BANGALORE UNIVERSITY

DEPARTMENT OF LIFE SCIENCE

Jnana Bharathi Campus
Bengaluru – 560 056.

Syllabus for

V & VI semester of Five Year Integrated B. Sc.- M.Sc.

Programme in

B I O L O G I C A L S C I E N C E S

Framed according to the National Education Policy (NEP 2020)

AUGUST 2023

Submitted by

Department of Life Science

Jnana Bharathi Campus

Bangalore University

Bengaluru

BANGALORE UNIVERSITY
DEPARTMENT OF LIFE SCIENCE

PROCEEDINGS OF THE MEETING OF BOARD OF STUDIES IN LIFE SCIENCE, FIVE YEARS INTEGRATED BIOLOGICAL SCIENCES AND ONE YEAR PG DIPLOMA IN CEART, HELD ON 11th AUGUST 2023 AT 11.00 AM IN THE CHAMBER OF THE CHAIRMAN, DEPARTMENT OF LIFE SCIENCE, BANGALORE UNIVERSITY, BENGALURU-560 056.

BOS Members Present :	Signature
INTERNAL MEMBERS	
1. **Dr. Shivashankar. M** Professor Dept. of Life Science, BUB	11/8/23
2. **Dr. Rajanna. L** Professor Dept. of Botany, BUB	11/08/23
3. **Dr. Usha Anandhi. D** Professor Dept. of Zoology, BUB	11/8/23
4. **Dr. Harini. B. P** Professor Dept. of Zoology, BUB	Harini. B. P 11/8/23
5. **Dr. Sreepriya. M** Professor Dept. of Microbiology & Biotechnology, BUB	11/8/23
6. **Dr. Manjunath N. H** Professor Dept. of Biochemistry, BUB	— Absent —
EXTERNAL MEMBERS	
7. **Dr. Nagaraja** Professor Dept. of Applied Zoology Kuvempu University, Shimoga-577451	11/08/2023
8. **Dr. Satish. S** Professor Dept. of Microbiology, University of Mysore, Manasagangothri, Mysore- 570 006.	11/8/23
9. **Dr. Devaraju. K. S** Professor Dept. of Biochemistry, Karnatak University, Dharwad-580001	11/8/23
10. **Dr. Harman D. Souza** Professor Dept. of Biotechnology, Manipal University, Manipal.	— Absent —

At the outset the Chairman welcomed the members of BOS in Life Science, Five years Integrated B. Sc. – M. Sc. Biological Sciences and One Year PG Diploma in Clinical Embryology and Assisted Reproductive Technology discussed on the following agenda and resolved accordingly.

1. **Approval of V and VI semester syllabus for Five years Integrated B. Sc. - M. Sc. Biological Sciences (NEP Scheme):**

The BOS Chairman placed the syllabus pertaining to V and VI Semester of Five Years Integrated B. Sc.- M. Sc. Biological Sciences (NEP scheme). After relevant discussion with modifications BOS members unanimously approved the V and VI semester syllabus which is effective from academic year 2023-24.

BOE - CHAIRMAN
Department of Life Science
Bangalore University
Bangalore - 560 056

Integrated UG/ Curriculum and Credit Framework for for Undergraduate/Postgraduate Programme in a multidisciplinary or interdisciplinary subject such as Biological Sciences, Life Sciences, Molecular Biology, Computer Applications, Data Analytics, etc.

Sem.	Discipline Specific – Core (DSC), Elective (DSE) Courses (Credits) (L+T+P)	Minor/ Multidisciplinary/ Open Elective (OE Courses (Credits) (L+T+P)	Ability Enhancement Courses (AEC)(Credits) (L+T+P) (Languages)	Skills Enhancement Courses (SEC) (Credits) (L+T+P)/ Value Added Courses (Credits) (L+T+P) (common for all UG Programs)/ Summer Internship.		Total Credits
I	DSC-C1(4), C2(2), C3(4), C4(2).	OE-1 (3)	L1-1(3), L2-1(3) (4 hrs each)	**SEC-1**: Digital Fluency (2) (1+0+2)/ Env. Studies (3)	Health, Wellness & Yoga (2) (1+0+2)	25/26
II	DSC-C5(4), C6(2), C7(4), C8(2).	OE-2 (3)	L1-2(3), L2-2(3) (4 hrs each)	Env. Studies (3)/ SEC-1: Digital Fluency (2) (1+0+2)	Sports/NCC/NSS/R&R(S&G)/ Cultural (2) (0+0+4)/ SEC (2)	26/25
III	DSC-C9(4), C10(2), C11(4), C12(2).	OE-3 (3)/ India and Indian Constitution (3)	L1-3(3), L2-3(3) (4 hrs. each)	**SEC-2**:AI/Cyber Security/Financial Edu. & Inv. Aw. (2) (1+0+2)	Sports/NCC/NSS/R&R(S&G)/ Cultural (2) (0+0+4)/ SEC (2)	25
IV	DSC-C13(4), C14(2), C15(4), C16(2).	India and Indian Constitution (3)/ OE-3(3)	L1-4(3), L2-4(3) (4 hrs. each)	**SEC-3**: Financial Edu. &Inv. Aw. /AI /Cyber Security (2) (1+0+2)	Sports/NCC/NSS/R&R(S&G)/ Cultural (2) (0+0+4)/ SEC (2)	25
V	DSC-C17(4), C18(2), C19(4), C20(2),	DSE-E1(3), E2(3)	Vocational-1(3)	**SEC-4**: Job Skills (3) (2+0+2)		24
VI	DSC-C21(4), C22(2), C23(4), C24(2),	DSE-E3(3), E4(3).	Vocational-2(3).	Internship (2)		23
	Disciplines/Inter-disciplines without research		Disciplines/Inter-disciplines with Research			
VII	DSC-C25(4), C26(2), C27(4), C28(2); Res. Methodology (4)	DSE-E5(3), Vocational-3(3)	DSC-C25(4), C26(2), C27(4), C28(2); Res. Methodology (4)	DSE-E5(3), Vocational-3(3) Res. Proposal formulation (2*)		22
VIII	DSC-C29(4), C30(2), C31(4), C32(2); Internship/Entrepreneurship (4)	DSE-E6(3), Vocational-4(3)	DSC-C29(4).	DSE-E6(3), Vocational-4(3) Research Project (10+2*)		22
IX	DSC-C33(4), C34(2), C35(4), C36(2); C37(4), Res. Proposal formulation (2*)	DSE-E7(3), Vocational-5(3).	DSC-C30(2), C31(4), C32(2), C33(4); C34(2), C35(4),	DSE-E7(3), Vocational-5(3),		22/24
X	Research Internship (4), Research Project (16+2*)		DSE-E8(3), E9(3), Research Internship (4), Research Project (10)			22/20
Students successfully completing the program will be awarded M.Sc. integrated Degrees in a Multidisciplinary or Interdisciplinary subject, upon securing 216 credits and satisfying the minimum credit requirements under each category of courses prescribed						

Note: Only those students who secure 75% marks or CGPA of 7.5 and above in the first six semesters may choose to undertake research in the fourth year.
A relaxation of 5% of marks or an equivalent relaxation of grade, may be allowed for those belonging to SC/ST/OBC (non-creamy layer)/Differently-Abled, Economically Weaker Section (EWS) and other categories of candidates as per the UGC guidelines.

Vice Chairman
Karnataka State Higher Education Council
Bengaluru - 09

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Program Outcomes

5 Years integrated B.Sc.-M.Sc. Biological Sciences (NEP Scheme) students will be able to:

PO1	**Domain Knowledge:** Comprehensive and detailed understanding of Plant and Animal Sciences.
PO2	**Problem Analysis:** Sense of enquiry and reasoning with the knowledge required to design, execute, and analyze the results of multidisciplinary biological experimentations in animal and plant model systems.
PO3	**Design and development of solutions:** Design and develop innovative solutions for society and environmental issues.
PO4	**Conduct investigations of complex problems:** Design experiments and investigate complex problems and problems specific research areas.
PO5	**Interdisciplinary learning:** Understanding of interdisciplinary relationship between cellular, molecular, and biochemical aspects of Life Sciences
PO6	**Modern Tool Usage:** To apply statistical and computational knowledge for the analysis high dimensional Genomics, Proteomics and Metabolomics data.
PO7	**Ethics:** Biological aptitude and Biosafety awareness
PO8	**Project Management:** Demonstrate planning and execution of research projects as a part of curriculum.
PO9	**Teamwork:** Collaborate efficiently and work with multidisciplinary teams
PO10	**Environment and Sustainability:** Develop understanding of how biological sciences affect broad societal issues including health and disease, food and natural resources, environmental sustainability, etc.
PO11	**Communication:** Honing of Communication skills required in the discipline including oral presentations of research data, published research articles, projects.
PO12	**Life Long Learning:** Students develop the ability to successfully continue with further studies and research in the field of Biological Sciences and allied subjects. Curriculum prepares students for the competitive exams like GATE/UGC-CSIR NET.

