Sant Gadge Baba Amravati University, Amravati

Part A

Faculty: **Science and Technology**

Programme: **M.Sc. Biotechnology (NEP v.23)**

Programme Outcome: Upon completion of the M.Sc. Biotechnology programme, the candidate would be able to:

PO1. Create manpower and human resource capable of high order thinking and skills.

PO2. Produce manpower equipped with the knowledge, skills, attitudes, and values that are required to lead a productive life and participate in the country's development process.

PO3. Get trained in Biotechnology wherein engineering and technology principles could be used to probe biological questions or to develop technologies, devices and systems that require substantive expertise in Biology, Agriculture, Pharmaceutical, Industrial, as well as Clinical Research components.

PO4. Acquire knowledge, critical thinking skills and experience in conducting cutting edge research.

PO5. Develop as human capital for advanced scientific research and entrepreneurship.

PO6. Create, select and apply appropriate techniques, resources and modern tools to complex activities with an understanding of the limitations.

PO7. Demonstrate effective adaptability to new and emerging technologies.

PO8. Identify, formulate, review research literature, and analyze complex problems reaching substantiated and innovative conclusions.

PO9. Apply ethical principles and commit to professional ethics and responsibilities and norms of the standard practices.

PO10. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO11. Use the strengths of others to achieve common goals, and use interpersonal skills to coach and develop others

Programme Specific Outcomes (PSOs):

PSO1: Postgraduate students will be able to demonstrate and apply their knowledge of cell biology, biochemistry, microbiology and molecular biology to solve the problems related to the field of biotechnology.

PSO2: Postgraduate students will be able to demonstrate and apply the principles of bioprocess engineering in the design, analysis, optimization and simulation of bioprocess operations.

PSO3: Students will be able to gain fundamental knowledge in animal and plant biotechnology and their applications.

PSO4: Students will be equipped to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek?

PSO5: Student will be able to (a) Describe fundamental molecular principles of genetics; (b) Understand relationship between phenotype and genotype in human genetic traits; (c) Describe the basics of genetic mapping; (d) Understand how gene expression is regulated.

PSO6: Students will be able to (a) To elaborate concepts of biochemistry with easy to run experiments; (b) To familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biochemistry.

PSO7: Students will be able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.

PSO8: Students will be able to gain hands on experience in gene cloning, protein expression and purification. This experience would enable them to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research.

PSO9: Students will be able to identify the societal as well as market needs and set up their own Start-ups

PSO10: Students will be industry ready for Biopharmaceuticals, Vaccines, Agribiotech as well as IT driven Biotech Industries.

The Employability Potential of the Programme:

The Biotechnology sector in India is extremely innovative and on the rise. Next few years are bound to see exponential growth in this sector. India is among the top 12 Biotechnology destinations in the world and ranks third in the Asia-Pacific region. The industry comprises around 5000 biotech companies, with 4,240 being start-ups and 760 being core biotech companies, with the number of startups expected to touch 10,000 by 2024.

India has 665 FDA-approved plants; 44% of the global abbreviated new drug applications (ANDA) and more than 1400 manufacturing plants, which are compliant with WHO's requirements. It is regarded as one of the most significant sectors in enhancing India's global economic profile. India has been blessed with a highly talented pool of students in biotechnology.

The National Biotechnology Development Strategy (2015 – 2020) and National Education Policy (2020) envision a quality education system to produce graduates equipped with the knowledge, skills, attitude, and values that are required to lead a productive life and participate in the country's development process. Improving employability in this sector is heavily dependent on the overall curriculum of the educational programs. Since the last curriculum revision exercise was undertaken long ago, it is necessary to update the current curriculum.

The curriculum updating exercise not only brings the course curricula at par with the current development in Biotechnology sector but also seeks to create manpower and human resource capable of high order thinking and skills. Remodeled-Biotech Curriculum designed and proposed by the Department of Biotechnology, Govt. of India, and Choice Based Credit System approved by Sant Gadge Baba Amravati University are the basis for revising this curriculum.

The M.Sc. Program of Biotechnology at Sant Gadge Baba Amravati University, started in 1994, with the aim to train students in Biotechnology wherein engineering and technology principles could be used to probe questions related with biological system or to develop technologies, devices and systems that require substantive expertise in Biology, Agriculture, Pharmaceutical, Industrial, as well as Clinical Research components. The students in this program acquire knowledge, critical thinking skills and experience in conducting cutting edge

research. This program develops human capital for advanced scientific research and entrepreneurship.

The programme has been aligned with the National Biotechnology Development Strategy (2015-2020) put forth by Department of Biotechnology, Ministry of Science and Technology, Government of India, which provides a strategic roadmap for India's emergence as a global Biotechnology innovation and manufacturing hub, which also highlight importance of human resource development and need for nurturing tailor-made human capital for advanced strategic research and entrepreneurship.

Department of Biotechnology, Sant Gadge Baba Amravati University feels validated in the quality of education and experience provide to our students when a large number of our students are successfully placed in Pharmaceutical and Vaccine Industries such as Serum Institute of India Limited (SIIL) Pune, Biologicals E Hyderabad, Dr. Reddy's Hyderabad, Intas Biopharmaceuticals Pvt. Ltd. Ahmedabad, Zydus Cadilla Ahmedabad, Sun Pharma Baroda, Biocon Biologics Bangalore, Enzene Bioscience Ltd. Pune, Yashraj Biotech Mumbai, Hetero Pharmaceuticals Hyderabad, Lupin Biotech Pune, Diagnostics and Toxicological Industries such as MyLab Discovery Solutions Pvt Ltd. Pune, Intox Pvt Ltd. Pune etc.

Several students having aptitude in Molecular Biology and Computational Biology have successfully placed in knowledge-based industries such as PierianDx Pune, Cognizant Pune, TCS Pune to name a few.

Several students have ventured in Agro-biotech field and joined the industries such as Jay Biotech, Du Pont India Hyderabad, Mahyco Jalna etc.

Students with research aptitude have created their own niche around the globe in organizations like Agriculture Science Center North Lexington, KY, School of Life Science and Chemical Technology, Ngee Ann Polytechnic, Singapore, NMBU - Norwegian University of Life Sciences, NOVO cellular medicine institute Trinidad and Tobago, Institute of Molecular Biology (IMB) Mainz, Germany, Molecular Diagnostics at Roche Tucson, Arizona, United States, Institute für Genetik, Uni Köln, Germany, IKEA Group Country Sustainability Business Partner, Sydney, New South Wales, Australia, University of Pittsburgh, Pennsylvania, United States, Weill Cornell Medicine, New York, Translational Medicine at Kite Pharma, Santa Monica, California, etc.

During 2020-22 two alumni have successfully launched their Start-Up namely Sustainethics Private Limited and Amogha BioSolutions Private Limited.

Distribution of Credits across Two Years PG Degree Program

M.Sc. Biotechnology

Course/Credits	Semester I	Semester II	Semester III	Semester IV	Total Credits offered	Minimum credits required
DSC	9	9	9	9	36	56
DSC-Laboratory	5	5	5	5	20	
DSE	4	4	4	4	16	16
Research Methodology	4				4	4
On Job Training, Internship, Apprenticeship, Field Project Related to Biotechnology		4* Cumulative			4	2
Research Project			4	6	10	10
Optional Co-Curricular Courses					3	0
Open Elective /GIC/ Open Skill/MOOC					Optional	0
Total	22	22	22	24	93	88

Note:

1 Exit Option:
   - 1.a PG Diploma (Biological Sciences) after Three Year UG Degree upon completion of First two semester of M.Sc. Biotechnology (42-44 Credits) and on-the-job training/internship of 04 credits during summer break.
   - 1.b 2 Years-4Semester PG Degree (M.Sc. Biotechnology) (88 Credits) after Three Year UG Degree

2 Entry Option:
   - 2.a Three Year UG Degree with any Life Science Major subject or Chemistry Major with any Life Science Subject Minor subject for entry in to M.Sc. (Biotechnology) Semester I
   - 2.b Four Year UG Degree with any Life Science Major/Honors for entry into M.Sc. (Biotechnology) Semester II

3 # Students may complete their internship /Field work/ OJT in First or Second semester Of MSc (Biotechnology) according to their convenience, 04 credits for 120 Hours (02 credits- Minimum 60 Hours OJT/FP/Internship is mandatory)

4 Open Elective /GIC/ Open Skill/MOOC can be studied during semester I to IV

5 Project will be allotted in Semester III. Students should prepare project proposals by identifying the problem, work on review of literature and present status, address the possible solution, prepare a plan of work and defend the proposal.

6 Students should carry out the Project work during Semester IV, submit the project report and defend it.

Semester I

S.No.	Course/ Credits	Subject Code	Course Title	Hours/Week	Credit
1.	DSC	DSC-I.1 BT	Biochemistry	3	3
2.	DSC	DSC-II.1BT	Cell Biology	3	3
3.	DSC	DSC-III.1BT	Molecular Biology	3	3
4.	DSC-LC	DSC-LC-I.1BT	Biochemistry	6*	1.5
5.	DSC-LC	DSC-LC-II.1BT	Cell Biology	6*	1.5
6.	DSC-LC	DSC-LC-III.1BT	Molecular Biology	6@	2
7.	RM - I	RM-I.1BT	Research Methodology – I	2	2
8.	RM – II	RM-II.1BT	Research Methodology - II	2	2
8.	DSE-I	DSE-I.1BT	Elective A to H	2	2
9.	DSE-II	DSC-II.1BT	Elective A to H	2	2
10.	Seminars			1	-
11.	Internal Assessment/ Evaluation			1	-
				37	22

Note:

1. * Practical 6 Hours comprises 3 hours hands-on and 3 hours Preparation, incubation and observation.

2. @ Practical 6 Hours comprises 4 hours hands-on and 2 hours Preparation, incubation and observation.

3. Students may complete their internship /Field work/ OJT in First or Second semester Of MSc (Biotechnology) according to their convenience, 04 credits for 120 Hours (02 credits-Minimum 60 Hours OJT/FP/Internship is mandatory)

DSE (Discipline Specific Elective)
DSE-A Cancer Biology; DSE-B Molecular Basis of Drug Discovery; DSE-C Clinical Trial & Research; DSE-D Phyto secondary Metabolites and its Bioactivity; DSE-E Nanobiotechnology; DSE-F DNA Fingerprinting, DSE-G Vaccines; DSE-H IPR

Semester II

S.No.	Course/ Credits	Subject Code	Course Title	Hours/Week	Credit
1.	DSC	DSC-I.2BT	Microbiology	3	3
2.	DSC	DSC-II.2BT	Immunology	3	3
3.	DSC	DSC-III.2BT	Plant Biotechnology	3	3
4.	DSC-LC	DSC-I.2BT	Microbiology	6@	2
5.	DSC-LC	DSC-II.2BT	Immunology	6*	1.5
6.	DSC-LC	DSC-III.2BT	Plant Biotechnology	6*	1.5
9.	DSE	DSC-I.2BT	Elective A to H	2	2
10.	DSE	DSC-II.2BT	Elective A to H	2	2
12.	On Job Training, Internship, Apprenticeship, Field Project Related to Biotechnology			60 Hours / 120 hours	2/4
13.	Seminars			1	-
14.	Internal Assessment/ Evaluation			1	-
				37	22/24

Note:

1. * Practical 6Hours comprises 3 hours hands-on and 3 hours Preparation, incubation and observation.

2. @ Practical 6Hours comprises 4 hours hands-on and 2 hours Preparation, incubation and observation.

3. Students may complete their internship /Field work/ OJT in First or Second semester Of MSc (Biotechnology) according to their convenience, 04 credits for 120 Hours (02 credits-Minimum 60 Hours OJT/FP/Internship is mandatory)

DSE (Discipline Specific Elective)
DSE-A Cancer Biology; DSE-B Molecular Basis of Drug Discovery; DSE-C Clinical Trial & Research; DSE-D Phyto secondary Metabolites and its Bioactivity; DSE-E Nanobiotechnology; DSE-F DNA Fingerprinting, DSE-G Vaccines; DSE-H IPR

OEC (Optional) can be studied during semester I to IV

Semester III

S.No.	Course/ Credits	Subject Code	Course Title	Hours/Week	Credit
1.	DSC	DSC-I.3BT	Genetic Engineering	3	3
2.	DSC	DSC-II.3BT	Bioprocess Engineering & Technology	3	3
3.	DSC	DSC-III.3BT	Bioinformatics and Computation Biology	3	3
4.	DSC-LC	DSC-LC-I.3BT	Genetic Engineering	6@	2
5.	DSC-LC	DSC-LC-II.3BT	Bioprocess Engineering & Technology	6*	1.5
6.	DSC-LC	DSC-LC-III.3BT	Bioinformatics and Computation Biology	3	1.5
7.	DSE	DSE-I.3BT	Elective		2
8.	DSE	DSE-II.3BT	Elective		2
9.	RP	RP-3BT	Research Project	4	4
11.	Seminars			1	-
12.	Internal Assessment/ Evaluation			1	-
	Total				22

Note:

1. * Practical 6Hours comprises 3 hours hands-on and 3 hours Preparation, incubation and observation.

