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. 2020-21 & III & IV w.e.f. 2021-22)

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 of 15 different skill honing courses. Student 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): Post Graduate Certificate in Molecular Biology
    2. Semester I and II (1 year, 44 credits): Post Graduate Diploma in Molecular Biology & Biotechnology
    3. Semester I, II and III (1.5 year, 66 credits) Advanced Post Graduate Diploma in 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 fulfils 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 allwalks 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 centred 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), generalising (adapting the solution to other problems) and forming algorithm (framing the rules to solve similar problems) through reflective thinking.

It alsoincorporates 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 biotechnologistsare organised in the*Atreya* series of lectures. *Madhavkar* Awareness campaign opens up an interface with the society alongwith*Anandam*-a program of building trusteeship. 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. Student 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 willearn skills for specific technologies through projects, experiments and trainings/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
- workingas 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, 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 Bandarsindari, **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 OceanResearch, Vasco da Gama, Ministry of Food Processing Industries, GOI, New Delhiand Forensic Science Department, Kota.

Two of the alumni joined 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, Sarv Haryana Gramin Bank andSBI.

7.2.**Progression to higher education**

Several students joined M Phil or PhD or Post Doctoral research at International and national institutes viz. IISc Bangalore, IISER Pune, RMIT University Melbourne, National Centre for Cell Science, Pune, National Chemical LaboratoryPune, Defence lab Jodhpur, IIT Jodhpur, CAZARI 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; GBPUA&T, Pantnagar; MSU, Vadodara, PU Chandigarh CUoR, MDSU, Ajmer JLNTU, Hyderabad, KGMU, Lucknow. There is a record of87 students that qualified 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 as '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 categorised 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 trainings 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 specified 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 also allow student to pick specific courses and add on to their

desired scheme of specialization.Experiments taking longer, 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*	30-34
*1P credit includes 1h tutorial and 2h of laboratory/practical exercise and/or demonstrations			
Long term project/ dissertation	10 P	20	375-425

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. Core courses include 4 credits of Foundation courses (Compulsory and elective). Of the remaining 52 core credits, one short term project (1P) will have to be done in each of the first three semesters, and one long term project work/dissertation (10P credits) in the fourth semester. In addition to the 20 credits in each semester, a course on *Anandam* (2 credits) will have to be done as a compulsory Foundation course.

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 number of courses accordingly.

8.9 Some courses have pre-requisites, i.e. they may be opted 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. Beginning of Semester

9.1 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.

9.2 **The 1st working day of each semester:** Orientation and allotment of students to departmental advisors/mentors.

9.3 **The 2nd working day of each semester:** Advisor-student meet in the concerned department and registration of students with the concerned course leaders.

9.4 **The 3rd day of semester:** Beginning of teaching

9.5 Students shall have to register for the courses for the semester within the first week of admission.

9.6 The maximum number of students to be registered in each course shall depend upon the physical facilities available.

9.7 In any department, preference for registration shall be given to those students of that department for whom the course is a Core course.

9.8 The registration for the elective course shall be on first come first served basis, provided the student fulfils prerequisites for that course, if any.

9.9 Normally, every course shall be offered by one course leader.

9.10 No course shall be offered unless a minimum of 3 students are registered.

9.11 Essential Foundation Courses shall be registered by all students as per the recommendation of the Program of Study.

9.12 Students admitted late will have to contact the concerned Head of the department, who in turn must introduce and guide him/her to the process of registration.

9.13 **Auditing a course**: Subject to the permission of the course leader, a student may opt to audit maximum two courses without assigning any credits. The student will be assessed the same way but will be awarded either 'satisfactory' ($\geq$40%) or 'unsatisfactory' grade based on performance.

9.14 **Class schedule:**Tentative time table of each department shall be displayed on its Notice Board on the 1st day of the semester and a copy should be made available to the Dean PG Studies/Principal and the Head(s) of the concerned Department, a day before the beginning of the semester.