Internship for graduate Programme (As Per UGC & AICTE)

Course title	Internship Discipline specific
No of contact hours	90
No credits	2
Method of evaluation	Presentations/Report submission/Activity etc.,

- Internship shall be Discipline Specific of 90 hours (2 credits) with a duration 4-6 weeks.
- Internship may be full-time/part-time (full-time during semester holidays and part-time in the academic session)
- Internship mentor/supervisor shall avail work allotment during 6^{th} semester for a maximum of 20 hours.
- The student should submit the final internship report (90 hours of Internship) to the mentor for completion of the internship.
- The detailed guidelines and formats shall be formulated by the universities separately as prescribed in accordance to UGC and AICTE guidelines.

V – SEMESTER								
Code	Subject	Paper Theory/ Practical	Instruction Hrs/week	Duration of Exam (Hrs)	Marks			Credits
					IA	Exam	Total	
BS 501 T	Molecular Biology (DSC)	Theory	4	2½	40	60	100	4
BS 502 P	Molecular Biology (DSC)	Practical	4	4	25	25	50	2
BS 503 T	Microbiology (DSC)	Theory	4	2½	40	60	100	4
BS 504 P	Microbiology (DSC)	Practical	4	4	25	25	50	2
BS505 T	Developmental Biology (DSE)	Theory	3	2½	40	60	100	3
BS 506 T	Plant and Animal Pathology (DSE)	Theory	3	2½	40	60	100	3
BS 507 T	Instrumentation Techniques in Biological Sciences (Vocational)	Theory	3	2½	40	60	100	3
BS 508 T	Job Skills: Vermi Technology (SEC)	Theory/ Practical	3	1½	20	30	50	3
						Total	**650**	**24**

VI - SEMESTER								
Code	Subject	Paper Theory/ Practical	Instruction Hrs/week	Duration of Exam (Hrs)	Marks			Credits
					IA	Exam	Total	
BS 601 T	Genetic Engineering (DSC)	Theory	4	2½	40	60	100	4
BS 602 P	Genetic Engineering (DSC)	Practical	4	4	25	25	50	2
BS 603 T	Immunology (DSC)	Theory	4	2½	40	60	100	4
BS 604 P	Immunology (DSC)	Practical	4	4	25	25	50	2
BS 605 T	Plant and Animal Reproduction (DSE)	Theory	3	2½	40	60	100	3
BS 606 T	Parasitology (DSE)	Theory	3	2½	40	60	100	3
BS 607 T	Biostatistics (Vocational)	Theory	3	2½	40	60	100	3
BS 608 P	Internship	Practical	2		20	30	50	2
	Students who want to exit after 3- years / undertake 3- year UG programme will be awarded B. Sc. Degree in Biological Sciences, upon securing 136 credits and satisfying the minimum credit requirements under each category of courses prescribed.				**TOTAL**		**650**	**23**

V SEMESTER

V SEMESTER - BIOLOGICAL SCIENCES
BS 501 T: MOLECULAR BIOLOGY

Program Name	B.Sc., Biological Sciences
Semester	V
Course Title	Molecular Biology (DSC)
Course Code	BS 501T
No. of Credits	4
Contact Hours	60 Hours
Duration of SEA/Exam	2½ Hours
Formative Assessment Marks	40
Summative Assessment Marks	60

Course Outcomes:

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

1. Acquire knowledge about recent developments and model organisms in the field of Molecular Biology.
2. The course provides comprehensive understanding of DNA and RNA structures.
3. Familiarize with the structure, organization and function of the genetic material at the molecular level in prokaryotes and eukaryotes.
4. Understand the mechanisms of DNA replication, transcription and translation both in prokaryotes and eukaryotes.
5. The course emphasizes the key concepts of post translational modifications.

	CONTENTS	**60 Hrs**
UNIT I	**INTRODUCTION TO MOLECULAR BIOLOGY**	**15 Hrs**
	• Central dogma of Molecular Biology. • Model organisms in the study of molecular biology: *Escherichia coli, Saccharomyces, Arabidopsis, Caenorhabditis elegans, Drosophila, Mus musculus, Homo sapiens.* • DNA as the genetic material: DNA as a storehouse of information, genes are mutable units, topology of nucleic acids, isolation of NAA/DNA. • Chromosomal DNA and its packaging: the structure of prokaryotic and eukaryotic chromosomes, chromatin and nucleosomal organization, DNA packing in several layers, nucleosomal remodeling • Recombination: breakage and reunion of heteroduplex DNA, Holliday junction	
UNIT II	**DNA REPLICATION AND REPAIR**	**15 Hrs**
	• The replicon, unit of replication • Rolling circle model of DNA replication. • Replication in Prokaryotes: initiation, elongation, termination and regulation. Apparatus for DNA replication: DNA polymerases, Okazaki fragments, leading and lagging strand synthesis, common events in priming replication at origin, methylation regulating initiation at origin), DNA polymerase I, II, III, IV and V, helicase, DNA ligase, DNA topoisomerase. • Replication in eukaryotes: Eukaryotic DNA polymerases, mechanism of replication. • DNA damage and repair mechanisms: DNA damage- Mechanisms involved in damage, Repair mechanisms-Direct repair, Miss-match repair assay for mismatch repair, Base excision repair (BER), Nucleotide excision repair (NER), SOS and Rec-A.	

UNIT III	TRANSCRIPTION AND POST-TRANSCRIPTIONAL MODIFICATIONS	15 Hrs
	• Transcription complex: promoters, factors, RNA polymerases. • Transcription in prokaryotes and Eukaryotes: Initiation-elongation-termination of transcription. • Transcription factors and their functions: zinc-fingers, helix-loop-helix, leucine zippers, homeo domains, steroid receptors. • Inhibitors of transcription. • Post transcriptional modifications of m-RNA, t-RNA and r-RNA. • Apparatus for nuclear splicing: spliceosome and lariat formation, alternative splicing, self-splicing by group I introns. Gene silencing.	
UNIT IV	**TRANSLATION AND GENE REGULATION**	**15 Hrs**
	• Genetic code: General features of Genetic code. • Mechanism of protein synthesis: initiation, elongation and termination in Prokaryotes and eukaryotes. • Inhibitors of protein synthesis. • Post-translational modifications of proteins. • Histone modifications: Acetylation of histone tails, Identification of histone acetyl transferases (HATs), Chromatin remodelling • Gene regulation: Gene regulation in prokaryotes (lactose and Tryptophan operon), gene regulation in eukaryotes, RNA interference.	

Pedagogy for theory and practical:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Formative Assessment Occasion/Type	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	**40**

V SEMESTER - BIOLOGICAL SCIENCES
BS 502 P: MOLECULAR BIOLOGY (PRACTICAL)

Program Name	B.Sc., Biological Sciences
Semester	V
Course Title	Molecular Biology (Practical)
Course Code	BS 502P
No. of Credits	2
Contact Hours	60 Hours
Duration of SEA/Exam	4 Hours
Formative Assessment Marks	25
Summative Assessment Marks	25

CONTENTS	
MOLECULAR BIOLOGY (PRACTICAL)	**60 Hours**
1. Isolation of nucleic acids from plants (young leaves, *Allium cepa*) and animals (butterfly or silkworm larva, adult Uzi fly, *Drosophila* larva) by: a. CTAB and b. SDS-Proteinase K method. 2. Isolation of plasmid DNA from bacterial culture. 3. Extraction of total RNA from bacterial culture. 4. Separation of nucleotide bases by paper chromatography. 5. Estimation of DNA content by Diphenylamine (DPA) method. 6. Estimation of RNA by Orcinol method. 7. Estimation of protein by Bradford method. 8. Agarose gel electrophoresis of DNA and RNA. 9. Polyacrylamide gel electrophoresis of proteins	

Formative Assessment	
Formative Assessment Occasion/Type	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/ Field Visits/ Experimental Documentation/ Record	5
Class performance / Participation/Attendance	5
Total Formative Assessment Marks	**25**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (Pos)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	-	3	-	3
CO2	3	3	2	3	3	-	-	3	-	2	-	3
CO3	3	2	3	3	2	-	-	2	-	3	-	3
CO4	2	1	1	2	-	-	-	-	-	1	-	2
CO5	2	1	1	2	-	-	-	-	-	1	-	2

Recommended Readings:

1. Experiments In Microbiology, Plant Pathology and Biotechnology. KR Aneja. 2022. New Age international Publishers. 6th edition.
2. Karp's Cell and Molecular Biology. Gerald Karp, Janet Iwasa & Wallace Marshall. 2019. Wiley publication. 9th edition.
3. Molecular Biology of the Cell. Alberts, B., Johnson, A., Raff, M., Robert, K., Walter, P. 2016. Garland Sciences, NY, 6th edition.
4. Molecular Biology Lab Manual. David NG. 2022. University of British Columbia. https://www.bioteach.ubc.ca › uploads › 2021/11
5. Molecular Biology. Lodish, Berk, Zipursky, Matsudaira, Baltimore & Darnell. 2016. Freeman Press. 8th edition.

