MAHARSHI DAYANAND SARASWATI UNIVERSITY
AJMER

Syllabus

Scheme of Examination and Courses of Study

Faculty of Science

M.Sc. Biotechnology

(Modular Choice Based Credit System)

(Semester I & II w.e.f. 2023-24 & III & IV w.e.f. 2024-25)

Program of learning: M.Sc. Biotechnology

M.Sc. (Biotechnology) is a program of learning under modular Choice Based Credit System that allows a student exit points after the successful completion of each semester. It comprises 15 different skill honing courses. Students seeking exit, prior to completion of M.Sc., may seek readmission in the concerned semester within a period of two years to complete the program. Minimum requirements for such provision are:

1. Program Duration

1. Semester I (6 months, 22 credits): PG Certificate in Molecular Biology
2. Semester I and II (1 year, 44 credits): PG Diploma in Molecular Biology & Biotechnology
3. Semester I, II and III (1.5 year, 66 credits) PG Diploma in Advanced Biotechnology
4. Semester I, II, III and IV (2 years, 88 credits) M.Sc. Biotechnology

2. **Minimum Eligibility**

2.1 B.Sc./B.Sc. (Hons)/B.Sc. B.Ed. in any discipline of biology or B.Sc. (Ag)/Graduate degree from medical or paramedical sciences/Graduate degree in Liberal Arts with any discipline of biology/B. Tech. (Biotechnology/Biochemical Engineering/Agricultural Engineering) with min. 50% marks

2.2 Relaxation in Minimum Qualifying Marks for the SC, ST and Persons with Disabilities Categories: 5%

3. **Criteria for Selection of Students for Admission:** Merit list as per the rules in prospectus

4. Program Objectives

The Master's Program in Biotechnology is a program of learning of that fulfills the aims to

- Prepare the students to occupy any work situation related to biotechnology and allied subjects.
- Use pedagogy that would allow the student to put up his/her best foot forward in all walks of life.

5. **Pedagogy**

The M.Sc. Biotechnology program at MDS University, Ajmer follows choice based credit system, semester system and modular system in its true spirit. Student has freedom of learning at his/her own pace to complete the degree in two years at a stretch or in a modular system wherein specific courses may be learnt in 6 months/1 year or 1.5 year and successful candidates may obtain PG Certificate in Molecular Biology and Biodiversity/PG Diploma in Molecular Biology & Biotechnology/Advanced PG Diploma in Biotechnology with an option to return back to continue their education within 2 years of having obtained these certificate/diplomas.

Other than traditional chalk and board lectures, pedagogy includes ICT based teaching and Socratic seminars to discuss topics in groups. Later allows them to assimilate knowledge through discussions and working together.

Flip learning is conducted on resources that are made available online through microsphere.wooqer.com. Online classes are conducted for specific needs. Innovation and incidental learning is provided through short term and long term scientific and society centered projects. Such project based learning enables computational thinking: decomposing (breaking down into smaller bits) the problem, recognising patterns (looking for similarities between and within problems), abstracting (taking the details and leaving the outliers), generalizing (adapting the solution to other problems) and forming algorithm (framing the rules to solve similar problems) through reflective thinking.

It also incorporates elements of crossover learning i.e. learning by seeing, feeling and interacting through field trips; enhancing skills and innovating through trainings and workshops (learning by doing). Inspirational lectures of eminent microbiologists and biotechnologists are organized in the *Atreya* series of lectures. *Madhavkar* Awareness campaign opens up an interface with the society. Communication skills are enhanced through seminars and popular writings in the form of a Wall magazine: Zoom-In.

Pedagogy promotes participation and responsibility by entrusting duties for the laboratories, and maintenance of the germplasm and cultivation systems. The department is open 24x7 for laboratory/project works.

6. Program Outcome

The students will learn Biotechnology and allied subjects to the extent that the knowledge and skills learnt may be used in industries, institutes and offices. Students will have practical skills in using tools, technologies and methods common to biotechnology and allied sciences.S/he will learn ethics of research and safety in laboratories.

The student will learn skills for specific technologies through projects, experiments and training/workshops. This exercise is to boost the self-confidence and enhance the abilities to

- discuss a problem or subject
- assimilate and conclude the discussion
- carry out a complete scientific work process independently using appropriate statistical design and tools
- critically evaluate methods and interpret results
- Communicate scientific information to the general public and fraternity of biotechnologists by writing well-structured reports and scientific publications and making posters and oral presentations
- use ICT for learning, organizing and analyzing data and presenting the information
- solve problems through computational thinking
- learn through seeing, experiencing, interacting and doing
- interact and give back to the society through trusteeship
- working as a team member and team leader

7.1. **Employment**

The alumni of the Department are Entrepreneurs, Regulatory and Quality Specialists, Operation specialists, managers, research and development officers, quality controllers and microbiologists in reputed biotechnology, microbiology, food and dairy, biopolymer, beverage and hospitality industries viz. Ortho Clinical Diagnostics, Melbourne Australia, Biobig Healthcare Solutions Pvt Ltd, Chandigarh, Shankarpack Poland, Ranbaxy, Reliance Life Science, J Mitra Diagnostics, Thermo Fisher Scientific, Glaxo, Dominos, Redico, Cadila Pharma, CottonConnect, Sun Pharma, Dabur Pharma, IPCA, Usha Remedies, SABMiller, Zydus Cadila, Vikas WSP, Taj Hotels, Coke, Bisleri and Pepsi.

Many are scientists and professors in renowned institutes such as the National Institute of Virology Pune, All India Institute of Medical Sciences, New Delhi, Central University of Rajasthan Bandarsindri, **Duke University Medical Centre Durham USA , Texas State University, University of Texas, RMIT University Melbourne Australia**, Central University of Haryana Mahendragarh, MGS University Bikaner, College of Horticulture & Forestry Jhalawar, CDFST, MP University of Ag & Tech, Udaipur, Agriculture University Jodhpur, Defence Research lab Tezpur, National Center for Polar and Ocean Research, Vasco da Gama, Ministry of Food Processing Industries, GOI, New Delhi and Forensic Science Department, Kota.

Two of the alumni joined the Indian Air Force, some opted for Rajasthan Public Services while many others are managers in banks viz. Canara Bank, Central Bank of India, Bank of Baroda, Union Bank of India, Rajasthan Gramin Bank, Rajasthan Cooperative Bank, Indian Bank, Sarva Haryana Gramin Bank and SBI.

7.2.**Progression to higher education**

Several students joined M Phil or PhD or Postdoctoral research at International and national institutes viz. IISc Bangalore, IISER Pune, RMIT University Melbourne, National Centre for Cell Science, Pune, National Chemical Laboratory Pune, Defence lab Jodhpur, IIT Jodhpur, CAZRI Jodhpur, CDRI Lucknow, IITR Lucknow, NIO Goa, IARI Delhi, IIT Delhi, NII Delhi, CSIR-IGIB Delhi, Defence lab Gwalior, Defence lab New Delhi, IISER Mohali, BITS Pilani, BISR Jaipur, FRI Dehradun, NDRI Karnal, NDDB Anand and Universities: DU & JNU, New Delhi; BHU, Varanasi;

GBPU A&T, Pantnagar; MSU, Vadodara, PU Chandigarh CUoR, MDSU, Ajmer JLNT U, Hyderabad, KGMU, Lucknow. There is a record of87 students that qualified for National level tests such as NET, GATE and SLET**.**

8. **Definitions and Credit Requirements**

8.1 An educational programme leading to the award of a Degree, Diploma or Certificate is a Program of Learning.

8.2 A course is a component of a program of learning which was earlier called 'paper'. It may comprise lectures/tutorials/laboratory work/field work/outreach activities/project work/vocational training/viva/seminars/term papers/assignments/presentations/ e-content/ self-study etc. or a combination of some of these.

8.3 Courses are categorized as

1. **Core Course**-Series of essential and fundamental courses without which the certificate/diploma/degree cannot be awarded,

2. **Elective Course**-Generic (Elective courses that may be opted in any other department/discipline and Discipline specific (Elective courses offered by the department i.e., within discipline)

3. **Foundation Course**- 1 or 2 credit compulsory or elective courses that are for personality development, soft skill development, improvement of physical and mental health, social and environmental consciousness, appreciation of art/literature, or subjects that may interest students of other disciplines etc.) and

4. **Skill enhancement courses** including training and workshops that may be assigned credits, assessed and graded.

8.4 Credit is a unit by which the course work is measured. It determines the number of hours of instructions required per week.

8.5 Credit is assigned to a particular course with due regard to specific Learning Outcomes, Educational Components and Workload requirements including 1 hour/week of tutorials. It also includes 10 minutes of discussion for each credit.

8.6 Each course may be of different size and credit, making it easier for specialists to set the question paper and allow students to pick specific courses and add on to their desired scheme of specialization. Experiments taking longer time do not get extra weightage based on duration.

	Credits	**Time (h/week)**	**Total hours/Semester**
Lecture	1 L	1	15-17
Tutorial	1 T	1	15-17
Practical/Field work/Short project /Laboratory work	1 P	3*	45-51
*1P credit includes 1h tutorial and 2h of laboratory/practical exercise and/or demonstrations			
Project work/Dissertation	8 P	16	240-272

8.7 A minimum of 80 credits are to be completed by the student, 30% (24 credits) of which will be elective including a minimum of 12 credits (15%) from other programs of studies (Minimum 9 from a single program of study other than M.Sc. Biotechnology) and 70% (56 credits) being core courses. Essentially 4 credits of Foundation courses (Compulsory and elective) will also need to be opted for the degree.

8.8 The maximum number of credits that a student may opt in a Semester shall not exceed 36 hours per week of teaching, and he/she shall be required to register for such a number of courses accordingly.

8.9 Some courses have prerequisites, i.e. they may be opted for only when the course listed as pre-requisite has been completed. Similarly, there may be courses with co-requisites, i.e. they are complete when the co-requisites are also completed and thus cannot be opted in isolation.

9.1 **Exit and Re-entry**

9.1.1 Semester I/PG Certificate in Molecular Biology: A student has to opt courses of minimum 20 credits (Core + Electives (Generic and/or Disciplinary) + Foundation Elective) in this semester. However, maximum credits will be limited to 36 hours of teaching only. If s/he drops after

successful completion of minimum 20 credits in 1st semester s/he will be awarded PG Certificate in Molecular Biology.

9.1.2 Semester I and II/PG Diploma in Molecular Biology & Biotechnology: A student has to opt courses of minimum 20 credits (Core + Electives (Generic and/or Disciplinary) + Foundation Elective) in this semester. However, maximum credits will be limited to 36 hours of teaching only. If s/he drops after successful completion of minimum 40 credits by the end of Semester II, s/he will be awarded PG Diploma in Molecular Biology & Biotechnology.

9.1.3 Semester I + II + III/PG Diploma in Advanced Biotechnology:A student has to opt courses of minimum 20 credits (Core + Electives (Generic and/or Disciplinary) + Foundation Elective) in this semester. However, maximum credits will be limited to 36 hours of teaching only. If s/he drops after successful completion of minimum 60 credits by the end of Semester III, s/he will be awarded PG Diploma in Advanced Biotechnology.

9.1.4 Semester I+II+III+IV/M.Sc. Biotechnology: A student has to opt courses of minimum 20 credits (Core + Electives (Generic and/or Disciplinary) + Foundation Elective) in this semester. However, maximum credits will be limited to 36 hours of teaching only. Successful completion of minimum 80 credits on completion of Semester IV will earn a student the degree of Master of Science in Biotechnology.

9.1.5 The student dropping the course with certificate/diploma/advanced diploma may rejoin the program for further study for completion of the degree.

10. **Credit Registration**

10.1 Students must register for the courses for the semester within the first week of admission.
10.2 The maximum number of students to be registered in each course shall depend upon the physical facilities available while a minimum must be decided by the Board of studies/Committee of course in Biotechnology.
10.3 Preference for registration of Courses in Biotechnology shall be given to those students for whom the course is a Core course.
10.4 The registration for the elective course shall be on a first come first served basis, provided the student fulfills the prerequisites for that course, if any.
10.5 Normally, every Lecture-based course shall be offered by one teacher. In case of the requirement of more than one teacher, a course leader will be announced by the Head of the Department who will be responsible for the management of the course (viz. class and assessment schedule, student attendance, marks, grades etc.).

11. Time for Credit Registration: Credit registration shall be over within seven days of the commencement of a Semester and no change except withdrawal from a course shall be permissible after that date.

12. Limits for the Registration of Credits per Semester

12.1 A student may register for a minimum of 20 credits and a maximum of 36 credits in a semester provided it does not exceed the contact teaching time of 36 hours. However, s/he will be eligible for the qualification certificate only after completion of minimum requisite credits in each category of courses of a program.
12.2 The maximum number of students to be registered in each course shall depend upon the physical facilities available.
12.3 Preference for registration shall be given to the students of that department for whom the course is a Core course.
12.4 The registration for the elective course shall be on a first come first served basis, provided the student fulfills prerequisites for that course, if any.
12.5 No course shall be offered unless a minimum of 3 students are registered.