9.15 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 must be arranged in the afternoon sessions only.

9.16 Course leaders would adjust the conflicting time slots on the basis of mutual understanding. Yet in case of any dispute, the Dean PG/Principal would give slot in the time table on the basis of priority to a course leader having more variety of students (i.e., having registrations of students from maximum number of departments).

9.17 If all classes cannot be accommodated to the usual period, then teaching hours may be extended. Teachers having classes starting early or in the late hours shall be free to leave/come to the campus compensating this time. Total stay in the campus shall be as per the UGC norms.

9.18 In no case however, a teacher must be given a time slot of both early and late hours on the same day.

10. Courses offered in M.Sc. Biotechnology

10.1 Core Courses

10.1.1 Semester I

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial + Lab/Field work)	Hours/week
BTC 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	Molecular Biology I	2	0	2
BTC 105 S Sk	Short term Project	0	1	3
BTC 106	Microbiology & Biochemistry Lab	0	3	9
		12	4	24

10.1.2 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	Molecular Biology II	2	0	2
BTC 203 Sk	Fermentation Technology	4	0	4
BTC 204S Sk	Short term Project	0	1	3
BTC 205Sk	Bioprocess & Physiology Lab	0	4	12
		10	5	25

10.1.3 Semester III

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
BTC 301 Sk	Synthetic Biology	4	0	4
BTC 302	Genetics and Molecular Genetics	3	0	3
BTC 303Sk	Biotechniques	4	0	4
BTC 304 S Sk	Short term Project	0	1	3
BTC305	Molecular Biology Lab	0	3	9
		11	4	23

10.1.4 Semester IV

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
BTC 401 L Sk	Project Work/Dissertation	Nil	10	20

10.2.1 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: Molecular Basis	2	0	2
BTEO12	Plant Developmental Biology	1	0	2
BTEO13Sk	Standard Operating Procedures	1	0	1
BTEO14	Entrepreneurship in Biotechnology	3	0	3
BTEO15	Industrial Microbiology	4	0	4
BTEO16	Medical Microbiology	4	0	4
BTEO17 Sk	Seminar/Workshop/Training	0	1	1

10.2.2 Disciplinary Elective Course for Semester II & IV

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
BTEE11	Immunology	4	0	4
BTEE12Sk	Biostatistics & Computational Biology	4	0	4
BTEE13 Sk	Bioinformatics	4	0	4
BTEE14	Omics Technologies	4	0	4
BTEE15	Hygiene in Industry	3	0	3
BTEE16	Introduction to Good Manufacturing Practices	3	0	3
BTEE17	Enzymology	3	0	3
BTEE18Sk	Seminar/Workshop/Training	0	1	3

10.3 Foundation Courses

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Field work)	Hours/week
Compulsory Foundation Course				
BT FC 00	*Anandam*-An Exercise in Trusteeship	0	2	2 (+ 2h after teaching hours)
Elective foundation Course				

BT FE01	Journal article: Evaluation and Presentation	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 foundation course being offered by any other department.

11. Specialization

Any student completing successfully a set of specified courses will be able to specialize in fields as depicted below:

1. **Molecular & Synthetic Biology**: With BTC 302 Genetics & Molecular Genetics (3L)8 credits of the following: BTEE13 Sk Bioinformatics (4L), BTEE14 Omics Technologies (4L)

2. **Plant Biotechnology**: Minimum 9 credits of the following: BTEO12 Plant Developmental Biology (1L), BOT 401 Cell & Molecular Biology of Plants (3L), BOT 407 Genetics & Cytogenetics (3L), BOT 416 Plant Biotechnology & Genetic Engineering (3L),MIEO 17 Geomicrobiology & Agricultural Microbiology (4L), MIEO 18 Sk. Techniques in Geomicrobiology & Agricultural Microbiology (2P)