V SEMESTER - BIOLOGICAL SCIENCES
BS 503 T: MICROBIOLOGY

Program Name	B.Sc., Biological Sciences
Semester	V
Course Title	Microbiology (DSC)
Course Code	BS 503T
Number of Credits	4
Contact hours	60 Hours
Duration of SEA/Exam	2½ Hours
Formative Assessment Marks	40
Summative Assessment Marks	60

Course Outcomes:

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

1. To understand microbial growth and metabolism, and the ways to control their growth by physical and chemical means.
2. Familiar with the culture, maintenance & application of microorganisms for economic benefit.
3. To study the interaction and reaction of microbial impacts and role of microorganisms in the environment, Aquaculture and Agriculture.
4. Learn basic concepts which are mandatorily required to get employed in the field of Microbiology.
5. Learn industrial applications of microbiology.

	CONTENTS	**60 Hrs**
UNIT I	**MICROBIAL GROWTH**	**15 Hrs**
	• Microbial taxonomy: Characteristic features and classification of Viruses, Bacteria, Actinomycetes, Micro and macro nutrients, growth factors. • Nutritional types of bacteria. Types of media (simple, complex, special). Isolation, purification, mass culturing, maintenance of microbes. • Effect of environmental factors on microbial growth: Temperature, Moisture, Light, Oxygen. Control of microbial growth (disinfection and sterilization). • Growth kinetics, Growth measurements, Generation time, Growth curve. Aerobic, Anaerobic, Batch, Continuous and Synchronous cultures. Biochemical tests for Identification of Bacteria (IMViC tests).	
UNIT II	**FOOD & DAIRY MICROBIOLOGY**	**15 Hrs**
	• Microbes in food, food spoilage, food preservation, fermented foods, toxins and food poisoning. • General account of Milk and milk products. Microbiology of raw and processed milk. Contamination of milk, source of contamination, Micro flora of milk and milk products. • Microbial spoilage of cereal and cereal products, fruits and vegetables, meat and meat products, fish and sea foods, poultry, packed foods, canned foods, milk and milk products • Microbiological standards for milk and milk products, pasteurization, Methods of preservation of milk and dairy products.	
UNIT III	**AGRICULTURAL MICROBIOLOGY**	**15 Hrs**

	• Introduction: Micro flora of rhizosphere, rhizoplane, and phylloplane. • Biological Nitrogen fixation, Phosphate solubilizing microorganisms such as Arbuscular Mycorrhiza (AM) and Plant Growth Promoting Rhizobacteria PGPR). Application of mycorrhizae and biofertilizers. • Cultivation and mass production of microbial bioinoculants- Species of *Azotobacter*, *Rhizobium*, *Azospirillum* • Microbial Inoculants: Definition and types of biopesticides. Bacterial Biopesticides: *Bacillus thuringiensis*, *B. sphaericus*, *B. popilliae, and Pseudomonas syringae.* Fungal Biopesticides: *Beauveria, Cephalosporium*, and *Trichoderma*). Viral Biopesticides: Nuclear Polyhedrosis virus and Baculovirus). Mode of action of toxins produced by*Bacillus thuringiensis* and *Pseudomonas.* Advantages and limitations of biopesticides.	
UNIT IV	**ATMOSPHERIC AND AQUATIC MICROBIOLOGY**	**15 Hrs**
	• Atmospheric Microbiology: Air borne microbes, Airspora of indoor and outdoor environment. Airborne diseases (Tuberculosis, DPT, Pontiac fever**,** Aspergillosis**,** Coccidioidomycosis, Influenza, SARS, Chicken Pox). Techniques of trapping airborne microorganisms (sedimentation, impaction, impingement, and filtration) and air samplers. • Aquatic Microbiology: Microbes of marine and fresh water, microbes in potable water, Most Probable Number (MPN). • Water borne diseases, water purification, waste water treatment. Sewage disposal and bioremediation.	

Pedagogy for theory and practical:
Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	**40**

V SEMESTER - BIOLOGICAL SCIENCES
BS 504 P: MICROBIOLOGY (PRACTICAL)

Program Name	B.Sc., Biological Sciences
Semester	V
Course Title	Microbiology (Practical)
Course Code	BS 504P
Number of Credits	2
Contact hours	60 Hours
Duration of SEA/Exam	4 Hours
Formative Assessment Marks	25
Summative Assessment Marks	25

CONTENTS	
MICROBIOLOGY (PRACTICAL)	**60 Hrs**
1. Methods of sterilization 2. Study of disinfectants 3. Preparation of media for culturing bacteria, fungi and yeast 4. Isolation and identification of microbes – from soil and plant materials 5. To perform sub-culturing – streaking techniques (Quadrant streaking and T streaking) 6. Staining of microorganisms – Gram staining, Negative staining, staining of fungi. 7. Study of bacterial growth curve 8. Effect of pH, temperature and UV light on bacterial growth. 9. To perform antibiotic resistance assay by Kirby-Bauer method 10. Enumeration of Bacterial colonies method (soil) 11. Microbes of milk and milk products – Standard Plate Count (SPC) and Direct Microscopic count (DMC) 12. Milk quality testing by Methylene blue dye reductase test (MBRT) 13. Measurement of fungi by Micrometry	

Formative Assessment	
Assessment Occasion/Type	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Experimental Documentation/ Record	5
Class performance/ Participation/Attendance	5
Total Formative Assessment Marks	**25**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	-	3	3	3
CO2	3	3	2	3	3	-	-	3	-	2	2	3
CO3	3	2	3	3	2	-	-	2	-	3	3	3
CO4	2	1	1	2	-	-	-	-	-	1	1	2
CO5	2	1	1	2	-	-	-	-	-	1	1	2

Recommended Readings:

1. Alexander N. Glazer, Hiroshi Nikaido, Microbial Biotechnology: Fundamental of applied Microbiology, 2nd Edition, Cambridge University Press, 2007
2. Elmer H. Marth, James L. Steele Applied dairy microbiology, CRC Press, 2001
3. Funke Case Tortora, Cram, Microbiology, Education – 2006
4. Johnson et.al., Microbiology and Immunology, Lippincot Williams & Willkin, NY, 2002.
5. Lansing M. Prescott, John P. Harley, Donald A. Klein, Microbiology, Science, 2001
6. Lynne I et.al., Microbiology for health careers, Thomson Delmer Learning, NY, 1999.
7. McCormick T, Essentials of Microbiology, Research & Education, NJ, 1998.
8. P. D. Sharma, Environmental microbiology, Science, 2005
9. Pelczar, Microbiology, Tata McGraw-Hill. 1998
10. Roger Y. Stanier, General microbiology, Science, 1987
11. Schelegel, H.G., General Microbiology, Cambridge University Press, London, 1996.
12. Thomas D. Brock, Michael T. Madigan, Biology of Microorganisms, Science, 10th edition
13. Waites M, Morgan N, Industrial Micro Biology, Blackwell Science, London, 2001.

V SEMESTER - BIOLOGICAL SCIENCES
BS 505 T: DEVELOPMENTAL BIOLOGY

Program Name	B.Sc., Biological Sciences
Semester	V
Course Title	Developmental Biology (DSE)
Course Code	BS 505T
Number of Credits	3
Contact hours	45
Duration of SEA/Exam	2½ Hours
Formative Assessment Marks	40
Summative Assessment Marks	60

Course Outcomes:

After the successful completion of the course, the student will be able to:
1. To understand the concepts in Developmental biology
2. To understand the early embryonic development and regeneration process.
3. To understand the developmental pathways in plants.
4. To understand the similarities and dissimilarities in the developmental patterns of monocot and dicot plants.
5. Learn reproductive patterns in plant development.

