ACADEMIC REGULATIONS & SYLLABUS

Faculty of Applied Sciences

Master of Science Programme
(Biotechnology/Microbiology/Biochemistry)

2017

CHAROTAR UNIVERSITY OF
SCIENCE & TECHNOLOGY

Education Campus – Changa, (ECC), hitherto a conglomerate of institutes of professional education in Engineering, Pharmacy, Computer Applications, Management, Applied Sciences, Physiotherapy and Nursing, is one of the choicest destinations by students. It has been transformed into **Charotar University of Science and Technology (CHARUSAT)** through an Act by Government of Gujarat. CHARUSAT is permitted to grant degrees under Section-22 of UGC- Govt. of India.

The journey of CHARUSAT started in the year 2000, with only 240 Students, 4 Programmes, one Institute and an investment of about Rs. 3 Crores (INR 30 million). At present there are seven different institutes falling under ambit of six different faculties. The programmes offered by these faculties range from undergraduate (UG) to Ph.D degrees including M.Phil. These faculties, in all offer 23 different programmes. A quick glimpse in as under:

Faculty	Institute	Programmes Offered
Faculty of Technology & Engineering	Charotar Institute of Technology	B.Tech M.Tech Ph.D
Faculty of Pharmacy	Ramanbhai Patel College of Pharmacy	B.Pharm M.Pharm Ph.D
Faculty of Management Studies	Indukaka Ipcowala Institute of Management	M.B.A PGDB M Ph.D
Faculty of Computer Applications	Charotar Institute of Computer Applications	M.C.A Ph.D
Faculty of Applied Sciences	P.D.Patel Institute of Applied Sciences	M.Sc M.Phil Ph.D
Faculty of Medical Sciences	Charotar Institute of Physiotherapy Charotar Institute of Nursing	B.PT B.Sc (Nursing)

The development and growth of the institutes have already led to an investment of over Rs.63 crores (INR 630 Million). The future outlay is planned with an estimate of Rs. 250 Crores (INR 2500 Million).

The University is characterized by state-of-the-art infrastructural facilities, innovative teaching methods and highly learned faculty members. The University Campus sprawls over 100 acres of land and is Wi-Fi enabled. It is also recognized as the Greenest Campus of Gujarat.

CHARUSAT is privileged to have 300 core faculty members, educated and trained in Stanford, IITs, IIMs and leading Indian Universities, and with long exposure to industry. It is also proud of its past students who are employed in prestigious national and multinational corporations.

From one college to the level of a forward-looking University, **CHARUSAT** has the vision of entering the club of the premier Universities initially in the country and then globally.

High Moral Values like Honesty, Integrity and Transparency which have been the foundation of ECC continue to anchor the functioning of **CHARUSAT**. Banking on the world class infrastructure and highly qualified and competent faculty, the University is expected to be catapulted into top 20 Universities in the coming five years. In order to align with the global requirements, the University has collaborated with internationally reputed organizations like Pennsylvania State University – USA, University at Alabama at Birmingham – USA, Northwick Park Institute –UK, ISRO, BARC, etc.

CHARUSAT has designed curricula for all its programmes in line with the current international practices and emerging requirements. Industrial Visits, Study Tours, Expert Lectures and Interactive IT enabled Teaching Practice form an integral part of the unique **CHARUSAT** pedagogy.

The programmes are credit-based and have continuous evaluation as an important feature. The pedagogy is student-centered, augurs well for self-learning and motivation for enquiry and research, and contains innumerable unique features like:

- Participatory and interactive discussion-based classes
- Sessions by visiting faculty members drawn from leading academic institutions and industry
- Regular weekly seminars
- Distinguished lecture series
- Practical, field-based projects and assignments
- Summer training in leading organizations under faculty supervision in relevant programmes.
- Industrial tours and visits
- Extensive use of technology for learning
- Final Placement through campus interviews

Exploration in the field of knowledge through research and development and comprehensive industrial linkages will be a hallmark of the University, which will mould the students for global assignments through technology-based knowledge and critical skills.

The evaluation of the student is based on grading system. A student has to pursue his/her programme with diligence for scoring a good Cumulative Grade Point Average (CGPA) and for succeeding in the chosen profession and life.

CHARUSAT welcomes you for a Bright Future

CHAROTAR UNIVERSITY OF SCIENCE AND TECHNOLOGY

Faculty of Applied Sciences

ACADEMIC REGULATIONS

M. Sc. (Biotechnology/Microbiology/Biochemistry) Programme

Charotar University of Science and Technology (CHARUSAT)
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Year – 2017

CHARUSAT

FACULTY OF APPLIED SCIENCES
ACADEMIC REGULATIONS
M. Sc. Programme

To ensure uniform system of education duration of post graduate programmes, eligibility criteria for and mode of admission, credit load requirement and its distribution between course and system of examination and other related aspects, following are the academic rules and regulations.

1. *System of Education*

The Semester system of education shall be followed across The Charotar University of Science and Technology (CHARUSAT) at Master's levels. Each semester will be at least 90 working day duration. Every enrolled student will be required to do a specified course work in the chosen subject of specialization and also complete a project/dissertation if any. Medium of instruction will be English

2. *Duration of Programme*

Postgraduate programme	(M.Sc.)
Minimum	4 semesters (2 academic years)
Maximum	6 semesters (3 academic years)

Maximum time allowed for completion of M Sc programme shall not be more than 8 semesters.

3. *Eligibility for admissions*

For the admission to M.Sc., programs in the subjects of Biological Sciences a candidate must have obtained a Degree of Bachelor of Science from any recognized University or a Degree recognized as equivalent thereto.

4. *Mode of admissions*

Admission to M.Sc. programme will be purely on merit and performance of the candidate at graduation.

5. *Programme structure and Credits*

A student admitted to a program should study the course and earn credits specified in the course structure.

6. *Attendance*

6.1 All activities prescribed under these regulations and listed by the course faculty members in their respective course outlines are compulsory for all students pursuing the courses. No exemption will be given to any student from attendance except on account of serious personal illness or accident or family calamity that may genuinely prevent a student from attending a particular session or a few sessions. However, such unexpected absence from classes and other activities will be required to be condoned by the Dean/Principal.

6.2 Student attendance in a course should be 80%.

7. Course Evaluation

7.1 The performance of every student in each course will be evaluated as follows:

7.1.1 Internal evaluation by the course faculty member(s) based on continuous assessment, for 30% of the marks for the course; and

7.1.2 Final examination will be conducted by the University for 70% of the marks for the course.

7.2 *Internal Evaluation*

7.2.1 Internal evaluation will be based on internal tests and several other tools of assessment like, quiz, viva, seminar etc., as prescribed by concerned teacher and decided by the faculty.

7.3 Internal Institutional evaluation for practicals

7.3.1 One internal practical test/viva will be conducted per semester totaling to 30 % internal marks for practicals.

7.3.2 In “Continuous evaluation” Students shall be evaluated in a continuous manner for their involvement in the practical, aptitude for learning, completion of practical related assignments, regularity in the practicals and record keeping.

7.4 University Examination

7.4.1 The final examination by the University for 70% of the evaluation for the course will be through written paper or practical test or oral test or presentation by the student or a combination of any two or more of these.

7.4.2 In order to earn the credit in a course a student has to obtain grade other than FF.

7.5 Performance at Internal & University Examination

7.5.1. If a candidate obtains minimum required marks per subject but fails to obtain minimum required overall marks, he/she has to repeat the university examination till the minimum required overall marks are obtained.(As per the clause 8.2 (iv).