3. **Animal Biotechnology**: Minimum 9credits of the following: BTC 302 Genetics & Molecular Genetics (3L), BTEO11 Developmental Biology of Animals: Molecular Basis (2L), BOT 407 Genetics & Cytogenetics (3L), Courses in MSc Zoology

4. **Medical Biotechnology**: BTC303 Sk Biotechniques (4L) and minimum 8 credits of the following: BTEO16 Medical Microbiology (4L), BTEE11 Immunology (4L), BTEE12 Biostatistics & Computational Biology (4L), MIEO 14 Virology (2L)

5. **Industrial Biotechnology**: Minimum 9 credits of the following: BTEO15/MIEO16 Industrial Microbiology (4L), BTEE15 Hygiene in Industry (3L), BTEE16 Introduction to GMP (3L), BTEE17 Enzymology (3L), BTEE12 Biostatistics & Computational Biology (4L), BTEO 13 Sk Standard Operating Procedures (1L)

6. **Food Biotechnology:**MIEE 16. Food Microbiology (3L), MIEE 17 Sk. Experimental Food Microbiology (2P), Institutional Food Administration and Food Science in Department of Food Science & Nutrition and Workshops on Food/Fruit preservation

7. **Environmental Biotechnology:** Minimum 9 credits of the following: BOT 441/MIEO 15Sk Microbiology of wastes and Waste Remediation (3L), MIEE 14. Basics of Biofuel & Bioenergy (3L), MIEE 15 Sk. Techniques in Biofuel & Bioenergy (2P), MIEO 17 Geomicrobiology & Agricultural Microbiology (4L), MIEO 18 Sk. Techniques in Geomicrobiology & Agricultural Microbiology (2P), BOT437/ENV412 Environmental Biotechnology (3L), ENV 401 Concepts of Ecology (2L), ENV 425 Eco toxicology (3L), ENV 402. Components of Environment (2L)

8. **Entrepreneurship in Biotechnology**: Minimum 9 credits of the following: BTEO14 Entrepreneurship in Biotechnology (3L), BTEE15 Hygiene in Industry (3L), BTEE16 Introduction to GMP (3L), BTEO 13 Sk Standard Operating Procedures (1L),BOT 463/ENV 410 Occupational Health (3L), Institutional Food Administration and Food Science in Department of Food Science & Nutrition and Workshops on Food/Fruit preservation

12. Detailed outline of Courses offered

12.1 Foundation Courses
Compulsory Foundation Course
BT FC 00.*Anandam*-An Exercise in Trusteeship (2T)
(2h instruction and interaction time+ 2h out of academic schedule every week)

Two credits of this compulsory course will be super numeral for the minimum credits required for the successful completion of each semester. Thus instead of minimum 20 credits per semester, minimum 22 credits will have to be opted by the student in each semester.

In this course, the student will be encouraged to do a good deed daily and project work will be assigned in groups to sensitize them towards social issues and instil in the students the joy of giving. The program will be run as below:

1. On the day of finalization of admissions, the Head of the Department will assign students to the mentors.

2. Mentors will orient students for this program, discuss subjects for the possible project works with the students and allow them to pick projects of their choice.

3. S/he will inform the Head of the Department, the names of students of each group and title(s) of the project(s) assigned to them within the first 15 days of admission.

4. In the teaching time table, 3 hours per week (30 min each day) will be assigned from the routine teaching hours for *Anandam*, wherein the datewise daily deed register will be signed and group project will be presented, reviewed and discussed by the mentor (32 hours per semester).

5. Additionally minimum 2 hours per week will be spent by the students to complete the project work outside the teaching hours (32 hours per semester).

6. Final report of the project work with photographs must be presented in front of all faculty members of the department and graded by them as per the point 8 below. (Each Guest faculty engaged for the purpose shall be paid remuneration as per norms for a maximum of 2 hours per week)

7. Reports of the project works will be uploaded on *Anandam* platform. The Head of the Department will ensure uploading of reports on the *Anandam* platform and act as *Anandam* Coordinator.