	CONTENTS	45 Hrs
UNIT I	**INTRODUCTION TO DEVELOPMENTAL BIOLOGY AND EMBRYONIC DEVELOPMENT**	**15 Hrs**
	• Introduction**:** Reproductive patterns **-** Parthenogenesis, Asexual reproduction (budding, fission, fragmentation), Sexual reproduction (Conjugation, oviparity, viviparity, ovo-viviparity). • Fertilization, Cleavage and its types, Blastulation, Gastrulation (frog & chick) organogenesis. • Concept of cell type determination, competence and differentiation. • Organizer concept**:** Primary organizer, formation of the neural tube and regions of the brain. • Metamorphosis**:** Concepts of metamorphosis, Types, Abnormal regulations, Neuroendocrine control of metamorphosis in insects and amphibians. • Regeneration**:** Cellular process, regulation and physiological changes during regeneration in planarians and amphibians. Factors affecting regeneration.	
UNIT II	**GAMETOGENESIS IN PLANTS**	**15 Hrs**
	Development of Gametophyte: Introduction. • Microsporogenesis : Development of anther (Microsporangium), Anther wall structure and development- epidermis, endothecium, middle layers, tapetum, Sporogenous tissue. Development of Microspores or Pollen grains, structure of pollen grain (microspore), unusual pollen tetrads. • Microgametogenesis: Dehiscence of anther and dispersal of developing pollen, pollination, types and their characteristics. Post pollination development of male gametophyte- formation of male gametes. Development of Female Gametophyte: Introduction.	

	Ovule – types, structure and development. Development of female gametophyte- Megasporogenesis, Megagametogenesis. Types and development of Female Gametophyte/Embryo sac. Structure of mature embryo sac, Embryo sac haustoria. Apomixis: A brief account.	
UNIT III	**FERTILIZATION AND EMBRYOGENY**	**15 Hrs**
	• Introduction: Pre-fertilization developments- Post pollination events; Pollen germination, Pollen tube growth, Path of Pollen tube, Pollen tube discharge Syngamy and Double Fertilization, Post Fertilization developments. Endosperm Development, Structure and Types of Endosperm. Physiology and cytology of endosperm, functions of endosperm and endosperm haustoria. • Classification of Embryogeny, early embryogenesis and structure of mature embryo of *Capsella bursa pastoris* (dicotyledon) and *Najus lacerata* and grass embryo (monocotyledon).	

Pedagogy:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	**40**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	-	3	3	3
CO2	3	3	2	3	3	-	-	3	-	2	2	3
CO3	3	2	3	3	2	-	-	2	-	3	3	3
CO4	2	1	1	2	-	-	-	-	-	1	1	2
CO5	2	1	1	2	-	-	-	-	-	1	1	2

Recommended Readings:

1. Balinsky.B.L. 1971. Introduction to Embryology (Saunders College pub.)
2. Carlson.B.M. 1998 Pattern's foundations of Embryology (Mc Graw Hill publications: New York)
3. Gilbert S.F. 2006 Developmental Biology 8th edn. (Sinquer Associates Publications, Sunderland
4. Stack. J.M.W. 1983 From Egg to Embryo: Determinants events in early development (Cambridge University Press)
5. Allard, R.W. 1999. Principles of Plant Breeding . John Wiley and Sons. New York.
6. Singh.B.D.1995. Plant Breeding- Principles and Methods. Kalyani Publishers, New Delhi.
7. Bhojwani, S.S., S.P. and P.K. Dantu, P.K. (2015). The Embryology of Angiosperms. Vikas Publishing House Pvt Ltd, New Delhi.
8. Singh, V., Pande, P.C. and Jain, D.K. (2012-13). Structure, Development and Reproduction in Angiosperms. Rastogi Publications, Meerut.

V SEMESTER - BIOLOGICAL SCIENCES
BS 506 T: PLANT AND ANIMAL PATHOLOGY

Program Name	B.Sc., Biological Sciences
Semester	V
Course Title	Plant and Animal Pathology (DSE)
Course Code	BS 506T
Number of Credits	3
Contact hours	45
Duration of SEA/Exam	2½ Hours
Formative Assessment Marks	40
Summative Assessment Marks	60

Course Outcomes:

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

1. Learn central concepts of disease and mechanism of disease causing organisms
2. Be familiar with terminologies used in description of plant pathology
3. Understand, learn, and appreciate life-cycles of selected pathogens, their effects on the host, resistance of hosts, and the various control and eradication methodologies.
4. Key concepts of animal pathology
5. Current updates on plant and animal pathogenesis.

	CONTENTS	45 Hrs
UNIT 1	**INTRODUCTION TO PLANT AND ANIMAL PATHOLOGY**	**15 Hrs**
	• Plant Pathology: History and principles of plant pathology, Concept, Description, Diagnosis and cycle terminology of disease, Importance of plant diseases. Life-cycle strategies of plant pathogens, host-pathogen interactions and co-evolution. • Animal Pathology: History and principles of animal pathology, Etiology, course and termination of disease.	
UNIT II	**STUDY OF PLANT AND ANIMAL PATHOGENESIS**	**15 Hrs**
	• Plant Pathogenesis: Study of Oomycetes, Ascomycetes, Basidiomycetes as disease causing agents. Disease cycle, host resistance, gene for gene concept, disease management with special emphasis on biological control. • Animal Pathogenesis: Terminologies (Degenerations, infiltration, necrosis), endogenous and exogenous pigmentations associated with animal pathology, circulatory and growth disturbances, reversible and irreversible cell injuries, different types of inflammation with special emphasis on chemical mediators.	
UNIT III	**STUDY OF PLANT AND ANIMAL DISEASES**	**15 Hrs**
	• Bacterial, Viral and Nematode pathogens of plants: Life cycle of selected pathogens affecting agricultural crops (Beans, tomato, rice, grapes, citrus, groundnuts, Ladies finger, tobacco). Integrated management of diseases by cultural, chemical, biological and host resistance method, importance of plant quarantine in disease management. • Fungal, viral and bacterial diseases of animals including disease management: Foot & mouth diseases of cattle, bird flu, mastitis in cattle, Grasserie, Flacherie, Muscardine, Pebrine (in silkworm and economically important insects), cocciodiosis, scrapie, brucellosis, Q fever, marine white spot disease.	

Pedagogy:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion/ type	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	**40**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	3	-	3	3
CO2	3	3	2	3	3	-	-	3	2	-	2	3
CO3	3	2	3	3	2	-	-	2	3	-	3	3
CO4	2	1	1	2	-	-	-	-	1	-	1	2
CO5	2	1	1	2	-	-	-	-	1	-	1	2

Recommended Readings:

1. Agrios GN. Plant pathology, 6th Edition, Elsevier academic press; 2005
2. Barger, Anne M., and Amy L. MacNeill, Clinical pathology and laboratory techniques for veterinary technicians. John Wiley & Sons, 2015.
3. F.E.G. Cox ed., Modern Parasitology, Blackwell Publishing, 1993.
4. G.L.Schumann & C.J. D'Arcy, Essential Plant Pathology, 2nd edition, 2009
5. George N. Agrios, Plant pathology, 5th edition, Elsevier academic press, 2000
6. JD Smyth, An Introduction to Animal Parasitology, 3rd edition, CUP, 1994
7. K. Starr Chester, Nature and prevention of plant diseases, 2006
8. R.S.Singh, Plant pathogens, Oxford and IBH publishing co., 1994
9. S.H. Gillespie & P.M. Hawkey ed. Medical Parasitology – A Practical Approach, OUP,1995

V SEMESTER - BIOLOGICAL SCIENCES
BS 507 T: INSTRUMENTATION TECHNIQUES IN BIOLOGICAL SCIENCES

Program Name	B.Sc., Biological Sciences
Semester	V
Course Title	Instrumentation Techniques in Biological Sciences (Vocational)
Course Code:	BS 507T
No. of Credits	3
Contact hours	45 Hours
Duration of SEA/Exam	2½ Hours
Formative Assessment	40
Summative Assessment Marks	60

Course Outcomes:

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

1. To familiarize the students about instruments used in biological laboratory.
2. To understand the principle and mechanism of bio-instruments.
3. To learn the applications for modern biological analysis.
4. In depth understanding of working of microscopes.
5. Key concepts of different types of Electrophoresis and chromatographic Techniques.