2. @ Practical 6Hours comprises 4 hours hands-on and 2 hours Preparation, incubation and observation.

DSE (Discipline Specific Elective)
DSE-A Cancer Biology; DSE-B Molecular Basis of Drug Discovery; DSE-C Clinical Trial & Research; DSE-D Phyto secondary Metabolites and its Bioactivity; DSE-E Nanobiotechnology; DSE-F DNA Fingerprinting, DSE-G Vaccines; DSE-H IPR

OEC (Optional) can be studied during semester I to IV

Semester IV

S.No.	Course/ Credits	Subject Code	Course Title	Hours/Week	Credit
1.	DSC	DSC-I.4BT	Animal Cell Science and Technology	3	3
2.	DSC	DSC-II.4BT	Industrial Biotechnology	3	3
3.	DSC	DSC-III.4BT	Environmental Biotechnology	3	3
4.	DSC-LC	DSC-LC-I.4BT	Animal Cell Science and Technology	6@	2
5.	DSC-LC	DSC-LC-II.4BT	Industrial Biotechnology	6*	1.5
6.	DSC-LC	DSC-LC-III.4BT	Environmental Biotechnology	6*	1.5
7.	DSE	DSE-I.4BT	Elective	2	2
8.	DSE	DSC-II.4BT	Elective	2	2
9.			Research Project	12	6
11.	Seminars			1	-
12.	Internal Assessment/ Evaluation			1	-
				45	24

Note:

1. * Practical 6Hours comprises 3 hours hands-on and 3 hours Preparation, incubation and observation.

2. @ Practical 6Hours comprises 4 hours hands-on and 2 hours Preparation, incubation and observation.

DSE (Discipline Specific Elective)
DSE-A Cancer Biology; DSE-B Molecular Basis of Drug Discovery; DSE-C Clinical Trial & Research; DSE-D Phyto secondary Metabolites and its Bioactivity; DSE-E Nanobiotechnology; DSE-F DNA Fingerprinting, DSE-G Vaccines; DSE-H IPR

OEC (Optional) can be studied during semester I to IV

Appendix A1

Sant Gadge Baba Amravati University, Amravati

FACULTY :

Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of Science (Biotechnology) following Three Years UG Programme wef 2023-24 (Two Years- Four Semesters Master's Degree Programme- NEPv23 with **Exit and Entry Option**

M. Sc. (Biotechnology) First Year Semester- I

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory +MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	Research Methodology – I	Th-Major	RM-I,1 BT	2			2	2		2	1.5	50				50	20		P
2	Research Methodology - II Classic Discoveries	Th-Major	RM-I.2	2			2	2		2	1.5	50				50	20		P
2	DSC-I.1 Biochemistry	Th-Major	DSC-I.1 BT	3			3	3		3	3	30	70			100	12	28	P
3	DSC-II.1 Cell Biology	Th-Major	DSC-II.1	3			3	3		3	3	30	70			100	12	28	P
	DSC-III.1 Molecular Biology	Th-Major	DSC.III.1 BT	3			3	3		3	3	30	70			100	12	28	P
4	DSE-I.1 /MOOC	Th-Major Elective	DSE-I.1BT	2			2	2		2	1.5	50				50	20		P
	DSE-II.1 /MOOC	Th-Major Elective	DSC-I!.1BT	2			2	2		2	1.5	50				50	20		P
5	DSC-I.1 Lab - Biochemistry and Analytical Techniques	Pr-Major	DSC-LC-I.1 BT			6*	6*		1.5	5	12			50	50	100	50		P

6	DSC-II.1 Lab Cell Biology	**Pr-Major**	DSC-LC-II-1 BT			**6***	**6***		**1.5**										
6	DSC-III.1 Lab Molecular Biology	**Pr-Major**	DSC-LC-III. 1BT			**6@**	**6@**		**2**										
8	# On Job Training, Internship/ Apprenticeship; Field projects **Related to Major @ during vacations cumulatively**	**Related to DSC**		**120 Hours cumulatively during vacations of Semester I and Semester II**						**4****									**P***
9	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**		**90 Hours Cumulatively From Sem I to Sem IV**															
	TOTAL									**23**						**600+50****			

L: Lecture, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note :

* Practical 6 Hours comprises 3 hours hands-on and 3 hours Preparation, incubation and observation. 2. @ Practical 6 Hours comprises 4 hours hands-on and 2 hours Preparation, incubation and observation.

On Job Training, Internship/ Apprenticeship; Field projects **Related to Major (During vacations of Semester I and Semester II) for duration of 120 hours mandatory to all the students, to be completed during vacations of Semester I and/or II. This will carry 4 Credits for learning of 120 hours. Its credits and grades will be reflected in Semester II credit grade report.**

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Sant Gadge Baba Amravati University, Amravati

FACULTY :

Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of Science (Biotechnology) following Three Years UG Programme wef 2023-24 (Two Years- Four Semesters Master's Degree Programme- NEPv23 with **Exit and Entry Option**

M. Sc. (Biotechnology) First Year- II [Level 6.0]

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory +MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	DSC-I.2 Microbiology	**Th-Major**	DSC-I. 2 BT	3			3	3		3	3	30	70			100	12	28	P
2	DSC-II.2 Immunology	**Th-Major**	DSC-II. 2 BT	3			3	3		3	3	30	70			100	12	28	P
3	DSC-III.2 Plant Biotechnology	**Th-Major**	DSC-III. 2 BT	3			3	3		3	3	30	70			100	12	28	P
4	DSE-I.2/MOOC	**Th-Major**	DSE-I. 2 BT	2			2	2		2	1.5	50				50	20		P
5	DSE-II.2/MOOC	**Th-Major**	DSE-II. 2 BT	2			2	2		2	1.5	50				50	20		P
5	DSC-I.2 Lab Microbiology	**Pr-Major**	DSC-LC-I. 2BT			6@	6		2	5	12			50	50	100	50		P
6	DSC-II.2 Lab Immunology	**Pr-Major**	DSC-			6*	6		1.5										

			LC-II. 2BT																
7	DSC-III.2 Lab Plant Biotechnology	**Pr-Major**	DSC-LC-III. 2BT			**6***	**6**		**1.5**										
9	# On Job Training, Internship/ Apprenticeship; Field projects **Related to Major @ during vacations cumulatively**	**Related to Major**		**120 Hours cumulatively during vacations of Semester I and Semester II**						**4* ***									**P***
8	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**		**90 Hours Cumulatively From Sem I to Sem IV**															
				Exit Option with a PG Diploma with 4 Credits On-the-job training/internship in the respective Major subject • **Student has to earn Total minimum 4 Credits cumulatively during Vacations of Semester I and Semester II from internship in order to exit after First Year with PG Diploma (42-44 Credits) after Three Year UG Degree**										
	TOTAL									**19+4***						**500**			

L: Lecture, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note :

* Practical 6 Hours comprises 3 hours hands-on and 3 hours Preparation, incubation and observation. 2. @ Practical 6 Hours comprises 4 hours hands-on and 2 hours Preparation, incubation and observation.

On Job Training, Internship/ Apprenticeship; Field projects **Related to Major (During vacations of Semester I and Semester II) for duration of 120 hours mandatory to all the students, to be completed during vacations of Semester I and/or II.**

This will carry 4 Credits for learning of 120 hours. Its credits and grades will be reflected in Semester II credit grade report.

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Sant Gadge Baba Amravati University Amravati

FACULTY :

Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of Science (Biotechnology) following Three Years UG Programme wef 2023-24 (Two Years- Four Semesters Master's Degree Programme- NEPv23 with **Exit and Entry Option**

M. Sc. (Biotechnology) Second Year Semester- III

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory+ MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	Contemporary Applied Technological Advancements in Research relevant/supportive to Major DSC-I.3 - Genetic Engineering	Th-Major	DSC-I. 3 BT	3			3	3		3	3	30	70			100	12	28	P
2	DSC-II.3 Bioprocess Engineering & Technology	Th-Major	DSC-II. 3 BT	3			3	3		3	3	30	70			100	12	28	P
3	DSC-III.3 Bioinformatics & Computational Biology	Th-Major	DSC-III. 3 BT	3			3	3		3	3	30	70			100	12	28	P
4	DSE-I.3 /MOOC	Th-Major Elective	DSE-I. 3 BT	2			2	2		2	1.5	50				50	20		P
5	DSE-II.3 /MOOC	Th-Major Elective	DSC-II. 3 BT	2			2	2		2	1.5	50				50	20		

																Minimum Passing Marks		
4	DSC-I.3 Lab/Pr Genetic Engineering	**Pr-Major**	DSC-LC-I. 3 BT			**6@**	**6@**		**2**									**P**
5	DSC-II.3 Lab Bioprocess Engineering & Technology	**Pr-Major**	DSC-LC-II. 3 BT			**6***	**6***		**1.5**	**5**	**12**			**50**	**50**	**100**	**50**	**P**
5	DSC-III.3 Lab Bioinformatics & Computational Biology	**Pr-Major**	DSC-LC-III. 3 BT			**6***	**6***		**1.5**									**P**
7	**Research Project Phase-I**	**Major**	RP-I. 3BT		**2**	**4**	**6**	**2**	**2**	**4**				**50**	**--**	**50**	**25**	**P**
8	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**		**90 Hours Cumulatively From Sem I to Sem IV**														
	TOTAL									**22**						**550**		

L: Lecture, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note:

* Practical 6 Hours comprises 3 hours hands-on and 3 hours Preparation, incubation and observation. 2. @ Practical 6 Hours comprises 4 hours hands-on and 2 hours Preparation, incubation and observation.

On Job Training, Internship/ Apprenticeship; Field projects **Related to Major (During vacations of Semester I and Semester II) for duration of 120 hours mandatory to all the students, to be completed during vacations of Semester I and/or II.**

Co-curricular Courses: In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Sant Gadge Baba Amravati University, Amravati

FACULTY :

Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of Science (Biotechnology) following Three Years UG Programme wef 2023-24 (Two Years- Four Semesters Master's Degree Programme- NEPv23 with **Exit and Entry Option**

M. Sc. (Biotechnology) Second Year Semester- IV [Level 6.5]

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory+ MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	DSC-I.4 Animal Cell Science & Technology	Th-Major	DSC-I. 4 BT	3			3	3		3	3	30	70			100	12	28	P
2	DSC-II.4 Industrial Biotechnology	Th-Major	DSC-II. 4 BT	3			3	3		3	3	30	70			100	12	28	P
3	DSC- III.4 Environmental Biotechnology	Th-Major	DSC-III. 4 BT	3			3	3		3	3	30	70			100	12	28	P
4	DSE-IV.1 /MOOC	Th-Major Elective	DSE-I. 4 BT	2			2	2		2	1.5	50				50	20		P
4	DSE-IV.2 /MOOC	Th-Major Elective	DSE-II. 4 BT	2			2	2		2	1.5	50				50	20		P

																	Minimum Passing Marks		
5	DSC-I.4 Lab Animal Cell Science & Technology	**Pr-Major**	DSC-LC-I. 4 BT			**2**	**6@**	**6@**	**2**										**P**
6	DSC-II.4 Lab Industrial Biotechnology	**Pr-Major**	DSC-LC-II. 4 BT			**2**	**6***	**6***	**1.5**	**5**	**12**			**50**	**50**	**100**	**50**		**P**
7	DSC-III.4 Lab Environmental Biotechnology	**Pr-Major**	DSC-LC-III. 4 BT			**2**	**6***	**6***	**1.5**										**P**
9	**Research Project Phase-II**	**Major**			**2**	**8**	**10**	**2**	**4**	**6**	**3**			**75**	**75**	**150**	**75**		**P**
10	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**		**90 Hours Cumulatively From Sem I to Sem IV**															
	TOTAL									**24**						**650**			

L: Lecture, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Table: Comprehensive Credits distribution amongst the type of Courses over Two Years (Four Semesters) PG Programme and Minimum Credits to be earned for PG Degree [Master in Science, Biotechnology]

Sr. No.	Type of Course		Total Credits Offered	Minimum Credits Required
1	**MAJOR**			
	i. DSC	**56**		**56**
	ii. DSE	**16**		**16**
	TOTAL		**72**	**72**
2	**Research Methodology and IPR (FSC/DSC: Major)**	**04**	**04**	**04**
2	On Job Training, Internship/ Apprenticeship; Field projects **Related to Major**	**04**	**04 for 120 Hours OJT/FP cum.**	**02 (Minimum 60 Hours OJT/FP is mandatory)**
3	**Research Project**	**10**	**10**	**10**
	OPTIONAL			
4	**Co-Curricular Courses (offline and/or online as applicable): Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts,** CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short		**Limited to Maximum 03 only (For 90 Hours of CC cumulatively)**	**00**

	term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.).			
	TOTAL			
	TOTAL		**93**	**88**