8. Grading as mentioned below will be done by the mentor concerned on the basis of how much time student had spent on the daily deeds and the project work:
=32h: C grade, 33-44h: B grade, 45-54h: A grade and 55-64h: O grade

9. Consolidated result will be communicated by the Head of the Department to the Controller of Examinations of the University.

Elective Foundation Course

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.

12.2 CORE COURSES

Semester I
BTC101 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 microscope. 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 finger printing 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., Kreig 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. Spriger-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. Mc Graw 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

Comparative cell architecture (3), Cell differentiation in plants and animals (4), Membrane structure and function (3), Structure and function of intracellular organelles and Nuclear sub compartments (4), Cytoskeleton and its dynamics (2)

Section B

Intra cellular transport of biomolecules (4), Principles of Cell – cell communication (Animals, plants and microbes) (5), Cell signaling in prokaryotes and eukaryotes (5)

Section C

Cell division (4), Cell migration (2), Aging and cell death (4), Cancer and stem cell biology (4)

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 matter. Cellular 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, carragenan, 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 polynucelotides. 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. Mc Graw Hill.

BTC 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, peptidyltransferase 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 S Sk. Short term Project (1P) (3h/week)

Student will be given basic experimental work to achieve specific goal so as to acquaint him/her with the handling of material.Planning experiments, preparing reagents, Lab safety protocols.

BTC 106Sk Microbiology & Biochemistry Lab (3P) (9h/week)

Student will learn aspetic 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 201Physiological Diversity (4h/week)

Section A Development and Bioenergetics

Cell wall in archea, 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 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 di oxide. Calvin cycle. C3, C4 pathway. Chemolithotrophy-Sulfur, iron, hydrogen, nitrogen oxidations. Methanogenesis, Luminiscence. Brief account of photosynthetic and accessory pigments-chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobilliproteins. 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. Mac Millan Education Ltd., London
4. Brun YV and Shimkets LJ 2000. Prokaryotic development. ASM Press.

BTC 202 Molecular Biology II (Pre requisite: 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 alternate 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/ generaland 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, Zippursky 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 gases.

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 process 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 system, problems associated with strain improvement program, 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. McNeul 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, Sinaeur 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 S Sk. Short term Project (1P) (3h/week)

Collecting literature and writing review for a specified problem alongwith basic experimental work towards standardizing the methodologies independently as well as in groups.
Skill: Work with cross functional teams for carrying out research activities, working effectively with others.
Sharing information with others to enable efficient delivery of work.
Writing a review article.
Communicating with other team members and people internal or external to the organization.
Provide and receive support and feedback from others in the team.

BTC 205 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 Sk. Synthetic Biology (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 Liveey 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)

BTY – 413 Analytical techniques and Molecular Diagnostics Credits 3

Learning Objectives: To understand the tools and techniques employed in biotechnology and molecular diagnostics.

Learning Outcomes: Understanding the tools and techniques employed in biotechnological manipulations and molecular diagnostics.

Section A
Separation Techniques

Sub cellular 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 ad 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 S Sk. Short term Project (1P) (3h/week)

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

BTC 305 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.

Semester IV

BTC 401 LSk Project Work /Dissertation (10P) (10hT+12h lab work/week)

Ten credits (22 hours of work/week/student) including 10hT/week/group of students allotted) will includeguidance, 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	Ground work (Review of literature)	1	1
2	Plan of work	1	1
3	Conduction of Experiments	2	14
4	Presentation of data	1	1
5	Analysis of data	2	2
6	Presenting weekly reports (20 min seminars+5min discussion)	1	1
7	Report Writing	1	1
8	Presentation as Seminar (8 min+2 min discussion) and Presentation as Poster Paper	1	1
	Total (1-9)	10	22

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 person 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 evaluation 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 biostatistician, 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.