	CONTENTS	45 Hrs
UNIT I	**MICROSCOPY & CENTRIFUGATION**	**15 Hrs**
	• **Microscopy**: Magnification and resolution of microscopes, components of light microscope. • Working principles and applications of microscopy: light, dark field, phase contrast, fluorescence microscopy, TEM, SEM, AFM, confocal microscopy, microtomy, ultramicrotomy, cryomicroscopy. • **Centrifugation Techniques**: Principle of sedimentation, types of rotors • Types- Ultracentrifugation, analytical centrifugation, density gradient centrifugation and preparative centrifugation. • Precautions and safety aspects/measures.	
UNIT II	**pH METER AND ELECTROPHORESIS**	**15 Hrs**
	• **pH meter** and its applications • **Electrophoretic Techniques**: General principle, effect of heat, electroendosmosis. • Support media (agarose and polyacrylamide gels), agarose gel electrophoresis of DNA and RNA, southern and northern blot transfer, PFGE (brief introduction to CHEF), Native PAGE, SDS-PAGE, Urea PAGE, gradient gels, isoelectric focusing, capillary electrophoresis, SSCP, DGGE.	
UNIT III	**CHROMATOGRAPHY AND SPECTROSCOPY**	**15 Hrs**
	• **Chromatography**: Principle, Apparatus, Distribution coefficient, selectivity factor. • Theoretical plates, peak broadening and resolution. • Types: Normal and reverse phase liquid chromatography, ion exchange, molecular exclusion, affinity chromatography, paper chromatography, Gel filtration chromatography, TLC, HPTLC, HPLC, GC. • **Spectroscopy**: Principles of Electromagnetic waves and their interaction with matter, theory and applications of CD, UV-VIS, IR, Raman, FRET and Applications	

Pedagogy:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	40

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	3	1	3	3
CO2	3	3	2	3	3	-	-	3	2	3	2	3
CO3	3	2	3	3	2	-	-	2	3	2	3	3
CO4	2	1	1	2	-	-	-	-	1	3	1	2
CO5	2	1	1	2	-	-	-	-	1	3	1	2

Recommended Readings:

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. Biochemistry. 6th Ed. Freeman, New York, 2006.
2. Cotterill, R. M. J. Biophysics: An Introduction, John Wiley & Sons, England, 2002.
3. Drenth, J. Principles of protein X-ray crystallography, 3rd Ed. Springer, Germany, 2007.
4. Garrett, R. H. and Grisham, C. M., Biochemistry, 3rd Ed. Brooks/Cole, Publishing Company, California, 2004.
5. Harrison, R.G., Todd, P., Rudge, S.R. and Petrides, B.B. Bioseparations: Science and Engineering, Oxford University Press, 2006.
6. Keeler, J., Understanding NMR Spectroscopy, John Wiley & Sons, England, (2002).
7. McHale, J.L., Molecular Spectroscopy, Prentice Hall, 1998.
8. Marimuthu, R., Microscopy and Micro techniques. MJP Publishers, 2008.
9. Mount, D. W., Bioinformatics: sequence and genome analysis, Cold Spring Harbor Laboratory Press, New York, 2001.
10. Nölting, B., Methods in Modern Biophysics. 2nd ed, Springer, Germany, 2006.
11. Pattabhi, V. and Gautham, N., Biophysics, Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi, 2002.
12. Robyt, John F. White, Bernard J. Biochemical Techniques: Theory and Practice Waveland Press, Inc., U.S.A. Published: 1990.
13. Wilson Keith and Walker John., Principles and Techniques of Biochemistry and Molecular Biology 6th Ed. Cambridge University Press, New York, 2005.

V SEMESTER - BIOLOGICAL SCIENCES
BS 508 T: VERMI TECHNOLOGY

Program Name	B.Sc., Biological Sciences
Semester	V
Course Title	Vermi Technology (SEC 4)
Course Code:	BS 508T
No. of Credits	3
Contact hours	45 Hours
Duration of SEA/Exam	1½ Hours
Formative Assessment	20
Summative Assessment Marks	30

Course Outcomes:

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

1. To understand about the earthworm, the major component of vermicomposting
2. To provide an overview of the process of using earthworms to decompose organic waste
3. To familiarize the students regarding problems and prospects of vermicomposting
4. Key concepts of commercial vermicomposting.
5. To understand the economics and advantages of vermicomposting.

	CONTENTS	45 Hrs
UNIT I	**INTRODUCTION TO VERMICULTURE**	**15 Hrs**
	• Morphology & Anatomy: Earthworms – Taxonomic position, external features- shape, size, colour, segmentation, setae and clitellum. Body wall, coelom, locomotion, digestive, circulatory, respiratory, excretory and nervous system. • Biology: Reproductive system- Male & Female, copulation, cocoon formation & fertilization, development of earth worm. • Habitat Ecology: Burrowers, casts, nocturnal, poikilothermal, ecological grouping – Epigeic species, Endogeic species and Anecics. • Diversity of species: Detailed study of *Lumbricus*	
UNIT II	**CONVENTIONAL AND COMMERCIAL COMPOSTING**	**15 Hrs**
	• Methods of Vermicomposting: Small- and large-scale Bed method, tank method, roof shed method, static pile windrows, top fed windrows, wedges and bin method, harvesting the compost, storage, Vermiwash-Preparation and application. • Nutritional composition of Vermicompost: Nutritional composition of vermicompost for plants, comparison with other fertilizers. Natural Enemies of Earthworms and mechanical death of worms during agri-practices. • Vermiwash: Extraction and processing. Benefits of vermiwash	
UNIT III	**ECONOMICS AND PROSPECTS OF VERMICOMPOSTING**	**15 Hrs**
	• Future perspectives: Predator / pathogen control in wormeries; Potentials and constraints of vermiculture in India. • Effect of vermicompost application on soil and plant growth: vermicompost as a organic manure and a good substitute of fertilizers. Influence of pests and microbes on vermiculture, control measures. Vermiculture and Vermicomposting, Advantages of Vermicomposting, Chemical composition of	

	vermicompost. Vermicomposting in everyday life earthworms and vermicomposting at commercial scale.	

Pedagogy:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	10
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	5
Class performance/ Participation/Attendance	5
Total Formative Assessment Marks	**20**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	3	1	3	3
CO2	3	3	2	3	3	-	-	3	2	3	2	3
CO3	3	2	3	3	2	-	-	2	3	2	3	3
CO4	2	1	1	2	-	-	-	-	1	3	1	2
CO5	2	1	1	2	-	-	-	-	1	3	1	2

Recommended Readings:

1. Aravind Kumar. 2005.Verms & Vermitechnology, A.P.H. Publishing Corporation, New Delhi.
2. Bhatnagar and Patla. 2007. Earthworm vermiculture and vermin-composting, Kalyani Publishers,New Delhi.
3. Jordan and Verma,2009. Invertebrate Zoology, Chand & Company Ltd.
4. Mary Violet Christy. 2008. Vermitechnology. MJP Publishers, Chennai.
5. Sultan Ahmed Ismail. 2005. The Earthworm Book. Other India Press, Goa, India. 2nd revised edition.

VI SEMESTER

VI SEMESTER - BIOLOGICAL SCIENCES
BS 601 T: GENETIC ENGINEERING

Program Name	B.Sc., Biological Sciences
Semester	VI Semester
Course Title	Genetic Engineering (DSC)
Course Code	BS 601T
No. of Credits	4
Contact hours	60 Hours
Duration of SEA/Exam	2½ Hours
Formative Assessment Marks	40
Summative Assessment Marks	60

Course Outcomes:

1. Mastering the skills of various techniques and tools for genetic manipulation of plant and genomes.
2. Provide an understanding of the ethics and patent rights associated with gene manipulation.
3. Student's exposure to the recent advances and ethics in the field of Genetic Engineering.
4. Acquire good knowledge on topics which could be applied in research fields of Life Science.
5. Key concepts of gene cloning and expression

	CONTENTS	**60 Hrs**
UNIT 1	**TOOLS OF GENETIC ENGINEERING**	**15 Hrs**
	• Introduction: Scope and importance of genetic engineering. • Enzymes in Genetic Engineering: Restriction endonucleases, DNA- and RNA Ligase, Phosphatases and kinases, DNase (DNase-I) and RNases (RNase A, H), S1- and Micrococcal nuclease, double and single stranded exonucleases. DNA Polymerases and RNA polymerases (Klenow fragment), template independent RNA polymerases, Topoisomerase. • Vectors: Plasmids (pBR322, pUC19/18, Ti), phage vectors, cosmids, phagemids, shuttle vectors, ARS, mini chromosomes, BACs, PACs, YACs. • Expression vectors: PET vectors, expression of proteins in bacteria, yeast, plants and animal cell lines by vectors.	
UNIT II	**GENE CLONING AND EXPRESSION**	**15 Hrs**
	• Various techniques and strategies used in gene cloning in prokaryotes (*E. coli*) and eukaryotes (*S. cerevisiae*), Linkers and Adaptors. Gene transfer methods: • Transformation in bacteria and yeast, transfection into plant and animal cells, selection of recombinant cells, expression of recombinant proteins. Construction of genomic and cDNA libraries, Selection of probes and labeling, Colony and plaque screening. • Applications of Recombinant DNA Technology: GMO (Bt cotton, golden rice, tomato, corn, brinjal, cow, sheep, poultry, fish). Gene therapy: rationale, types and gene therapy vectors (viral, non-viral), drawbacks of gene therapy. Clinical trials and outcomes.	