8 Grading

9 Grading Scheme: Relative grading based on ten point scale will be adopted.

Letter Grade	**AA**	**AB**	**BB**	**BC**	**CC**	**CD**	**DD**	**FF**
Grade Point	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**0**

The class awarded to a student in the programme is decided by the final CGPA

8.2 The student's performance in any semester will be assessed by the Semester Grade Point Average (SGPA). Similarly, his performance at the end of two or more consecutive semesters will be denoted by the Cumulative Grade Point Average (CGPA). The SGPA and CGPA are calculated as follows:

(i) SGPA = $\sum C_i G_i / \sum C_i$ where C_i is the number of credits of course i
G_i is the Grade Point for the course i
and i = 1 to n, n = number of courses in the semester

(ii) CGPA = $\sum C_i G_i / \sum C_i$ where C_i is the number of credits of course i
G_i is the Grade Point for the course i
and i = 1 to n, n = number of courses of all semesters up to which CGPA is computed.

(iii) No student will be allowed to move further if CGPA is less than 3 at the end of every academic year.

In case, a student, of postgraduate programme or postgraduate diploma, gets less than 40% marks in end-semester examination and less than 50% marks overall (combining continuous evaluation and end-semester examination) in a particular course, he / she will not be graded in that course till he / she reappears in said course and obtains specified minimum marks.

9. Awards of Degree

9.1 Every student of the programme who fulfils the following criteria will be eligible for the award of the degree:

- 9.1.1 He should have earned at least minimum required credits as prescribed in course structure; and
- 9.1.2 He should have cleared all internal and external evaluation components in every course; and
- 9.1.3 He should have secured a minimum CGPA of 5.0 at the end of the programme;
- 9.1.4 In addition to above, the student has to complete the required formalities as per the regulatory bodies.

9.2 The student who fails to satisfy minimum requirement of CGPA will be allowed to improve the grades so as to secure a minimum CGPA for award of degree. Only latest grade will be considered.

10 *Award of Class:*

The class awarded to a student in the programme is decided by the final CGPA as per the following scheme:

Award of Class	**CGPA Range**
First Class with Distinction	CGPA ≥ 7.50
First class	7.50 > CGPA ≥ 6.50
Second Class	6.50> CGPA ≥ 5.50
Pass Class	5.50 > CGPA ≥ 4.00

11 *Transcript:*

The transcript issued to the student at the time of leaving the University will contain a consolidated record of all the courses taken, credits earned, grades obtained, SGPA,CGPA, class obtained, etc.

Teaching scheme for

(Biotechnology/Microbiology/Biochemistry)

M.Sc. Biotechology (Semester I)

	Semester I						Theory Evaluation			Practical Evaluation			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total-II**	**Total I+II**
	Core Compulsory												
MS711	Microbiology	3	-	-	3	3	30	70	100	-	-	-	100
MS712	Biochemistry	4	-	-	4	4	30	70	100	-	-		100
MS713	Cell Biology	3	-	-	3	3	30	70	100	-	-		100
MS714	Molecular Biology	4	-	-	4	4	30	70	100	-	-	-	100
HS703.01E HS704 E	**Humanities (any one to be selected)** Languages (French/ German) Academic Speaking	-	2	-	2	2	-	-	-	30	70	100	100
	University Elective-I (any one to be selected)	-	2	-	2	2	-	-	-	30	70	100	100
MS715	Laboratory	-	12	-	12	6	-	-	-	60	140	200	200
MS716	**Term paper (Audit course)**	-			2	2	-	-	-	-	-	-	-
	Library	**-**	**-**	**-**	**2**	**0**	-	-	-	-	-	-	
	Total	**18**	**12**		**34**	**26**	-	-	-	-	-	-	**800**

M.Sc. Biotechnology (Semester II)

	Semester II						Theory Evaluation			Practical Evaluation			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total -II**	**Total I+II**
	Core Compulsory												
MS761	Bioanalytical Techniques	3	-	-	3	3	30	70	100	-	-	-	100
MS762	Immunology	3	-	-	3	3	30	70	100	-	-	-	100
MS763	Genetic Engineering	3			3	3	30	70	100				100
BT761	Bioprocess engineering and Technology	3	-	-	3	3	30	70	100	-	-		100
BT762	Molecular Genetics	3	-	-	3	3	30	70	100	-	-		100
BT763	Biotechnology Laboratory- I	-	12	-	12	6	-	-	-	60	140	200	200
HS705 E	Academic writing	-	2	-	2	2	-	-	-	30	**70**	**100**	100
	University Elective :II **(any one to be selected)**	**-**	**2**		**2**	**2**	-	-	-	**30**	**70**	**100**	100
MS764	Critical analysis of Classical papers (Audit course)	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	-
	Library	**-**	**-**	**-**	**2**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Total	**19**	**12**	**-**	**34**	**26**							**900**

M.Sc. Biotechnology (Semester III)

	Semester III						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total -II**	**Total I+II**
	Core Compulsory												
MS 811	Omics and Bioinformatics	3	-	-	3	3	30	70	100	-	-		100
MS 812	Biostatistics	2	-	-	2	2	15	35	50	-	-	-	50
BT821	Plant and Animal Biotechnology	4	-	-	4	4	30	70	100	-	-	-	100
BT822	Industrial Biotechnology	3	-	-	3	3	30	70	100	-	-		100
BT823	Environmental Biotechnology	3	-	-	3	3	30	70	100	-	-	-	100
BT824	Biotechnology Laboratory- II	-	12	-	12	6	-	-	-	60	140	200	200
BT825 BT826 BT827	Elective (Select any one) Agricultural Biotechnology Forensic Biotechnology Ecology and Conservation Biotechnology	**2**			**2**	**2**	15	35	50	**-**	**-**	**-**	**50**
MS813	Research Seminar (Audit course)	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Library	**-**	**-**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
		17	**12**	**0**	**32**	**24**							**700**

M Sc Biotechnology (Semester IV)

	Semester IV						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total II**	**Total I+II**
	Core Compulsory	-	-	-	-	-	-	-	-	-	-	-	
MS861	Research Methodology	2	-	-	2	2	15	35	50	-	-	-	50
MS862	Research Project Proposal	-	-	-	-	2	-	-	-	-	100	-	100
BT861	Research Project	-	36	-	36	18	-	-	-	200	300		500
  BT 862 BT 863 BT 864 BT 865	**Electives** (Select any One) Developmental genetics Cancer biology Plant pathology Bioentrepreneurship	2	-	-	2	2	15	35	50		-	-	50
	Total	4	36		40	24							700

Teaching scheme for M Sc Microbiology

M.Sc. Microbiology (Semester I)

	Semester I						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total -II**	**Total I+II**
	Core Compulsory												
MS 711	Microbiology	3	-	-	3	3	30	70	100	-	-	-	100
MS712	Biochemistry	4	-	-	4	4	30	70	100	-	-		100
MI711	Cell Biology and Microbial physiology	3	-	-	3	3	30	70	100	-	-		100
MS714	Molecular Biology	4	-	-	4	4	30	70	100	-	-	-	100
HS703.01E HS704 E	**<u>Humanities (any one to be selected)</u>** Languages (French/ German) Academic Speaking	-	2	-	2	2	-	-	-	30	70	100	100
	<u>University Elective-I (any one to be selected)</u>	-	2	-	2	2	-	-	-	30	70	100	100
MS715	Laboratory		12	-	12	6	-	-	-	60	140	200	200
MS716	**Term paper (Audit course)**				2	2							
	Library	**-**	**-**	**-**	**2**	**0**							
	Total	**18**	**12**		**34**	**26**							**800**

M.Sc. Microbiology (Semester II)

	Semester II						Theory Evaluation			Practical Evaluation			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total -II**	**Total I+II**
	Core Compulsory												
MS761	Bioanalytical Techniques	3	-	-	3	3	30	70	100	-	-	-	100
MS762	Immunology	3	-	-	3	3	30	70	100	-	-	-	100
MS763	Genetic Engineering	3			3	3	30	70	100				100
BT761	Bioprocess engineering and Technology	3	-	-	3	3	30	70	100	-	-		100
MI761	Microbial genetics	3	-	-	3	3	30	70	100	-	-		100
MI762	Microbiology Laboratory- I	-	12	-	12	6	-	-	-	60	140	200	200
HS705 E	Academic writing	-	2	-	2	2	-	-	-	30	**70**	**100**	100
	University Elective :II **<u>(any one to be selected)</u>**	**-**	**2**		**2**	**2**	-	-	-	**30**	**70**	**100**	100
MS764	Critical analysis of Classical papers (Audit course)	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	-
	Library	**-**	**-**	**-**	**2**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Total	**19**	**12**	**-**	**34**	**26**							**900**

