology and Biotechnology*. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
- Raghavan, V. (2000). *Developmental Biology of Flowering plants*, Springer, Netherlands.
- Johri, B.M. (1984). *Embryology of Angiosperms*, Springer-Verlag, Netherlands.

Course category	Course code	Course Name	L	T	P	C
C	BOT1852	Plant Physiology	4	0	0	4

### UNIT I: Plant-water Relations

Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap-cohesion-tension theory. Transpiration and factors affecting transpiration, anti-transpirants, mechanism of stomatal movement.

## UNIT II: Mineral Nutrition and Nutrient Uptake by Plants

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents. Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

## UNIT III: Translocation in the Phloem

Experimental evidence in support of phloem as the site of sugar translocation. Pressure-Flow Model; Phloem loading and unloading; Source-sink relationship.

## UNIT IV: Plant Growth Regulators

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.

## UNIT V: Physiology of Flowering

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy. Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

### Text Books

1. Salisbury and Ross (2006). *Plant Physiology*, 1<sup>st</sup> edition, Cbs Publication.
2. Pandey, S.N. and Sinha, B.K. (2005). *Plant Physiology*, 4<sup>th</sup> edition, S. Chand Publication.

### Reference Books

- Hopkins, W.G. and Huner, A. (2008). *Introduction to Plant Physiology*, 4<sup>th</sup> edition. John Wiley and Sons, U.S.A.
2. Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A. (2015). *Plant Physiology and Development*, 6<sup>th</sup> edition Sinauer Associates Inc., USA.

Course category	Course code	Course Name	L	T	P	C
DSE	BOT1853	Horticultural Practices and Post-Harvest Technology	4	0	0	4

## UNIT I: Introduction Horticultural Plants

Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism. Ornamental plants:

Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plants [rose, marigold, gladiolus, carnations, orchids, poppies, gerberas, tuberose, sages, cacti and succulents (*Opuntia*, *Agave* and *Spurges*)] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail and areca palms, semul, coral tree).

## UNIT II: Fruit and Vegetable Crops and Flowering Plants

Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango,

chillies and cucurbits). Floriculture: Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows and exhibitions.

### **UNIT III: Horticultural Techniques**

Application of manure, fertilizers, nutrients and PGRs; Weed control; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Scope and limitations. Landscaping and garden design: Planning and layout (parks and avenues); gardening traditions- Ancient Indian, European, Mughal and Japanese Gardens; Urban forestry; policies and practices.

### **UNIT IV: Post-harvest Technology**

Importance of post-harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of preservation and processing; Methods of minimizing losses during storage and transportation; Food irradiation-advantages and disadvantages; food safety.

### **UNIT V: Disease Control and Management**

Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; Crop sanitation; IPM strategies (genetic, biological and chemical methods for pest control); Quarantine practices; Identification of common diseases and pests of ornamentals, fruits and vegetable crops. Horticultural Crops-conservation and Management: Documentation and conservation of germplasm; Role of micropropagation and tissue culture techniques; Varieties and cultivars of various horticultural crops; IPR issues; National, international and professional societies and sources of information on horticulture.

Course category	Course code	Course Name	L	T	P	C
DSE	BOT1854	Plant Breeding	4	0	0	4

### **UNIT I: Plant Breeding**

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.

### **UNIT II: Methods of Crop Improvement**

Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants-Procedure, advantages and limitations.

### **UNIT III: Quantitative Inheritance**

Concept, mechanism, examples of inheritance of Kernel colour in wheat, Skin colour in human beings. Monogenic vs polygenic Inheritance.

### **UNIT IV: Inbreeding Depression and Heterosis**

History, genetic basis of inbreeding depression and heterosis; Applications.

### **UNIT V: Crop Improvement and Breeding**

Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

### **Text Books**

1. Singh, B.D. (2005). *Plant Breeding: Principles and Methods*, 7<sup>th</sup> edition, Kalyani Publishers.
2. Chahal, G.S. and Gosal, S.S. (2002). *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Alpha Science International Limited.