UNIT III	PCR AND DNA SEQUENCING	15 Hrs
	• PCR types/variants of PCR – Real time PCR, Reverse transcription PCR, Nested PCR, colony PCR, Multiplex PCR and inverse PCR. Applications of PCR. Gel electrophoresis- AGE and PAGE. Blotting techniques- DNA, RNA, protein. • Dideoxy and chemical methods of DNA Sequencing, automated sequencing, synthetic oligonucleotides. Next Generation Sequencing (NGS): Steps of NGS, NGS Methods: MPSS, Pyrosequencing, Ion semiconductor sequencing, Illumina sequencing, Nanopore sequencing, SMRT sequencing. Applications of DNA sequencing.	
UNIT IV	**BIOETHICS, BIOSAFETY AND IPR**	**15 Hrs**
	• Introduction to ethics: Ethics codes. Human subject research: history and standards; federal regulation of research, protection. Human Genome project: Ethical implications of Human Genome Project. Genetics and ethics: privacy and confidentiality, discrimination and commercialization, ethics in animal experimentation, ethical issues in human organ transplantation and xenotransplantation, ethics in food and drug safety. Environmental release of microorganisms and genetically engineered organisms. • Biosafety- Biosafety management. Biosafety regulation- national and international guidelines on rDNA technology. Cartagena protocol on biosafety. • Introduction to IPR. Patents-Gene Patenting, Trademarks, Copyrights, Industrial Designs, Geographical Indications. Future Developments of Intellectual Property Rights	

Pedagogy for theory and practical:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion/ type	Marks
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/ Field Visits/ Seminar.	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	40

VI SEMESTER - BIOLOGICAL SCIENCES
BS 602 P: GENETIC ENGINEERING (PRACTICAL)

Program Name	B.Sc., Biological Sciences
Semester	VI Semester
Course Title	Genetic Engineering (Practical)
Course Code	BS 602P
No. of Credits	2
Contact Hours	60 Hours
Duration of SEA/Exam	4 Hours
Formative Assessment	25
Summative Assessment	25

CONTENTS	
GENETIC ENGINEERING (PRACTICAL)	**60 Hrs**
1. Isolation of DNA/RNA/Plasmid from bacteria 2. Isolation of DNA/RNA from animal and plant sources 3. Restriction digestion analysis 4. Ligation of restricted fragments 5. PCR amplification study using thermal cycler and analysis of the products 6. RAPD- Random Amplified Polymorphic DNA 7. Preparation of competent *E.coli* cells 8. Cell disruption techniques 9. Solid-liquid separation methods: Sedimentation, Filtration, Centrifugation 10. Micro injection and transformation 11. Fibroblast culture from chick embryo 12. *Agrobacterium* mediated transformation	

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/ Field Visits/ Experimental Documentation/ Record	05
Class performance/ Participation/Attendance	05
Total Formative Assessment Marks	**25**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	3	1	3	3
CO2	3	3	2	3	3	-	-	3	2	3	2	3
CO3	3	2	3	3	2	-	-	2	3	2	3	3
CO4	2	1	1	2	-	-	-	-	1	3	1	2
CO5	2	1	1	2	-	-	-	-	1	3	1	2

Recommended Readings:

1. DNA Sequencing and Gene Cloning: An introduction. Pallav Singh, Deepak Sharma, Rahul Singh Thakur, Lambert Academic Publisher, 2012.
2. Furrow B, Greaney T, Johnson S, Jost T. Bioethics: Health Care Law and Ethics. West Academic Press; 6th edition, 2008.
3. Genes VIII by Benjamin Lewis. Oxford University & Cell Press, 2004.
4. Genetic Engineering Vol. 4, Williamson Edition, Academic Press Inc. Ltd, 1983.
5. Intellectual property rights: innovation, governance and the institutional, Birgitte Andersen, Law – 2006
6. Introduction to Genetic Engineering by Nicholl. Cambridge Low Price Edition, 2012.
7. IPR, Biosafety and Bioethics by Goel D, Parashar S. Pearson Publisher, 2013.
8. Molecular cloning Volumes I, II and III. Sambrook J et al (1989, 2000). Cold Spring Harbor laboratory Press, New York, USA.
9. Molecular Diagnostics: Current research and Applications. Jim Huggett and Justin O'Grady, 2014.
10. Next Generation Sequencing. Steven R Head, Phillip Ordoukhanian, Daniel R Salomon, 2018.
11. PCR: Theory and Technology. Mark A.Behlke, Tom Brown, et al., 2019.
12. Principles of gene manipulation - An introduction to genetic engineering, Old R.W., Primrose S.B., Blackwell Scientific Publications, 1993.
13. Recombinant DNA by James D.Watson, Scientific American Books, 1992.
14. Vectors: A survey of molecular cloning vectors and their uses. Rodriguer and Denhardt,Butterworth Publishers, Stoneham, Massachusetts, 1989

VI SEMESTER - BIOLOGICAL SCIENCES
BS 603 T: IMMUNOLOGY

Program Name	B.Sc., Biological Sciences
Semester	VI Semester
Course Title	Immunology (DSC)
Course Code:	BS 603T
No. of Credits	4
Contact hours	60 Hours
Duration of SEA/Exam	2½ Hours
Formative Assessment	40
Summative Assessment Marks	60

Course Outcomes:

1. Introduce the students to the central concepts of immunity and immune system.
2. Familiarize the students with mechanisms of immune action & immunological dysfunction.
3. Make the student understand, learn, and appreciate immunological techniques & their application.
4. Key concepts of humoral and cellular immunity
5. A perspective on the clinical immunology

	CONTENTS	**60 Hrs**
UNIT I	**INTRODUCTION TO IMMUNOLOGY**	**15 Hrs**
	• Historical account; Types of infection and nature of infectious agents, immunity. • Cells of the immune system: Haematopoiesis, Lymphocytes- their origin, differentiation and functions: B-Lymphocytes, T lymphocytes, antigen presenting cells (APC) - macrophages, dendritic cells and NK cells, Granulocytes. • Organs of the immune system: Primary and secondary lymphoid organs. • Nonspecific host defense mechanisms: Innate immunity, Anatomical, physical and physiological barriers; lysozyme and other antimicrobial agents. • Phagocytosis: Mechanisms of phagocytosis (oxygen dependent and oxygen independent); PRR and PAMPs, Acute phase response, TLRs and significance. • Acquired immunity, Types of immune responses; mechanism of immune response. Effector mechanisms of immunity, • Antigens: Types and classification; Factors affecting antigenicity.	
UNIT II:	**TYPES OF IMMUNITY**	**15 Hrs**
	• Types: Humoral and cellular immunity. Humoral immunity: B-lymphocytes and their activation. Structure and function of immunoglobulins; immunoglobulin classes and subclasses, genetic control of antibody production, idiotypes and idiotypic antibodies. • Complement system: System and its biological functions; Major pathways of complement activation (Classical, alternate and lectin pathway). • Cellular immunity: Thymus derived lymphocytes (T cells) their classification, TCR, Co-stimulatory molecules, CD-28 and CTLA 4 and Antigen presentation. • Major histocompatibility complex: HLA-1 and HLA-2, structure and functions. Processing and presentation of antigens by HLA-1 and HLA-2. Polymorphisms of HLA complex. Linkage disequilibrium. Regulation of	