<u>M Sc Microbiology (Semester III)</u>

	Semester III						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total -II**	**Total I+II**
	Core Compulsory												
MS811	Omics and Bioinformatics	3	-	-	3	3	30	70	100	-	-		100
MS812	Biostatistics	2	-	-	2	2	15	35	50	-	-	-	50
MI821	Industrial Microbiology	4	-	-	4	4	30	70	100	-	-	-	100
MI822	Medical Microbiology	3	-	-	3	3	30	70	100	-	-		100
MI823	Environmental Microbiology	3	-	-	3	3	30	70	100	-	-	-	100
MI 824	Microbiology Laboratory- II	-	12	-	12	6	-	-	-	60	140	200	200
MI825 MI826 MI827	Electives (any one) Applied Microbiology Agricultural Microbiology Microbial Ecology and Diversity	**2**			**2**	**2**	15	35	50				**50**
MS 813	Research Seminar (Audit course)	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Library	**-**	**-**	**-**	**2**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
		17	**12**	**0**	**32**	**24**							**700**

M Sc Microbiology (Semester IV)

	Semester IV						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University /**	**Total-II**	**Total I+II**
	Core Compulsory												
MS861	Research Methodology	2	-		2	2	15	35	50	-	-		50
MS862	Research Project Proposal	-	-	-	-	2	-	-	-	-	100	-	100
MI861	Research Project	-	36		36	18				200	300		500
  MI862 MI863 MI864	Electives (Select any One) Quality control and Assurance Industrial waste treatment Microbiology based entrepreneurship	2	-		2	2	15	35	50		-	-	50
	Total	4	36		40	24							700

Teaching scheme for M.Sc. Biochemistry

M.Sc. Biochemistry (Semester I)

	Semester I						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total-II**	**Total I+II**
	Core Compulsory												
MS711	Microbiology	3	-	-	3	3	30	70	100	-	-	-	100
MS712	Biochemistry	4	-	-	4	4	30	70	100	-	-		100
MS713	Cell Biology	3	-	-	3	3	30	70	100	-	-		100
MS714	Molecular Biology	4	-	-	4	4	30	70	100	-	-	-	100
  HS703.01E HS704 E	**Humanities (any one to be selected)** Languages (French/ German) Academic Speaking	-	2	-	2	2	-	-	-	30	70	100	100
	University Elective-I (any one to be selected)	-	2	-	2	2	-	-	-	30	70	100	100
MS715	Laboratory		12	-	12	6	-	-	-	60	140	200	200
MS716	**Term paper (Audit course)**				2	2							
	Library	**-**	**-**	**-**	**2**	**0**							
	Total	**18**	**12**		**34**	**26**							**800**

M.Sc. Biochemistry (Semester II)

	Semester II						Theory Evaluation			Practical Evaluation			
Course Code		L	P	T	Contact hours	Total Credits	Institute	University	Total-I	Institute	University	Total -II	Total I+II
	Core Compulsory												
MS761	Bioanalytical Techniques	3	-	-	3	3	30	70	100	-	-	-	100
MS762	Immunology	3	-	-	3	3	30	70	100	-	-	-	100
MS763	Genetic Engineering	3			3	3	30	70	100				100
BC761	Bioenergetics and metabolism	3	-	-	3	3	30	70	100	-	-		100
BT762	Molecular Genetics	3	-	-	3	3	30	70	100	-	-		100
BC763	Biochemistry Laboratory- I	-	12	-	12	6	-	-	-	60	140	200	200
HS705 E	Academic writing	-	2	-	2	2	-	-	-	30	**70**	**100**	100
	University Elective :II **(any one to be selected)**	**-**	**2**		**2**	**2**	-	-	-	**30**	**70**	**100**	100
MS764	Critical analysis of Classical papers (Audit course)	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	-
	Library	**-**	**-**	**-**	**2**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Total	**19**	**12**	**-**	**32**	**26**							**900**

M Sc Biochemistry (Semester III)

	Semester III						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total -II**	**Total I+II**
	Core Compulsory												
MS811	Omics and Bioinformatics	3	-	-	3	3	30	70	100	-	-		100
MS812	Biostatistics	2	-	-	2	2	15	35	50	-	-	-	50
BC821	Plant Biochemistry and Physiology	4	-	-	4	4	30	70	100	-	-	-	100
BC822	Enzymology	3	-	-	3	3	30	70	100	-	-		100
BC823	Human Physiology and disorders	3	-	-	3	3	30	70	100	-	-	-	100
B824	Biochemistry Laboratory- II	-	12	-	12	6	-	-	-	60	140	200	200
 BC825 BC826	Elective (select anyone) Neurochemistry Protein Engineering	**2**			**2**	**2**	15	35	50				**50**
MS813	Research Seminar (Audit course)	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
	Library	**-**	**-**	**-**	**2**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
		17	**12**	**0**	**30**	**24**							**700**

M Sc Biochemistry (Semester IV)

	Semester IV						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total II**	**Total I+II**
	Core Compulsory												
MS861	Research Methodology	2	-		2	2	15	35	50	-	-		50
MS862	Research Project Proposal	-	-	-	-	2	-	-	-		100	-	100
BC861	Research Project	-	36		36	18				200	300		250
  BC862 BC863	**Electives** (Select any One) Animal cell and tissue culture Clinical Biochemistry	2	-		2	2	15	35	50		-	-	50
	Total	4	36		40	24							700

Detailed Syllabus

MS711 MICROBIOLOGY

Credits (Theory): 03 **Semester I**
Credit hours: 45

A. Objectives of the Course

- To help students to understand the diversity of microorganisms and their respective habitats.
- To help them recognize, describe, and differentiate between the structure and function of prokaryotic and eukaryotic cells.
- To make them understand various characters of microorganisms that could be considered for their classification and nomenclature.
- To help them understand various techniques that could be used for the study of evolutionary relationship amongst microorganisms
- To make them understand the nutritional requirements of microorganisms, and the pattern of their growth when cultivated in laboratory as pure cultures.
- To make them aware of the basic classification of microorganisms based on their growth requirements, and factors affecting their growth.

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B. Outline of the Course

Sr. No.	Title of the units	Minimum numbers of hours
1.	**Introduction to microorganisms and methods of their study**	**09**
2.	**Molecular evolution and microbial systematics**	**09**
3.	**Diversity of prokaryotic microorganisms**	**09**
4.	**Diversity of fungi**	**09**
5.	**Microbial nutrition and growth**	**09**

C. Detailed Syllabus

Sr. No.	Title of the units	Minimum numbers of hours
1.	**Introduction to microorganisms and methods of their study** Introduction to microbiology and brief history, the nature of the microbial world, diverse groups ofprokaryotic and eukaryotic microorganisms, microscopy, stains and staining techniques, sterilization, control of microorganisms, isolation, cultivation and preservation of microorganisms, safety in the microbiological laboratory	09
2.	**Molecular evolution and microbial systematics** Early earth, origin of biological molecules, the evolutionary time scale-eras, periods and epoch, major events in the evolutionary time scale, the first cell, evolution of prokaryotes and eukaryotes, spontaneity of mutations, evolutionary change in nucleotide sequences, concept of microbial species, theories and methods of microbial systematics, nomenclature, Molecular Chronometers methods of determining	09

	evolutionary relationships, phylogenetic relationships of microorganisms, Bergey's Manual of Systematic Bacteriology	
3.	**Diversity of microorganisms- I** Principles of microbial diversity- distribution, abundance and ecological niche, microbial diversification, morphological, cultural, molecular and genomic methods for study of microbial diversity, salient features of major groups of Domain Prokaryotes and Archea, exploitation of microbial diversity, viral diversity	09
4.	**Diversity of microorganisms- II** General characteristics, diversity, classification and economic importance of cyanobacteria, algae and fungi, salient features of Chytridiomycota, Mastigomycota, Zygomycota, Ascomycota, Basidiomycota and Deuteromycota, identification and general cultivation methods for economically important cyanobacteria, fungi and algae	09
5.	**Microbial nutrition and growth** Principles of microbial nutrition, nutritional categories of microorganisms, culture media for cultivation of microorganisms, batch, fed-batch and continuous growth, synchronous growth, mathematical nature and expression of microbial growth, measurement of microbial growth, microbial growth curve, attached growth and biofilms. Influence of environmental factors on microbial growth	09

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning Outcomes

➢ The students will be able to
- appreciate the role of diverse group of microorganisms in environment.
- recognize, describe, and differentiate between the structure and function of prokaryotic and eukaryotic cells.
- isolate and classify novel microorganisms from the environment and study its taxonomy.
- understand the nutritional requirements of microorganisms, and the pattern of their growth when cultivated in laboratory as pure cultures.