Table A: Comprehensive Credit Distribution for CC

S. N.	Activities (offline/online as applicable)	Credits at Levels						Letter Grade
		College	University State		Zone if exist		National International if exist	
1	Health and wellness, Yoga* Competitions *If a Course (online/offline) on Yoga is completed for 60 Hours, 2 credits will be awarded to the student (1 Credit = 30 Hours)	1	2	3	4	5	6	P (Pass)
2	Unnat Bharat Abhiyan [UBA]	1	2	3	4	5	6	P (Pass)
3	Sports and fitness activities (see separate **Table B**)	1	1 / 2	2 / 3	3 / 4	4 / 5	5 / 6	P (Pass)
4	Cultural activities, Fine/Applied/Visual/Performing Arts	1	2	3	4	5	6	P (Pass)

5	N.S.S. activities Camps	1	2	3	4	5	6	P (Pass)
6	Academic activities like Research Paper/Article/Poster presentations, Aavishkar, start-up, Hackathon, Quiz competitions, other curricular, co-curricular activities, students exchange programme etc. Research Paper/Article published	1 --	2 1	3 2	4 -	5 4	6 6	P (Pass) P (Pass)
7	Participation in Summer school/ Winter School / Short term course (not less than 30 hours 1 or 2 weeks duration) (not less than 60 hours 2 or 3 weeks duration) Scientific Surveys, Societal Surveys Field Visits, Study tours, Industrial Visits,	2 Credits 4 Credits 2 Credits 1 Credit						P (Pass) P (Pass) P (Pass) P (Pass)
8	NCC Activities	As given in **Table C**						

Table B: Credit Distribution for Sports and Fitness

Sr. No.	Particulars of Sports Status (Individual/ Team)	Credits	Letter Grade
1	College Level Participation	1	P (Pass)
2	University Level Participation	1	P (Pass)
3	University Level Rank 1, 2, 3	2	P (Pass)
4	State Level Participation	2	P (Pass)
5	State Level Rank 1, 2, 3	3	P (Pass)
6	Zonal Level Participation	3	P (Pass)
7	Zonal Level Rank 1, 2, 3	4	P (Pass)
8	National Level Participation	4	P (Pass)
9	National Level Rank 1, 2, 3	5	P (Pass)
10	International Level Participation	5	P (Pass)
11	International Level 1,2,3	6	P (Pass)

Table C: Credit Distribution for NCC activities

Sr. No.	Particulars of NCC Activities	Credits	Letter Grade
1	Participation in NCC activities	1	P (Pass)
2	'B' Certificate obtained	2	P (Pass)
3	'C' Certificate obtained	3	P (Pass)

4	State Level Participation	4	P (Pass)
5	National level Participation	5	P (Pass)
6	International Level Participation	6	P (Pass)

Syllabus Prescribed for TWO Year PG Programme
Programme: M.Sc. Biotechnology
Semester 1

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSC-I. 1 BT	**Biochemistry**	45

Cos

Students after completion of this course would be able to…..

1. Gain fundamental knowledge in biochemistry;
2. Demonstrate an understanding of fundamental biochemistry principles, including topics specific to chemistry and biochemistry.
3. Describe the chemistry of carbohydrates, lipids, proteins, amino acids and nucleic acids
4. Determine the molecular basis of various pathological conditions from the perspective of biochemical reactions.
5. Evaluate inter relationships of the pathways.
6. Judge how the energy sources are managed in an efficient manner.
7. Determine interdependence as well as intricate equilibrium of the pathways and their regulation.
8. Identify the classes of enzymes: exploit the mechanism of enzyme action and factors affecting action for product optimization.
9. Identify the commercial applications of enzymes

Unit	Content
Unit I	**Proteins and Amino Acids** **(8 periods)** Amino acids: Classification, properties, peptide bond, Proteins: Classification and function, evolution of protein structure, Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding. Introduction to molecular dynamic simulation. Protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, haemoglobin, chymotrypsin etc.; Anabolism and catabolism of Amino Acids.
Unit II	**Enzymes as Biocatalysts** **(8 periods)** International classification of enzymes. Enzyme Kinetics; Methods for measuring kinetic and rate constants of enzyme reactions and their magnitudes, Inhibitors. Isozymes Enzyme turnover: methods of its measurements and significance Allosteric enzymes, sigmoidal kinetics and their physiological significance. Symmetric and sequential modes for action of allosteric enzymes, negative and positive cooperativity, General mechanisms of enzyme regulation: Feedback inhibition and feed forward stimulation, enzyme repression, induction and degradation, control of enzyme activity by products and substrates; Co-enzymes and cofactors: Water soluble vitamins and their co-enzymes, metalloenzymes. Ribozymes and abzymes, Enzymes as druggable targets.
Unit III	**Carbohydrates** **(8 periods)** Carbohydrates: Glycolysis and TCA cycle; Glycogen breakdown and synthesis; Gluconeogenesis; Interconversion of hexoses and pentoses; Mitochondrial respiratory chain: Organization of carrier, proton gradient, iron sulphur proteins and cytochromes. Reversed electron transfer, respiratory controls andoxidative phosphorylation, uncouplers and inhibitors of energy transfer ATP: Synthetase complex, microsomal electron transport, partial reduction of oxygen, superoxides ATP cycle and cell bioenergetics.
Unit IV	**Lipids** **(7 periods)** Classification (simple, compound and derived lipids), Structure, function and their industrial significance, Oxidation of lipids; Biosynthesis of fatty acids; Triglycerides; Phospholipids; Glyco and Lipoproteins, Sterols, membrane lipids and lipid rafts, Circulating lipids with relevance to pathological changes.

Unit V	**Nucleic Acids:** **(7 periods)** Nucleotides, types and structures, their synthesis, de novo and salvage pathway, Regulation of pathways. Structure of DNA: A, B and Z forms.
Unit VI	**Techniques** **(7 periods)** Basic principles of protein purification; tools to characterize expressed proteins. Sequencing of proteins, Sanger-Edman, MS-ESI, MALDI-TOF, Physical and chemical methods for study of Protein-protein and protein-ligand interactions. and sequencing of nucleic acids. Dideoxy, automated, Nanopore, Ion torrent, Illumina,

Course Material/Learning Resources

1. Lehninger's Principles of Biochemistry (5th edition) by Nelson DL, and Cox MM, CBS Publications, 2008, ISBN: 9780230226999, 023022699X
2. Biochemistry by Stryer L. (5th edition) W.H. Freeman & Co., New York, USA, 2002, ISBN, 0716730510, 9780716730514
3. Fundamentals of Enzymology (3rd edition) by Price NC and Stevens L. Oxford University Press, NY, USA, 1999 .ISBN: 019850229X 0198502303
4. Principles of protein structure by Shulz and Schirmer, Springer Verlag, 1979, ISBN: 978-1-4612-6137-7
5. Fundamentals of Enzymology by Royer. 1982 ,ISBN 10: 0471046752 ISBN 13: 9780471046752
6. Harper's Biochemistry. (31st Edition) Ed. Murray RK, Granner DK, Mayes PA and Rodwell VW. Appleton and Lange, Stamford, Connecticut. McGraw Hill Companies, 2018, ISBN-10 : 1259837939 ISBN-13 : 978-1259837937
7. Textbook of Biochemistry with Clinical Correlations. (6th Edition) Ed. Thomas M. Devlin.Wiley-Liss Publishers. 2005, ISBN 0-471-67808-2.
8. Genes IX. by Lewin B. Pearson Education International, NJ, USA, 2007. ISBN : 0763740632, 978-0763740634
9. Fundamentals of Biochemistry. (5th Edition) Ed Voet D and Voet JG. And Pratt CW. John Wiley & Sons, Inc., 2016, ISBN: 1118918401, 978-1118918401
10. Biochemistry by Garrett and Grisham, Reginald H. Garrett, Charles M. Grisham (5th edition) Cengage Learning, 2012 ISBN: 1133106293, 978-1133106296
11. The Protein Protocols Handbook. Editor John M. Walker, Humana Press, 2009, ISBN10 160327474X ISBN13 9781603274746
12. Biochemistry by Dr. Swagata Dasgupta https://onlinecourses.nptel.ac.in/noc22_cy06/preview
13. https://www.skillmd.com/course/biochemistry-nptel-video-lessons/
14. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=MNhNzp1RQlU+6LM40KjY1Q==

Syllabus Prescribed for M.Sc. I Year PG Programme
Programme: M.Sc. Biotechnology
Semester1

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods)**
DSC-II. 1 BT	**Cell Biology**	**45 hrs**

Cos

Students after completion of this course would be able to…..

1. Interpret/differentiate how cells work in healthy and diseased states
2. Use knowledge to work in animal, plant and medical science to develop new vaccines, more effective medicines, plants with improved qualities
3. Make career as scientist by carry out research on disease or disorder such as meningitis, malaria, diabetes, a type of cancer, cystic fibrosis, or Alzheimer's disease.
4. Complete the prerequisite for making career in research in advance fields such as Forensic Science, Plant Sciences as well as Microbial science.
5. Use information and technologies of cell biology to clone plants as well as animals; to produce and insure high quality food available at low costs; to produce better medicines and organs for many people who may need transplantation.
6. Describe how cells transport materials and communicate..
7. Critique biotechnology currently being used to diagnose and treat diseases.

Unit	**Content**
Unit I	**Origin of cells and unicellular evolution: (8 Periods)** Origin of basic biological molecules; abiotic synthesis of Organic monomers and polymers , concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; Origin of eukaryotic cells; Evolution of Unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism. Diversity of cell size and shape. Cell theory - Structure of Prokaryotic and Eukaryotic cells- Isolation and growth of cells **Microscopic Techniques :** Visualization of cells and sub cellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells,Scanning and Transmission microscopes, different fixation and staining techniques for EM, Freeze-etch and Freeze-fracture methods for EM, image processing methods in microscopy.
Unit II	**Membrane structure and function: (8 Periods)** Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. **Structural organization and function of intracellular organelles:** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility, Cell motility- cilia, flagella of eukaryotes and prokaryotes**.**
Unit III	**Cell signaling:. (8 Periods)** Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two component systems, light signaling in plants, bacterial chemotaxis and quorum sensing. **Cellular communication:** Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. General importance of cell communication in immune system.
Unit IV	**Cell division and cell cycle: (7 Periods)** Mitosis and meiosis, Overview of cell cycle, their regulation, phases in cell cycle,regulation and control of cell cycle, Checkpoints. **Cell Death:** different modes of cell death and their regulation (apoptosis, necrosis, necroptosis, autophagy, senescence etc.).

Unit V	**Host parasite interaction:** **(7 Periods)** Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.
Unit VI	**Virus as tool to study cell biology** : **(7 Periods)** Introduction to Viruses (different types of viruses)., Classification, Host response to viral infection (anti-viral immunity). Drugs against viral infection.

Course Material/Learning Resources

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014).
4. Lewin's Genes XII. Burlington, MA: Jones & Bartlett Learning.
5. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.).Washington: ASM ; Sunderland.
6. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World ofthe Cell. Boston (8th Ed.). Benjamin Cummings.

Web link to Equivalent MOOC on SWAYAM if relevant:https://nptel.ac.in/courses/102103012

https://onlinecourses.nptel.ac.in/noc22_bt18/preview

https://archive.nptel.ac.in/courses/102/108/102108086/ https://nptel.ac.in/courses/122103039

Web link to Equivalent Virtual Lab if relevant:

Cell Biology | Learn Science at Scitable (nature.com)

https://www.nature.com/scitable/topic/cell-biology-13906536/

https://youtu.be/URUJD5NEXC8

https://youtu.be/RKmaq7jPnYM

Syllabus Prescribed for M.Sc. I Year PG Programme
Programme: M.Sc. Biotechnology
Semester1

Code of the Course/Subject	**Title of the Course/Subject**	**(Total Number of Periods)**
DSC-III. 1 BT	**Molecular Biology**	**45 Hrs**

COs

Students after completion of this course would be able to…..

1. Gain fundamental knowledge in genome at molecular level.;
2. Demonstrate an understanding of various cellular processes at molecular level, including processes such as specific gene expression and protein synthesis.
3. Compare the genomes of different living system/
4. Create physical map of genomes
5. Identify and differentiate vital characteristics / processes unique in pathogens and use them as target for drug development.
6. Identify mutations in genomes and use them in disease diagnostics.
7. Improve the strains of industrially important microbes by using tools of molecular biology.