12.6 Students admitted late will have to contact the concerned Head of the department, who in turn must introduce and guide him/her through the process of registration.
12.7 Elective courses of a department may be offered or not in a particular semester at a college/department, depending on the availability of faculty and infrastructure. Thus the list of electives being offered must be displayed on the Notice Board of the Department.

13. Beginning of Semester
13.2 The 1st working day of each semester: Orientation and allotment of students to departmental advisors/mentors.
13.3 The 2nd working day of each semester: Mentor-Mentee meet in the concerned department and register students with the concerned course leaders.
13.4 The 3rd day of the semester: Beginning of teaching

14. Class schedule
14.1 Tentative timetable of each department shall be displayed on its Notice Board on the 1st day of the semester and the Head(s) of the concerned Department, a day before the beginning of the semester.
14.2 Being Choice based, it would not be possible to hold practical classes in both morning and afternoon as it would be difficult to adjust time clashes with courses offered in other departments, thus Practical classes will be arranged in the afternoon sessions only.
14.3 Course leaders would adjust the conflicting time slots on the basis of mutual understanding and must give slots in the timetable on the basis of priority to a course leader having more variety of students (i.e., having registrations of students from a maximum number of departments).

15. Courses offered in M.Sc. Biotechnology

15.1 Core Courses

15.1.1 Semester I

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial + Lab/Field work)	Hours/week
BTC 101/ MIC 101	Essentials of Microbiology	3	0	3
BTC 102	Cells and their organization	3	0	3
BTC 103	Molecules of life	4	0	4
BTC 104/ MIC 104	Molecular Biology I	2	0	2
BTC 105	Microbiology & Biochemistry Lab	0	4	12
	IDE/DE	3 or more		
	FC	Min 1		

Minimum 20 credits to be opted

15.1.2 Semester II

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
BTC 201	Physiological diversity	4	0	4
BTC 202/MIC 202	Molecular Biology II	2	0	2
BTC 203 Sk	Fermentation Technology	4	0	4
BTC 204 Sk	Bioprocess & Physiology Lab	0	4	12
	SE	2-4 or more		
	IDE	2-4 or more		
	FC	Min 1		

Minimum 20 credits to be opted

15.1.3 Semester III

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
BTC 301 /MIC 301Sk	Genetic Engineering	4	0	4
BTC 302	Genetics and Molecular Genetics	3	0	3
BTC 303Sk	Biotechniques	4	0	4
BTC 304	Molecular Biology Lab	0	4	12
BTC305	Short Term Project		1	3
	SE	3 /4 or more		
	IDE	3 /4 or more		
	FC	Min 1		

Minimum 20 credits to be opted

15.1.4 Semester IV

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
BTC 401 Sk	Project Work/Dissertation	Nil	8	20

MIC 401/BTC 402	Research Design	3		3
	DSE	4	0	4
	DSE/IDE	4 or more		4
	FC	1		1

Minimum 20 credits to be opted

15.2.1 Disciplinary Elective Courses for Semester I and III

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
BTEO11	Developmental Biology of Animals	3	0	3
BTEO12	Plant Developmental Biology	2	0	2
BTEO13	Documentation in Pharmaceutical Industry	2	0	2
BTEO14	Entrepreneurship in Biotechnology	3	0	3
BTEO15/MIEO 16	Industrial Microbiology	4	0	4
BTEO16	Medical Microbiology	4	0	4
BTEO17 Sk	Seminar/Workshop/Training	0	1	1
BTEO18	Hygiene in Pharma Industry	3	0	3
BTEO 19	Plant Cell-Microbe Interactions	3	0	3
BTEO 20	Short Term Project	0	1	3

15.2.2 Disciplinary Elective Course for Semester II & IV

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
BTEE11/MIEE11	Immunology	4	0	4
BTEE12/MIEE20 Sk	Biostatistics & Computational Biology	4	0	4
BTEE13/MIEE19 Sk	Bioinformatics	4	0	4
BTEE14	Omics Technologies	4	0	4
BTEE15	Good Manufacturing Practices in Pharma Industry	3	0	3
BTEE16/MIEE18	Enzymology	3	0	3
BTEE17Sk	Seminar/Workshop/Training	0	1	3
BTEE18	Animal Biotechnology	3		3
BTEE19	Nanobiotechnology	4	0	4
BTEE 20	Plant Tissue Culture and Germplasm conservation	3	0	3
BTEE 21	Short Term Project		2	6

16 Foundation Courses

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
Elective foundation Course				
BT FE01	Journal article: Evaluation and Presentation	2	0	2

BTFE02	Holistic Living: Nurturing Values, Connection, and Sustainable Practices	2	0	2

Foundation courses will be available in all semesters; however, they will be offered on the basis of availability of time with the faculty. A student can also pick a foundation course being offered by any other department.

17. Detailed outline of Courses

17.1 Foundation Courses

BT FE 01 Journal Article: Evaluation and Presentation (2L) (2h/week)

Outcome: The student will learn how to review a manuscript and, in the process, will also learn how to write a better manuscript for publication in any journal.

Basis and process of evaluation of manuscripts submitted for peer reviewing by the editors of journals. Each student will have to evaluate an article from the point of view of publication in a journal and then present his/her analysis.

BT FE 02 Holistic Living: Nurturing Values, Connection, and Sustainable Practices (2L) (2h/week) (Ability Enhancement Course)

The course will be taught through brainstorming sessions and/or Socratic Seminars on following topics. The goal is to help improve communication, develop a value system based on cooperation, teamwork and relationship building

Section A

Existence, Life: What is it? Death and Immortality, Simplicity vs complexity, Machine vs System, Macro and Microsystems, Diversity and its celebration
Activity: Plant parenting-Adapt a tree-pair in the Garden of togetherness

Section B

Whom would you like to emulate?-the role models, Happiness, sense of satisfaction and pride, Goal and Preferences of Life: Earth-Living beings-Nation-City-Society-Family-Us-Me. We are because the EARTH is.
Activity: Practicing Unwaste and freedom from Plastic, Low calorie development

Section C

Joy and Happiness, Independence-interdependence and relationships, Peace and Harmony (learn to share and care), Tolerance and Intolerance, Differentiation vs discrimination:
Gender-Class-Religion-Caste. Information, Knowledge and Wisdom
Activity: Persistent Happiness-Achieve, Attain, Obtain, Care, Share and Help

17.2 CORE COURSES

Semester I

BTC101/MIC 101 Sk. Essentials of Microbiology (3L) (3h/week)

Course objectives: To expose the student to an overview of the diversity of the prokaryotes, difficulties and requirements in studying microorganisms and basic microbiological techniques that will allow him/her to solve ANY problem related to microorganisms in the industries and institutes.
Learning Outcome: The student will learn about

- Methods in the taxonomy of the microorganisms
- Microscopes, their types and microscopy.
- Asepsis and Basic microbiological methods.
- Concepts of biosafety and biohazards.

Section A (16L)

History and scope of Microbiology. Prokaryotes, Eukaryotes. Archaebacteria and eubacteria. Morphology and ultrastructure of bacteria. Specialized components of microorganisms and their structure and function. Shapes and arrangement of bacteria. Observing microorganisms: Principles and use of microscopes. Bright field, Dark field, Phase contrast, fluorescence, interference, Confocal, Atomic Force and Electron microscopes. Stains and staining techniques.

Section B (15L)

Aseptic techniques: Principles and methods of Sterilization and Disinfection. Disinfectants and their mode of action. Antibiotics, their classification and mode of action. Isolation and purification of microorganisms. Environmental and nutritional requirements. Culture Medium and its types. Cultivation of bacteria, Nutritional types.

Growth and its kinetics. growth yields, Cell Division Asynchronous, synchronous, batch and continuous cultures. steady state growth and continuous growth. Maintenance and preservation of pure cultures. Measurement of growth and factors affecting growth. Enumeration of microorganisms, *in situ* studies, sampling, isolation techniques and determination of biomass and growth.

Biohazards: Concept of biohazards with cases highlighting importance. Biosafety: Principles and measures.

Section C (14L)

Diversity of acellular self-replicating structures. Microbial diversity of forms, differentiation of cells, their organization and functions? Archaea, Bacteria, Protozoa, Algae and Fungi.

Basis of classification of bacteria. Phylogenetic and phenetic approaches. Chemotaxonomy, Genetic and molecular methods: G+C ratio, Nucleic acid hybridization. DNA-DNA and DNA-RNA hybridization. PCR-method and application. 16S, 23S rRNA and IGS sequencing, RFLP, RAPD, STRR & LTRR, REP –PCR based DNA fingerprinting methods. Numerical taxonomy and Polyphasic approach in taxonomy. Major groups of bacteria according to Bergey's Manual of Systematic Bacteriology.

Text Books:

1. Salle A.J. Principles of Bacteriology.
2. Brock T.D., Madigan M.T. Biology of microorganisms. Prentice Hall.
3. Pelczar M.J., Chan E.C.S., Krieg N.R. Microbiology. McGraw Hill.
4. Stanier RY, Ingraham J.L., Wheelis M.L., Painter P.R. 1999. General Microbiology. MacMillan Education Ltd., London.
5. Schlegel. General Microbiology. Cambridge University Press, Cambridge.
6. Prescott. Microbiology
7. Priest. Bacterial Taxonomy

References:

1. Bergey's Manual of Determinative Bacteriology. 9/e
2.Bergey's Manual of Systematic Bacteriology (2/e) P.H.A. Sneath, N.S. Mair, M. Elizabeth (eds).
3. Balows A., Thuper A.G., Dworkin M., Harder W., Schleifer K. 1991. The Prokaryotes. Springer-Verlag.
4. Birge E.A. 1992. Modern Microbiology. Wm. C. Brown, Oxford.
5. Gunsales I.C., Stanier R.Y. The Bacteria. Vol. I, II, III. Academic Press.
6. Joklik W.K., Zinssers. Microbiology. McGraw Hill.

Websites

1.Life in a drop of water. http://www.youtube.com/watch?v=_cpBK2t0Yeo
2.Microbes in the News. http://commtechlab.msu.edu/SITES/dlc-me/news/news.html
3.Society for Microbiology Education resources. http://www.sgm.ac.uk/en/education/resources/index.cfm
4.Society for Microbiology http://www.sgm.ac.uk/ An extensive list of links to microbiology resources including professional societies, publications, and online materials.
5.American Society for Microbiology LABORATORY PROTOCOLS http://www.microbelibrary.org/about/51
6.American Society for Microbiology http://www.asmcue.org/
7.MicrobeWorld http://www.microbeworld.org/ MicrobeWorld is a division of ASM with a dedicated team that scours the internet finding every new microbiology report daily.
8.Meet the Scientist with Carl Zimmer, Carl Zimmer interviews microbiologists about their research in some of the hottest and most exciting areas of research today. http://www.microbeworld.org/index.php?option=com_content&view=category&layout=blog&id=37&Itemid=155
9.Small Things Considered http://schaechter.asmblog.org/

10.Twisted Bacteria: https://twitter.com/twistedbacteria blog written by César Sánchez, a scientist turned editor. César was the editor for Trends in Microbiology prior to writing full-time on his own site. On his blog you can find new information in the field of microbiology.

BTC 102 Cells and their Organization

Section A

Key principles of the cell theory, contributions of early scientists (e.g., Robert Hooke, Anton van Leeuwenhoek), Comparative cell architecture,
Membrane structure and function, fluid mosaic model, role in cell communication and signaling in prokaryotes and eukaryotes, Membrane Transport: Passive and active transport mechanisms, diffusion, osmosis, facilitated diffusion, active transport.Structure and function of intracellular organelles and Nuclear sub compartments, Cytoskeleton and its dynamics

Section B

Cellular Energetics: Overview of cellular metabolism, catabolic and anabolic pathways.
ATP and Cellular Respiration: Role of ATP in cellular energy transfer, overview of glycolysis, Krebs cycle, and oxidative phosphorylation.
Photosynthesis: Light-dependent and light-independent reactions, role of chloroplasts, photosynthetic pigments.
Cell Communication and Signaling: Cell Signaling Pathways: Introduction to signal transduction, types of signaling molecules (e.g., hormones, neurotransmitters), receptor types.
Cell-Cell Interactions: Cell adhesion molecules, intercellular junctions, cell-to-cell communication in multicellular organisms.