	expression of HLA-1 and 2. • Immunosuppression, immune tolerance. Significance of immunological tolerance in prevention of autoimmunity.	
UNIT III	**CLINICAL IMMUNOLOGY**	**15 Hrs**
	• Immunohematology: Blood groups, Blood transfusion and Rh incompatibilities. • Mechanism: T cell activation, cytokines and their role in immune response; Leukocyte migration, homing and trafficking. Inflammation; hypersensitivity of macrophage activation and granuloma formation, immune regulations, immune response to infectious organisms, vaccines. • Autoimmunity: Auto-antibodies in humans, pathogenic mechanisms, experimental models of auto immune diseases, treatment of auto immune disorders. • Tissue transplantation: Auto -, iso-, allo- graft rejection, evidence and mechanism of graft rejection, prevention of graft rejection, tissue typing, immunosuppressive drugs, HLA and disease. • Tumour immunology: Tumour antigens, mechanisms of immunity to tumour antigens, Immunodiagnosis of tumours and cancer immunotherapy.	
UNIT IV	**IMMUNOTECHNIQUES AND THEIR APPLICATIONS**	**15 Hrs**
	• Antigen- antibody interactions: Affinity and avidity, determination of affinity and avidity constants. Principle, procedure and applications of Immunoprecipitation. Immunodiffusion (Ouchterlony Double diffusion, Single Radial Immunodiffusion, Immunoelectrophoresis), Neutralisation, agglutination, Complement fixation, immunofluorescence, RIA, ELISA micro–ELISA Techniques. • Polyclonal and monoclonal antibodies: Applications in disease diagnosis, Production of monoclonal antibodies by hybridoma technology, • Vaccines: Types and application, Common vaccination schedule in India.	

Pedagogy for theory and practical:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	**40**

SEMESTER VI - BIOLOGICAL SCIENCE
BS 604 P: IMMUNOLOGY (PRACTICAL)

Program Name	B.Sc., Biological Sciences
Semester	VI Semester
Course Title	Immunology (Practical)
Course Code	BS 604P
No. of Credits	2
Contact Hours	60 Hours
Duration of SEA/Exam	4 Hours
Formative Assessment	25 Marks
Summative Assessment	25 Marks

CONTENTS	
IMMUNOLOGY (PRACTICAL)	**60 Hrs**
1. Study of Blood groups: ABO typing. 2. Separation of serum from blood samples. 3. Isolation and enumeration of lymphocytes using haemocytometer. 4. Partial purification of IgG from serum by ammonium sulphate fractionation method. 5. Flocculation test: VDRL test. 6. Agglutination test: Widal test. 7. Immunodiffusion tests: Ouchterlony double immunodiffusion method (ODD) and Single Radial immunodiffusion (SRID). 8. Demonstration of ELISA/Dot ELISA. 9. Immunoelectrophoresis: IEP, Counter current IEP & Rocket IEP. 10. Western Blotting technique.	

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/ Field Visits/ Experimental Documentation / Record	05
Class performance/ Participation/Attendance	05
Total Formative Assessment Marks	**25**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	3	1	3	3
CO2	3	3	2	3	3	-	-	3	2	3	2	3
CO3	3	2	3	3	2	-	-	2	3	2	3	3
CO4	2	1	1	2	-	-	-	-	1	3	1	2
CO5	2	1	1	2	-	-	-	-	1	3	1	2

Recommended Readings:

1. Abdul K. Abbas, Andre K. Lightman, Jordan S. Pober, Cellular and Molecular Immunology, 7th edition, 2012.
2. Benjamini, E., Coico, R., and Sunshine, G., Immunology a short course, 4th edition. Wiley-Lisst, New York, 2000.
3. David Male, R. Stokes Peebles, Victoria Male., Immunology, 9th edition, Elsevier, 2021.
4. Delves, Martin, Burton & Roitt, Essential Immunology, 12th edition, Wiley-Blackwell, 2011.
5. Klaus D. Elger , Immunology-understanding of Immune system. Wiley-Liss. NY, 1996.
6. Kuby Owen., Punt Sstanford., Immunology, 7th edition, Mac Milan, 2013.
7. Manzoor Ahmad Mir., Basics and Fundamentals of Immunology, 1st Edition, Nova Biomedical Publishers, New York, USA, 2020.
8. Martin F. Flajnik., Nevil J. Singh., & Steven M. Holland., Fundamental Immunology, 8th edition, Walters Kluwer, 2022.
9. Tizard, I.R., Immunology, 4th edition, Saunders College Pub, 1995.

VI SEMESTER - BIOLOGICAL SCIENCES
BS 605 T: PLANT AND ANIMAL REPRODUCTION

Program Name	B.Sc., Biological Sciences
Semester	VI
Course Title	Plant and Animal Reproduction (DSE)
Course Code	BS 605T
Number of Credits	3
Contact hours	45
Duration of SEA/Exam	2½ Hours
Formative Assessment Marks	40
Summative Assessment Marks	60

Course Outcomes:

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

1. To understand the fascinating facts of reproduction in plants that plays a key role in applied aspects of Science.
2. To understand its significance and problems.
3. To understand the role of hormones in both male and female reproductive system.
4. To understand the mechanisms involved in animal reproduction.
5. Learn the key concepts of fertilization and reproductive system

	CONTENTS	**45 Hrs**
UNIT I	**INTRODUCTION TO PLANT REPRODUCTION AND**	**15 Hrs**
	• Angiospermic flower: Calyx, corolla, androecium, gynoecium. Reproduction: Types of reproduction: Vegetative (Asexual reproduction): types, advantages and disadvantages. Transition from shoot apex to flowering apex. Specification of floral organs, ABC Model: *Arabidopsis thaliana*, homeotic mutants. • Pollination: Structural adaptations of pollen dispersals, pollen viability, storage and germination, pollen – pistil interaction, genetic control of pollen - pistil interaction and pollen allelopathy. • Pollen sterility: Genetic and cytoplasmic male sterility, chemical induction of male sterility, utilization of male sterility in hybrid seed production.	
UNIT II	**SEX DETERMINATION, DIFFERENTIATION AND REPRODUCTIVE SYSTEM**	**15 Hrs**
	• Sex determination & differentiation**:** Chromosomal sex determination, Accessory reproductive organs and external genitalia (male &female) with suitable examples. • Female Reproductive System**:** Anatomy of the female reproductive system, Ovulation, Corpus luteum, Menstrual cycle and their hormonal regulation. • Male Reproductive System**:** Anatomy of the male reproductive system, Spermatogenesis and hormonal regulation, functions of Sertoli cells and Leydig cells. Functions and process of semen formation.	

UNIT III	FERTILIZATION IN MAMMALS AND CONTROLLING MEASURES	15 Hrs
	• Fertilization**:** Pre-fertilization and post-fertilization events, implantation, gestation, placenta, parturition, mammary glands, lactation and its hormonal regulation. • Fertility control in males and females- Natural methods, barrier methods, intrauterine devices, contraceptive devices. STD's and their control methods. • Infertility**:** Mode of Infertility, *In-vitro* fertilization (IVF), Zygote intra-fallopian transfer (ZIFT), Gamete intra-fallopian tube transfer (GIFT).	

Pedagogy:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	**40**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	3	1	3	3
CO2	3	3	2	3	3	-	-	3	2	3	2	3
CO3	3	2	3	3	2	-	-	2	3	2	3	3
CO4	2	1	1	2	-	-	-	-	1	3	1	2
CO5	2	1	1	2	-	-	-	-	1	3	1	2

Recommended Readings:

1. Bhojwani, S.S., S.P. and P.K. Dantu, P.K. (2015). The Embryology of Angiosperms. Vikas Publishing House Pvt Ltd, New Delhi.
2. Singh, V., Pande, P.C. and Jain, D.K. (2012-13). Structure, Development and Reproduction in Angiosperms. Rastogi Publications, Meerut.
3. Gifford E.M., and Foster, A.S. (1989). Morphology and Evolution of Vascular Plants. W.H. Freeman, New York.
4. Balin. H and Glasser. S, 1976 : Reproductive Biology (Experia Medica Amsterdam)
5. Birkhead. R.T. David J.H and Pitnick S, 2009: Sperm biology-An evolutionary perspective

(Elsevier/ Academic press).
6. Richard E.J.1991. Human Reproductive biology (II Ed) (Academic Press; USA)
7. Schimdi 1971. Biology of Lactation (Academic press: USA)
8. Wooding P & Burton G. 2008. Comparative Placentation; Structure, functions & evolution (Springer).