Unit	**Content**
UnitI	**Introduction to molecular biology, basic concept of molecular biology. (8-periods)** **DNA Replication :** Prokaryotic and eukaryotic replication. Models of replication, theta modeof replication, rolling circle model of replication, Bi directional replication, replication oflinear DNA, unidirectional replication. Functions of various proteins involved in prokaryoticreplication of DNA and eukaryotic replication. Properties of various replication enzymes.Replication of telomeres and enzymes involved in telomere replication. DNA damage andRepair; Various enzymes involved in repair of DNA. **Recombination of DNA:** Recombination of viral DNA in genome, various models ofrecombination, Homologous and site-specific recombination**.**
UnitII	**Transcription**: **(8-periods)** Prokaryotic and eukaryotic transcription. Various RNA polymerases and their properties. Role of sigma sub factor in initiation of transcription. Various domains of subunits of RNA polymerase. Structure and regulation of prokaryotic and eukaryotic genes. Initiation and elongation transcription factors. Various mechanisms of termination of transcriptions. Transcriptional and post transcriptional gene silencing. **Modification of RNA** : 5‘ cap formation, 3‘ end processing, addition of polyA tail, enzyme involved in polyadenylation and function of poly A tail. Splicing of RNA, classes of introns, exon ligation, editing, Nuclear transport of RNA, and stability of RNA.
UnitIII	**Translation:** . **(8-periods)** Organization of prokaryotic and eukaryotic translation machinery. Structure of prokaryotic and eukaryotic ribosomes and their components. Shine Dalgarno sequence, Ribosomal protein synthesis. Regulation of protein synthesis, co and post translational protein modification. Non ribosomal protein synthesis. **Protein localization:** Synthesis of secretory and membrane protein. Mechanism of secretion of extracellular enzymes, Mechanism of localization of proteins in nucleus, chloroplast, mitochondria, peroxisomes and receptor mediated endocytosis.
UnitIV	**Organization of genes and chromosomes**: **(7-periods)** Operon: *lac* and Arabinose operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatinand chromosomes, heterochromatin, euchromatin, transposons.
Unit V	**Control of gene expression at transcription and translation level** : **(7-periods)** Regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in geneexpression and gene silencing
UnitVI	**Molecular mapping of genome: (7-periods)** Genetic and physical maps, physical mapping and map based cloning, choice of mapping population, simple sequence repeat loci, Southern and fluorescence in situ hybridization for genome analysis, Chromosome microdissection and micro cloning.

Course Material/ Learning Resources :

1. Molecular Biology (Fifth edition) by Robert Weaver
2. Molecular Biology LabFax, TA. Brown (Ed.), Bios Scientific Publishers Ltd., Oxford, 1991
3. Molecular Biology of the Gene (7th Edition), J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M. Weiner, The Benjamin/Cummings Publ. Co., Inc., California, 1987.
4. Molecular Ceii Biology (8th Edition) J. Darnell, H. Lodish and D.Baltimore, Scientific American Books, inc., USA, 1994
5. Molecular Biology of the Cell (6th Edition) B. Alberts, D. Bray, J.Lewis,M. Raff, K. Roberts, and J.D. Watson. Garland publishing, Inc., New York, 1994
6. Gene XII (12th Edition) Benjamin Lewin, Oxford University Press, U.K., 1998
7. Molecular Biology and Biotechnology. A comprehensive desk reference, R.A. Meyers (Ed.) VCHPublishers, Inc., New York, 1995
8. Genomes, by T.A. Brown

Web link to Equivalent MOOC on SWAYAM if relevant:

https://nptel.ac.in/courses/102106025

https://onlinecourses.swayam2.ac.in/cec20_ma13/preview

https://alison.com/tag/molecular-biology

https://www.classcentral.com/course/swayam-molecular-biology19952

Syllabus Prescribed for Two Year PG Programme

Programme: M.Sc. Biotechnology

Semester 1

Code of the Course/Subject	Title of the Course/Subject (Laboratory/Practical/practicum/hands-on/Activity)	(No. of Periods/Week)
DSC-LC-I. 1 BT	**Biochemistry & Analytical Techniques**	**6 H/Week**

Cos

By the end of the Lab/Practical Course, generally students would be able to:

1. Elaborate concepts of biochemistry with easy to run experiments;
2. Familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biochemistry.
3. quantify the biochemical parameters
4. Create and evaluate the reports of biochemical / diagnostic laboratory.
5. Design the Enzymatic process for product formation
6. Evaluate and compare the Biochemical processes.

* List of Practical/Laboratory Experiments/Activities etc.

1	To preparing various stock solutions and working solutions that will be needed for the course.
2	To prepare an Acetic-Na Acetate Buffer and validate the Handerson-Hasselbach equation.
3	Amino Acid Titration and pI determination
4	To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
5	Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
6	Isolation, Purification and characterization of an enzyme from a suitable source
7	Enzyme Kinetic Parameters: Km, Vmax and Kcat.
8	Experimental verification that absorption at OD 260 is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.
9	Identification of an unknown sample as DNA, RNA or protein using available laboratory tools.
10.	Analysis of data from Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy, SPR, ITC,other new techniques).
11.	Analysis of mass of small molecules and fragmentation patterns by Mass Spectrometry.

Learning Resources

1. An Introduction to Practical Biochemistry by David Plummer (3rd Edition), Mc Graw Hill Edition.
2. Laboratory Manual In Biochemistry by J Jayaraman. New Age International Publisher.
3. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker (7th Edition). Cambridge University Press, New York

Virtual Lab Biochemistry Virtual Lab II : Biotechnology and Biomedical Engineering : Amrita VishwaVidyapeetham Virtual Lab https://vlab.amrita.edu/?sub=3&brch=64

Syllabus Prescribed for Two Year PG Programme

M.Sc. Biotechnology

Semester 1

Code of the Course/Subject	**Title of the Course/Subject** (Laboratory/Practical/practicum/hands-on/Activity)	**(No. of Periods/Week)**
DSC-LC-II. 1BT	**Cell Biology**	**6 H/Week**

Cos

By the end of the Lab/Practical Course, generally students would be able to:

1. Use various types of microscope for analysis of cellular objects.
2. Use various types of microscopes for detection of pathogens as well as disease diagnostics.
3. Analyse chromosome aberrations and cancer detection
4. Plan and execute experiments for research in Cellular and molecular biology

1. Principle and utility of microscopy

2. Observation of distinguishing features of prokaryotic and eukaryotic cells

3. To measure the dimension of a microscopic an object using ocular and stage micrometer

4. Preparation of blood smear and differential staining of blood cells

5. Preparation of onion root tip squash and observation of different stages of cell division.

6. To Observe growth and differentiation in single cells (pollen grains) by hanging drop culture method.

7. To estimate the amount of chlorophyll present in the given sample

8. Biological Membranes
   i. Use a Colorimeter to measure color changes due to disrupted cell membranes.
   ii. Determine the effect of osmotic balance on biological membranes.
   iii. Determine the effect of detergents on biological membranes.
   iv. Determine the effect of pH on biological membranes.
9. Cell fractionation and organ isolation
   i. Mitochondria Isolation
   ii. Chloroplast Isolation
   iii. Membrane protein extraction
   iv. Nuclear protein extraction
   v. Subcellular protein extraction
10. Analyze the Human karyotype chart for diferent genetic disorders

Recommended Textbooks and References:

1. Cell Biology Laboratory Manual by William H. Heidcamp
http://www.ihcworld.com/_protocols/lab_protocols/cell-biology-lab-manual-heidcamp.htm

2. Biological Membranes - Vernier https://www.vernier.com/experiment/bwv-9_biological-membranes/

Syllabus Prescribed for Two Year PG Programme
Programme: M.Sc. Biotechnology Semester1

Code of the Course/Subject	Title of the Course/Subject (Laboratory/Practical/practicum/hands-on/Activity)	(No. of Periods/Week)
DSC-LC-III. 1BT	**Laboratory IV: Molecular Biology**	**06**

COs

After completion of the course the student would be able to

1. Design the strategy to isolate the DNA from particular biological specimen.
2. Develop the restriction map of given DNA
3. Determine the quantity of the isolated DNA.
4. Determine the purity of the isolated DNA.
5. Generate differences between RNA and DNA isolation
6. Choose or select appropriate method of cell lysis for the isolation of DNA from different sources.

*List of Practical/Laboratory Experiments/Activities etc.

1	Isolation of genomic DNA from blood (Animal Cell)
2	Isolation of genomic DNA from Spinach leaf (plant Cell)
3	Isolation of DNA from Bacteria
3	Isolation of Plasmid DNA
4	Agarose Gel electrophoresis
5	DNA quantification
6	To determine purity of isolated DNA
7	Restriction Enzyme digestion of plasmid DNA
8	UV mutagenesis to isolate amino acid auxotroph
9	In vitro transcription
10	In vitro translation
11	Isolation of RNA

Course Material/Learning Resources

1. Molecular Cloning: A Laboratory Manual by Joseph Sambrook, David W. Russell. CSHLPress, 2001
2. Short Protocols in Molecular Biology (5th ed.) A Compendium of Methods from Current Protocols in Molecular Biology, by Frederick M Ausubel, Roger Brent, Robert E Kingston,David D Moore, J G Seidman, John A Smith, Kevin Struhl.
3. Molecular Biology Lab Manual by Julie B. Wolf Molecular Biology Lab Manual(ihcworld.com)
4. DNA Extraction & Purification/DNA Extraction from Bacteria and Other Organisms Protocols(protocol-online.org)

Syllabus Prescribed for TWO Year PG Programme
Programme: M.Sc. Biotechnology
Semester 1

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Period)
RM I. 1BT	**Research Methodology I**	30

COs

The objectives of this course are to give a background on the history of science, emphasizing the methodologies used to do research, use the framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

Students should be able to:

• Understand the history and methodologies of scientific research, applying these to recent published papers;
• Understand and practice scientific reading, writing and presentations;
• Appreciate scientific ethics through case studies.

Unit	Content
Unit I	History of science and science methodologies - Empirical science; the scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology
Unit II	Preparation for research - Choosing a mentor, lab and research question; maintaining a lab notebook.
Unit III	**Statistical Analysis:** Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design. **Statistics using R, Spreadsheet and Excel**
Unit IV	**IPR**: Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Recommended Textbooks and References:

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009).
Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.
6. Billingsley, P. (1986). Probability and Measure. New York: Wiley.
7. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press.
8. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley.
9. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
10. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
11. Complete Reference to Intellectual Property Rights Laws. (2007).nSnow White Publication Oct.

Syllabus Prescribed for TWO Year PG Programme
Programme: M.Sc. Biotechnology
Semester 1

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Period)
RM.II.1BT	**Research Methodology II**	30

The objectives of this course are to familiarize students with classic literature to make them appreciate how groundbreaking discoveries were made without, necessarily, use of high-end technologies.

Students should be able to train in the exercise of hypothesis building and methods of addressing the hypothesis with readily available technology.

How does the Course Module work? Students may be divided in groups and each group may be responsible for one classical paper. Each week there may be a 1.5 hour presentation cum discussion for each of the papers. At the end of the semester each student will be asked to write a mini-review (2-3 pages long) on any one classical paper, other than the one he/she presented/discussed. A list of sixteen classic papers and some suggested reference materials:

Molecular Biology

1. Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from Pneumococcus type III. Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.

2. Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56. Note: Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.

3. Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8 Note: In this one page paper Watson and Crick first described the structure of DNA double helix Study help - Watson_Crick_Nature_1953_annotated

4. Transposable mating type genes in Saccharomyces cerevisiae James Hicks, Jeffrey N. Strathern & Amar J.S. Klar; Nature 282, 478-483,1979 Note: This paper provided evidence for ‘cassette hypothesis’ of yeast mating type switches i.e. interconversion of mating types in yeast (S. cerevisiae) occurs by DNA rearrangement.

5. Messelson & Stahl experiment demonstrating semi-conservative replication of DNA. Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82 Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"

6. In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990 Note: This paper demonstrates that the telomerase contains the template for telomere synthesis

Cell Biology

1. A protein-conducting channel in the endoplasmic reticulum Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371-80 Note: This paper demonstrates the existence of a protein conducting channel Study help - A brief history of Signal Hypothesis.

2. Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15 Note: In this groundbreaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion

3. A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45 Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC) Suggested reference paper - A biochemical assay for identification of PCC.

4. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16 Note: This paper describes setting up of an in vitro reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP etc.

5. A complete immunoglobulin gene is created by somatic recombination Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14 Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.

6. A novel multigene family may encode odorant receptors: a molecular basis for odor recognition Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87 Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in Drosophila olfactory epithelium where a large family of odorat receptors is expressed.

7. Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 Note: This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.

Developmental Biology/Genetics

1. Mutations affecting segment number and polarity in Drosophila Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980 Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.

2. Information for the dorsal--ventral pattern of the Drosophila embryo is stored as maternal mRNA Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7 Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes

3. Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7 Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cillia in it. Suggested Reference paper - Design and execution of a embryonic lethal mutation screen in mouse.