12.3 Elective Courses

Semester I & III

BTEO11 Developmental Biology of Animals (2L) (2h/week)

Learning Objectives: To understand the molecular basis of embryonic development and cellular differentiation in living systems.
Learning Outcomes: Understanding concepts of embryonic development and cellular differentiation in animal and plants.

Section A

Basic concepts of Development (3), Gametogenesis, Fertilization (3) Early Development: Cleavage, Gastrulation and Axis Development (6)

Section B

Building with Ectoderm (3), Building with Mesoderm (6)

Section C

Building with Endoderm (5), Development in Health and Diseases (3)

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.

BTEO13Sk Standard Operating Procedure (1L) (1h/week)

This will be a seminar as well as tutorials based course.

Section A

HACCP, What is it? Principles of HACCP. SOPs. How to prepare SOP Manuals.

Section B

Food plant SOPs, Food Safety pyramid, Implications of material recall, Benefits of SOPs, Contents of SOP manuals, Process of preparing SOPs. Sanitation SOPs for Meat and poultry establishments,Food Safety and Hygiene Practices

Section C

SOPs for Personnel hygiene in pharmaceutical industry, SOP for Industrial hygiene.

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); CraigShimasaki, 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 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, quinolinones). 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. Duncun
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 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 andprocess of infection – Crossing physical, chemical and biological barriers, Colonization, Association, Adhesion. Invasion of host tissue and toxigenesis with details 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, hypal 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 pathogenecity – cytoskeletal modulation of host cell, virulence genes and pathogenecity 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, Small pox, 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, gonorrhoea,

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. Ananthnarayanan 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 (brain storming, activities, etc.) and picking up topic, organizing thoughts, preparing an abstract and the write-ups, preparing power point 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.).

Semesters II and IV

BTEE11 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. Alphafoetal proteins, Carcinoembryonic antigen.

Section C

Immune tolerance and autoimmunity. Immunosuppression-Specific, nonspecific. Autoimmunity-theories, mechanism 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. Essential 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 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 aid and as word processor. Use of 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. Waardlaw (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 Imalaya 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 Sk. Bionformatics (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 Liveey 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), ingel tryptic digestion followed by liquid chromatography-tandem MS (geLC-MS/MS)

BTEE 15 Hygiene in Industry 3L (3h/week)

Section A

Introduction to the diversity of biological contaminants that are hazardous with examples from bacteria, fungi, yeasts, prion, viruses

Sampling biologicals and general air quality, health and safety precautions, documentation, Industrial hygiene measurements, ventilation

Section B

Biological sampling and cultural and speciation methods and accreditation

Introduction to toxicology of bio-contaminants: Dose response relationship, Potency, Route of exposure and its effects, Toxicity, risk assessment

Section C

Containment of infection, decontamination and maintenance of the facilities, biosafety levels, laws and regulations

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

BTEE16 Introduction to Good Manufacturing Practices (3L) (3h/week)

Section A

GMP

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

Requirements and principles of GMP.The 4 Ps of GMP.

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

Obtaining International GMP Certification and maintaining the GMP continuum

Principles and overview of the Pharmaceutical Quality System

Personnel- Organizational setup, Key personnel, Background and duties of the Qualified person, Personnel training and hygiene.

Premises and equipment related practices

Section B

GLP & GDocP

Fundamentals of Good Laboratory Practices, GLP compliance.

GDocP- Documentation, Generation and control of documentation, Types of documents and specifications, Manufacturing formula and processing instructions, Packaging instructions, Procedures and records. Preparation of SOPs

Production- General principles, Prevention of cross-contamination in production, Guidelines for starting materials, Processing operations, Packaging materials and operations, Guidelines for finished products.

Section C

Pharmaceutical Quality Management System

Pharmaceutical Quality Management System- Change Control, Deviation, Incident, CAPA, OOS /OOT, Stability Studies, Trainings, Risk Management, Gap Assessment

Basic understanding of quality assurance and validation.

Quality Control- General principles, Main tasks of the Quality control department, Controlling agencies- Conducting and Facing Self-Inspection and Quality Audits facing first, second & third party audits, Complaint handling and product recall.