### Reference Books

1. Singh, B.D. (2005). *Plant Breeding: Principles and Methods*, 7<sup>th</sup> edition, Kalyani Publishers.
2. Chaudhari, H.K. (1984). *Elementary Principles of Plant Breeding*, 2<sup>nd</sup> edition, Oxford-IBH.
3. Acquaaah, G. (2007). *Principles of Plant Genetics & Breeding*. Blackwell Publishing.

### UNIT II: Methods of Crop Improvement

Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants-Procedure, advantages and limitations.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1855	Reproductive Biology of Angiosperms Practical	0	0	4	2

1. Anther: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.
3. Pollen grains: Fresh and acetolyzed showing ornamentation and aperture, pseudomonads, polyads, pollinia (photographs, fresh material), ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test. germination: Calculation of percentage germination in different media using hanging drop method.
4. Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).
5. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.
6. Intra-ovarian pollination; Test tube pollination through photographs.
7. Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
8. Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1856	Plant Physiology Practical	0	0	4	2

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on Avena coleoptile elongation (IAA Bioassay).
8. To study the induction of amylase activity in germinating barley grains.
9. Demonstration experiments

- a) To demonstrate suction due to transpiration.
- b) Fruit ripening/Rooting from cuttings (Demonstration).
- c) Bolting experiment/Avenacoleptile bioassay (demonstration).

### Practical Reference Book

1. Bajracharya, D. (1999). *Experiments in Plant Physiology-A Laboratory Manual*. Narosa Publishing House, New Delhi.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1857	Horticultural Practices and Post-Harvest Technology Practical	0	0	4	2

1. Field trip: Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.
3. Nursery and field management techniques.
2. Preparation of different manures: Preparation of EM compost, green manure, vermin-compost.

### Practical Books

1. Kumar, M.K. (2016). *Practical Manual of Horticulture*, 1<sup>st</sup> edition, Bioech Publication.
2. Prasad, V.M. and Vikram, B. (2018). *Practical Manual on Fundamentals of Horticulture and Plant Propagation*, 1<sup>st</sup> edition, Write and Print Publications.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1858	Plant Breeding Practical	0	0	4	2

1. Study of germplasm.
2. Study of floral structure of self-pollinated and cross pollinated crops.
3. Emasculation and hybridization techniques in self and cross pollinated crops.
4. Artificial pollination in self-pollinated crop (any one crop).
5. Experiments on epistatic interactions and data analysis.
6. Study on probability and Chi-square test and heritability analysis.

### Practical Books

1. Singh, B.D. (2005). *Plant Breeding: Principles and Methods*, 7<sup>th</sup> edition, Kalyani Publishers.
2. Chahal, G.S. and Gosal, S.S. (2002). *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Alpha Science International Limited.
1. Singh, B.D. (2005). *Plant Breeding: Principles and Methods*, 7<sup>th</sup> edition, Kalyani Publishers.
2. Chaudhari, H.K. (1984). *Elementary Principles of Plant Breeding*, 2<sup>nd</sup> edition, Oxford-IBH.
3. Acquaah, G. (2007). *Principles of Plant Genetics & Breeding*. Blackwell Publishing.

# **SEMESTER-VI**

Course category	Course code	Course Name	L	T	P	C
C	BOT1861	Plant Metabolism	4	0	0	4

### UNIT I: Concept of Metabolism

Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).

### UNIT II: Carbon Assimilation

Historical background, photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO<sub>2</sub> reduction, photorespiration, C<sub>4</sub> pathways; Crassulacean acid metabolism; Factors affecting CO<sub>2</sub> reduction.

### UNIT III: Carbohydrate Metabolism and Lipid Metabolism

Synthesis and catabolism of sucrose and starch. Carbon Oxidation: Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, amphibolic role, anaplerotic reactions, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration. ATP-Synthesis: Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers. Lipid metabolism: Synthesis and breakdown of triglycerides,  $\beta$ -oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination,  $\alpha$  oxidation.