Syllabus Prescribed for TWO Year PG Programme

Programme: M.Sc. Biotechnology

Semester II

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSC-I. 2 BT	**Microbiology**	45

COs

On completion of this course, students would be able to:

1. Isolate and identify microorganisms from different ecosystem
2. Optimize growth conditions for maximize biomass as well as product formation using microbes.
3. Monitor and assess presence or absence of specific organism in samples from a range of sources.
4. Develop new techniques, products and processes.
5. Make strategy and plan methods to prevent the spread of disease.
6. Grow microbial cultures, e.g. for use in the food and drink industry or in agriculture
7. Develop products such as enzymes, vitamins, hormones and antimicrobials.

Unit	Content
Unit I	**Microbial characteristics** **(8 periods)** Introduction to microbiology and microbes, Bacterial cell structure and components, Description of various groups of microorganisms with typical example. Bacterial cell structure and components, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; selective media, bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.
Unit II	**Microbial diversity: Scope and Importance** **(8 periods)** Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification;classification of bacteria, Bergey's Manual; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic andpropionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilicarchae, Thermoplasma; eukarya: algae, fungi, slime molds and protozoa; extremophiles, anaerobes and unculturable microbes.
Unit III	**Control and management of microorganisms** **(8 periods)** Sterilization – High temperature- Tyndallization, Pasteurization, inspissation, incineration, moist heat under pressure, Disinfection and antisepsis - Mode of action and evaluation; Various physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms; Low temperature – preservation; filtration- membrane filters, depth filters; centrifugation; radiation- principle, use and Quality control.
Unit IV	**Viruses** **(7 periods)** Introduction: History and principles of virology, virus taxonomy, introduction to replication Strategies; Virus structure and morphology, Applicability of animal, plant viruses and bacteriophages, general properties of viruses,, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles –viroids and prions. Life cycles of viruses, Principles of biosafety, Infrastructure requirement; containment facilities, maintenance and handling of laboratory animals and requirements of virological laboratory.
Unit V	**Host-microbes interaction** **(7 periods)** Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics **Antibiotics** – Classification, Mode of Action, mechanism of resistance, Evaluation – Disc Diffusion; MIC – Broth dilution, agar dilution; MBC; E- test with Quality control for each method; Emergence of resistance to drugs; Biofilms and their significant role.
Unit VI	**Biosafty and Biosecurity** **(7 periods)** Guidelines of Biosafety as per hazardous groups, biosafty levels. Animal house biosafety.

Recommended Textbooks and References:

1. Aidan Coffey and Colin Buttimer (2020). Bacterial Viruses: Exploitation for Biocontrol and Therapeutics.Book: 978-1-913652-51-7. Ebook: 978-1-913652-52-4.
2. Akikazu Sakudo and Takashi Onodera (2019**).** Prions: Current Progress in Advanced Research (Second Edition).Book: 978-1-910190-95-1. Ebook: 978-1-910190-96-8.
3. David Greenwood, Richard C. B. Slack, John F. Peutherer (2007). Medical Microbiology: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and Control. 17th Edition. Elsevier HealthSciences.
4. Donald R. Demuth, Richard Lamont (2006). Bacterial Cell-to-Cell Communication. Role in Virulence and Pathogenesis. (Advances in Molecular and Cellular Microbiology, Series Number 11) 1st Edition. CambridgeUniversity Press.
5. Jason C. Gallagher, Conan MacDougall (2016). Antibiotics Simplified. 4th Edition. John and Bartlett Publishers.
6. Larry R. Snyder, Joseph E. Peters, Tina M. Henkin, Wendy Champness (2014). Molecular Genetics of Bacteria, 4th Edition.ASM Press.
7. Matthai, W., Berg, C. Y., & Black, J. G. (2005). Microbiology, Principles and Explorations. Boston, MA: John Wiley & Sons.
8. Matthew A. Wallig, Wanda M. Haschek, Colin G. Rousseaux (2009). 2 nd edition. Fundamentals of Toxicologic Pathology. Elsevier
9. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). Microbiology (5th ed.). New York: McGraw-Hill.
10. Roger G. Finch, David Greenwood, S. Ragnar Norrby, Richard J. Whitley (2010). Antibiotic and Chemotherapy: Anti-Infective Agents and Their Use in Therapy. Saunders Elsevier
11. Scott C. Weaver, Mark Denison, Marilyn Roossinck and Marco Vignuzzi (2016). Virus Evolution: Current Research and Future Directions. Book: 978-1-910190-23-4. Ebook: 978-1-910190-24-1
12. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's Microbiology. New York: McGraw-Hill.
13. Wendy Champness, Tina M. Henkin, Joseph E. Peters, Larry R. Snyder (2014). Molecular Genetics of Bacteria.ASM Press
14. Stainer, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R. General Microbiology The MacMillan Press Ltd.
15. Madigan, M.T., Martinko, J.M. and Parker, J. Brock Biology of Microorganisms, Prentice-Hall.(1996)
16. Cappuccino, J.G. and Sherman, N. Addison Wesley. Microbiology - a Laboratory Manual
17. Microbiological Applications, (A Laboratory Manual in General Microbiology) Benson, H.J. WCB: WmC. Brown Publishers.
18. Dariel Burdass, John Grainger & Janet Hurst., Basic Practical Microbiology: A manual © 2016 Microbiology Society

Syllabus Prescribed for TWO Year UG/PG Programme
Programme: M.Sc. Biotechnology
Semester II

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSC-II. 2 BT	Immunology	45

COs

Students after completion of this course would be able to…..

1. Identify the cellular and molecular basis of immune responsiveness.
2. Describe the roles of the immune system in both maintaining health and contributing to disease.
3. Describe immunological response and how it is triggered and regulated.
4. Demonstrate a capacity for problem-solving about immune responsiveness.
5. Transfer knowledge of immunology into clinical decision-making through case studies presented in class.
6. Develop diagnostic tools.
7. Develop Biologicals for therapeutic applications.

Unit	Content
Unit I	**Immunology (8 periods)** Fundamental concepts, types and overview of the immune system. Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; Antigens: immunogens, haptens; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system. Organs of immune system, primary and secondary lymphoid organs. Pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP);
Unit II	**Immune responses generated by B and T lymphocytes. (8 periods)** Immunoglobulins - basic structure, classes and subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses.
Unit III	**Antigen-antibody interactions and modifications (8 periods)** Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI-Cell mediated immunological techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays.
Unit IV	Antibodies **(7 periods)** Antibody fractionation, Type of antibody fragments, Preparation of Fab, F(ab") 2, Fc fragments of IgG, IgM fragmentation, advantages of antibody fragments and Applications in various fields. Antibody labeling: Antibody conjugates, Secondary antibodies, Types of labels: Biotin, Enzyme reporters, Fluorescent tags, Label used for different techniques.
Unit V	**Immunogenetics (7 periods)** Major histocompatibility complex genes and their role in immune responsiveness, disease susceptibility, autoimmune and infectious diseases, Transplantation and HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, Hypersensitivity reactions-genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR- Killer cell immunoglobulin-like receptors complex.
Unit VI	**Applications of antibodies (7 periods)** Use of antibodies in therapeutics and diagnostics, Concept of Antibody engineering and their types; Production and Purification of polyclonal antibodies in rabbits, mice etc. Antibodies as therapeutic tools- viz mouse, chimeric, humanized and full human antibodies. Antibody Discovery platforms - like Hybridoma Technology, Phage Display Technology, Yeast Display Technology & B-cell sorting etc. Antibody production in mammalian cells such as CHO and HEK293 cell lines. Antibodies for the treatment of different types of cancer, immune mediated disorders, infectious diseases, cardiovascular/Homeostasis, Neurological disorder, Genetic disease, Ophthalmic disorders, Musculoskeletal disorders etc. Antibodies for Diagnostic uses - like in detection of Dengue, Malaria, Chikungunya, Covid-19, TB (Both ELISA and RAPID kits) etc.

Recommended Textbooks and References:

1. Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai (2022). Basic Immunology: Functions and Disorders of the Immune System 6th Edition. Elsevier
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub
3. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press
4. Helen Chapel, Mansel Haeney, Siraj Misbah, Neil Snowden (2014). Essentials of Clinical Immunology, Includes Wiley E-Text, 6th Edition. Wiley-Blackwel
5. Ian Tizard (2005).Immunology: An Introduction. CENGAGE LEARNING (RS)
6. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
7. Lauren M. Sompayrac (2019). How the Immune System Works 6th Edition. Wiley Blackwell.
8. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
9. Parham, P. (2005). The Immune System. New York: Garland Science.
10. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
11. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt (2017). Roitt's Essential Immunology, 13th Edition. Wiley-Blackwell
12. Pravash Sen. Gupta, Clinical Immunology. Oxford University Press. 2003.
13. Noel R. Rose, Herman Friedman, John L. Fahey. Manual of Clinical Laboratory Immunology. ASM. 3rd ed., 1986.
14. https://archive.nptel.ac.in/courses/102/105/102105083/ Immunology
15. https://nptel.ac.in/courses/102103038 Cellular & Molecular Immunology

Syllabus Prescribed for Two year PG Programme
Programme: M. Sc. Biotechnology
Semester II

Code of the course/Subject	Title of the Course/Subject	(No. Of periods)
DSC-III. 2 BT	**Plant Biotechnology**	**45**

COs :

Students after completion of this course would be able to…..

1. create the foundation for plant biotechnology by revising the plant physiology.
2. Gain sound knowledge of principles, practices and application of plant tissue culture.
3. Become familiar to the techniques involved in genetic transformation of plants.
4. Become aware of the basics of rules and regulations about GMOs.
5. Set up Plant tissue culture laboratory horticulture and floriculture
6. Develop safer and better Gene edited crops

Unit I : Plant physiology I	Photosynthesis: Chloroplast, structure, function, plastid DNA, C3 & C4 pathways, photorespiration,., Photoperiodism, Plant hormones (7 periods)
Unit II: Plant physiology II	Stress physiology - Responses to plant pathogens: Genetic basis of plant pathogen interactions, R genesand R gene mediated resistance, Biochemistry of plant defense reactions, Responsesto abiotic stress: osmotic adjustment and its role in tolerance to drought and salinity,flooding and oxygen deficit, genes induced by water stress (7 periods)
Unit III: Plantphysiology III and Tissue culture	Pathways for secondary metabolites: Shikimate, isoprene and phenylpropanoid pathways; their regulations and applications in industry Introduction to cell and tissue culture as a technique to produce novel plants and hybrids; Mineral nutrition and Water uptake by plants, Tissue culture media (composition and preparation) (7 periods)
Unit-IV : Cell and tissue culture	Initiation and maintenance of callus and suspension culture, single cell clones. Organogenesis, somatic embryogenesis, transfer and establishment of cut whole plant in soil Shoot tip culture ; rapid clonal propagation and production of virus free plants, concept of elite plant; somaclonal variations; Embryo culture and embryo rescue; Protoplast isolation, culture and fusion selection of hybrid cells and regeneration of hybrid plants, symmetric and asymmetric hybrids, cybrids; Anther, pollen and ovary culture for production of haploids plants and homozygous line; Cryopreservation , Slow growth and DNA banking for germplasm conservation; Green house and green home technology. (8 periods)
Unit V: Plant transformation technology	Basis of tumour formation , hairy root, features of Ti and Ri plasmid, Mechanisms of DNA transfer , role of virulence genes, use of Ti and Ri plasmid as vector, binary vector; Use of 35S and plant specific promoters, genetic markers, use of reporter genes, reporter genes with introns, use of scaffold attachment regions; Methods of nuclear transformation, viral vectors and their application , multiple gene transfer; Vectors-lessor direct DNA transfer and particle bombardment, electroporation, microinjection, Chloroplast transformation, Cre-Lox Technology. (8 periods)
Unit-VI : Application of plant Transformationfor productivity and performance:	Herbicides resistance, phosphoinothricin, glyphosate, sufonyl urea, atrazine; Insect resistance , Bt genes, Non-Bt like protease inhibitors, alpha amylase inhibitors; Virus resistance, coat protein mediated , nucleocapsid genes, diseases resistance ; Nematode resistance, abiotic stress, post harvest losses, long shelf life of fruits and flowers; Male sterile lines, bar and barnase systems, Genome edited plants, Debate over GM crops. (8 periods)

Recommended Textbooks and References :