F. Recommended Study materials:

Text Books:
- Brock Biology of Microorganisms **(**13th Edition) by Madigan, Martinko, Stahl
- Prescott's, Microbiology, (10th Edition)
- Principles of Microbiology by R.M Atlas

Reference books:
- Bergey's Manual of Systematic Bacteriology : 2nd Edition

MI711 CELL BIOLOGY AND MICROBIAL PHYSIOLOGY

Credits (Theory): 04 **Semester I**
Credit hours: 60

A. Objectives of the Course

- To help students to
  - Understand the structure and functions of biological molecules
  - Differentiate between prokaryotes and eukaryotes, and their cellular components
  - Understand the cell- cell communication among microbes
  - Understand the mechanisms of energy generation in organisms
  - Understand the functioning of enzymes
  - Appreciate the physiological diversity of microorganisms
  - Study the cell division and differentiation among microorganisms

B. Outline of the Course

Sr. No	Title of the Units	Minimum numbers of hours
1.	**Cell organelles, Cell structure and Biomembranes**	09
2.	**Cell communication**	09
3.	**Advanced Techniques and methods in cell biology**	09
4.	**Bioenergetics, Enzyme Kinetics and regulation**	11
5.	**Physiological diversity in microorganisms**	11
6.	**Bacterial cell division and differentiation**	11

C. Detailed Syllabus

Sr. No.	Title of the unit	Minimum numbers of hours
1.	**Cell organelles, Cell structure and Biomembranes** Comparison of prokaryotic and eukaryotic cells, specialized cells, Molecular organization and functions of biomembranes, cell permeability, mechanisms of transport across membranes, electrical properties of membranes Nucleus, endoplasmic reticulum golgi bodies, lysosomes, mechanisms of protein translocation, membrane trafficking, vesicular transport mitochondria and chloroplast, peroxisomes	**09**
2.	**Cell communication** Cytoskeleton, Cell-Cell and cell-extracellular matrix interactions, cell- cell communication in microbes, cellular junctions	**09**
3.	**Advanced Techniques and methods in cell biology** Methods of cell disruption and fractionation, isolation of organelles, Microscopic methods, Cell culture techniques, Applications of flow-cytometry and cell sorting (FACS), Cytological localization.	**09**
4.	**Bioenergetics, Enzyme Kinetics and regulation** Gibbs free energy, endergonic and exergonic reactions,. Standard state free energy changes-DG, DG^0 and $DG^{'0}$, Relationship between	**11**

	equilibrium constant and DG'°, Importance of Coupled reactions, High energy compounds, Factors affecting the enzyme activity. Kinetics of a single-substrate enzyme catalysed reaction, Michealis-Menten Equation, Km, Vmax, L.B Plot,. Kinetics of Enzyme Inhibition. Kinetics Allosteric enzymes.Feedback Regulation, Allosteric Regulation, Reversible Covalent Modification and Proteolytic Activation	
5.	**Physiological diversity in microorganisms** Physiological diversity and unique physiological features in microbes, features of metabolism of inorganic compounds, utilization of substrates other than glucose, special fermentation pathways Types of stress and adaptations in extremophiles	**11**
6.	**Bacterial cell division and differentiation** Cell division in gram positive and gram negative bacteria (*Bacillus*, *Myxobacteria* and Caulobacteria as model organisms); molecular events during endospore formation, differentiation and development of myxobacteria and caulobacteria, physiological uniqueness of biofilm mode of growth. Heterocyst in cyanobacteria	**11**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning Outcomes

➢ The students will be able to

- Understand the prokaryotic and eukaryotic cell structure and its functioning
- Know the communication among cells in the environment
- Understand the mechanisms of energy generation in organisms
- Understand the functioning of enzymes
- Appreciate the physiological diversity of microorganisms
- Study the cell division and differentiation among microorganisms

F. Recommended Study materials:

Text Books:

- Essentials of Cell and Molecular Biology: by de Robertis E. D. P. and E. M. F. , Holt Saunder's International Edition (new edition)
- The Physiology and Biochemistry of Prokaryotes, by White, D (2000) Oxford University Press, Oxford
- The Biochemistry of Cell Signalling- Ernst J. M. Helmreich (Indian Edition)-2005 Oxford University Press
- Microbial physiology by Moat, Foster and Spector. New edition, Wiley-Liss,
- Bacterial Metabolism by Gerhardt Gottschalk, Springer, 1986.

MS712 BIOCHEMISTRY

Credits (Theory): 04
Credit hours: 60 **Semester-I**

A. Objectives of the Course

- Biochemistry is, in simplest terms, the study of the chemistry of living things. The general objective of this course, therefore, is to train students to understand biological processes and events by learning the logic of chemistry.
- It is far more than simply memorizing structures and metabolism; the fascination of the field is to see how and why biological molecules are built the way they are and how this makes life possible–on many levels and with an amazing degree coordination and control.
- The degree of biological sophistication that allows you to read this document and (hopefully) make sense of it is truly amazing!

B. Outline of the Course

Sr. No	Title of the Units	Minimum numbers of hours
1	Biomolecules	20
2	Metabolism of biomolecules	20
3	Principles of enzyme catalysis	20

C. Detailed Syllabus

Sr. No	Title of the Units	Minimum numbers of hours
1	**Biomolecules** Carbohydrate: Key structures, Monosaccharides, Disaccharides, Polysaccharides, Glycoconjugates, Glycoproteins and Glycolipids, Introduction to Sugar Code Protein: Introduction to proteins. Basics of protein Structure and function. Lipid: Fatty acids, glycerols, phospholipids, sphingolipids, sterols, lipoproteins, membrane phospholipids and prostaglandins	**20**
2	**Metabolism of biomolecules** Carbohydrate metabolism: Glycolysis, Kreb's cycle, oxidative phosphorylation and Pentose Phosphate Pathway, Gluconeogenesis, glycogenesis, and glycogenolysis. Lipid metabolism: Transport of fatty acid, oxidation of fatty acids (α,β,ω) Oxidation of unsaturated and odd chain fatty acids Cholesterol metabolism. Biosynthesis of amino acids, amino acid breakdown and urea cycle. Biosynthesis and breakdown of purine and pyrimidine nucleotides.	**20**
3	**Principles of enzyme catalysis** Structure and characteristics of enzymes, enzyme catalyzed reactions Basic aspects of Enzyme Kinetics: Michaelis- Menten equation, enzyme inhibition and types of inhibitors. Concept of multienzyme complexes: Fatty acid synthase and dehydrogenase complexes. Concept of enzyme regulation: Allosteric (example ATCase), chemical modification and calmodulin mediated regulation.	**20**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

By the end of this course, students will be able to:

- Students will know the chemical structures and chemistry of biological polymers (proteins, carbohydrates, lipids and nucleic acids) and their monomers (amino acids, sugars, fatty acids and other lipid monomers, and nucleotides).
- Students will be able to understand the roles of these biological molecules in living cells.
- Students will be able analyze enzyme kinetic data as well as the bioenergetics/thermodynamics of biochemical reactions.