Section C

Cell Cycle Regulation: Phases of the cell cycle (G1, S, G2, M), checkpoints, regulation of cell cycle progression.
Mitosis and Meiosis: Overview of mitotic and meiotic cell divisions, significance in growth, development, and reproduction.
Cellular Senescence and Apoptosis: Mechanisms of programmed cell death, implications in development and disease.
Stem Cell Biology: Overview of stem cell types (embryonic, adult, induced pluripotent stem cells), potential applications in biotechnology and medicine.
Cell Differentiation: Molecular mechanisms underlying cell fate determination, role of transcription factors and signaling pathways.

Books & References

REFERENCES:

Alberts B., Johnson A., Lewis J., Raff M., Roberts Keith; Walter P. (eds) c2002: *Molecular Biology of the Cell*, Garland Science, New York and London.

Copper G.M. & Hausman R.E. 2004: *The Cell: A Molecular Approach*, 3rd ed., Sinauer Associates, Inc, Sunderland, Massachusetts.
Lodish H., Berk A, Zipursky SL, et al. 2000: *Molecular Cell Biology*, 4th ed, W.H. Freeman, New York.

LINKS:

https://www.ncbi.nlm.nih.gov/books
http://www.di.uq.edu.au/sparqglossary#b
https://micro.magnet.fsu.edu
https://cellbiology.med.unsw.edu.au

BTC 103 Molecules of Life (4L) (4h/week)

Section A Instrumentation and Carbohydrates

Definition and characteristics of life. Composition of living matterCellular environment. Water, its structure and properties. Physiological buffers. pH. pH indicators. Redox potential and redox indicators. Solutions and other concepts.

Instrumentation: Centrifugation, Colorimetry, Photometry, Nephelometry, Vis, UV-Vis and IR spectroscopy, Flame photometry. Electrophoresis, Chromatography: PC, TLC, Column chromatography, GC and HPLC.

Biomolecules: Structure, function, diversity and distribution. Carbohydrates: Definition, Mono-Di-Tri-Poly-saccharides. Sugars and their derivatives. Structure, occurrence and biological importance of polysaccharide viz. cellulose, agar agar, alginic acid, agarose, carrageenan, pectins, sialic acid, blood group polysaccharides, chitin, bacterial cell wall polysaccharides.

Section B Lipids

Lipids: Definition and classification. Classification and nomenclature of Fatty acids. Systematic nomenclature and classes of glycerides: MAG, DAG, TG; Phospholipids: PA, PG, PE, PS, LPC, PI and plasmalogens; Sphingolipids, Sphingosine, Ceramide, sphingomyelin, glycolipids, cerebrosides, gangliosides, sialic acids. Properties and functions of phospholipids and prostaglandins. Classes and structure. Chemistry of sterols, bile acids, steroid hormones, plant sterol, ergosterol, stigmasterol, cholesterol, glucocorticoid, mineralocorticoids. Lipoproteins-classification, composition and importance. Role of lipid in cellular architecture and function.

Section C Proteins, Nucleic acids and other Biomolecules

Structural features, nomenclature, classification and chemistry of proteins. Amino acids: Classification, structure and properties. Enzymes as biocatalysts. Enzyme classification. Specificity. Active site, Unit activity. Isozymes, Enzyme kinetics. Michaelis-Menten equation for simple enzymes.

Nucleic acids: Importance and general composition. Purine and pyrimidine bases. Tautomeric forms of bases. Structure of nucleosides and nucleotides. Deoxynucleotides, cyclic nucleotides and polynucleotides. Watson and Crick model of DNA. Types of DNA and RNA. Peptidoglycans. Vitamins and hormones.

Text Books:

1. Stryer L. 2001. Biochemistry 5/e, W.H. Freeman. New York.
2. Zubey G.L., Parson W.W. and Vance D.E. 1994. Principles of Biochemistry. Wm. C. Brown, Oxford.
3. Lehninger 2000. Principles of Biochemistry. 3/e. Nelson and Cox (Worth) Pub.
4. Harper's Biochemistry 1999. McGraw Hill.

BTC104/MIC 104 Molecular Biology I (2L) (2h/week)

Section A Nucleic acids

Experimental evidence for nucleic acids as genetic information carriers, DNA and RNA structure and function, forces that stabilize nucleic acids. Structural variants of DNA and RNA, Organization of nucleic acids in prokaryotes and eukaryotes. Physical and chemical properties of DNA: Absorption, Density, Denaturation, Renaturation, solubility, size fractionation. DNA topology. Topoisomerases and their role in maintaining DNA topology

Section B DNA replication

Different modes of DNA replication, Structure of prokaryotic DNA polymerase in comparison with eukaryotic polymerases. DNA replication mechanism, Asymmetric and dimeric nature of DNA polymerase III and simultaneous synthesis of leading and lagging strands. Leading strand synthesis, Lagging strand synthesis, events taking place at the replication fork. Termination of replication and segregation of daughter molecules, Replication of linear genomes, mitochondrial DNA, Retroviruses and their unique mode of DNA synthesis. Inhibitors of DNA replication (blocking precursor synthesis, nucleotide polymerization, altering DNA structure).

Section C Gene Expression

Structural features of RNA (rRNA, tRNA and mRNA) and relation to function. Initiator and elongator class of tRNA, ribosome binding site on mRNA and corresponding site on rRNA, peptidyl transferase activity of 23 S rRNA. Transcription: general principles, basic apparatus, types of RNA polymerases.
Steps for transcription: Initiation, elongation and termination, inhibitors of RNA synthesis. Polycistronic and monocistronic RNAs. Maturation and processing of RNA: Methylation, cutting and

trimming of rRNA, capping, polyadenylation and splicing of mRNA, cutting and modification of tRNA. mRNA turnover mechanism. RNAi. Catalytic RNA, Group I and group II intron splicing. RNase P.

Books:

Genes VII. Lewin (Oxford University Press) 2000
E.coli and Salmonella, Cellular and molecular biology. 2nd edition. Neidhart e al., 1996 ASM Press.
Molecular Cell Biology. Lodish, Berk, Zippursky (WH Freeman)
Matsudaira, Baltimore, Darnell 4th edition 2000

BTC105 Microbiology & Biochemistry Lab (3P) (9h/week)

Students will learn aseptic techniques and handling of microorganisms and will perform experiments for qualitative and quantitative analysis of biological molecules.

Additional skills: Searching Material Safety data Sheets, reading and understanding them. Keeping alphabetic records of such sheets.
Strong understanding of ethics (scientific and biological), hazards including biohazards and laboratory safety issues. Understanding risk and impact of not following defined procedures/work instructions.
Types of documentation in organization, importance of maintaining the same and different methods of recording information.
Knowledge about the appropriate authority for reporting any imbalances.

Semester II

BTC 201 Physiological Diversity (4h/week)

Section A Development and Bioenergetics

Cell wall in archaea, bacteria, algae, fungi and plants. Membrane chemistry of prokaryotes and eukaryotes. Peptidoglycan, chitin, cellulose, hemicelluloses and lignin. Biopolymers as cell components. Cell division. Synthesis of cell wall and its regulation in bacteria. Transport in cells. Cell-cell signaling mechanisms. Quorum sensing: A and C signaling system. Microbial development. Sporulation and morphogenesis. Hyphae versus yeast forms and their significance. Multicellular organization of selected microbes, dormancy.

Bioenergetics: Basic aspects: entropy, enthalpy, bonding energy. Phosphorylation. Flow of energy through the biosphere. Strategy of energy production in the cell, oxidation – reduction reactions, coupled reactions and group transfer. ATP production. Structural features of biomembranes. Transport, free energy and spontaneity of reaction. G, G^0, G' and equilibrium. Strategies of metabolism. Prokaryotic and eukaryotic metabolism and fueling reactions.

Section B Catabolism

Catabolic principles and breakdown of carbohydrates. Lipids, proteins and nucleic acids. Respiratory metabolism- Embden Mayer Hoff pathway, EntnerDoudoroff pathway. Glyoxylate pathway. Kreb's cycle. Oxidative and substrate level phosphorylation. Reverse TCA cycle. Gluconeogenesis. Pasteur effect. Fermentation of carbohydrates. Homo- and heterolactic fermentations. ETC- Electron carriers. Artificial electron donors. Inhibitors, Uncouplers.

Section C Anabolism

Carbohydrates-anabolism, autotrophy, oxygenic and anoxygenic photosynthesis. Autotrophic generation of ATP, Fixation of carbon dioxide. Calvin cycle. C3, C4 pathway. Chemolithotrophy-Sulfur, iron, hydrogen, nitrogen oxidations. Methanogenesis, Luminescence. Brief account of photosynthetic and accessory pigments-chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobiliproteins. Assimilation of nitrogen, dinitrogen, nitrate nitrogen, ammonia, synthesis of major amino acids. Polyamines. Synthesis of polysaccharides. Biosynthesis of amino acids, fatty acids and nucleotide bases.

Text Books:

1. Caldwell, DR 1995. Microbial physiology and metabolism. Brown Pub.
2. Moat AG & Foster JW 1999. Microbial Physiology. Wiley

3. Stanier RY, Ingraham JL,Wheelis ML and Painter PR 1986. General Microbiology. MacMillan Education Ltd., London
4. Brun YV and Shimkets LJ 2000. Prokaryotic development. ASM Press.

BTC 202/MIC 202. Molecular Biology II (Prerequisite: BTC104/MIC 104) (2L) (2h/week)

Section A Regulation of gene expression

Control of transcription by interaction between RNA polymerases and promoter regions, use of alternative sigma factors. Operon concept, constitutive/ induced, negatively/ positively controlled, catabolite repression, inducers, repressors and corepressors. Negative regulation- *E. coli lac* operon; Positive regulation: *E. coli ara*operon, Regulation by attenuation- *his* and *trp operons*; Antitermination- N protein and *nut* sites in Regulatory circuits: SOS regulon, stringent response and regulation by small molecules such as ppGpp and cAMP, antisense RNA, heat shock response, regulation of rRNA and tRNA synthesis.

Section B Genetic code and Translation

Origin of the genetic code, Evolution of the genetic code, General features and characters of the genetic code, Why is the code universal?
Review of RNA types and functions, Structure of the ribosome. Pre-initiation, Initiation of translation, mechanism of action of aminoacyltRNAsynthetase, identity elements, Factors involved in initiation. Chain elongation, elongation factors and their regeneration, Termination of translation. Polyribosomes, coupled transcription and translation. Regulation of translation, Rates and energetics of translation. Post transcriptional modification of proteins. Translational inhibition, synthesis of exported protein on membrane bound ribosomes. Signal hypothesis, In vitro transcription and translational systems.

Section C Recombination

Homologous/ general and non homologous/ illegitimate recombination, Holiday model, single strand invasion, and double strand break model of recombination, Site specific, replicative, nonreplicative, reciprocal, nonreciprocal recombination. Enzymes required for recombination in *E.coli*, other recombination systems: FL/FRT and Cre/Lox recombination. Genetic analysis using recombination. Advantages of genetic recombination.

Reference Books:

1. Lewin Genes VII. (Oxford University Press) 2000
2. E.coli and Salmonella, Cellular and molecular biology. 2nd edition.
3. Neidhart e al., 1996 ASM Press.
4. Lodish, Berk, Zipursky Molecular Cell Biology. (WH Freeman)
5. Matsudaira, Baltimore, Darnell 4th edition 2000

BTC 203 Fermentation Technology (4L) (4h/week)

Section A Bioreactors

Bioreactors: Design of a basic fermenter, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices, probes for online monitoring, measurement and control of process. Reactors for specialized applications: Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors, their basic construction and types for distribution of gasses.

Transport phenomena in fermentation: Gas- liquid exchange and mass transfer, oxygen transfer, critical oxygen concentration, determination of Kla, heat transfer, aeration/agitation and their importance. Sterilization of Bioreactors, nutrients, air supply, products and effluents.

Section B Fermentation and Downstream Processing

Fermentation process: Media formulation, selection of components, buffers, precursors, pH adjustment. Growth of cultures in the fermenter. Kinetics of growth with respect to substrate utilization. Specific growth rate. Batch culture, Fed-batch and continuous culture. Steady state in a

chemostat. Yield of biomass and product. Inoculum development. Storage of cultures for repeated fermentations, scaling up of processes from shake flask to industrial fermentation.

Downstream processing: Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration: Physical, chemical and enzymatic methods. Methods of extraction of the product. Purification of the product: Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

Section C Strategies to reduce cost of production

Expenses for industrial organisms, strain improvement, media sterilization, heating, cooling, aeration, agitation, Cost of plant and equipments, batch process cyclic time, continuous culture, recovery and effluent treatments**,** Cost recovery due to waste usages and recycling

Prospecting: Isolation and screening microbial cultures, Screening for primary and secondary metabolites, enrichment and specific screening for the desired product. Modification of medium and techniques of fermentation.

Strain improvement: Mutation and screening of improved cultures, random and strategic screening methods, strategies of strain improvement for primary and secondary metabolites with relevant examples. Use of recombinant DNA technology and protoplast fusion techniques.