VI SEMESTER - BIOLOGICAL SCIENCES
BS 606 T: PARASITOLOGY

Program Name	B.Sc., Biological Sciences
Semester	VI
Course Title	Parasitology (DSE)
Course Code	BS 606T
Number of Credits	3
Contact hours	45
Duration of SEA/Exam	2½ Hours
Formative Assessment Marks	40
Summative Assessment Marks	60

Course Outcomes:

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

1. Learn the central concepts of Comparative aspects of symbiosis
2. Be familiar with ecology & evolution of parasites
3. Understand, learn, and appreciate life-cycles of selected parasites representing various phyla, their effects on the host, resistance of hosts, and the various control and eradication methodologies.
4. Understand key concepts of molecular parasitology.
5. Understand clinical management of parasitic diseases.

	CONTENTS	**45 Hrs**
UNIT 1	**INTRODUCTION TO PARASITOLOGY**	**15 Hrs**
	• Comparative aspects of symbiosis, mutualism, commensalism, parasitism. • Types of hosts: Definitive, Intermediate, Paratenic, Accidental, Reservoir host • Types of parasites: Ectoparasites & Endoparasites, Facultative & Obligatory parasites, Pseudoparasites, Occult parasites, Aberrant parasites). • Host-parasite interactions: Hypobiosis, Zoonosis • Vectors, Classification and their role in parasites transmission.	
UNIT II	**EVOLUTION OF PARASITES AND MOLECULAR PARASITOLOGY**	**15 Hrs**
	• Introduction to Parasitic ecology • Parasitic populations (macro & microparasites, population structure, multiple species infections) • Modes of parasitic reproduction (asexual, viviparity, hermaphroditism), • Parasite epidemiology and evolution. Modes of transmission of parasites and methods of dissemination of infective stages of parasites • Molecular mechanisms of susceptibility & resistance, immunity & immune responses, and xenobiotics.	
UNIT III	**LIFECYLE, BIOLOGY, DISTRIBUTION, DISEASE AND CLINICAL MANAGEMENT OF PARASITIC DISEASES**	**15 Hrs**

	• Protozoan parasites: *Entameoba histolytica*, *Plasmodium* sp., *Trypanosoma* sp., *Leishmania* sp. • Helminth parasites: Flat worms, blood flukes, liver flukes, intestinal flukes and lung flukes. • Nematode & arthropod parasites: Hookworms, pinworms, lungworms, root knot nematodes, Ascaris; lice, bugs, fleas, ticks & mites. • Classification, occurrence, biology and management of plant parasites: Cuscuta, Striga, Viscum, Loranthus.	

Pedagogy:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	**40**

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	-	-	2	3	1	3	3
CO2	3	3	2	3	3	-	-	3	2	3	2	3
CO3	3	2	3	3	2	-	-	2	3	2	3	3
CO4	2	1	1	2	-	-	-	-	1	3	1	2
CO5	2	1	1	2	-	-	-	-	1	3	1	2

Recommended Readings:

1. F.E.G. Cox ed., Modern Parasitology, Blackwell Publishing, 1993.
2. G.L.Schumann & C.J. D'Arcy, Essential Plant Pathology, 2nd edition, 2009
3. George N. Agrios, Plant pathology, 5th edition, Elsevier academic press, 2000
4. JD Smyth, An Introduction to Animal Parasitology, 3rd edition, CUP, 1994
5. K. Starr Chester, Nature and prevention of plant diseases, 2006
6. R.S.Singh, Plant pathogens, Oxford and IBH publishing co., 1994
7. S.H. Gillespie & P.M. Hawkey ed. Medical Parasitology – A Practical Approach, OUP,1995

VI SEMESTER – BIOLOGICAL SCIENCE
BS 607 T: BIOSTATISTICS

Program Name	B.Sc., Biological Sciences
Semester	VI
Course Title	Biostatistics (Vocational)
Course Code	BS 607T
No. of Credits	3
Contact Hours	45
Duration of SEA/Exam	2½ Hours
Formative Assessment Marks	40
Summative Assessment Marks	60

Course Outcomes:

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

1. To familiarize the students with applications and analysis of Biostatistics.
2. Acquire knowledge for the design of experiments using biostatistics.
3. Applying concepts to big data in biology (omics technologies and clinical data)
4. To understand the graphs and statistical methods from the standard research articles.
5. Understand key concepts of probability, correlation and hypothesis tests.

	CONTENTS	45 Hrs
UNIT I	**DESCRIPTIVE STATISTICS & SAMPLING**	**15 Hrs**
	DESCRIPTIVE STATISTICS: Introduction to Biostatistics: basic concepts, Data Types, and Presentation, Measures of Central Tendency, Measures of Variability and Dispersion, Measures of Skewness and Kurtosis **SAMPLING**: Sample, Different Sampling techniques: Simple Random Sampling, Stratified Random Sampling, and Systematic Random Sampling techniques. **DESIGN OF EXPERIMENTS:** Terminologies in experimental designs, Principals of an experimental design, Completely Randomized Design(CRD), Randomized Block Design (RBD), Statistical Analysis of CRD and RBD.	
UNIT II	**PROBABILITY DISTRIBUTION AND CORRELATION**	**15 Hrs**
	PROBABILITY AND PROBABILITY DISTRIBUTIONS: Permutations and Combinations, Random Experiment, Sample space, Types of event, the definition of probability, conditional probability, addition, and multiplication rules of probability and some simple problems, Bayes Theorem and Likelihood, Random Variable, Binomial, Poisson and Normal probability distribution, Central limit theorem. **CORRELATION AND REGRESSION ANALYSIS**: Introduction, General Concepts of Simple Linear Regression, Fitting Regression Lines-(Ordinary Least Squares), and non-linear regression. The Pearson's Correlation Coefficient, Spearman's Rank Correlation Coefficient, Statistical Inference for Correlation coefficients	

UNIT III	TESTS OF SIGNIFICANCE	15 Hrs
	STATISTICAL INFERENCE: Population and Sample, Random sample, parameter, and statistics, sampling distribution of sample means, Standard error, Estimation, Confidence interval for means, and proportion. Testing of hypothesis: basic concepts and definitions, types of errors. Relationship between Confidence Intervals and Statistical Significance, Comparison of Mean of two samples (t-distribution), Comparison of mean of three or more samples (F-distribution)-Analysis of variance in One-way classification, Two-way classification. Chi-Square test for goodness of fit and independence of attributes in contingency tables. Normality Tests and Outliers Concepts of Population, Nonparametric statistics, sign test, rank sum test, rank correlation, and Kruskal-Wallis test.	

Pedagogy:

Lecturing, Tutorials, Group/Individual Discussions, Seminars, Assignments, Counseling, Remedial Coaching. Field/Institution/Industrial visits, Hands on training, Case observations, Models/charts preparations, Problem solving mechanism, Demonstrations, Project presentations, Experiential documentation, and Innovative methods.

Formative Assessment	
Assessment Occasion	**Marks**
House Examination/ Test	15
Written assignment/ Presentation/ Project/ Term Papers/Field visits/ Seminars	15
Class performance/ Participation/Attendance	10
Total Formative Assessment Marks	40

Course Articulation Matrix: Mapping of Course Outcomes (Cos) with Program Outcomes (POs)

Program Outcomes (POs) Course Outcomes (COs)/	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	2	3	-	2	3	1	3	3
CO2	3	3	2	3	3	3	-	3	2	3	2	3
CO3	3	2	3	3	2	3	-	2	3	2	3	3
CO4	2	1	1	2	2	2	-	-	1	3	1	2
CO5	2	1	1	2	-	3	-	-	1	3	1	2

Recommended Readings:

1. Stanton Glantz, Primer of Biostatistics, 7th edition (2011), McGraw-Hill Medical. ISBN- 13: 978-0071781503.
2. Motulsky, H. (2014). Intuitive biostatistics: a nonmathematical guide to statistical thinking. Oxford University Press, USA
3. Van Belle, G., Fisher, L. D., Heagerty, P. J., & Lumley, T. (2004). Biostatistics: a methodology for the health sciences (Vol. 519). John Wiley & Sons
4. Le, C. T., & Eberly, L. E. (2016). Introductory biostatistics. John Wiley & Son
5. Wayne W. Daniel and Chad L. Cross. Biostatistics: A Foundation for Analysis in the Health Sciences (2018). ISBN: 978-1-119-49657-1