- Students will know the reactions of major metabolic pathways: Central Metabolism (Glycolysis-Gluconeogenesis, Pentose phosphate Pathway, Citric Acid Cycle and Respiratory Electron Transport System, Glyoxylate Cycle; Beta-oxidation of fatty acids and be able to analyze the regulation of these pathways.

F. Recommended Study materials:

- Lehninger Principles of Biochemistry by David Nelson and Michael Cox , Fifth Edition Freeman Company. (2005)
- Biochemistry by Jeremy Berg, John Tymoczko and LubertStryer, Fifth Edition, Freeman Company;
- Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer. East-West Press Edition (2004)
- Harper's Biochemistry by Robert.KK.Murray 26/e, 2003.
- Fundamantals of Biochemistry by Debajyothi Das 11/e, 2002.
- Fundamentals of biochemistry- Life at the molecular level By: Voet, Voet and Pratt, Secondedition, 2006.
- Human Biochemistry by James.M.Orten&Oho.W.Neuhaus, 10/e, 1983.
- Fundamentals of Biochemistry. Life at the molecular level. Voet and Voet
- Fundamentals of Enzymology by Price and Stevens
- Enzymology by Dixon and Webb

MS713 CELL BIOLOGY

Credits (Theory): 03 **Semester–I**

Credit hours: 45

A. Objectives of the Course

- Differentiate between prokaryotes and eukaryotes cells and detailed physiological functions of their cellular components
- Cell communication and signaling mechanisms to co-ordinate physiological processes and their responses to environmental changes
- Understanding the mechanism of cell cycle regulation and cell death mechanism along with its implications in cancer
- Tools/ techniques and experimental design to study cell organelles and cellular processes
- Introduce the students to the biology of stem cells and the cellular aspects of developmental biology

B. Outline of the Course

Sr. No	Title of the Units	Minimum numbers of hours
1	**Cell structure and membrane biology**	**07**
2	**Cell organelles: Organization and Protein trafficking**	**09**
3	**Cellular interactions**	**07**
4	**Eukaryotic Cell signaling**	**08**
5	**Cell cycle regulation**	**07**
6	**Tools and techniques of cell biology**	**04**
7	**Basics of Cell differentiation and Stem Cell Biology**	**03**

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Cell structure and membrane biology**	7
	Comparison of prokaryotic and eukaryotic cells, specialized cells like neurons and muscle cells, Fluid mosaic model, functions of biomembranes, membrane proteins, cell permeability, mechanisms of transport across membranes, electrical properties of membranes	
2	**Cell organelles: Organization and Protein trafficking**	9
	Nucleus, endoplasmic reticulum, golgi bodies, lysosomes: organization and mechanisms of protein translocation, protein sorting and export from Golgi, mechanism of vesicular transport, mitochondria and chloroplasts, peroxisomes	
3	**Cellular interactions**	7
	Cytoskeleton, Extracellular matrix: composition and organization, Cell-Cell and cell-extracellular matrix interactions	
4	**Eukaryotic Cell signaling**	8
	Mechanisms of cell signaling, Types of receptors- membrane bound, cytosolic and nuclear receptors, signal transduction pathways, regulation of signal transduction, comparison with prokaryotic cell signalling	
5	**Cell cycle regulation**	7
	Cell cycle and its control, cell death mechanisms, implications in cancer	
6	**Tools and techniques of cell biology**	4
	Methods of cell disruption, subcellular fractionation fractionation, Microscopic methods, Basic cell culture techniques, Applications of flow-cytometry and cell sorting (FACS), model organisms	
7	**Basics of Cell differentiation and Stem Cell Biology**	3
	Stem cells: origin, plasticity and hierarchy, concept of Potency and commitment, determination, cell fates	

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be performed and analyzed by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- Students will gain insight into wide range of basic concepts in cell and developmental biology.
- Students shall develop appreciation towards the intricacies of cell structure and function, their dynamic properties in living cells and their critically programmed co-ordination for the functioning of the whole organism and its development.
- Students will acquire detailed understanding on how cellular processes are mediated by hierarchical levels of organization from molecules to whole cells to intercellular interactions.
- Students shall gain insights into understanding of experimental design and methodology covering molecular and cellular techniques used to study cell organization and function.
- Students shall get exposure to developing specialized areas of cell biology with emphasis on critical thinking towards analysis of experimental findings and its alternative interpretations.

F. Recommended Study materials:

- Molecular biology of the Cell by Bruce Alberts.
- Molecular biology of the Cell by Lodish .
- Cell and Molecular Biology' 8th Edition by E.D.P. De Robertis
- Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Cell Biology, Genetics, Molecular Biology: Evoloution and Ecology P S Verma and V K Agarwal, S Chand publications, 2004
- Cell Biology 2nd Edition, by Seong S. Han, Ruth Ashley, Gary Hann Rastogi publications
- Essentials of Cell and Molecular Biology: by de Robertis E. D. P. and E. M. F. , Holt Saunder's International Edition (new edition)
- Essentials of Molecular Biology, 4th edn., by Malacinski GM (2003) Jones & Batiett, London. (ISBN: 0-7637- 2133-6)
- The Physiology and Biochemistry of Prokaryotes, by White, D (2000) Oxford University Press, Oxford
- The Biochemistry of Cell Signalling- Ernst J. M. Helmreich (Indian Edition)-2005 Oxford University Press

MS714 MOLECULAR BIOLOGY

Credits (Theory): 04 **Semester I**
Credit hours: 60

A. Objectives of the Course

- To gain a thorough understanding of the basic principles of molecular biology. To understand the tools of DNA technology. To be able to read and interpret scientific papers. To design approaches to addressing questions in molecular biology and to interpret experimental data in molecular biology**.**
- To become proficient with a number of advanced and basic tools in molecular biology. To interpret and design experiments.
- To keep a laboratory notebook, to gain the confidence and skills necessary to be able to attempt new laboratory procedures and troubleshoot their implementation. To be competitive for employment in an introductory laboratory research position.

B. Outline of the Course

Sr. No.	Title Of The Unit	Minimum numbers Of Hours
1	**Nucleic Acid Structure And Genome Organization**	**15**
2	**DNA Replication, Recombination And DNA Repair**	**15**
3	**Transcription And Post Transcriptional Mechanisms**	**10**
4	**Translation**	**10**
5	**Gene Regulation**	**10**

C. Detailed Syllabus

Sr. No.	Title of the Unit	Minimum numbers of hours
I	**Nucleic Acid Structure And Genome Organization**	**15**
	DNA as a genetic material, DNA structure, DNA topology, supercoiling, knot and catenanes, topoisomerases I and II, C-value paradox, structure of mRNA, rRNA and tRNA; packaging in viruses, prokaryotes and eukaryotes, structure of chromatin and chromosomes, DNA-protein interactions, interrupted genes, gene families, unique and repetitive DNA, transposons, special DNA structures	
II	**DNA Replication, Recombination And DNA Repair**	**15**
	DNA replication in DNA viruses, prokaryotes and eukaryotes; enzymes involved and mechanism of replication, replication models, regulation of replication, role of telomerases, DNA synthesis in retroviruses, replication, extra-chromosomal replicons, inhibitors of replication, Recombination signal, Mechanism of recombination, gene conversion, Mutation, DNA repair, Transposition.	
III	**Transcription And Post Transcriptional Mechanisms**	**10**
	Organization of transcriptional units, Prokaryotic transcription, eukaryotic transcription, transcription factors, transcription activators and repressors, RNA polymerases, formation of initiation complex and its regulation, post transcriptional modifications, RNA transport, RNA splicing and processing, mRNA stability and localization, catalytic RNA, non-coding RNAs	
IV	**Translation**	**10**
	Ribosomes, Initiation, elongation and termination of translation: initiation factors and their regulation, elongation and elongation factors, translational proof reading, using the genetic code, post translational modification of proteins, translational inhibitors, role of tRNA, aminoacylation of tRNA, aminoacyl tRNA synthetase	
V	**Gene Regulation**	**10**
	Operon concept, phage strategies: Regulation of phages (T4, T7 and λ), prokaryotic transcription regulation: regulation of *lac, ara, his* and *trp* operons, eukaryotic transcription regulation: chromatin remodeling, gene silencing, regulatory RNAs, regulatory circuits Synthetic biology-Preliminary concepts	

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- By the end of this course, students will be able to:
- Be able to describe various theoretical models of the creative process.
- Identify and interact with creative pockets in the community to continue to re-energize their skills.
- Develop understanding about the molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes
- Gain basic concepts of synthetic biology and its applications
- Be able to Interpret and critique data from primary research articles.