Production of recombinant molecules in heterologous systems, problems associated with strain improvement programs, improvement of characters other than products and its application in the industry.

Preservation of cultures.

Books:

1. Principles of Fermentation Technology by Stanbury, P.F., Whitekar A. and Hall. 1995., Pergaman. McNeil and Harvey.
2. Fermentations - A practical approach. IRL.
3. Bioprocess Technology: Fundamentals and Applications. Stockholm KTH.
4. Biochemical Reactors by Atkinson B., Pion, Ltd. London.
5. Biotechnology - A Text Book of Industrial Microbiology by Cruger.
6. Fermentation Biotechnology: Industrial Perspectives by Chand.
7. Biochemical Engineering Fundamentals by Bailey and Ollis, Tata McGraw Hill, N.Y.
8. Biotechnology. Volume 3. Edited by H. J. Rehm and G. Reed. Verlag Chemie. 1983.
9. Advances in Biochemical Engineering by T.K. Bhosh, A.Fiechter and N. Blakebrough. Springer Verlag Publications, New York.
10. Biotechnology- A textbook of Industrial Microbiology by Creuger and Creuger, Sinauer Associates.
11. Bioprocess Engineering Kinetics, Mass Transport, Reactors, and Gene expressions by Veith, W.F., John Wiley and Sons.
12. Applied Microbiology Series.
13. Industrial Microbiology by L.E. Casida, Wiley Eastern
14. Bioseparation: Down stream processing for Biotechnology by Belter, P.A. Cussler, E.L. and Hu, W.S., John Wiley and Sons, N.Y.
15. Separation process in Biotechnology by Asenjo, J.A. Eds. Marcel Dekkar, N.Y.
16. Bioprocess Engineering Principles by Doran, Acad. Press, London.
17. Bioreaction Engineering Principles by Nielsen, J. and Villadsen, plenum Press, N.Y.
18. Fermentation, Biocatalysis and bioseparation, Encyclopedia of Bioprocess Technology by Chisti, Y., Vol. 5, John Wiley and Sons, N, Y.
19. Cussler E L 1984. Diffusion. Cambridge University Press.
20. Fermentation Microbiology and Biotechnology EL-Mansi &C.F.A.Bryce eds
21. Bioprocess Engineering P.K. Ghosh
22. Bioseparations: principles and techniques B. Sivasankar, PHI, New Delhi
23. Process Biotechnology Fundamentals S. N. Mukhopadhyay
24. Demain, A.L. and Davies, J.E. (1999). Manual of Industrial Microbiology and Biotechnology. ASM Press.
25. Glick, B.R. and Pasternak, J.J. (1994). Molecular Biotechnology, ASM Press.

BTC 204 Sk Bioprocess & Physiology Lab (4P) (12h/week)

Experiments on Industrial Microbiology and fermentation technology. Experiments to determine enzymes, existence of certain physiological activity and evaluation of a physiological process in a living system.

Additional skills:
Planning an experiment. Recording data, Interpreting and Presenting results.
Working principles of pharmaceutical, brewery and food industry environment
Knowledge of different standard reference material and use of Computer/application software.

Semester III

BTC 301/MIC 301 Sk. Genetic Engineering (4L) (4h/week)

Section A
Nucleic acid sequencing and manipulation

DNA sequencing: Maxam Gilbert method, Sanger's sequencing, automated sequencing, High throughput sequencing technologies. Essential enzymes used in Genetic engineering. Restriction nucleases: endo and exonucleases, DNA ligase: Properties and specificity, S1 nuclease, BAL 31 nuclease, DNA polymerase, polynucleotide kinase, DNase, RNase, methylase, phosphatase. Reverse transcriptase, its activity and mode of action.

Methods of nucleic acid detection, Polymerase chain reaction (PCR) and its applications, Variations in PCR and their applications, Methods of nucleic acid hybridization, Probe and target sequences, Nucleic acid mutagenesis *in vivo* and *in vitro*.

Section B
Cloning

Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), Quantification and storage of nucleic acids, Genomic DNA libraries: Procedures for Partial, Representative, Enriched, Large-insert DNA libraries, Half-arm cloning. cDNA libraries: Prominent Adapters/Linkers based directional cloning.

Cloning strategies: Vector preparation and diverse cloning strategies viz. blunt end cloning, directional cloning, TA-cloning of PCR products, linkers and adaptors based cloning Methodologies. Cloning vectors: Plasmids, Lambda phages, single stranded DNA vectors (M13, fd, f1); Cosmids, Phasmids and Phagemids, Fosmids, YACs, BACs, PACs. Plant Transformation vectors: Introduction to T_i, R_i plasmids and BIBACs. Expression Vectors for high level protein expression

Section C
Gene transfer and Recombinant selection

Gene transfer techniques: biological methods, Gene transfer techniques: chemical methods, Gene transfer techniques: physical or mechanical methods, *Agrobacterium*- mediated gene transfer in plants, Chloroplast transformation.

Selection and screening of recombinant transformants: Introduction to marker and reporter genes and selection strategies, Labeling and detection of nucleic acid sequences: End-Labeling (3'- and 5'), Random priming and Nick translation using radioactive non-radioactive labeling techniques. Site Directed Mutagenesis: Cassette mutagenesis, Primer extension (single primer method), PCR methods for site-directed mutagenesis, selection of mutant peptides by phage/plasmid display).

Text Books:
1. Maloy*et al*. 1994. Microbial Genetics, Jones & Bartlett Pub.
2. Dale J.W. 1994. Molecular Genetics of Bacteria. John Wiley & sons
3. Streips & Yasbin. 1991. Modern Microbial Genetics. Niley Ltd.
4. Old & Primrose. 1994. Principles of Gene Manipulation. Blackwell Scientific Pub.
5. Sambrose& Russell. 2000. Molecular cloning. 3 volumes. CSH Press
6. 2000. Genome Analysis. 4 volumes. CSH Press

7. Peruski Jr. and Peruski 1997. The internet and the new biology: Tools for Genomic and Molecular Research. (ASM Press).
8. Hunt SP and Livery R (ED).2000. Functional genomics: practical approach (OUP).
9. Schena M. DNA microarrays: A practical approach (OUP).
10. Roderic D. M. Page, Edward C. Holmes (1998). Molecular Evolution: A Phylogenetic Approach. Blackwell publishing, USA.
11. Principles of Genome Analysis: A Guide to Mapping and Sequencing DNA from Different Organisms by S. B. Primrose (Paperback - Jan 1998)
12. Microbial Genome Methods by Kenneth W. Adolph (Hardcover - Oct 28, 1996)
13. Genome Mapping and Sequencing by Ian Dunham (Hardcover - Sep 1, 2003).
14. Brendan Wren (Editor), Nick Dorrell (2002) Functional Microbial Genomics (Volume 33) (Methods in Microbiology), Academic Press, UK.

BTC 302 Genetics and Molecular Genetics (3L) (3h/week)

Learning Objectives: To understand principles of classical and molecular genetics with emphasis on organization of genome and differential gene expression.
Learning Outcomes: Understanding concepts of genetics and molecular genetics, gene regulation and genetic manipulations (Prokaryotes and Eukaryotes).

Section A
Genetics

Introduction to genetic principles (2), Linkage, Recombination and Sex Linked Inheritance (5), Chromosomal Aberrations (4), Basic concepts of population genetics (3).

Section B
Genome Organization

Structure and Organization of Genomes (4), Structural elements & their functions (5), Coding sequences of genomes & their characteristics (5)

Section C
Genome functions and their regulation

Major Genome Function (6), Differential Gene Expression & their regulation (6), DNA Damage and Repair Systems (3)

Books:
Principles of Genetics: D. Peter Snustad and Michael J. Simmons (8th Edition).
Molecular Biology of the Gene: Watson, Baker, Bell, Gann, Levine &Losick (7th Edition).
iGenetics; A molecular Approach: Peter J. Russell (5th Edition).
Molecular Genetics of Bacteria: Larry Snyder (4th Edition).
Lewin's GENES: Benjamin Lewin (11th Edition).

BTC 303 Biotechniques Sk(4L) (4h/week)

Section A
Separation Techniques

Subcellular fractionation and criteria of functional integrity. Separation techniques for different biomolecules (Filtration, Centrifugation, Density gradient centrifugation, Chromatography: CC, PC, TLC, GC, HPLC, Electrophoresis).

Section B
Biophysical Techniques

Small and macromolecule quantification (Colorimetry, Photometry, Nephelometry, Flame photometry, Vis, UVand Atomic Absorption Spectroscopy). Physical techniques in protein, nucleic acids and polysaccharide structure analysis. (IR, NMR, LASER Raman spectroscopy, Mass spectroscopy, Mossebäuer spectroscopy, Differential calorimetry, X-Ray crystallography).

Section C
Molecular Diagnostics

Molecular tools in taxonomy, ecology and molecular diagnosis, Sequencing proteins and Nucleic acids. PCR, Real Time PCR and QPCR, DNA sequencing. Immunological techniques: Agglutination, Complement fixation, Ouchterloney, Rocket electrophoresis, ELISA and Western blotting.

Text Books:

1. Branden &Tooze 1991.Introduction to Protein Structure. Garland Pub. Comp.
2. Adams *et al.* 1992. Biochemistry of Nucleic Acids. Chapman & Hall.
3. Rhodes, G. 1993. Crystallography made crystal clear. Academic Press.
4. Van Holde*et al.* 1998. Principles of Physical Biochemistry. Prentice Hall.

BTC 304 Sk. Molecular Biology Lab (3P) (9h/week)

Experiments based on Molecular Biology, Microbial Genetics and Synthetic Biology
Additional skills: Knowledge on different standard reference material and use of Computer/application software.

BTEE 21, BTEO 20, BTC 305 S Sk. Short term Project (1P) (3h/week)

Students will be given experimental work, and optimize techniques to achieve specific goals.
Skill: How to plan, conduct, record, analyze and report an activity. Data presentation through software.

Semester IV

BTC 401 LSk Project Work /Dissertation (8P) (7hT+9h lab work/week)

Eight credits (16 hours of work/week/student) including 8hT/week/group of students allotted) will include guidance, explanations, discussions for field work, project work/dissertation work to meet specific goals in an independent individual/group effort. Details are as below:

S. No.	Course	Credits (batch limit 10 students)	Student workload (h/week)
1	Plan of work	1	1
2	Conduction of Experiments	1	9
3	Presentation of data	1	1
4	Analysis of data	1	1
5	Presenting weekly reports (20 min seminars+5min discussion)	3	3
6	Presentation as Seminar (8 min+2 min discussion) and Presentation as Poster Paper	1	1
	Total (1-6)	08	16

Skills to be learnt
Writing skills
Record and communicate details of work done to appropriate people
Use written/typed report or computer based record/electronic mail
Write detailed reports for investigation.
Maintain proper and concise records as per given format.

Reading Skills
Searching Material Safety data Sheets, reading and understanding them. Keeping alphabetic records of such sheets.
Read and understand manuals, SOPs, health and safety instructions, memos, reports, job cards etc.

Read images, graphs, diagrams.

Oral Communication (Listening and Speaking skills)
To know and understand how to be clear and precise in communication; communicate confidential and sensitive information discretely to authorized persons as per SOP. Listen effectively.

Decision making
How to evaluate multiple options on defined, objective parameters and appropriately use the escalation matrix for complex decisions

Critical Thinking
Know and understand how to apply balanced judgment to different situations; apply, analyze and evaluate information to define action steps and provide sound, constructive, objective opinion.

Planning and Organizing
Know and understand how to plan and organize investigation as per deadlines.

Analytical Skills
Know and understand how to identify, define and resolve problems using a structured methodology and suggest improvements (if any) in process based on experience.
Work with biostatisticians, scientists in the other field and from different regions collaboratively to develop study design and pursue research further.
Know different standard reference material and use Computer/application software .

MIC 401/BTC 402 Research Design (3L) (3h/week)

Section A Introduction to Research and Research Design

Introduction to Research: Information and knowledge. How is knowledge created? What is Research? What is science? Why do we do research? Scientific method: Overview and key components.Types of research. Fact, concept, Hypothesis, theory, law and principle.
Research Design: Basic principles and purpose of research design. Finding research problem, formulating research questions and hypotheses, Use of internet and Search engines for research articles and information. Identifying, deconstructing and reconstructing a problem, Formulating clear and concise research questions. Understanding the importance of a well-defined research problem.

Section B Research Plan and Experimental Design

Preparing a research plan, Types of reasoning and research, Maintaining and assessing quality of research. Data gathering tools: Observation, questionnaire, interview, scaling methods, case study. Experimental research: Experimental design and sampling. Ethical considerations in experimental designs. Designing experiments with controls. Sampling and its types. Common experimental designs. Analysis of variance in Completely randomized design.