1. Amritrao, P.V.D.A. Evans, W.P. Sharp and Bajaj Y.P.S. (1990) Handbook of Plant Cell Culture volumes I-V, McGraw Hill Publishing Co. New York.
2. Bhojwani S.S. And Rajdan M.K. (1983). Plant Tissue Culture : Theory and practice.Elsevier, ISBN: 9780080539096
3. Reinert J. and Bajaj Y.P.S. (1977). Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture, By Springer - Verlag, Berlin. ISBN: 978-3-662-02281-8, 978-3-662-02279-5.
4. Grierson, D. and Coyey S.N. (1988) Molecular Biology, Ed. 2, Springer. ISBN : 0751401447, 978-0751401448.
5. Bhojwani S.S. (1991). Plant tissue culture : Application and limitations, Elsevier, Amsterdam. ISBN: 9780444598479
6. Chawla H. S (2000). Introduction to plant Biotechnology, Ed. 3, Oxford and IBH Publishing C. Pvt. Ltd., ISBN: 978-81-204-1732-8
7. Dixon R.A. and Gonzales, IRL Press, Plant Cell Culture: A Practical Approach. Ed. 2, IRL Press. ISBN: 0-19-963402-5, 978-0-19-963402-6
8. Debergth P.C. and Zimmerman (1990) : Micro propagation : Kluwer, Academic Publication, Dordrecht. ISBN: 978-94-009-2075-0
9. Stanton B. Gelvin, Robbert A. Schilperoort (1984) : Plant Molecular Biology manual, Springer Link. ISBN: 978-94-011-0511-8
10. Buchnan B. B. (2015). Biochemistry and Molecular Biology of Plants, 2nd Ed., Wiley. ISBN : 9780470714218, 978-0470714218
11. Glick B. R. and Pasternack J. J (2002). Molecular Biotechnology: Principles and Applications of Recombinant DNA, 3rd Ed., American Society for Microbiology, ISBN : 1555812244, 978-1555812249
12. Primrose S. W. and Teyman R. M. (2014). Principles of Gene Manipulation: An Introduction to Genetic Engineering, John Wiley Blackwell Publication, ISBN 8126548398, 978-8126548392
13. Taiz L, Zeiger E, Moller I M, Murphy A. (2018). Plant Physiology and Development, 6th Ed., OUP USA; ISBN : 1605357456, 978-165357454

Syllabus Prescribed for Two year PG Programme
Programme: M. Sc. Biotechnology
Semester II

Code of the Course/Subject	**Title of the Course/Subject** (Laboratory/Practical/practicum/hands-on/Activity)	**(No. of Periods/Week)**
DSC-LC-I. 2 BT	**Microbiology**	**6 H/Week**

COs

By the end of the Lab/Practical Course, generally students would be able to:

1. Isolate, characterize and identify common bacterial and fungal organisms;
2. Determine bacterial load of different samples;
3. Perform antimicrobial sensitivity tests;
4. Preserve bacterial and fungal cultures.

1. Preparation of simple laboratory nutrient media (Nutrient agar/broth, MacConkey's agar). ii. Checking sterilization efficiency of autoclave using a biological/chemical indicator.

2. Demonstration of Special staining techniques: i. Grams Staining ii. Endospore staining

3. Isolation of bacteria by streak plate technique (Colony and cultural characteristics) 1 4 Enumeration of bacteria from fermented food / soil / water by: i. Spread plate method ii. Pour plate method.

4. To study the effect of different parameters on growth of *E. coli:* pH, temperature, sodium chloride concentration.

5. Biochemical characterization of bacteria: a. Sugar utilization test (minimal medium + sugar) b. Sugar Fermentation test c. IMViC d. Enzyme detection – Gelatinase, Catalase, Oxidase e. Oxidative-fermentative test.

6. Primary screening of industrially important organisms: a. Organic acid producing microorganisms b. Antibiotic producing microorganisms (crowded plate technique).

7. Bacteriological tests for potability of water a. MPN, Confirmed and Completed test. b. Membrane filter technique (Demonstration).

8. Induction of mutations by using physical mutagen (e.g. UV rays/ chemical mutagen).

9. Study of mutations by Ames test

10. Isolation of mutants by any suitable method c. Demonstration of UV survival curve.

11. Isolation and demonstration of bacteriophages from infected water.

Recommended Textbooks and References:

2. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings PublishingCompany.
3. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8 th ed.). Arnolds.
4. P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology.

Syllabus Prescribed for Two Year PG Programme
Programme: M. Sc. Biotechnology

Semester II

Code of the course/Subject	Title of the Course/Subject	(No. Of periods / week)
DSC-LC-II. 2BT	**Immunology**	6

COs :

The candidate will gain hands-on knowledge and acquire adequate skill required to identify and enumerate immune cells and also perform agglutination reactions.

By the end of the Lab/Practical Course, generally students would be able to:

1. Carry out routine clinical test
2. Use modern instruments used in diagnostic labs
3. Develop and purify antibodies
4. Develop immunological tests for detection and quantitation of specific molecules etc.

*List of Practical/Laboratory Experiments / Activities etc.

1. Preparation of the Blood film and Identification of various immune cells by morphology using–Leishman staining/ Giemsa staining.
2. Differential leucocyte counts and Total count of blood cells.
3. Precipitation tests (a) ring test (b) slide test in given solution of an antigen and antibody.
4. Single radial Immunodiffusion (Mancini's Technique) using antigen and antibody samples.
5. Heamagglutination Reactions- Blood Grouping – forward and reverse, Rh Typing, Coomb's test, TPHA.
6. Immune-electrophoresis of given antigen and antibody.
7. Serum protein electrophoresis (SPEP) for separating proteins based on their net charge, size, and shape.
8. Serum lysozyme activity as inflammatory markers for diagnosis of sarcoidosis.
9. Purification of IgG from serum.
10. Detection of Dengue/Malaria/ Chikungunya, Covid-19, TB (Both ELISA and RAPID kits)

Recommended textbooks and references:

1. C P Talwar, S. K. Gupta (2017). Hand Book Of Practical And Clinical Immunology. Vol 2. 2nd ed. CBS Publishers & Distributors, ISBN: 9788123900186
2.Tobili Y. Sam-Yellowe (2021). Immunology Overview and Laboratory Manual. Springer Link ISBN: 978-3-030-64686-8

Virtual Lab: https://ivl1-au.vlabs.ac.in/Introduction.html

Syllabus Prescribed for Two Year PG Programme
Programme: M. Sc. Biotechnology
Semester II

Code of the course/Subject	Title of the Course/Subject	(No. Of periods / week)
DSC-LC-III. 2 BT	**Plant Biotechnology**	**6**

COs :

By the end of the Lab/Practical Course, generally students would be able to:

1. Design their own experiments related to plant tissue culture
2. Should be able to determine the culture conditions for various explants to get desirable results.
3. Acquire the skills required to culture and multiply economically important plants
4. Set up Plant tissue culture laboratory horticulture and floriculture
5. Develop safer and better Gene edited crops

.

*List of Practical/Laboratory Experiments / Activities etc.

1. Prepare culture media with various supplements for plant tissue culture
2. Isolation of explant, induction of callus, establishment and maintenance of callus
3. Organogenesis and plant regeneration through clonal propagation.
4. Induction of embryogenesis in anthers of Datura stramonium
5. Effect of various growth hormones on cell divisions and cell proliferation
6. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
7. Embryogenesis in cultured cells from different explants.
8. Micropropagation of banana, citrus Papaya, Sugarcane etc.
9. Hardening of tissue culture raised plants.
10. Cell suspension culture from different tissues.
11. Isolate plant protoplast by enzymatic and mechanical methods (available material).
12. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometeric methods.

Recommended textbooks and references:

1. Bhojwani S.S. And Rajdan M.K. (1983). Plant Tissue Culture: Theory and practice, .Elsevier, ISBN: 9780080539096
2. Reinert J.and Bajaj Y.P.S. (1977). Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture, By Springer - Verlag, Berlin. ISBN: 978-3-662 02281-8, 978-3-662-02279-5.
3. Reinert J.and Yeoman M. M. (Plant Cell and Tissue Culture: A laboratory manual, McDonald P., (1982), Springer - Verlag, Berlin. ISBN: 3642817866, 978-3642817861
4. Chawla H. S (2000). Introduction to plant Biotechnology, Ed. 3, Oxford and IBH Publishing C. Pvt. Ltd., ISBN: 978-81-204-1732-8
5. Dixon R.A. and Gonzales (1995). Plant Cell Culture: A Practical Approach, Ed. 2, IRL Press. ISBN: 0-19-963402-5, 978-0-19-963402-6

Part B

Syllabus Prescribed for TWO Year PG Programme

Programme: M.Sc. Biotechnology

Elective Courses

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSE-A. 1 to 4 BT	**Cancer Biology**	**30**

COs

Students after completion of this course will be able to…..

1. Analyse the changes in the cells leading to cancer
2. Formulate new assay systems for detection of cancer.
3. Get motivated to design markers.
4. Help to develop new drugs

Unit	Content
Unit I	Hallmarks of cancer Cancer: Introduction to cancer, the nature of cancer cancer types and their prevalence, class organization. Hall Marks of Cancer: Evasion of Apoptosis, Limitless replicative potential, Sustained Angiogenesis, Inflammation. Diseased and cancerous cell: morphological and microscopic features, important tumor markers
Unit II	Molecular basis of Key Players Carcinogens, tumor virology, oncogenes, tumor suppressor genes, cell cycle regulation in cancer development, role of genomic instability in cancer pathogenesis, Histone acetylases/deacetylases in cancer progression, Understanding of post transcriptional and post translational modifications in cancer cell, angiogenesis and malignancy, stem cell biology & cancer stem cells.
Unit III	Altered pathways Hypoxia/ tumor cell microenvironment and important signaling pathways involved in cancer progression, Pathways involved in cell differentiation/ immortalization in cancer. Systems Biology in cancer, epigenetics in cancer, MicroRNAs and cancer, cell death: necrosis and apoptosis.
Unit IV	Techniques involved in detection Detection: Use of Immunoglobins, Biomarkers in detection, cytological screenings, karyotyping, chromosome painting, FISH, other techniques involved in detection. Role of Histopathological & Immunocytochemical techniques in cancer diagnostics and research, initiation and propagation of cancer cells in cell culture systems: Evaluation of important properties and their relevance with human biology
Unit V	Conventional and new treatments Discovery and clinical validation of a targets in cancer, tools, techniques & important parameters involved in screening new bioactive(s) as possible anticancer agent(s), Cell cycle regulators: Role as therapeutic targets in cancer, gene silencing and RNAi technology in cancer treatment.

Course Material/Learning Resources

1. The Biology of Cancer. Weinberg R. A. (2013), 2nd Ed. Garland Publishing Inc, ISBN-10 : 0815342209, 978-0815342205
2. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics. Pecorino Lauren, (2021), 5th Ed. OUP Oxford, ISBN-10 : 0198833024, 978-0198833024
3. The Cell: A Molecular Approach. Cooper G. M and Housman R. E, (2009), 5th Ed. Sinauer Associates Inc, ISBN-10 : 0878933972, 978-0878933976
4. https://www.nature.com/scitable/ebooks/cntNm-16550193/
5. https://bookboon.com/en/introduction-to-cancer-biology-ebook
6. https://themedicalbiochemistrypage.org/category/specialized-topics/cancer/

Part B

Syllabus Prescribed for TWO Year UG/PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSE-B 1 to 4 BT	**Molecular Basis of Drug Discovery**	**30**

COs

Students after completion of this course will be able to…..

1. Recall the major steps of drug development and their corresponding processes
2. Interpret relationships between molecule concentration and enzyme or receptor activity
3. Compute a molecule's pharmacokinetic parameters from *C*p-time data points
4. Correlate a molecule's structure to its metabolic behavior
5. Prioritize the viability of weakly active molecules for potential drug development
6. Propose molecules with improved properties based upon data from related structures

Unit	Content
Unit I	Pre-Regulatory Medicine: Natural products, Early Synthetic drugs, Pharmacophores, Need for Regulations. Drug development outline, Target based drug discovery and Phenotype based discovery, drug repurposing. Concept to market
Unit II	Proteins and their structures, Enzymes: Enzyme kinetics, Enzyme inhibition and its measurements, IC50 and Ki, Receptors and Ligands, Occupancy theory: Emax and Kd, Binding and Response, Upregulation and down-regulation
Unit III	Blood and drug transport: Serum binding, ADME, Pharmacokinetics, Oral Bioavailability, Understanding Cp and complexity of dosing, Metabolism of drug, Pro-drug..
Unit IV	Binding, Structure and Diversity: Intermolecular forces, Drug Target Complementarity, Molecular diversity, Molecular libraries, Building libraries.
Unit V	Lead Discovery: In vitro screening, fragment based screening, Filtering hits, Selective optimization of side activities, Natural products Lead optimization: functional group replacements, Alkyl group replacements, Isosters, Directed Combinatorial Libraries, Peptidomimetics

Course Material/Learning Resources

1. MEDICINAL CHEMISTRY: THE MOLECULAR BASIS OF DRUG DISCOVERY: Medicinal Chemistry Made easy. Barnabas Ifitumi Samuel .ISBN-13: 979-8458903875
2. Basic Principles of Drug Discovery and Development. (11th Edition). Benjamin Blass. ISBN: 9780124115255
3. Drug Discovery and Evaluation Pharmacological Assays (2nd Edition). H. Gerhard Vogel (Ed.). ISBN 3-540-42396-6 Springer-Verlag
4. Computer-Aided Drug Design Virtual Lab https://vlab.amrita.edu/index.php?sub=3&brch=277

Part B

Syllabus Prescribed for TWO Year PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSE-C 1 to 4 BT	**Clinical Trial and Research**	**30**

COs

Students after completion of this course will be able to…..