F. Recommended Study materials:

1. Lewin’s Genes IX
2. Molecular biology of the gene by J D Watson
3. Genomes by T A Brown
4. An introduction to human molecular genetics: mechanisms of inherited diseases
5. Jack j. Pasternak 2000.
6. Computational biology and genome informatics jason t. L. Wang , cathy 2003 world scientific
7. Genome transcriptome and proteome analysis by alain bernot, james2004 john wiley and sons
8. Methods in biotechnology and bioengineeringby s. P. Vyas, d.2002cbs publishers
9. Molecular genetics of bacteria jeremy dale, simon f 2004 john wiley and sons.
10. Practical handbook of biochem and mol.bio geralal .jasmen.
11. Molecular biology by David Freifelder
12. A genetic switch by Mark Pthasne.
13. Microbial genetics by David Freifelder
14. Essential of molecular biology by David Freifelder
15. Principles of Genome analysis
16. Bacteriophages by John Douglas
17. Biotechnology an Introdoction by Susan R. Barnum.
18. Biotechnology Volumes by H.J. Rehm & Reed
19. Genes IX by lewin
20. Molecular biology of the gene by J.D.Watson.
21. Gene cloning and DNA analysis by T.A.Brown.
22. From genes to Clone
23. Molecular Biology Lab fax I & II : T. A. Brown
24. Molecular Biotechnology –Glick
25. Molecular Genetics of Bacteria 4th Edition by Dale, J.W., Park, S.F. (2005) Wiley and Sons Inc
26. Intellectual Property Rights on Biotechnology, by Sigh, KC BCIL, New Delhi
27. Introduction to Modern Virology 4th Edition by Dimmock N J, Primrose S. B. 1994. Blackwell Scientific Publications. Oxford.
28. DNA Science by David .A.Micholas
29. Synthetic biology- a primer by Freemont

M.Sc. Semester II
(Biotechnology/Microbiology/Biochemistry)

MS761: BIOANALYTICAL TECHNIQUES

Credits (Theory): 03 **Semester II**
Credit hours: 45

A. Objectives of the Course

Bioanalytical techniques form the basis for all aspects of modern applied biology. A clear understanding of the principles of modern analytical techniques is crucial to all involved in the isolation and analysis of bio-organic compounds. It is intended that students will further develop the analytical skills and knowledge gained at B.Sc. level. The objective in this course will be to provide students with comprehensive overview current developments in bioanalytical techniques. This course will help the student gain a deeper insight into the techniques they use for analysis and research.

- To make student understand about basic techniques for isolation, purification and analysis of biological molecules
- Expose students to separation and detection techniques
- Basic understanding of instrumentation routinely used in biotechnology

B. Outline of the Course

Sr. No	Title of the units	Minimum numbers of hours
1	**Microscopy Techniques and Spectroscopy Techniques**	**15**
2	**Measurement of colligative properties**	**3**
3	**Separation techniques**	**8**
4	**Molecular Biology Techniques**	**15**
5	**Electrochemical and radio isotope techniques**	**4**

C. Detailed Syllabus

Sr. No	Title of the units	Minimum numbers of hours
1	**Microscopy Techniques** Principle and applications of light, phase contrast, fluorescent microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning tunneling microscopy (STM), atomic force microscopy (AFM), confocal microscopy	**3**
2	**Spectroscopy Techniques** UV/Vis, fluorescence, circular dichroism (CD), NMR, ESR, X-ray diffraction, light scattering, mass spectrometry, atomic absorption spectroscopy, surface plasma emission spectroscopy, IR and Raman spectroscopy	**12**
3	**Measurement of colligative properties** Viscosity, osmosis, surface tension, diffusion, dialysis	**3**
4	**Separation techniques** Centrifugation: Types and Applications Electrophoresis: Types of electrophoresis, instrumentation and applications: Capillar,Agarose gel, SDS-PAGE, 2D-Elecrophotresis Chromatography: Types of chromatography, instrumentation and applications: paper, TLC, HPTLC, Column, HPLC, GC	**8**
5	Molecular Biology Techniques Isolation, purification and analysis of DNA (Genomic and plasmid), RNA , Proteins and Lipids, Instrumentation and applications of PCR and Its modifications (reverse transcriptase PCR, real time PCR, anchored PCR, emulsion PCR, SAGE etc), Blotting techniques,DNA Sequencing techniques, Sanger's Method and Next generation sequencing methods, Protein sequencing, Microarray, SAGE, RFLP, RAPD, AFLP	**15**
6	**Electrochemical and radio isotope techniques** Radiosisotope techniques: types and applications Guideline to use radio isotopes Electrochemical Techniques: types and application	**4**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

- Topic will be discussed in the interactive class room sessions using black board teaching and power point presentations.
- Practical session will be conducted in the highly equipped lab and experiments will be carried out by students individually
- For better understanding appropriate examples and case studies will be discussed.
- Special interactive problem solving sessions will also be conducted.
- Course material will be provided to the students from various primary and secondary information
- Unit test will be conducted regularly as part of continuous evaluation and students will be counseled to improve their performance

E. Student learning outcome

By the end of this course, students will be able to:

- An detailed understanding of the concepts and principles of sample preparation
- A thorough knowledge of difference microscopic techniques, spectroscopic techniques, Chromatography techniques, Immaging techniques and the techniques for the measurments of colligative properties
- Acquired a fundamental and critical understanding of the current approaches to the analysis of bimolecules.

After successful completion of course,

- Student will have insights of routine instruments used in biotechnology
- Students will be able to troubleshoot the errors in the analytical experiments
- Students will be able to analyze and interpret the data obtained using instrumentation
- Various applications of instruments in biotechnology

F. Recommended Study materials:

Reference books:

- Biochemical Calculations by Segel. I. R. - 1995 - John Wiley and Sons.
- Spectrometric Identification of Organic compounds by R M Silverstein and F X Webster, Sixth edition (2002)
- Spectroscopy: D.R.Browning
- Validation Standard Operating Procedures, 2nd edn., by Haider, SI (2006) CRC Press Taylor and Francis Group, NY (ISBN: 0-8493-9529
- Analytical biochemistry by Wilson and walker.
- Biochemical Methods by Pingoud A. et al.
- Instrumental methods of chemical analysis by Anand and Chatwal, Himalaya Publishing Co.
- Physical Biochemistry, applications to biochemistry and molecular biology, second edition (Freifelder, David)
- Prescott’s Microbiology by Willey, Sherwood,Woolverton Tata McGraw Hill
- Gene cloning: An introduction by TA Brown
- Principles of Gene manipulations and genomics by Primrose
- Principles and techniques of Biochemistry and Molecular Biology by Wilson and Walker
- Standard Methods of Biochemical analysis by S.R. Thimmaiah
- Biotechnology Exploartions : Applying the fundamentals By Judith A Scheppler, Pattricia E Cassin and Rosa M Gambler

MS762 IMMUNOLOGY

Credits (Theory): 03 **Semester II**
Credit hours: 45

A. Objectives of the Course

- To enable the students to
  - widen their insights into immunology and modern developments of the same
  - advance their knowledge about vaccines and immunotechnology