Section C Statistical Tools

Data Gathering and Statistical tools: Selection and use of measurement tools. Assumptions, limitations, bias, repeatability. Evaluation of reliability, validity, precision and accuracy in measurements.
Presenting results Classification, tabulation, Graphic representation and frequency distribution. Descriptive statistics- Types of data. Normal distribution. Measurements to summarize information. Principles to choose (assumptions, applicable data type, interpretation and limitations) specific tools for central tendency and dispersion and drawing inference. Probability and probability of error.
Hypothesis testing: Statement of hypothesis, Null and alternate hypothesis. Confidence limits, Types of errors, Standard Error.
Tests of significance: Principles to choose (assumptions, applicable data type, interpretation and limitations) specific tools for various tests of significance.
Determining interactions: Correlation and regression for parametric and non-parametric data. Use of spreadsheets.

Continuous Assessment Indicators: Research proposal, Experimental design project, Data analysis assignments, Research report and presentation

Recommended Texts:

1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by John W. Creswell and J. David Creswell.
2. Practical Research: Planning and Design by Paul D. Leedy and Jeanne Ellis Ormrod.
3. The Craft of Research by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams.

17.3 Elective Courses

Semester I & III

BTEO11 Developmental Biology of Animals (3L) (3h/week)

Course objectives: The proposed course titled as Developmental Biology of animals aims to provide a thorough grounding on the fundamental concepts of genetics, epigenetics, metabolism, growth, morphogenesis and differentiation in developing organisms. Introduce the students to early embryonic development.

Learning Outcomes:

- Describe the morphological processes that transform a fertilised egg into a multicellular organism.
- Explain the molecular, biochemical and cellular events that regulate the development of specialized cells, tissues and organs during embryonic development.

Section A: Basic concepts of development

Principles of Developmental Biology- Potency, commitment, specification, induction, competence, determination and differentiation, morphogenetic gradients, cell fate and cell lineages. Stem cells, genomic equivalence and the cytoplasmic determinants, imprinting, mutants and transgenic in analysis of development. Environmental control of gene regulation, Epigenetic regulation of developmentally relevant genes.

Section B: Gametogenesis, fertilization and early development

Production of gametes, cell surface molecules in sperm-egg recognition in animals, zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and , neural tube formation, cell migration; Axis specification in Drosophila; origin of anterior posterior and dorsal- ventral patterning- role of maternal genes, patterning of early embryo by zygotic genes; segmentation genes- the gap genes, the pair– rule genes, the segment polarity genes, the homeotic selector genes- bithorax and antennapedia complex. Formation of germ layers in animals; embryogenesis.

Section C Morphogenesis and organogenesis in animals

Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination. Embryonic stem cells and their applications; medical implications of developmental biology: genetic errors of human development

Books recommended

Developmental Biology 11th edition by Scott F. Gilbert; Sinauer.
Molecular Genetics of Plant Development (1998); Howell, S.H. Cambridge University Press.

BTEO12 Plant Developmental Biology (Online Swayam Course) (1L) (19h)

By Dr. Shri Ram Yadav IIT Roorkee

About the course: Plant Developmental Biology encompasses the study of how complex multicellular plants are developed from a single zygotic cell. This course will provide an overview of mechanisms underlying the meristem function during growth and development, cell specification, differentiation and organogenesis in the flowering plants. It also describes the approaches used to study plant development. This course will be highly useful for the students to enhance their knowledge and develop their research interest in the field of developmental biology.

Section A

Introduction

Life cycle of an angiosperm plant, Plant growth and development, Embryonic and post-embryonic development, Characteristics of plant development

Section B

Molecular Genetics of Plant Development

Generation and characterization of developmental mutants, studying temporal and spatial expression pattern of developmental regulators, Functional genomics, Genetic manipulation of plant for studying development

Section C

Root and Shoot development

Organization and maintenance of root apical meristem, radial patterning during vascular development, Root branching; lateral root development

Organization and maintenance of shoot apical meristem, Organogenesis and organ polarity, Floral transition, Floral organ patterning and determinacy, Cell-to-cell communication during development

BOOKS AND REFERENCES

1. Leyser, O. and Day, S. Mechanisms in plant development. John Wiley & Sons. 2009.
2. Howell, S.H.Molecular genetics of plant development. Cambridge University Press. 1998.
3. Taiz, L. and Zeiger, E. Plant Physiology. Sinauer Associates. 2010 5th Eds.
4. Raven, P.H. Evert, R.F. and Eichhorn, S.E. Biology of plants. Macmillan. 2005 8th Eds.

BTEO13 Sk Documentation in pharmaceutical industry: (2L) (2h/week)

Section A

Introduction to Documentation

Overview of the importance of documentation in pharmaceuticals. Role of documentation in regulatory compliance and quality management. Three tier documentation, Policy, Procedures and Work instructions, and records, Regulatory Framework for Documentation

Section B

Types of Documents in Pharma, Differentiating between policies, procedures, work instructions, and records, Overview of key documents: SOPs, batch records, , Master Formula Record, Batch Formula Record, Quality audit plan, specification and test procedures, Protocols and reports Distribution records. Importance of each document type in pharmaceutical operations

Section C

Creating Effective Standard Operating Procedures (SOPs)- Principles of writing clear and concise SOPs, SOP structure and formatting. Recordkeeping and Data Integrity- Importance of accurate and complete recordkeeping.

Ensuring data integrity in electronic and paper-based systems Strategies for maintaining the integrity of critical records.

Document Control and Change Management- Establishing a document control system. Change control procedures and impact assessments

Books:

DR Crane:Writing Standard Operating Procedures: The Quick and Easy Way to Produce High Quality SOPs (Practical Office Guide Book 1)
DeAnne Roberts: Creating Standard Operating Procedures: Tools for Small Business
Giles Johnston: Effective SOPs: Make Your Standard Operating Procedures Help Your Business Become More Productive (The Business Productivity Series Book 6)
Atul Mathur: Writing High-Quality Standard Operating Procedures: A Practical Guide to Clear, Concise, and Correct SOPs
JA Vasconcellose.Quality Assurance for the Food Industry: A Practical Approach
J Isenhour. Standardizing Standard Operating Procedures: How To Write Them and Communicate Them, So People Will Follow Them
T Foster and PC Vasavada. Beverage Quality and Safety
SI Haider. Validation Standard Operating Procedures: A Step by Step Guide for Achieving Compliance in the Pharmaceutical, Medical Device, and Biotech Industries. CRC Press

BTEO14 Entrepreneurship in Biotechnology (3L) (3h/week)

Learning Objectives: To understand the processes of value addition to develop novel products, services and their possible commercialization.
Learning Outcomes: Understanding innovations and entrepreneurship in biotechnology.

Section A

Integration of Science, technology and business. Basic principles and practices of management- Definition, concepts and application; Organization types, coordination, control and decision making in management (7).
Entrepreneurship in the biotechnology context; Case studies of successful and unsuccessful bio-entrepreneurs (4).
Biotechnology: emerging industries with examples from Transgenics, Environmental biotechnology, New drug development, DNA chip technology, Stem cell research, Tissue engineering. Contract Research Organization, marketing consultancy, bio-learning module etc. (4)

Section B

Factors affecting biotech business: (finance, infrastructure, equipment, manpower, resources, project location, end product, quality issues, etc.) (6)
Core concept of Market: Identification and evaluation of market potential of various bio-entrepreneur sectors. Marketing, Marketing research- concept and techniques (5)
Role of Indian government and schemes, financial institutions in fostering bio- entrepreneurship (4)

Section C

Personality and attitude, Organizational behavior, Leadership (3), Principles of effective communication Body language, public speaking, presentations, business proposal writing. (3) Communication aid and application of technology (3), Career Opportunities in the Life Sciences Industry (3). Public policy, regulatory and ethical challenges facing the entrepreneurial biotechnology firm (3).

Books

Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies (2014); Craig Shimasaki, ed. Elsevier Inc.
Innovation and Entrepreneurship in Biotechnology, An International Perspective Concepts, Theories and Cases (2006); Damian Hine and John Kapeleris Edward Elgar Publishing Limited
Information for startups from Govt of India website, BIRAC website.

BTEO15/MIEO16 Sk Industrial Microbiology (4L) (4h/week)

Section A

Microbial Fermentations: Metabolic pathways and metabolic control mechanisms. Industrial production of citric acid, lactic acid, enzymes (alpha-amylase, lipase, xylase, pectinases, proteases), acetone- butanol, lysine and glutamic acid. Vitamin B_{12} and riboflavin fermentation.

Section B

Microbial production of therapeutic compounds (beta-lactam, aminoglycosides, ansamycins (Rifamycin), peptide antibiotics, quinolones). Biotransformation of steroids.

Modern trends in microbial production of bioplastics (PHB, PHA), bioinsecticides (thuricide), biopolymer (dextran, alginate, xanthan, pullulan), Biofertilizers (*Azotobacter*, *Rhizobium*, Cyanobacteria, Mycorrhiza, *Azolla* and Phosphate solubilizing microorganisms).

Section C

Alcoholic brews: Types and their production.

Biofuels. Useful features of biofuels. Gasohol. Production of ethanol from sugar, molasses, starch and cellulosic materials. Ethanol recovery. Biogas production (biomethanation). Algae as biodiesel feedstock and its production. Microbial production of hydrogen gas. Microbial Fuel Cell.

Immobilization. Techniques for whole cell and enzyme immobilization. Application and advantages of cell and enzyme immobilization in pharmaceutical, food and fine chemical industries.

Books

1. Biotechnological Innovations in Chemical Synthesis. BIOTOL. Publishers / Butterworth- Heinemann.
2. Industrial Microbiology by G. Reed (Ed), CBS Publishers (AVI Publishing Co.)
3. Biology of Industrial Microorganisms by A.L. Demain.
4. Genetics and Biotechnology of Industrial Microorganisms by C.l.Hershnergey, S.W. Queener and Q. Hegeman. Publisher ASM.
5. Annual Reports in Fermentation Processes by D. Pearlman, Academic Press.
6. Fundamentals of Biochemical Engineering by Bailey and Ollis.
7. Annual Review of Microbiology by Charles E. Cliffton (Volumes)
8. Biotechnology, A Textbook of Industrial Microbiology by Creuger and Creuger, Sinaeur associates.
9. Manual of Industrial Microbiology and Biotechnology 2nd edition by Davis J.E. and Demain A.L. ASM publications.
10. Biotechnology: A Text Book of Industrial Microbiology by W. Crueger& A. Crueger, Panima Publishing Corporation, New Delhi/Bangalore, 2000.
11. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker &S.J. Hall, Aditya Books (P) Ltd., New Delhi, 1997.
12. Modern Industrial Microbiology & Biotechnology by N. Okafer, Scientific Publishers, Enfield, USA., 2007.
13. Fermentation Microbiology and Biotechnology by El Mansi & Bryce, Taylor & Francis, London, Philadelphia, 1999.
14. Fermentation Biotechnology by O.P. Ward, Open University Press, Milton Keynes, U.K., 1989
15. Industrial Microbiology: An Introduction by Waites, Morgan, Rockey & Highton, Blackwell Science, 2001.
16. Biology of Industrial Microorganisms A.L. Duncan
17. Microbial Biotechnology A. N. Glazer and H. Nikaido
18. Molecular Industrial Mycology Leong & Berka
19. Manual of Industrial Microbiology and Biotechnology, Demain& Davies, 2nd ed.
20. Microbial Biotechnology A. N. Glazer and H. Nikaido
21. Biotechnology An Introduction Susan R. Barnum
22. Topics in Enzyme & Fermentation Biotechnology Volumes by Wisemen

BTEO16 Medical Microbiology (4L) (4h/week)

Section A Cellular Microbiology

Prokaryotic and Eukaryotic signaling mechanisms: Eukaryotic cell-to-cell signaling. Endocrine signaling. Prokaryotic signaling: Quorum sensing. Bacterial pheromones. Intracellular signaling. Signaling pathways.

Normal microbial flora of the human body and its role. Sources, vehicles and reservoirs of infection. Pathogenesis: Microbial pathogenicity, transmissibility, infectivity, virulence and virulence factors. Opportunistic pathogens, true pathogens.
Virulence and process of infection – Crossing physical, chemical and biological barriers, Colonization, Association, Adhesion. Invasion of host tissue and toxigenesis with detailed account of virulence factors – Adhesins (pili, capsule, hemagglutinins). Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Invasins (Fibrinolysins, hyaluronidase, hemolysins, hyphal extensions), Evasins (catalase, coagulase, Siderophores, Leucocidins, Kinins), Toxins (diphtheria, cholera, tetanus toxins and endotoxins of Gram negative bacteria – mode of action and in vivo and in vitro assay systems). Mechanisms of bacterial resistance to host cellular (phagocytosis) and humoral defenses. Molecular basis of bacterial pathogenicity – cytoskeletal modulation of host cell, virulence genes and pathogenicity islands.