### UNIT IV: Nitrogen Metabolism

Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

### UNIT V: Mechanisms of Signal Transduction

Receptor-ligand interactions; Second messenger concept, Calcium calmodulin, MAP kinase cascade.

### Text Books

1. Mitra, D., Ghua, J. and Mitra, J.N. *Studies in Botany: Volume II*, Moulik Library, Calcutta.

### Reference Books

- Hopkins, W.G. and Huner, A. (2008). *Introduction to Plant Physiology*, 4<sup>th</sup> edition. John Wiley and Sons, U.S.A.
- Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A. (2015). *Plant Physiology and Development*, 6<sup>th</sup> edition, Sinauer Associates Inc., USA.
- Harborne, J.B. (1973). *Phytochemical Methods*. John Wiley & Sons, New York.

Course category	Course code	Course Name	L	T	P	C
C	BOT1862	Plant Biotechnology and Bioinformatics	4	0	0	4

### UNIT I: Plant Tissue Culture

Historical perspective; Composition of media; Nutrient and hormone requirements (role of vitamins and hormones); Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and

fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

## **UNIT II: Recombinant DNA technology**

Restriction Endonucleases (History, Types I-IV, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Tiplasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC). Gene Cloning:

Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR. Methods of gene transfer: Agrobacterium-mediated, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics-selectable marker and reporter genes (Luciferase, GUS, GFP).

## **UNIT III: Applications of Biotechnology**

Pest resistant (Bt-cotton); herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato, Golden rice); Improved horticultural varieties (Moon dust carnations); Role of transgenics in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Genetically Engineered Products-Human Growth Hormone; Humulin; Biosafety concerns.

## **UNIT IV: Bioinformatics**

Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics. Databases: Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System. Biological Sequence Databases: National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database. Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan (DDBJ): Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

## **UNIT V: Sequence Alignments**

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

**Molecular Phylogeny and Application of Bioinformatics:** Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

## **Text books**

1. Satyavathi, C.T, Bharadwaj, C., Srivastava, SK, Anand, G.R. and Prasad, S.V. S. (2014). *Biotechnology*, 2<sup>nd</sup> edition, New Vishal Publication.
2. Chawla, H.S. (2008). *Introduction to Plant Biotechnology*, 3<sup>rd</sup> edition, Oxibh Publication.
3. Umesha, S., (2005). *Plant Biotechnology*. The Energy and Resources Institute Publication.

## **Reference Books**

1. Bhojwani, S.S. and Razdan, M.K., (1996). *Plant Tissue Culture: Theory and Practice*. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R. and Pasternak, J.J. (2003). *Molecular Biotechnology-Principles and Applications of Recombinant DNA*. ASM Press, Washington.

- Bhojwani, S.S. and Bhatnagar, S.P. (2011). *The Embryology of Angiosperms*. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
- Snustad, D.P. and Simmons, M.J. (2010). *Principles of Genetics*. John Wiley and Sons, U.K. 5th edition.
- Stewart, C.N. Jr. (2008). *Plant Biotechnology & Genetics: Principles, Techniques and Applications*. John Wiley & Sons Inc. U.S.A.

Course category	Course code	Course Name	L	T	P	C
DSE	BOT1863	Industrial and Environmental Microbiology	3	0	2	4

### UNIT I: Scope of Microbes in Industry and Environment

Bioreactors/Fermenters and fermentation processes: Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

### UNIT II: Microbial Production of Industrial Products

Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin)

### UNIT III: Microbial Enzymes of Industrial Interest and Enzyme Immobilization

Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).

### UNIT IV: Microbes and Quality of Environment

Distribution of microbes in air; Isolation of microorganisms from soil, air and water. Microbial flora of water: Water pollution, role of microbes in sewage and domestic waste water treatment Systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.