BTEE17 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, Henry-Nucgaekkus-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, Eadsie-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 (brain storming, activities, etc.) and picking up topic, organizing thoughts, preparing an abstract and the write-ups, preparing power point 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.).

13. Assessment and Evaluation

13.1.1 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.
13.1.2 A student shall not be permitted to repeat any course only for the purpose of improving the grade.
13.1.3 It comprises of in-term continuous assessment and end term assessment.

13.2 **In term Continuous Assessment**

13.2.1 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.
13.2.2 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

13.2.3 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.
13.2.4 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.

13.2.5 **Seminars**

13.2.5.1 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 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 seminars 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.
13.2.5.2 Final presentation of the seminar will be assessed by the seminar leader and another faculty member appointed by the Head of the Department.

13.3 End-Semester examination

13.3.1 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.
13.3.1 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.
13.3.2 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.

13.4 Conduct of End-Semester Exams and Evaluation
13.4.1 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.
13.4.2 An alternative Question paper should also be made available for any contingency.

13.5 Scheme of the End Semester question paper
13.5.1 All Question Papers for the End Semester will be set out of a maximum of 60 marks.
13.5.2 Question paper for each Core and Elective theory course with more than 2 credits will have three sections: Part A, B and C.
13.5.2.1 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.
13.5.2.2 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.
13.5.2.3 Part C (Maximum 36 marks) will have total 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.
13.5.3 Questions papers for theory courses having 1 or 2 credits may be set by the examiner in a way covering the entire curriculum of the course and need not follow the pattern at **13.5.2** as they have very short content.
13.5.4 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.

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

13.7 **Practical examinations**: There will be a panel of examiners consisting of one external and one internal examiner.
13.7.1 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

13.8 **Short/medium 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/medium 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

13.9 **Long term project/dissertation/research work**: Evaluation of long term projects/dissertation/research work shall be done by a panel of examiners consisting of one external and one internal expert. Distribution of marks for the evaluation of Long term projects may be as below:

S. No.	Item	Max Marks
1	Ground work/Review of literature	5
2	Plan of work	5
3	Conduction of Experiments	5
4	Presentation of data	5
5	Analysis of data	10
6	Presenting weekly reports (20 min seminars+5min discussion)	15
7	Report Writing	5
8	Presentation as Seminar (8 min+2 min discussion) and Presentation as Poster Paper to the supervisor	10
9	Attendance	10
10	Presentation of seminar (10 min) in front of examination panel (One external, one internal)	10
11	Viva Voce	20
	Total (1-11)	100

13.10 **Skills taught through workshops/trainings**

13.10.1 Only those showing 100% attendance will be assessed.

13.10.2 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.

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

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

14. 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 cancelled.

15. Consolidation of Marks

15.1 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/trainings 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.

15.2 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.

15.3 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.

16 Due Courses

16.1 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.

16.2 S/he may be permitted to register for the end-semester examination in the semester in which the course is offered next.

16.3 Only one attempt will be allowed for the end term examination of due courses in which a student has failed.

16.4 Student who has 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 fail 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.

17 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.

17.1 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.

17.1.1 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 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.

17.1.2 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

17.1.3 K should not be rounded off to less than two decimal places. The numbers given in Range of Marks column, (X-K), (X-2K), (X-3K), etc., can be rounded off to the nearest whole number.

17.1.4 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

17.1.5 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 + 8x2 +10x3 + 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.

17.1.6 Student 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.

17.1.7 A CGPA of 6.0 and above shall be placed in First class.

17.1.8 Student who has secured less than 40% marks in any course gets F Grade and he is treated as failed in that course.

17.1.9 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.

18. Conditions for the Award of the Degree/Diploma/Certificate

18.1 In case a student admitted to the Program successfully completes the course of *Anandam* in each semester but 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

18.2 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.

19. Grade Card

19.1 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).