Section B Human Diseases (Viral)

Exogenous and endogenous infection. Respiratory, skin, wound and burn infection, venereal infections, alimentary tract infection, arthropod-borne blood infections and laboratory infections. Diagnosis, symptoms, etiology, treatment, prevention and disease development in man with reference to Hepatitis, Cancer, HIV, Dengue, Polio, Mumps, Smallpox, Chicken pox, Measles, SARS, MERS, Ebola, Swine flu, Chicken Guinea, Infectious hepatitis and AIDS. Viral vaccines (Conventional, genetic recombinant vaccines used in National Immunization programs with examples. Newer generation vaccines including DNA vaccines with examples). Interferons and antiviral drugs.

Section C Human Diseases (Bacterial and Protozoan)

Causal organisms, diagnosis, symptoms, toxic components, etiology and disease development in man with reference to TB, leprosy, typhoid, cholera, diphtheria, gonorrhea, tetanus, syphilis, trachoma, amoebic & bacterial dysentery, malaria and kala azar. Antibiotics, their classification and mode of action.

Text Books:

1. Morag C. and Timbury M.C. 1994. Medical virology. X/e. Churchill Livingstone, London.
2.Topley and Wilson 1995. Text book on Principles of Bacteriology, Virology and Immunology. Edward Arnold, London.
3. Ananth Narayanan R and Jayaram C.K. 1997.Textbook of Microbiology. Orient Longman.
4. Mackie and McCartney. 1996. Medical Microbiology. Vol.1. Microbial Infection, Vol. 2. Practical Medical Microbiology. Churchill Livingstone.
5. Shanson DC. Wright PSG1982. Microbiology in Clinical Practice.
6. Baron EJ, Peterson LR and Finegold SM. 1990. Bailey and Scott's Diagnostic Microbiology. Mosby

BTEO17 Sk. Seminar/Workshop/Training (1T/1P) (1h/week)

The course will prepare the student for public speech and defense of the ideas presented. It would train student for the need and preparations for various forms of public speaking (Keynote address, workshops, seminars, team engagement (brainstorming, activities, etc.) and picking up topic, organizing thoughts, preparing an abstract and the write-ups, preparing powerpoint presentations, presenting less and providing more, giving credits to sources, overcoming nervousness, developing instant rapport with audience-using humor, quotes, statistics, poetry, cartoons, eye contact with individuals without making them uncomfortable, preparing them to cast stage presence by way of Voice control, Body language, Delivery, Audience relations, Inoculation messages and overcoming fear.

Alternatively or additionally, a workshop or training conducted by the Department for a minimum of 6 days will be considered as a skill course of 1P credit which would include time for lecture(s) and activities (demonstration(s), experimental work, hands on activity) and assessment covering a minimum of 9 h of lectures/tutorials including assessment and 12h of activities (experimentation/hands on work/demonstration etc.).

BTEO 18 Hygiene in Pharma Industry 3L (3h/week)

Section A

Importance of hygiene in industrial settings, Regulatory bodies, Overview of the regulations and standards relevant to hygiene in the pharma industry, Introduction to occupational safety regulations, Types of hazards

Section B

Microbial hazards, route of entry and consequences, Microbiological risk assessment: An overview of steps involved. Cleaning and sanitation practices, Personal hygiene and significance of PPE gowning.

Section C

Containment of infection, introduction to the Cleanroom concept and biosafety levels, HACCP

Suggested Readings

MJ Boss and DW Day (eds). Biological Risk Engineering Handbook: Infection Control and Decontamination. Lewis publishers

EE Hakalehto. Microbiological Industrial Hygiene. Nova Science Publishers

BTEO 19 Plant Cell-Microbe Interactions (3L) (3h /week)

Section A

Introduction to plant -microbe interactions -Overview of plant microbe interaction (2), Plant immune system and microbial pathogenesis(2), Plant immune responses, recognition and signaling in plant immunity (3), Hypersensitive response and systemic acquired resistance (3). Microbial pathogenesis strategies (2), Mechanisms employed by pathogens to infect plants (2), Effector proteins and virulence factors (3).

Section B

Molecular Mechanism of Plant -Microbe Interactions (3) Signal transduction in plant -microbe interactions (4), Plant receptors and microbial signals(2), Cross-talk in signaling pathways (2).

Section C

Genetics and Genomics aspects (3) , Plant and Microbial genes involved in interactions (2), Comparative genomics and evolution (3), Engineering plant-microbe interactions(3) , Genetic modifications for enhanced resistance(3) , Synthetic biology approaches (2) , Climate change and its impacts on interactions (2).

Recommended texts:

Plant-Microbe Interactions by Gary Stacey and Libo Shan

Molecular Plant-Microbes Interactions by C. Staskawicz et al.

Beneficial Plant-Microbes Interactions by Ajit Verma and Narendra Tuteja

Semesters II and IV

BTEE11/MIEE11 Immunology (4L) (4h/week)

Section A

Immune response: Humoral, cellular, actively acquired, passively acquired. Natural or innate immunity. Determinants of innate immunity. Species and strains. Individual differences. Influence of age, hormonal influence, nutritional factors, mechanical barriers and surface secretions, Tissue metabolites with bactericidal properties (lysozymes, nucleins, histones, protamines). Basic peptides of tissues-Leukins, Phagocytins, Lecterin, Heme compounds), Other Non specific immune mechanisms: Opsonization, Inflammatory reactions, Interferon, Complement system: Structure, properties and functions. Complement pathways and biological consequence of complement activation.

Immune system: Organs and cells involved in immune system and immune response. Lymphocytes, their subpopulation, their properties and functions, Membrane bound receptors of lymph cells. Helper T cells in immune response. T cell suppression in immune response.

Antigens, structure, properties and types of antigens, antigen specificity, haptens. Adjuvants-antigen specificity, form, dose and route of entry of antigen. Vaccines and toxoids.

Section B

Immunity to infection- Theories of antigen recognition. Immunoglobulins, Structure, heterogeneity, types and subtypes, properties. Diversity of antibodies and its generation. Lymphoid cell interactions. *In vivo*-immune memory.

Major Histocompatibility Complex and Tumor Immunology: Structure and functions of MHC and HL-A system. HL-A and tissue transplantation. Tissue typing methods for organ and tissue transplantations in humans. Graft versus host reaction and rejection. Tumor specific antigens. Immune response to tumors. Immunodiagnosis of tumors. Detection of tumor markers. Alpha Fetal proteins, Carcinoembryonic antigen.

Section C

Immune tolerance and autoimmunity. Immunosuppression-Specific, nonspecific. Autoimmunity-theories, mechanisms and diseases with their diagnosis. Hypersensitivity reactions-Antibody mediated hypersensitivity. Type I- Anaphylaxis. Type II- Antibody dependent cell cytotoxicity. Type III- Immune complex mediated reactions. Type IV-Cell mediated hypersensitivity reactions. Antigen-antibody reactions- *In vitro* methods-agglutination, precipitation, complement fixation, immunofluorescence, ELISA, Radioimmunoassays. *In vivo* methods- Skin tests and immune complex tissue demonstrations. Applications of these methods in diagnosis of microbial diseases.

Text Books:

1. Henderson *et al*. 1999. Cellular Microbiology. Wiley.
2. de Bruijn *et al*. 1998. Bacterial genomics. Chapman & Hall.
3. Dorman C.J. 1994. Genetics of bacterial virulence. Blackwell.
4. Barrett J.T. 1983. Textbook of immunology: An introduction to immunochemistry and immunology. Mosby, Missouri.
5. Boyd R.F. 1984. General Microbiology. Times Mirror/Mosby (College Pub, St. Louis).
6. Davis, Dulbecco. Microbiology.
7. Broude A.I. 1981. Medical Microbiology and infectious diseases. W.B. Saunders & Co., Philadelphia.
8. Chapel and Haeney 1984. Essentials of Clinical Immunology. Blackwell Sci.

References:

1. Clark W.R. 1991. The experimental foundations of modern immunology. John Wiley
2. Mackie & McCartney. Medical Microbiology. 14/e.
3. Bailey & Scott's Diagnostic Microbiology.
4. Franklin TJ, Snow GA. 1981.Biochemistry of antimicrobial action. Chapman & Hall, New York.
5. Roitt IM. 1995. Essential Immunology. Blackwell Sci. Oxford.
6. Roth J.A. 1985. Virulence mechanisms of bacterial pathogens. American Society for Microbiology. Washington D.C.
7. Smith CGC. 1976. Epidemiology and infections. Medowfief Press Ltd. Shildon, England.
8. Stiem F. 1980. Immunological disorders in infants and children. W.B. Saunders & Co. Philadelphia.
9. Todd IR. 1990. Lecture notes in immunology. Blackwell Sci. Pub. Oxford.
10. Roitt IM, Brostoff and Male 1995. Immunology 4/e Gower Medical Pub Co..
11. Kuby J 1994. Immunology. 2/e. W.H. Freeman and Co., New York.

Websites

CELLS Alive! About unique images of microorganisms that make you sick, and the blood cells that do battle to keep you well. Includes links to sites offering further information on microbiology, infectious diseases and cell biology. http://www.cellsalive.com/

BTEE12/MIEE20 Sk. Biostatistics & Computational Biology (4L) (4h/week)

Section A

Science, scientific methods, scientific approach. Types of research. Exploratory and descriptive. Hypothesis, theory and principle. Meaning, scope and need of statistics. Data, population, sample, statistic. Variables and their types. Basic assumptions in qualitative and quantitative, parametric and non-parametric studies.

Basic principles of research design. Purpose of designing. Theory and design in quantitative research. Definition and types of qualitative research. Methods and techniques of data collection: Group discussions, interviews, key informants, in depth interviews, observations, social mapping.

Data gathering tools: Observation, questionnaire, interview, scaling methods, case study. Experimental research: Reliability and validity of measuring instruments. Precision and Accuracy. Probability. Sampling and its types.

Section B

Interpreting Results: Assumptions, bias, repeatability. Descriptive statistics- Classification and tabulation of data. Proportion and count data. Graphic representation and frequency distribution. Statistical inference. Measures of Central Tendency- Mean, mode median. Measures of dispersion- Mean, deviation, standard deviation, variance and coefficient of variance.

Hypothesis testing: Statement of hypothesis, Null and alternate hypothesis. Confidence limits, Types of error, Standard Error. Parametric and Non parametric tests of significance: goodness of fit, Student's t-, F -, chi square, Kruskaal Wallis' H-, Wilcoxon's T- and Mann Whitney's U- test.

Section C

Correlation (Pearson's and Spearman's), testing significance of correlation coefficient. Linear regression. Coefficient of determination.

Experimental designs, their types, advantages, disadvantages. Analysis of variance: One way and two way ANOVA. Critical difference or least significant difference.

Data processing and presentation of results. Use of spreadsheets and statistical tools in computers. Computers in laboratory (LIMS) and learning (CAL), taxonomy, clinical microbiology, fermentation technology, simulation and modeling. Computers as audio visual aids and as word processors. Use of the internet. Search engines, finding scientific articles - Pubmed – public biological databases.

Books

1. Bliss C.I.K. 1967. Statistics in Biology. Vol. I. Mc Graw Hill, New York.
2. Campbell R.C. 1974. Statistics for Biologists. Cambridge University Press, Cambridge.
3. Hewitt W. 1977. Microbiological assay. Academic press, New York.
4. Hardlaw A.C. 1982. (i) Four point parallel line assay of penicillin pp. 370-379. (ii) Microbiological assay of a vitamin-nicotinic acid. Pp. 214-233. In: S.B. Primrose and A.C. Wardlaw (eds) Sourcebook of experiments for the teaching of microbiology. Academic Press, London.
5. Wardlaw A.C. 1985. Practical statistics for experimental biologists. John Wiley and sons, New York.
6. Ron White. 2000. How computers work. Techmedia.
7. Preston Gralla 2000. How the internet works. Techmedia
8. Holmes D., Moody, P. Dine D. 2006. Research Methods for the Biosciences. Oxford University Press.
9. Kothari CR 1990. Research methodology- Methods and Techniques (2/e). VishvaPrakashan, C.A. Division of Wiley Eastern, New Delhi.
10. Gupta S 1999. Research methodology and statistical techniques. Deep and Deep Publications, New Delhi.
11. Scrimshaw NS and Gleason GR 1992. Rapid assessment procedures. Quantitative methodologies for planning and evaluation of health related programs. International Nutrition Foundation for Developing Countries, Boston.
12. Van Maanen 1983. Quantitative methodology. Sage publications.
13. Cook TD and Reichardt CS 1979. Qualitative and quantitative methods in evaluation research. Sage Pub., London.
14. Creswell J 1994. Research design: Qualitative and quantitative approaches. Thousand Oaks. CA, Sage Pub.
15. Denzin NK and Lincoln YS 1994. Handbook of qualitative research. Sage pub.
16. Mienert CL 1986. Clinical trials: Design, conduct and analysis. Oxford Univ Press, New York.
17. Arora PN Malhon PK (1996). Biostatistics Himalaya Publishing House, Mumbai.