1. Demonstrate competency in biopharmaceutical clinical trial research designs and regulatory affairs management to meet the health and medical needs of current and future biopharmaceutical product consumers
2. Evaluate critical domestic and global regulatory and health care issues that challenge and influence biopharmaceutical product development
3. Effectively assess and manage ethical clinical trial programs and biopharmaceutical development projects
4. Manage innovative biopharmaceutical/biotechnology products through the discovery processes and into the clinical trial phases via identifying research questions and testable hypotheses
5. Demonstrate advanced critical thinking skills necessary to enhance employment opportunities or advance within the biopharmaceutical industry
6. Effectively communicate and collaborate with health care providers and regulatory agencies to develop culturally diverse domestic and global strategies for biopharmaceutical product approvals

Unit	Content
Unit I	**Clinical trial Introduction:** Fundamentals of clinical research, Introduction to healthcare, Introduction to Good Clinical practices, Communication skill, Introduction to New Drug Development process, Preclinical studies: Selection of animals, selection of doses, protocol preparation and execution. Different phases of clinical trials: Phase I, Phase II, Phase III, Bridging studies, Post marketing studies, Sample size determination and Power of a study, Blinding and unblinding of subjects.
Unit II	**Regulatory Guidelines and Quality assurance** Clinical Research regulations in India – CDSCO / ICMR guidelines, Schedule Y, Clinical trial application requirements in India, Investigational New Drug (IND), An abbreviated new drug application (ANDA and New Drug application (NDA). Guidelines from, **International Council for Harmonisation (**ICH), United states-Food and Drugs administration (US-FDA), Medicines and Healthcare Products Regulatory Agency (MHRA) and Clinical Research regulations in Europe (EMEA). Quality Assurance and Quality Control in Clinical Trials, Audit conducts and compliances, Preparing for FDA/ Pharmacovigilance inspections, Fraud and misconduct management.
Unit III	**Clinical Trial Ethics and safety:** Ethics committees, constitution and practices, Declaration of Helsinki and Informed consent process, Liability and indemnity in clinical trials (Insurance and Indemnity: roles and responsibility), Ethics and clinical trials in special population. Adverse events and reporting of adverse events, Risk –benefit assessment of adverse events. Ethical committees (EC), Data Safety Monitoring Board (DSMB).
Unit IV	**Scientific Writing and data management:** Clinical Protocols, Investigator's Brochure, Informed Consent Form, Case report forms (CRF), Contracts and agreements, Trial Master File preparation and maintenance, Investigator Site File, Pharmacy File, Dairy Cards Clinical Data Management (CDM):, Data management plan, Study set-up, Data entry, CRF tracking and corrections, Central lab, Interactive Web Response Systems (IWRS) Interactive Voice Response Systems (IVRS), source data. Data cleaning, managing laboratory data, Data transfer and database lock, Quality Control and Quality Assurance in CDM, Data mining and warehousing Clinical Data Analysis.
Unit V	**Clinical Trial Management:** Clinical site management: Review of source documents, CRF, Inform consent form (ICF), investigational Product (IP) storage, accountability and reconciliation, Study Procedure, EC communications, Safety reporting, Monitoring visit reporting and follow-up Close-Out visit: Study related documents collection, Archival requirement, Investigational Product reconciliation and destruction, Close-Out visit report. Investigational Drug Management: Storage and transport of drugs, packaging and labelling of materials for blinded and unblinded studies. Query management.

Course Material/Learning Resources

1. Lawrence M. Friedman, Curt D. Furberg, David DeMets. Fundamentals of Clinical Trials. Springer Cham.
2. Warren S. Browner. Publishing and Presenting Clinical Research, Third Edition. Lippincott Williams & Wilkins (LWW)
3. Dr. Stephen B Hulley, Steven R Cummings, Warren S Browner. Designing Clinical Research. Lippincott Williams & Wilkins (LWW)
4. Susanne Prokscha. Practical Guide to Clinical Data Management, Third Edition. CRC Press
5. WHO. Handbook for Good Clinical Research Practice: guidance for implementation. https://apps.who.int/iris/handle/10665/43392

Part B

Syllabus Prescribed for TWO Year PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSE-D 1 to 4 BT	**Phytosecondary Metabolites and its Bioactivity**	**30**

Course Outcomes

Students should be able to:

1. Identify and characterize the plants which produces various metabolites.
2. Identify major categories of plant metabolites and their classification, identification and analysis.
3. Identify and demonstrate various lab techniques for their isolation and purification.
4. Demonstrate and evaluate interactions between metabolites for preventing human healt**h.**

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Unit	Content
Unit I	Strategies For Discovery Of Bioactive Phytochemicals, Strategies For Choosing A Plant Species Or Plant Tissue, Tools For Determination Of Active Components From Plants, Isolation And Characterization Of Plant Constituents, Phytochemical Analysis And Assay.
Unit II	QSAR And Molecular Modelling of Bioactive Phytochemicals 1. Lignans And Tannis, As Antiviral And Antitumour Agents 2. Isoflavonoids As Phytoestrogens And Flavonoids As Antiestrogens 3. Antioxidants Phenolics: Physiochemical Properties 4. Curcumins And Related Compounds As Blockers Of Signal Transduction In Inhibition Of Tumour Promotion 5. Bioactive Components For Treatment Of Diseases.
Unit III	Phyto-Antimicrobial (PAM)- Agents As Multifunctional Food Additives; PAM From Oils; PAM From Spices; PAM From Herbs (Aloe); PAM Thiosulphonates From Garlic; PAM Polyphenolics From Green Tea.
Unit IV	Phytobioactives From Plants, Their Compositions And Original Constituents, Natural Extracts; Specific Process Development Require High Performing Technology Such As Extraction With Supercritic CO2; Enzymatic Biopurification Or Bioconversion; Characterizing Fraction And Components By Analytical Methods Including HPLC, TLC, Flurometry And Spectrophotometry.
Unit V	Validating Structure And Functional Claims Using An Assay Of Invitro Cell Based And Cell Free Assays Targeted Towards- Cosmatics And Neutraceutical Applications; Some Of Assays Including Antioxidant Activity; Antimicrobial Activity: UV Protection; Antiinflamatery Effects; Skin Cell Regeneration; Antimutagenic Activity; Induction Of Chemopreventive Enzymes.

Course Material/Learning Resources

1. Anita Patil (2020). Phytosecondary metabolites: isolation, characterization and their biological properties. STUDERA PRESS ISBN 978-93-85883-19-4
2. Crozier Alan Et.Al (2013). Plant Secondary Metabolites Occurrence Structure and Role In The Human Diet by Crozier Alan Et.Al, Wiley India Pvt Ltd
3. Mohammed Wasim Siddiqui, Kamlesh Prasad (2016). Plant Secondary Metabolites, Biological and Therapeutic Significance. Volume 1. CRC Press
4. Mohammed Wasim Siddiqui, Vasudha Bansal, Kamlesh Prasad (2016). Plant Secondary Metabolites, Stimulation, Extraction, and Utilization. Volume 2. CRC Press
5. Satish C Bhatla, Manju A. Lal (2019). Plant Physiology, Development and Metabolism. Springer
6. Swapna Thacheril Sukumaran, Shiburaj Sugathan, Sabu Abdulhameed (2020).Plant Metabolites: Methods, Applications and Prospects. Springer

Part B

Syllabus Prescribed for Two Year PG Programme
Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSE-E 1 to 4 BT	**Nanobiotechnology**	30

COs

On successful completion of this course, students should be able to ….

1. Develop a basic scientific concept behind the properties of materials at nanometer scale,
2. Design applications of Nanotechnology inspired from Nature.
3. Formulate methods of Nanomaterial synthesis.
4. Derive information about nanomaterial using different characterization techniques

Unit	Content
Unit I	**Introduction to Bionanotechnology:** Concepts, historical perspective and overview of nanoscale materials; effect of length scale on properties; challenges and opportunities associated with biology on the Nanoscale, Nanotechnology in Nature (Lotus effect, Gecko Effect and Iridescence Phenomena); Biomimetic etc.**(6-periods)**
Unit II	**Nanomaterial Synthesis:** Top-down and bottom-up approach of nanomaterial Synthesis, Different methods of nanomaterial synthesis (Physical, Chemical, Biological and Hybrid), Synthesis of Nanoparticles by Biological system, Extracellular biosynthesis with a case study of silver and gold nanoparticles, Intracellular biosynthesis case by Bacteria.**(6-periods)**
Unit III	**Characterization Techniques:** characterization and analysis of nanoparticles by different techniques such as UV-Visible spectroscopy, Nuclear Magnetic Resonance (NMR), Electron Microscopy (SEM, TEM, STEM) , Probe Microscopy (AFM), X-RD, FTIR, ICP-MS etc.**(6-periods)**
Unit IV	**Applications of nanomaterials :** Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development, Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates. **(6-periods)**
Unit V	**Nanotoxicity** : Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment; Guidelines and Best Practices for Safe Handling of Nanomaterials in Research Laboratories and Industries.**(6-periods)**

Course Material/Learning Resources

1. Gero Decher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature; Wiley-Liss
3. Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press
4. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.nptel.ac.in/noc19_bt28/preview

https://nptel.ac.in/courses/118107015

https://nptel.ac.in/courses/118102003

https://onlinecourses.nptel.ac.in/noc19_mm21/preview

Weblink to Equivalent Virtual Lab if relevant:

https://youtu.be/ebO38bbq0_4

https://youtu.be/Vs5j0CLPHlI

Part B

Syllabus Prescribed for TWO Year UG/PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSE-F 1 to 4 BT	**DNA Fingerprinting**	**30**

COs

Students after completion of this course will be able to…..

1. Learn the basics of DNA Fingerprinting,
2. Use technique of DNA Fingerprinting, Linage markers,
3. Solve problems of DNA fingerprinting,
4. Follow ethics of DNA analysis
5. Carryout DNA analysis and legal aspects
6. Study the classical papers and case study with an outcome to learn the presentation of case studies.

DNA Fingerprinting, applications and legal aspects

Unit	Content
1.	**RFLP base DNA Fingerprinting** History of DNA profiling, RFLP based DNA profiling, multilocus probes, locus specific probes, applications in Forensic science¸ advantages and disadvantages of RFLP based DNA profiling
2.	**PCR based DNA Fingerprinting** PCR STR based DNA profiling, Automation in detection of PCRSTR profile, classification of STR, history of STR for DNA profiling, STR profiling used for sex determination, problems of Amelogenin markers, advantages and disadvantages of STR based DNA profiling, problems of DNA profiling.
3.	**Linage markers** Lineage marker: mt DNA, method of mt DNA analysis, Y-STR profiling, methodology for Y STR analysis, Y STR database and its application, technique, Applications of lineage markers. Problems of Linage markers.
4	**DNA analysis: Legal system, application of database, ethics and social implication** DNA and Legal system in India, Indian DNA bill, DNA fingerprinting database, Combined DNA Indexing System (CODIS). Forensic genetics and ethical, legal and social implications
5	**Case studies using DNA analysis** Atleast 4 case studies for DNA analysis using research papers e.g Czar Nicohlas II case, Prince Branciforte Barresi, Anna Anderson case etc

Course Material/Learning Resources

1. Gill et al (1985) Forensic application of DNA Fingerprints. Nature 318, 577.
2. Jefferys et al (1985) Individual specific DNA fingerprints of Human DNA. Nature 316, 76.
3. Jefferys et al (1985) Positive identification of an immigration test case using human DNA fingerprints. Nature 317,818.
4. Jefferys et al (1985) Hypervariable Minisatellite regions in human DNA Nature, 314, 67
5. Rogave et al (2008) Genomic identification in the historical case of the Nicholas II royal family, PNAS www.pnas.org/cgi/content/full/ 0811190106/DCSupplemental
6. Clobel et al (2009) The Identification of the Two Missin g Romanov Children Using DNA Analysis, Plos 4, e4838
7. Wayman and White (1980) A highly polymorphic locus in human DNA, Proc. Nati. Acad. Sci. USA Vol. 77, No. 11, pp. 6754-6758,
8. An Introduction to Forensic Genetic (2007) William Goodwin ed
   John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England
9. DNA Technology in Forensic Science DNA Technology in Forensic Science
10. Mildred K Cho and Pamela Sankar (2004) Forensic genetics and ethical, legal and social implications beyond the clinic, Nat Genet. 2004 November ; 36(11 Suppl): S8–12.

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
	DSE-G 1 to 4	
BT	**Vaccine**	30 **hrs**

COs

The course is intended to provide an overview and current developments in different aspects of vaccine biotechnology

On completion of this course, students should be able to gain knowledge about

• Conventional and new generation vaccines;

• Adjuvants, immunomodulators and modern vaccine delivery systems.