### UNIT V: Microbes in Agriculture and Remediation of Contaminated soils

Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

### Reference Books

- Pelzar, M.J. Jr., Chen E.C. S. and Krieg, N.R. (2010). *Microbiology: An Application Based Approach*. Tata McGraw Hill Education Pvt. Ltd., Delhi.
- Tortora, G.J., Funke, B.R. and Case. C.L. (2007). *Microbiology*, 9<sup>th</sup>. Pearson Benjamin Cummings, edition San Francisco, U.S.A.

Course category	Course code	Course Name	L	T	P	C
DSE	BOT1864	Biostatistics	3	0	2	4

### UNIT I: Biostatistics

Definition-statistical methods-basic principles. Variables-measurements, functions, limitations and uses of statistics.

### UNIT II: Collection of Data Primary and Secondary

Types and methods of data collection procedures-merits and demerits. Classification-tabulation and presentation of data-sampling methods.

### UNIT III: Measures of Central Tendency

Mean, median, mode, geometric mean - merits and demerits. Measures of dispersion -range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co-efficient of variations.

### UNIT IV: Correlation

Types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression.

### UNIT V: Statistical Inference

Hypothesis-simple hypothesis-student 't' test-chi square test. **(Practical based):** 1. Calculation of mean, standard deviation and standard error. 2. Calculation of correlation coefficient values and finding out the probability. 3. Calculation of 'F' value and finding out the probability value for the F value.

### Reference Books

1. Dannel, W.W. (1987). *Biostatistic*, New York, John Wiley Sons.
2. Sundarrao, P.S.S and Richards, J. Christian. *An introduction to Biostatistics*, 3<sup>rd</sup> edition, Medical College, Vellore.
3. Selvin, S. (1991). *Statistical Analysis of Epidemiological data*, New York University Press.
4. Freedman, P. *The Principles of scientific research*, Pergamon Press, New York.
6. Campbell, R.C. (1998). *Statistics for Biologists*. Cambridge University Press.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1865	Plant Metabolism Practical	0	0	4	2

1. Chemical separation of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.
6. To demonstrate activity of Nitrate reductase in germinating leaves of different plant sources.
7. To study the activity of lipases in germinating oilseeds and demonstrate mobilization of lipids during germination.
8. Demonstration of fluorescence by isolated chlorophyll pigments.
9. Demonstration of absorption spectrum of photosynthetic pigments.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1866	Plant Biotechnology and Bioinformatics Practical	0	0	4	2

1. (a) Preparation of MS medium (b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.
2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis and artificial seeds through photographs.
3. Isolation of protoplasts.
4. Construction of restriction map of circular and linear DNA from the data provided.

5. Study of methods of gene transfer through photographs: Agrobacterium-mediated, direct genetransfer by electroporation, microinjection, microprojectile bombardment.
6. Study of steps of genetic engineering for production of Bt cotton, Golden rice, FlavrSavr tomato through photographs.
7. Isolation of plasmid DNA; Restriction digestion and gel electrophoresis of plasmid DNA.
8. Nucleic acid and protein databases; Sequence retrieval from databases.
9. Sequence alignment; Sequence homology and Gene annotation.
10. Construction of phylogenetic tree.

### Practical books

1. Giri, CC. and Giri, A. (2007). *Plant Biotechnology: Practical Manual*. I.K. International Publication.
2. *Plant Biotechnology Practical Manual*, SRM University.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1867	Industrial and Environmental Microbiology Practical	0	0	4	2

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Course category	Course code	Course Name	L	T	P	C
SEC	BOT1868	Biostatistics-Practical	0	0	4	2

1. Calculation of mean, standard deviation and standard error
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value

### Reference Books

1. Danniel, W.W. (1987). *Biostatistic*, New York, John Wiley Sons.
2. Sundarrao, P.S.S and Richards, J. Christian. *An introduction to Biostatistics*, 3<sup>rd</sup> edition, Medical College, Vellore.
3. Selvin, S. (1991). *Statistical Analysis of Epidemiological data*, New York University Press.
4. Freedman, P. *The Principles of scientific research*, Pergamon Press, New York.
6. Campbell, R.C. (1998). *Statistics for Biologists*. Cambridge University Press.