18. Sokal & Rohif (1973). Introduction to Biostatistics, Toppan Co. Japan.
19. Stanton A & Clantz, Primer of Biostatistics (2005). The McGraw Hill Inc., New York

BTEE13/MIEE19 Sk. Bioinformatics (4L) (4h/week)

Section A

Introduction to bioinformatics. Microbial and eukaryotic genomes. Genome analysis, Introduction to genomic libraries and gene cloning. DNA sequencing technologies : Conventional sequencing and automated sequencing, Next generation sequencing technologies. Database: Types of databases, Database structure, accession codes and identifiers, Database searching tools

Section B

Homology, Introduction to sequence alignment. Global, local and semiglobal alignments, optimal and suboptimal alignments. Pairwise alignments: Dot blots, Dynamic programming algorithms, Gap penalties, scoring matrices for DNA and Protein, Heuristic methods: BLAST, FASTA . Suffix Trees and suffix arrays. Patterns, Profiles and Multiple sequence alignments. Software for multiple alignment. Annotations of genes.

Section C

Phylogenetic analysis :Introduction to Molecular phylogeny: Cladistics, Phylogenetic tree construction: additive trees and ultrametric trees, rooted, unrooted trees and tree shapes, data likelihood, distance, parsimony and probabilistic methods, softwares for making phylogenetic trees – MEGA, Phylip. Annotation of genome, Gene prediction.

DNA microarray. Analysis of single nucleotide polymorphisms using DNA chips. Proteome analysis: Two dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectroscopy. Protein microarray.

Text Books:

1. 2000. Genome Analysis. 4 volumes. CSH Press
2. Peruski Jr. and Peruski 1997. The internet and the new biology: Tools for Genomic and Molecular Research. (ASM Press).
3. Hunt SP and Livery R (ED).2000. Functional genomics: practical approach (OUP).
4. Schena M. DNA microarrays: A practical approach (OUP).
5. Baxevanis A.D. and Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins 3rd Ed. John Wiley and Son Inc., 2005.
6. Higgins & Taylor Bioinformatics 2000
7. Roderic D. M. Page, Edward C. Holmes (1998). Molecular Evolution: A Phylogenetic Approach. Blackwell publishing, USA.
8. Principles of Genome Analysis: A Guide to Mapping and Sequencing DNA from Different Organisms by S. B. Primrose (Paperback - Jan 1998)
9. Microbial Genome Methods by Kenneth W. Adolph (Hardcover - Oct 28, 1996)
10. Genome Mapping and Sequencing by Ian Dunham (Hardcover - Sep 1, 2003).
11. Brendan Wren (Editor), Nick Dorrell (2002) Functional Microbial Genomics (Volume 33) (Methods in Microbiology), Academic Press, UK.
12. W.J. Ewens, Gregory Grant,(2005). Statistical Methods in Bioinformatics: An Introduction (Statistics for Biology & Health), Springer
13. Bryan Bergeron (2003).Bioinformatics Computing. First Indian Edition, Prentice Hall
14. Cynthia Gibas& Per Jambeck (2001). Developing Bioinformatics Computer Skills: Shroff Publishers & Distributors Pvt. Ltd (O'Reilly), Mumbai
15. HH Rashidi & LK Buehler (2002). Bioinformatics Basics: Applications in Biological Science and Medicine, CRC Press, London
16. Des Higgins & Willie Taylor (2002). Bioinformatics: Sequence, structure and databanks, Oxford University Press

BTEE 14 Omics Technologies (4L) (4h/week)

Section A

Genomics

Principles, applications, advantages and disadvantages of Restriction Fragment Length Polymorphism (RFLP), Allele Specific Oligonucleotide (ASO) probes, amplified fragment length polymorphism (AFLP), polymerase chain reaction (PCR), random amplified polymorphic DNA (RAPD), and DNA microarray technologies.

Section B

Transcriptomics

Principles, applications, advantages and disadvantages of Gene expression arrays (quantification of transcript abundance, single/multiple 3' probes), Genome tiling arrays (identification of transcribed sequences, multiple probes along the genome), alternative splicing arrays (quantification of different RNA isoforms and probes in exons and exon-exon junctions), RNA-tag sequencing (quantification of transcript abundance and single end reads of each RNA species) and whole RNA sequencing (identification of transcribed sequences and multiple reads. hybridization-based sequence-base, Taq-based methods, Sequence –based, Taq base- methods (serial analysis of gene expression (SAGE), cap analysis of gene expression (CAGE), Massively Parallel Signature Sequencing (MPSS), RNA-seq, Whole Transcriptome Shotgun Sequencing (WTSS), Expressed Sequence Taqs (EST), ENCyclopedia Of DNA Elements (ENCODE)

Section C

Proteomics & Metabolomics

Principles, applications, advantages and disadvantages of 2-dimensional difference gel electrophoresis (2D DIGE), matrix-assisted laser desorption/ionization (MALDI) imaging MS, Electron Transfer Dissociation – Mass Spectrometry (ETD-MS) and reverse-phase protein array, Liquid Chromatography MS (LC-MS), liquid chromatography tandem MS (LC-MS/MS), in gel tryptic digestion followed by liquid chromatography-tandem MS (geLC-MS/MS)

BTEE16 Fundamentals of Good Manufacturing Practices in Pharma Industry (3L) (3h/week)

Section A

GMP

What is GxP, GMP, cGMP- general idea and goals

Important regulatory authorities - WHO,TGA, MHRA, MCC, HPFBI, PICS, EU, ICH, USFDA and the new Schedule M.

Key principles of GMP- Pharmaceutical Quality System, Risk Management in GMP

Documentation and Recordkeeping

Section B

GMP in Manufacturing Operations-

Facility Design and Maintenance, Cleanroom Requirements, Equipment Qualification and Calibration, Validation Processes

Personnel Training and Hygiene- GMP Training Programs, Personal Hygiene and Gowning Practices

Material Management- Raw Material Specifications, significance of raw material specifications in pharmaceutical manufacturing, how raw material quality impacts the quality of the final product, critical elements of raw material specifications, supplier collaboration

Validation Processes

Section C

Quality Control and Assurance and Quality Control Laboratories, Batch Release and Quality Assurance, Final Product Testing and Batch Release, Out-of-Specification (OOS) and Deviation Handling

GMP Compliance and Inspections- Regulatory Inspections, Preparation for Regulatory Audits, Responding to Inspection Findings

Continuous Improvement in GMP- Corrective and Preventive Actions (CAPA), Change Control

BTEE17/MIEE18 ENZYMOLOGY (3L) (3h/week)

Section A

Enzymology- Introduction, Nomenclature and classification, General characteristics of enzymes, Activation energy, coupled reactions, active site and its importance, Factors influencing catalytic efficiency.

Enzyme kinetics, Rapid Equilibrium, Briggs-Haldane kinetics and Henry-Michealis-Menten's equations, Steady State approach, significance of Km, Haldane equation, Velocity vital Substrate concentration curves.

Methods of plotting enzyme kinetics data-Lineweaver-Burk, Hanes-Woolf, Woolf-Augustinsson-Hofstee, Eadie-Scatchard; Advantages and disadvantages of the methods, Comparisons and applications; Integrated form of the Henry-Michaelis-Menten equation.

Section B

Equilibrium dialysis, Scatchard plot for equilibrium binding, Effect of pH on enzyme stability and activity, Effect of temperature on enzyme stability, Arrhenius equation.

Formation of E.S covalent intermediates, transient kinetics, flow techniques (continuous, stopped, quenched), Temp-Jump. General mechanistic principles: Role of proximity effect, bound distortion, multistep catalysis, bifunctional catalysis and solvent effects.

Section C

Regulation of enzyme activity: Feedback inhibition, reversible covalent modification, irreversible covalent modification, allosteric concept, Aspartate transcarbamylalse, ligand-protein interaction, scatchard plot, Hill plot, cooperativity index, Models for allostery (MWC, KNF), Half site reactivity.

Enzyme Inhibition, Models and types of inhibition.

Applied enzymology: Application of enzymes in analytical labs. (clinical and industrial), enzymes as industrial catalysts, Immobilized enzymes, enzyme electrodes, assay of enzyme activities for diagnostic purposes, abzymes, recent developments.

Books

1. Cook P. F., Cleland W.W. Enzyme Kinetics and Mechanism. Garland Science Publishing, London, England and New York, USA, 2007.
2. Buchholz K., Kasche V., Bornscheuer U.T. Biocatalysts and Enzyme Technology.

BTEE18 Sk. Seminar/Workshop/Training (1T/1P) (1h/week)

The seminar course will prepare the student for public speech and defense of the ideas presented. It would train student for the need and preparations for various forms of public speaking (Keynote address, workshops, seminars, team engagement (brainstorming, activities, etc.) and picking up topic, organizing thoughts, preparing an abstract and the write-ups, preparing powerpoint presentations, presenting less and providing more, giving credits to sources, overcoming nervousness, developing instant rapport with audience-using humor, quotes, statistics, poetry, cartoons, eye contact with individuals without making them uncomfortable, preparing them to cast stage presence by way of Voice control, Body language, Delivery, Audience relations, Inoculation messages and overcoming fear.

Alternatively or additionally, a workshop or training conducted by the Department for a minimum of 6 days will be considered as a skill course of 1P credit which would include time for lecture(s) and activities (demonstration(s), experimental work, hands on activity) and assessment covering a **minimum** of 9 h of lectures/tutorials including assessment and 12h of activities (experimentation/hands on work/demonstration etc.).

BTEE19. ANIMAL BIOTECHNOLOGY (3L) (3h/week)

Course objectives: To introduce the principles, practices and application of animal biotechnology in Tissue Engineering, Vaccines and biopharmaceuticals.

Learning Outcomes:

- Describe gene transfer technologies for animals and animal cell lines.
- Describe the limitations and challenges facing the animal industries and disciplines.
- Explain the potential applications of current or developing biotechnologies to these animal related fields.

Section A

Primary Culture and Culture of Specific Cell Types

Introduction to the balanced salt solutions and simple growth medium. Chemical, physical and metabolic functions of different constituents of culture medium. Isolation of tissue, Steps involved in primary cell culture, Subculture and propagation, Cell lines, Nomenclature, Cell line designations, Routine maintenance, Immortalization of cell lines, Cell transformation. Cell cloning and Cell separation, Cell synchronization. Epithelial, Mesenchymal, Tumor cell culture. Measurement of viability and cytotoxicity

Section B

Characterization, Contamination and Cryopreservation of Cell Line:

Morphology, Chromosome Analysis, DNA Content, RNA and Protein, Enzyme Activity, Antigenic Markers, Tumorigenicity, Cell counting, Plating Efficiency, Labeling Index, Generation Time, Source of contamination, Type of microbial contamination, Monitoring, Eradication of contamination, Cell banks, Transporting cells. Retroviral Gene transfer method and molecular pharming, applications of transgenic animal technology.

Section C

Applications of animal cell culture including stem cell applications

Animal cloning basic concept, Techniques, relevance and ethical issues, embryo transfer, SCNT, embryo-splitting, embryo sexing, embryos, in situ and ex situ preservation of germplasm, in utero testing of foetus for genetic defects, pregnancy diagnostic kits, anti-fertility animal vaccines, gene knockout technology and animal models for human genetic disorders. Different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD.