Unit	**Content**
Unit I	Vaccine types & design History of vaccines, Types of vaccines: Conventional vaccines; Live, attenuated and killed vaccines; New generation vaccines; Subunit vaccines; Synthetic peptide vaccines; Anti-idiotype vaccines; Recombinant DNA vaccines; Deleted mutant vaccines; Reassortment vaccines; Marker vaccines; DNA vaccines; Edible vaccines, Virus like particles, Core like particles, Design of Microneedles Formulations for Vaccine Delivery
Unit II	Immune response to vaccination Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.
Unit III	Vaccine Technologies New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).
Unit IV	Safety of Vaccines Standardization of vaccines; Safety, sterility and potency testing

Recommended Textbooks and References:

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immuno Biology: the Immune System in Health and Disease*. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby Immunology*. New York: W.H. Freeman.
3. Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
DSE-H 1 to 4 BT	**IPR**	**30**

Cos

On completion of this course, students would be able to:

1. Formulate the rationale for and against IPR and especially patents;
2. Derive IPR Policy of India and be familiar with broad outline of patent regulations;
3. Compose different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;
4. Build knowledge of different types of IPR in general related with Biotechnology in particular.
5. Develop ability to file different types of IPR..

Unit	Content
Unit I	**Introduction to IPR :** Introduction to intellectual property; types of IP: patents, trademarks,copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of'prior art': invention in context of "prior art"; patent databases - country-wise patent searches(USPTO, EPO, India); analysis and report formation(.**6-periods)**
Unit II	**Patenting:** Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.**(9-periods)**

Course Material/Learning Resources

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
4. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.
5. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies, MIT Press
6. World Trade Organisation. http://www.wto.org
7. World Intellectual Property Organisation. http://www.wipo.int
8. International Union for the Protection of New Varieties of Plants. http://www.upov.int
9. National Portal of India. http://www.archive.india.gov.in
10. National Biodiversity Authority. http://www.nbaindia.org

Web link to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.nptel.ac.in/noc22_hs59/preview

https://onlinecourses.nptel.ac.in/noc21_mg96/preview

GUIDELINES FOR EVALUATION OF STUDENTS AND PAPER SETTERS

1. The medium of Instructions and for examination shall be English.
2. The pattern of question paper for external evaluation of all DSC having 3 credits will be broadly based on the following pattern:
    a. MCQ - 20 Questions - multiple choice questions from the entire course syllabus for one mark each.
    b. The syllabus has been divided into units equal to the number of questions to be answered in the paper. In each unit, there will be a question either a long answer type or a short answer type.
    c. The number of questions will be in accordance with the unit prescribed in the syllabi for each course i.e. there will be one question on each unit.
    d. For every question long answer type or short answer type there will be an alternate choice from the same unit. However, there will be no internal choice in a question.
    e. The division of marks between long answer and short answer type questions will be in the ratio of 40 and 60.
    f. Each short type question shall contain 4 to 6 short sub-questions with no internal choice.

3. Evaluation of AEC III (Critical Analysis of Classical Papers)
   Students may be divided into groups and each group may be responsible for one classical paper. Each weekthere may be a 1.5-hour presentation cum discussion for each of the papers. At the end of the semester, each student will be asked to write a mini-review (2-3 pages long) on any one classical paper, other than the one he/she presented/discussed.

4. The internal marks assigned to each course shall be awarded on the basis of continuous evaluation
    a. At the beginning of each semester, every teacher shall inform his/her students unambiguously about the method he/she proposes to adopt a scheme of marking for internal assessment.
    b. The teacher shall announce the schedule of activities for the internal evaluation in advance in consultation with the Head of the Department.
    c. Normally the teacher concerned may conduct three written tests spread periodically during the semester and award the marks on the test on passing any two tests.
    d. The internal marks shall be displayed on the notice board within one week and the answer sheet shall be shown to the student. Grievances if any, of the student regarding Internal Assessment marks shall be settled by the Head of Department in consultation with the concerned teacher.
    e. Final submission of internal marks to the University shall be before the commencement of the theory examination.

5. The question should be based on Bloom's Taxonomy levels of (a) Remembering (b) Understanding (c) Application (d) Analysis.

Remember: -

Skill Demonstrated	Question Ques / Verbs for tests
• Ability to recall information like facts, conventions, definitions, jargon, technical terms, classifications, categories, and criteria ability to recall methodology and procedures, abstractions, principles, and theories in the field • Knowledge of dates, events, places. • Mastery of subject matter	List, define, describe, state, recite, recall, identify, show, label, tabulate, quote, name, who, when where, etc.

Understand: -

Skill Demonstrated	Question Ques / Verbs for test
• Understanding information grasp • meaning • translate knowledge into new context inter- • pret facts, compare, contrast order, group, • infer causes predict consequences •	Describe, explain, paraphrase, restate, associate, contrast, summarize, differentiate interpret, discuss.

Apply: -

Skill Demonstrated	Question Ques / Verbs for test
•• Use information use methods, concepts, laws, theories in new • situations solve problems using required skills of knowledge • Demonstrating correct usage of method or procedure	Calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, experiment, show, examine, modify.

Analysis: -

Skill Demonstrated	Question Ques / Verbs for test
• break down a complex problem into parts. Identi- fy the relationships and interactionsbetween the • different parts of the complexproblem.	Classify, outline, break down, categorize, analyse,dia-gram, illustrate, infer, select.

Evaluation (Judging)Analysis: -

Skill Demonstrated	Question Ques / Verbs for test
Evaluation questions encourage students to de-velop opinions and make valuable decisions about issues based on specific criteria	. Assess, Critique, Determine, Evaluate, Judge, Justify, Measure & Recommend **Examples of questions:** ● "How could you select...?" ● "How could you prove...?" ● "How would you prioritize...?" ● "What information would you use to support...?"

Synthesis (Creating)

Skill Demonstrated	Question Ques / Verbs for test
These questions encourage students to create something new by using a combination of ideas from different sources to form a new whole	. Arrange, Combine, Create, Design, Develop Formulate, Integrate & Organize **Examples of questions:** ● "What could be changed to improve...?" ● "How would you test...?" ● "What way would you design...?" ● "What outcome would you predict for...?"

The Weightage of marks should be given preferably in the range of :

(a)	Remembering	10 to 20%
(b)	Understanding	30 to 45%
(c)	Application	30 to 45%
(d)	Analysis	10 to 20%
(e)	Evaluation (Judging)	10 to 15%
(f)	Synthesis (Creating)	10 to 15%
		100 to 160%

Types of Questions: -

a) Multiple Choice Question (M.C.Q.): -

1. **Relevant content:** The question should be based on relevant and important content.
2. **Application of knowledge, not only theory:** The question tests the application of knowledge, and does not only test how the candidate recalls isolated theoretical facts.
3. **Focused questions and homogeneous answers:** The question focuses on one relevant aspect of the topic, and all proposed answers belong to the same content dimension (i.e., diagnosis, causes, management decisions, etc.)
4. **Clear and unambiguous answer:** The best answer clearly stands out. Avoid "correct" answers with existing controversial doctrines.
5. **Appropriate level of difficulty (50% -90% correct answers):**

   Too difficult - even the best candidates need to guess

   Too easy - weak candidates get a "present"

6. **Unambiguous, concise, and simple phrasing:** Avoid trick questions and double negatives. Use only common abbreviations, short sentences, etc.

   Avoid imprecise qualifications (often, usually, etc.)

7. **Avoid clues:**

   Clues can help candidates guess the correct answer. Examples are:

- One answer is much more detailed than the others
- Only one answer follows grammatically from the stem • Non-logical order of the answers

General strategies

- **Test comprehension and critical thinking, not just recall**
  Ask MCQ so as to interpret facts, evaluate situations, explain cause and effect, make inferences, and predict results.

- **Use simple sentence structure and precise wording**

Write test questions in a simple structure that is easy to understand. And try to be as accurate as possible in your word choices. Words can have many meanings depending on colloquial usage and context.

- **Use familiar language.**

The question should use the same terminology that was used in the course. Avoid using unfamiliar expressions or foreign language terms, unless measuring knowledge of such

language is one of the goals of the question. Students are likely to dismiss distracters with unfamiliar terms as incorrect.

- **Place most of the words in the question stem**

While using a question stem, rather than an entire question, ensure that most of the words are in the stem. This way, the answer options can be short, making them less confusing and more legible.

- **Avoid giving verbal association clues from the stem in the key.**

If the key uses words that are very similar to words found in the stem, students are more likely to pick it as the correct answer.

- **Avoid trick questions**

Questions should be designed so that students who know the material can find the correct answer. Questions designed to lead students to an incorrect answer, through misleading phrasing or by emphasizing an otherwise unimportant detail of the solution, violate this principle.

- **Avoid negative wording**

Students often fail to observe negative wording and it can confuse them. As a result, students who are familiar with the material often make mistakes on negatively worded questions. In general, avoid having any negatives in the stem or the options. In the rare cases where you use negatives be sure to emphasize the keywords by putting them in upper case, and bolding or underlining them.

- **Avoid double negatives**

Don't use combinations of the words like not, no, nor, the -un prefix, etc in the same question.

- **Make the choices grammatically consistent with the stem.**

Read the stem and each of the choices aloud to make sure that they are grammatically correct.

- **As far as possible, keep all answer choices of the same length**.

This can be difficult to achieve, but expert test-takers can use answer length as a hint to the correct answer. Often the longest answer is the correct one. When one can't get all four answers to the same length, two short and two long can be used.

- **Place the choices in some meaningful order.**

When possible, place the choices in numerical, chronological, or conceptual order. A better-structured question is easier to read and respond to.

- **Randomly distribute the correct response.**

- The exam should have roughly the same number of correct answers that are a's, b's, c's, and d's (assumingthere are four choices per question)

- **Avoid using "all of the above"**

If "all of the above " is an option and students know two of the options are correct, the answer must be "all of the above". If they know one is incorrect, the answer must not be "all of the above". A student may also read the first option, determine that it is correct, and be misled into choosing it without reading all of the options.

- **Avoid using "none of the above"**

The option "none of the above" does not test whether the student knows the correct answer, but only that he/she knows the distracters aren't correct.

- **Refrain from using words such as always, never, all, or none.**

Most students know that few things are universally true or false, so distracters with these words in them canoften be easily dismissed.

- **Avoid overlapping choices**

Make the alternatives mutually exclusive. It should never be the case that if one of the distracters is true, another distractor must be true as well.

- **Avoid questions of the form "Which of the following statements is correct?"**

There is no clear question being asked, and the choices are often heterogeneous. Such questions are better presented in the form of True/ False questions.

- **Instruct students to select the "best answer" rather than the "correct answer"**

By doing this, you acknowledge the fact that the distracters may have an element of truth to them and discourage arguments from students who may argue that their answer is correct as well.

Designing stems

- **Express the full problem in the stem.**

When creating the item, ask yourself if the students would be able to answer the question without looking at the options. This makes the purpose of the question clear.

- **Put all relevant material in the stem.**

Do not repeat each of the alternative information that can be included in the stem. This makes options easier to read and understand, and makes it easier for students to answer the question quickly.

- **Eliminate excessive wording and irrelevant information from the stem.**

Irrelevant information in the stem confuses students and leads them to waste time.

Designing alternatives

- **Limit the number of alternatives.**

Use between three and five alternatives per question. Research shows that three choice items are about as effective as four or five-choice items, mainly because it is difficult to come up with plausible distracters.

- **Make sure there is only one best answer.**

Avoid having two or more options that are correct, but where one is "more" correct than the others. The distracters should be incorrect answers to the question posed in the stem. **Make the distracters appealing and plausible.**

All of the wrong answer choices should be completely reasonable. If the distracters are farfetched, students will too easily locate the correct answer, even if they have little knowledge. When testing for recognition of key terms and ideas keep the distractors similar in length and type of language as the correct solution. When testing conceptual understanding, distractors should represent common mistakes made by students.

. b) Short Answer (SA) descriptive 2 - 3 marks as applicable)

A short answer question as the term indicates is one to which a brief answer can be given. When the students are required to give a brief and precisely defined response, the suitable type is the restricted response questions. The specific form of the answer should also be indicated, e.g., List, Define, Give a reason, etc. While framing a question requiring a short answer it should be ensured that:

1. The statement constituting the question is simple, clear, and unambiguous.
2. The scope of the answer is limited.
3. The direction given in the question is clear.
4. The question constitutes a valid testing situation for the ability under consideration
5. The question is likely to be interpreted in the same way by teachers/ students/ examiners.
6. The question does not require further restructuring.

b) Long Answers (LA) (10marks)

Long Answer (LA)

As the term indicates a long answer question is the one that needs a comprehensive explanation incorporating different ideas. The question should require the student to organize his ideas, choose the form of his answer, and answer in his own words. While framing a question requiring a long answer it should be ensured that:

1. The situation presented in the question is not new to most of the students.
2. The student will not be able to produce the full, memorized answer.
3. The question involves the use of judgment on the part of the student.
4. The answer can be completed within the limited time given.
5. The length and the scope of the answer are specified.