B. Outline of the Course

Sr. No.	Title of Unit	Minimum numbers of hours
1.	**Immune system and immunity**	**10**
2.	**Immune processes**	**10**
3.	**Hypersensitivity and autoimmunity**	**8**
4.	**Vaccines**	**8**
5.	**Immunotechnology**	**9**

C. Detailed Syllabus

Sr. No.	Title of Unit	Minimum numbers of hours
1.	**Immune system and immunity** Innate and adaptive immunity, cells and organs of the immune system, antigens and antibodies, structure and functions of antibody molecules, generation of antibody diversity	**10**
2.	**Immune processes** Humoral and cell mediated immune responses, B and T cell epitopes, primary and secondary immune modulation, antigen processing and presentation, MHC molecules activation and differentiation of B and T cells, the complement system	**10**
3.	**Immune system in health and disease** Hypersensitivity, inflammation, tolerance, autoimmunity transplantation, immune deficiencies, immunity to infectious agents, blood groups, cancer immunology	**8**
4.	**Vaccines** Introduction to vaccines, live attenuated vaccines, killed vaccines, subunit vaccines; conjugate vaccines, toxoid as vaccines, recombinant vaccines, polyvalent vaccines	**8**
5.	**Immunotechnology** Antigen-antibody reactions, immunodiagnostics, hybridoma technology and monoclonal antibodies, antibody engineering	**9**

D. Instructional Methods and Pedagogy

The topics will be discussed in an interactive class room sessions using conventional blackboard teaching to power-point presentations. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests and surprise quizzes will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Practical sessions, related to the basic principle of the topics, will be conducted in a highly equipped biological laboratory. Experiments will be performed and analyzed by students either in dictated groups or individually.

E. Student Learning Outcomes

After the successful completion of the course a student will be able to

- Understand the immune system, various aspects of immunity and immune responses and the role of various cells and molecules in the innate and adaptive immunity.
- Imbibe the concepts of antigens and antibodies, their types and structures and how diversity is generated in antibody molecules.
- Elaborate the role of B and T cells in humoral and cell mediated immunity.
- Know the implications of inflammation, hypersensitivity and immune deficiencies on health of the host.
- Understand the hypersensitivity fundamentals and role of autoimmunity in diseases.
- Imbibe the concepts of vaccines, understand the antigen antibody reactions and immunotechnology

F. Recommended Study materials:

- Kuby Immunology by Jenni Punt, Judy Owen, and Sharon Stranford 7th Edition W. H. Freeman and Company, New York (2013)
- Immunobiology by Charles A. Janeway, Jr., Paul Travers, Mark Walport, Mark J. Shlomchik; 6th Edition, Garland Science (2005)
- Prescott‟s, Microbiology by Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton, 7th Edition. McGraw Hill (2008).
- Immunology and Immunotechnology by Ashim K. Chakravarty. Oxford University Press (2006)
- ImmunoBiology the Immune System in Health and Disease by Janeway, Walport and Travers. 6th Edition. Garland Science (2005)

MS763 GENETIC ENGINEERING

Credits (Theory) : 03 **Semester II**
Credit hours: 45

A. Objectives of the Course

- The course is meant to deliver aspects of genetic modifications and rDNA tools useful for implementing targeted change in genetic material in prokaryotic and eukaryotic hosts.
- The course aims to train the students to select appropriate gene targets, engineering tools and analytical techniques in order to design and validate genetic engineering strategies for successful analysis and/or improvisation of bioprocess targeted in a given host.
- The course also aims to convey the importance of considering various aspects of gene source, host physiology and probable outputs of genetic modification, while building strategies to create transgenic organism

B. Outline of the Course

Sr.No	Title of the Units	Minimum numbers s of hours
1	**Molecular cloning and rDNA technology tools**	4
	Cloning And Expression In Prokaryotic Systems	
2	**Cloning and selection of recombinant DNA in *E. coli***	9
3	**Specialized vectors**	5
4	**Principles in optimizing gene expression**	6
5	**Alternative Strategies of Gene Cloning**	7
	Cloning And Expression In Eukaryotic Systems	
6	**Heterologous expression in yeast**	5
7	**Heterologous expression in insects, plants and animal cells**	9

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers s of hours
1	**Molecular cloning and rDNA technology tools**	4
	Restriction enzymes and other DNA modifying enzymes, Cloning vectors, Prokaryotic and Eukaryotic host systems, Basic steps in genetic engineering, objectives of genetic engineering	

2	**Cloning And Expression In Prokaryotic Systems**	
	Cloning and selection of recombinant DNA in *E. coli*: Choice of vectors (plasmids, cosmids, phage based vectors, BAC, YAC), Cloning of restriction fragments and PCR products, Methods of introducing DNA into bacterial cells, Screening and selection of recombinant DNA –antibiotic selection, alpha complementation, use of reporter genes, restriction mapping, PCR	**9**
3	**Specialized Vectors**	**5**
	Shuttle vectors, suicide vectors, expression vectors, fusion vectors	
5	**Principles in optimizing gene expression**	**6**
	Inducible gene expression, Factors influencing gene expression, heterologous expression, host engineering, role of site directed mutagenesis, design of engineering strategies	
6	**Alternative Strategies of Gene Cloning**	**7**
	Construction and screening of genomic and cDNA libraries, cloning and expression in non-*E. coli* Gram negative bacteria and Gram positive bacteria	
	CLONING AND EXPRESSION IN EUKARYOTIC SYSTEMS	
7	**Heterologous expression in yeast**	**5**
	Cloning vectors, selection strategies, advantage of yeast as alternate expression system, yeast surface display, yeast two and three hybrid systems, *Saccharomyces* and *Pichia* as model hosts for recombinant protein production	
8	**Heterologous expression in insects, plants and animal cells**	**9**
	Baculovirus mediated expression, Methods of gene transfer in animal cells and plant cells, *Agrobacterium* mediated transformation of plant cells, Plant and animal viruses as vectors, factors affecting expression in plants and animal cells, strategies to create knockout (KO) cells and transgenic animals, GMOs and their applications	

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be performed and analyzed by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

Upon successful completion of this subject, students should:

- be able to outline the range of genetic modification vectors, tools and techniques implicated in devising genetic engineering strategies
- be able to identify strategies for gene isolation, construction of libraries and screening of recombinant clones
- appreciate the complexities associated with engineering the expression of recombinant genes of industrial, environmental or therapeutic importance
- be able to devise and validate genetic engineering strategies suitable for a targeted bioprocess

F. Recommended Study materials:

- Principles of Gene Manipulation and Genomics, Third Edition (2006) S.B. Primrose, S.B. and R.M. Twyman, Blackwell Publishing Company, Oxford, UK. 2.
- Gene Cloning and DNA Analysis: An Introduction. Fifth Edition (2006) T.A. Brown, Wiley-Blackwell, UK.
- Molecular Cloning. A Laboratory Manual. Volume 1-3. Third Edition (2001) A. Sambrook and D.W. Russell, Cold Spring Harbor Laboratory Press, New York, USA.