BTEE 20 Nanobiotechnology (4L) (4 h/week)

Section A

Definition and significance of nanoscale materials. Historical development and milestones in nanomaterial research. Types of Nanomaterials: Zero, One , Two and Three-Dimensional Nanomaterials, Examples of Key Nanomaterials: Carbon Nanotubes, Graphene, Carbon Dots, Metal Nanoparticles, Metal Oxide-Based Nanomaterials, Semiconductor Nanomaterials, Quantum Dots, Hybrid Nanoparticles, Bio-nanomaterials, Polymer Nanoparticles, Lipid Nanoparticles

Properties of nanomaterials: Size-Dependent Properties, Quantum effects, Plasmonic effects in metal nanoparticles, mechanical properties at nanoscale, thermal and electrical properties, magnetic properties, surface area and reactivity

Section B

Fabrication Methodologies: Top-Down Approaches Reduction of bulk materials into nanoscale structures- Techniques include ball milling, lithography, and laser ablation. Bottom-Up Approaches - Building nanoscale structures from atomic or molecular components. Techniques include chemical vapor deposition, sol-gel synthesis, and self-assembly. Biological synthesis

Measurement and Characterization tools: Microscopy vs Spectroscopy, Scanning Electron Microscope (SEM), Atomic Force Microscope (AFM), X-Ray Diffraction, Ultraviolet-Visible (UV-Vis) Spectroscopy, Raman Spectroscopy

Section C

Nanocarriers for Drug Delivery: Liposomes, Micelles, Polymeric Nanoparticles

Targeted Drug Delivery-Active Targeting and Passive Targeting
Controlled Release Systems: Sustained Drug Release and Triggered Release

BTEE 21 Plant Tissue Culture and Germplasm conservation (3L) (3h/week)

Section A

Plant tissue culture: Concepts of cell theory and cellular totipotency (2), Landmarks in plant tissue culture (1), Differentiation, dedifferentiation, re-differentiation (2), Hormones used in PTC (2), Explant for the plant tissue culture and response of explants in vitro-callus formation (3). Organogenesis (direct and indirect) and embryogenesis (direct and indirect) (3). Micro propagation (1), Types of PTC(2)

Section B

Methodology: Sterilization (physical and chemical methods), culture media, Murashige and Skoog's (MS medium) (3), medium for micropropagation/clonal propagation of plants (2). Secondary metabolites production: Strategies for enhancing production in tissue culture (3). Commercial aspects and industrial applications of PTC (3)

Section C

Cryopreservation and Germplasm conservation-definition and concept (2), techniques of cryopreservation, cold storage , long term and short term storage, applications (3). Germplasm conservation: preservation of cell, tissue, organ and whole organism (3). Concept of gene bank, DNA bank, Seed bank, Pollen bank (4).

Suggested Readings:

1. Bhojwani, S. S. (1990). Plant Tissue Culture: Applications and Limitations,Elsevier,Amsterdam.
2. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
3. Singh, B. D. (2007). Biotechnology: Expanding Horizons. Kalyani Publishers.
4. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
5. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH:Science
6. T. Engelmann and A.M. Dulloo. Cryopreservation and DNA banking
7. M.R. Davey and P. Anthony. Plant conservation Biotechnology

18. Assessment and Evaluation

18.1.1 All courses except for the Seminars/Workshop/Training in a PG program shall have continuous assessment which would include In term assessment (40% marks) by the course leader (including attendance above 75%, two quizzes and one assignment) and an End term examination (60%) at the level of the University.
18.1.2 A student shall not be permitted to repeat any course only for the purpose of improving the grade.
18.1.3 It comprises in-term continuous assessment and end term assessment.

18.2 **In term Continuous Assessment**

18.2.1 It is mandatory for all students to participate in all the in-term continuous assessment and course-related activities for award of the marks. Therefore a schedule of in-term continuous assessment tests shall be prepared by the Course Leader and informed to the students.
18.2.2 Each course leader shall organize a continuous assessment of each of the courses assigned to him/her. The internal assessment shall be as per the following breakup:

S. No.	Item	Max Marks
1	Tests/Term Papers/Quizzes (1 x 20 or 2 x10)	20
2	Assignments (May include Case Demos/Presentations/Write ups/ Viva etc.)	10
3	Attendance	10
	Total	40

18.2.3 In-term Continuous Assessment marks shall be displayed within a week from the date of conduct of examination and all corrected answer books with comments, if any, shall be shown to students.
18.2.4 Marks for attendance must be given as below:

Attendance (%)	Marks	Attendance (%)	Marks
75	1	86-88	6
76	2	89-91	7
77-79	3	92-94	8
80-82	4	95-97	9
83-85	5	98-100	10

Percentage of attendance in decimal values must be rounded off to the nearest number; i.e. <0.5 as the nearest lower number and 0.5 or more as the nearest higher number.

18.2.5 **Seminars**
18.2.5.1 A seminar leader nominated by the Head of the Department to act as a guide to the students will assign topics for the seminars to the students. They will present an Abstract not exceeding 500 words along with a few important references. The seminar leader will give a schedule for providing abstracts, showing presentations to him/her, date and time of the final presentation and submission of the write-up of the seminar. Students will present their seminar presentations in front of the faculty, research scholars and students of the Department as per the schedule provided by the seminar leader, informed to the Head of the Department and faculty, and displayed on the Notice Board.
18.2.5.2 Final presentation of the seminar will be assessed by the seminar leader and another faculty member appointed by the Head of the Department.

18.3 End-Semester examination
18.3.1 An End Semester examination shall be conducted by the University for all courses offered to the student by the department except for the Seminar/Workshop/Training. The duration of the end semester examination shall be 3 hours.
18.3.1 A schedule of End term examinations be prepared by the Examination Section and displayed at the departments at least one-month ahead of the conduct of the examination.
18.3.2 No student who has less than 75% attendance in any course shall be permitted to attend the end-semester examination and s/he shall be given grade of FA-failure due to lack of attendance. S/He shall be asked to repeat that course the next time it is offered.

18.4 Conduct of End-Semester Exams and Evaluation
18.4.1 End-Semester Examination shall be conducted by the University by inviting Question Papers from the External Examiners except for the Foundation courses/Seminars/Skill based training/ workshop courses.
18.4.2 An alternative Question paper should also be made available for any contingency.

18.5 Scheme of the End Semester question paper
18.5.1 All Question Papers for the End Semester will be set out of a maximum of 60 marks.
18.5.2 Question paper for each Core and Elective theory course with more than 2 credits will have three sections: Part A, B and C.
18.5.2.1 Part A (Maximum 9 marks) will have 9 questions of 1 mark each, all of which must be attempted by the candidate. This part will have at least three questions set from each unit of the course contents of the paper. Word limit for the answers is 20 only.
18.5.2.2 Part B (Maximum 15 marks) of the question paper will have 5 compulsory questions. A minimum of 1 question will be asked from each unit of the course content. Each question will carry 3 marks. Word limit for the answer is 50 only.
18.5.2.3 Part C (Maximum 36 marks) will have a total of 3 questions, one from each unit of the course content. Each question will carry 12 marks and will have one choice from the same unit. Word limit for the answer to each question is 400 only.
18.5.3 The answer books of end-term examination (theory) should be evaluated by the External Examiner except for the Foundation courses/seminars/skill based training/workshop based courses.

18.6 **The Foundation Course** must be assessed by the examiner nominated by the Head of the Department concerned.

18.7 **Practical examinations**: There will be a panel of examiners consisting of one external and one internal examiner.

18.7.1 Following shall be the distribution of marks in practical courses:

S. No.	Item	Maximum marks
1	Experimental work assigned during examination	50
2	Attendance	10
3	Record	20
4	Viva voce	20

18.8 **Short term projects**: A panel of examiners consisting of one external (a faculty from the departments of MDS University, other than that of the DoM/faculty from local institutions/institutions from other cities) and one internal examiner (faculty from the DoM) must evaluate short term projects. Following shall be the distribution of marks for the short-term projects:

S. No.	Item	Maximum marks
1	Project report	60
2	Attendance	10
3	Viva voce	30

18.9 **Project work/dissertation**: Evaluation of project work/dissertation shall be done by a panel of examiners consisting of one external and one internal expert. Project will be evaluated based on regularity (attendance and reporting work, Groundwork/Review of Literature, plan of work, conduction of experiments, presentation of data, analysis of data, presentation of weekly reports, report writing, presentation skills etc.).

18.10 Skills taught through workshops/trainings

18.10.1 Only those showing 100% attendance will be assessed.

18.10.2 A student will be assessed by the coordinator of the training/workshop on one or combined basis of presentations (oral/poster/write-ups/report) or oral/written quiz out of a maximum of 100 marks and graded as per the CBCS norms.

18.10.3 The system of assessment must be informed to the participants prior to the start of the course.

18.10.4 The grades will be informed by the Head of the Department along with the title of workshop/training to the Controller of Examinations for inclusion in the grade-sheet of the student concerned.

19. Promotion

A student who registers for the end semester examination shall be promoted to the next semester on the basis of an undertaking that if s/he fails in the previous semester, his/her admission shall be treated as canceled.

20. Consolidation of Marks

20.1 The Head of the Department must send the list of the consolidated awards for In-term continuous assessment of each course and awards for seminars and creditable skill based workshops/training to the examination section. The examination section shall consolidate the marks of the In-term and End-Term Assessment and prepare a consolidated Statement of Marks.

20.2 In order to declare the pass, a Student should get a minimum of 40% marks in the aggregate of In-term and End-term assessment.

20.3 A candidate who has successfully completed all the Core courses in a semester and accumulated not less than minimum number of credits prescribed shall be eligible to receive the Certificate/Diploma/Advanced Diploma/Degree.

21 Due Courses

21.1 Any student who has failed in a maximum of three courses may be allowed to keep the term provided s/he meets the attendance requirement and has a minimum of 40% marks in in-term continuous assessment.
21.2 S/he may be permitted to register for the end-semester examination in the semester in which the course is offered next.
21.3 Only one attempt will be allowed for the end term examination of due courses in which a student has failed.
21.4 Students who have failed due to insufficient attendance and/or less than 40% marks in in-term continuous assessment should repeat the course as and when it is offered. However s/he will be considered a failure if the number of courses where s/he has failed due to attendance or the number of courses in which s/he has failed is more than two.

25 Grading and Grade Card
The Examination Section shall prepare two copies of the results, one with marks to be sent to the Department and another for the University Office, not later than 15 days after the last day of semester examinations.
25.1 In this system, **grade Point** is a numerical weight allotted to each letter grade on a 10-point scale. **Credit Point** is the product of grade point and number of credits for a course and **Letter Grade** is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P, F and FA.
25.1.1 Performances of students in each course are expressed in terms of marks as well as in Letter Grades. In case of fractions the marks shall be rounded off to the nearest integer. The class interval for the purpose of awarding the grades can be arrived at by dividing the difference between the highest mark secured and the minimum pass mark by 7 as there are seven passing grades. The formula is given below:

K = (X-40)/7

Where, K = class interval, X= the highest mark in the subject.

25.1.2 The grades will be awarded as shown in the following table:

Range of Marks in %	Letter Grade	Points for Calculation of GPA/ CGPA
X to (X-K)+1	O	10
(X-K) to (X-2K)+1	A+	9
(X-2K) to (X-3K)+1	A	8
(X-3K) to (X-4K)+1	B+	7
(X-4K) to (X-5K)+1	B	6
(X-5K) to (X-6K)+1	C	5
(X-6K) to 40	P	4
Below 40	F	0
Failure due to lack of attendance	FA	0

25.1.3 K should not be rounded off to less than two decimal places. The numbers given in the Range of Marks column, (X-K), (X-2K), (X-3K), etc., can be rounded off to the nearest whole number.
25.1.4 Absolute grading may be done as below in courses where the number of students registered is less than 10.

Range of Marks in %	**Letter Grades**	**Points for Calculation of GPA/ CGPA**
81-100	O	10
71-80	A+	9
66-70	A	8
61-65	B+	7
56-60	B	6
50-55	C	5
40-50	P	4
<40	F	0
Failure due to lack of attendance	FA	0

25.1.5 The GPA and CGPA will be calculated as weighted average of points secured by the student in all the courses registered by him/her. The weights are the number of credits for each course. For example, a student getting an A+ grade in 4 credit course, A grade in 2 credit course, O grade in a 3 credit course and F grade in a 3 credit course will have a GPA as (9x4 + 8 x 2 +10 x 3 + 0x3)/(4+2+3+3)=(36+16+30+0)/12=82/12 = 6.83 out of 10.0; GPA = 6.83. The CGPA shall also be calculated on similar lines taking all subjects taken by the students in all semesters.
25.1.6 Students with a CGPA of 9.0 and above and who did not fail in any of the courses taken by him/her shall be awarded Distinction.
25.1.7 A CGPA of 6.0 and above shall be placed in First class.
25.1.8 Students who have secured less than 40% marks in any course get F Grade and will be treated as a failure in that course.
25.1.9 A candidate who has successfully completed all the Core courses in a semester and accumulated not less than the minimum number of Credits prescribed shall be eligible to receive the Certificate/Diploma/Advanced Diploma/Degree.

26. Conditions for the Award of the Degree/Diploma/Certificate
26.1 In case a student admitted to the Program opts out of the program after successful completion of -

- 22 credits of Semester I, he/she will be awarded PG Certificate in Molecular Biology
- 44 credits of Semester I and II he/she will be awarded PG Diploma in Molecular Biology & Biotechnology
- 66 credits of Semester I, II and III, he/she will be awarded Advanced PG Diploma in Biotechnology
- 88 credits till Semester I, II, III and IV, M.Sc. in Biotechnology

26.2 Students opting out with the PG Certificate/PG Diploma/Advanced PG Diploma may be permitted to get entry into the Program within a maximum period of two years to complete their master's degree.

27. Grade Card
27.1 The University Office shall issue a Grade card for the students containing the marks and grades obtained by the student in the previous semester and Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA).
27.2 For the conversion of grade points to percentage of marks, the following formula shall apply:
Percentage of Marks= GPAx9.5.