BT761 BIOPROCESS ENGINEERING AND TECHNOLOGY

Credits (Theory): 03 **Semester II**
Credit hours: 45

A. Objectives of the Course

- To introduce and appreciate the scope and future of bioprocess technology
- To learn how microorganisms with industrially important features can be screened
- To understand how process fluids, air and other utilities can be sterilized and asceptic conditions maintained.
- To know the basis for choice of cultivation methods
- To understand the types of bioreactor configurations available, principles of their design and their operation
- To understand the role of mass and heat transfer, aeration and mixing in bioprocesses.
- To introduce to various methods of cultivation of microbial, plant and animal cells.
- To learn control of bioprocesses
- To elaborate the various methods available for recovery and purification of biotechnological products
- To understand economic considerations involved in bioprocess industry

B. Outline of the Course

Sr. No	Title of the topics	Minimum numbers of hours
1	**Basic principles of bioprocess technology**	15
2	**Bioreactor design and operation**	8
3	**Bioprocess design and scale-up**	7
4	**Advanced cultivation methods**	10
5	**Down-stream processing**	5

C. Detailed syllabus

Sr. No	Title of the units	Minimum numbers of hours
1	**Basic principles of bioprocess technology** Scope and future of bioprocess technology, process organisms, IPR and regulatory considerations in the use of process organisms, screening for microorganisms and their activities, cultivation media, contamination and its control, sterilization of process fluids, air and utilities, improvement of microbial strains and productivity, validations, solid substrate cultivation	15

2	**Bioreactor design and operation** Choosing the cultivation method, mechanically and non-mechanically agitated reactors, immobilized enzyme and cell reactors, mass transfer, aeration, heat transfer, mixing, rheology of process fluids, control of bioprocesses, sensors	**8**
3	**Bioprocess design and scale-up** Stoichiometry and energetics of microbial growth and product formation, balances in reacting systems, bioprocess kinetics and modelling, process scale-up and its difficulties, process flow sheeting, process economics	**7**
4	**Advanced cultivation methods** Approaches and bioreactor designs for cultivation of algal, plant and animal cells, suspension cultures, comparison with cultivation of microbial cells, methods for microalgal cultivation, stem cell cultivation, tissue engineering, products of animal cell cultures, use of recombinant organisms in bioprocessing, high cell density cultivations, mixed cultures	**10**
5	**Down stream processing of fermentation products** Strategies to recover and purify products, separation of insoluble products, cell disruption, separation of soluble products, concentration of biological products with special emphasis on proteins, product formulation- microbial cells and soluble products	**5**

D. Instructional Methods and Pedagogy:

- The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations.
- The topics will taught using numerical problems, case studies, simulations, animations, softwares.
- Interactive problem solving sessions will be also conducted by respective faculty members on regular basis.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Unit tests, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.
- Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self study.
- Industrial visits/tours will be conducted for providing on-site understanding of the concepts of bioprocess engineering and technology gained during the theory and practical sessions.
- Mini-projects and/or dissertation project in the subject area of bioprocess technology will be carried out.

E. Student learning outcome

By the end of this course, students will:

- Appreciate the scope and future of bioprocess technology.
- Understand how microorganisms can be screened for production of metabolites and activities.
- Understand how process fluids, air and other utilities can be sterilized and aseptic conditions maintained.

- Delineate how cultivation methods are decided based on the product and the process organism.
- Become aware of the types of bioreactor configurations available and the principles of their design
- Appreciate the role of mass and heat transfer, aeration and mixing in bioprocesses.
- Understand the Stoichiometry of bioreactions, mass balances, basic modeling of bioprocesses
- Know various methods of cultivation of microbial, plant and animal cells and how bioprocesses can be controlled. and
- Understand and apply the various methods available for recovery and purification of biotechnological products
- Understand the economic considerations in bioprocess operations and bio-products development

F. Recommended Study materials:

- Biochemical engineering by Aiba, Humphrey and Millis
- Metabolic engineering: principles and methodologies by G. Stephanopoulos
- Algal Bioprocess Technology By Lele and Kumar
- Principles of Fermentation Technology By F. Stanbury
- Fundamentals of Biochemical Engineering by Bailey
- Comprehensive Biotechnology volume I, II, III and IV By Moo Young
- Manual of Industrial Microbiology and Biotechnology Davies, Arnold L. Demain
- Fermentation Microbiology and Biotechnology By El-Mansi
- Industrial Microbiology By Casida Jr.
- Bioprocess engineering principles By P. Doran
- Process Biotechnology By S. N. Mukhopadhyay
- Bioreaction Engineering By K. Schugerl
- Basic Biotechnology, Colin Ratledge, Bjorn Kristiansen 2 nd Edition, Cambridge University Press, 2001.
- Bioseparations Science and Engineering by Roger Harrison et al., , Oxford University Press, 2003.
- Elementary Principles of Chemical Processes by R.W. Rousseau and R.M. Felder, 3rd Edition, J. Wiley, New York, 2000.
- D.M.Himmelblau, Basic Principles and Calculations in Chemical Engineering, 6Th Edition, Prentice Hall of India. New Delhi, 1996.
- Stoichiometry B.I.Bhatt and S.M.Vora, 3rd Edition, Tata McGraw Hill. New Delhi. 1996.
- R. B. Bird et al., Transport Phenomena, 2nd Edition, Wiley, 2006
- Bioprocess Engineering: System, Equipment And Facilites, (English) By Lyderson. WILEY INDIA PVT LTD
- Product Recovery in Bioprocess Technology,BH 1st Edition (English) 1st Edition. AFFILIATED EAST-WEST PRESS PVT. LTD.-NEW DELHI
- Bioprocess Technology (English). Moser Manor. Springer, New York
- Bioseparations: Principles And Techniques 1st Edition (English) 1st Edition. Shivashankar. PHI learning
- Bioseparations Downstream Processing For Biotechnology (English). **:** Paul A. Belter E. L. Cussler Wei-Shou Hu, Wiley India Pvt Ltd. New Delhi

- Bioprocess Engineering: Kinetics, Biosystems, Sustainability, and Reactor Design by Shijie Liu, 2012 Elsevier Science Ltd; 1 edition
- Bioprocess Engineering: An Introductory Engineering and Life Science Approach by K. G. Clarke 2013 Woodhead Publishing Ltd; 1 edition
- Bioprocess Engineering by Biswajit Mukherjee, 2013 Black Prints
- Chemical and Bioprocess Engineering: Fundamental Concepts for First-Year Students by Ricardo Simpson and Sudhir K Sastry, 2013, Springer

BT762 MOLECULAR GENETICS

Credit (Theory): 03
Credit hours: 45 **Semester I1**

A. **Objectives of the Course**

- Introduction to basic of inheritance, the role of inheritance in development of human.
- To develop the understanding of methods used in genetic analysis.
- Comparative genetics of Microbes, plant and eukaryotic genetics.
- To develop the analytical skills in analyzing the complex genetic interaction.

B. Outline of the Course

Sr.No	Title of the Units	Minimum numbers of hours
1	**Inheritance biology**	15
2	**Microbial genetics and extrachromosomal inheritance**	15
3	**Mutations, molecular markers and gene mapping methods**	15

C. Detailed Syllabus

Sr. No.	Title of the units	Minimum numbers of hours
1	**Inheritance Biology**	
	Mendelian principles, concept of gene, extensions of Mendelian principles, genomic imprinting, linkage and crossing over, sex linkage, sex limited and sex influenced characters, Pedigree analysis, lod score for linkage testing, model organisms, Statistical tools used for study of genetics	**15**
2	**MICROBIAL GENETICS AND EXTRACHROMOSOMAL INHERITANCE**	
	Methods of genetic transfers in bacteria, mapping genes by interrupted mating, fine structure analysis of genes, phage genetics and molecular Switch, Microbial strains used to study the genetics, Mu as a genetic tool, plasmids and their control, genetic rearrangements and their evolutionary significance; Phase variation in Salmonella, Inheritance of Mitochondrial and chloroplast genes, maternal inheritance, somatic recombination and tetrad analysis	**15**

3	MUTATIONS, MOLECULAR MARKERS AND GENE MAPPING METHODS	
	Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants, mutations: Types, causes and detection, mutant types – lethal, conditional, biochemical, chromosomal aberrations, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Karyotypes, genetic disorders, basis population genetics-Hardy-Weingberg Law its applications, genetic drift, heritability and its measurements	**15**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Animation and tutorials will be given for in-depth understanding of the subject.

E. Student learning outcome

By the end of this course, students will be able to:

- Describe various theoretical models of the creative process, capable to analyze the scientific concepts with observational mind and logical analysis of problems.
- Able to understand the modern techniques of Animal and Plant breeding
- The main objective of this study to develop concepts on fundamentals of heredity.
- Development of novel skills for enhancing the scientific knowledge of society.

F. Recommended Study materials:

- Principles of genetics, third edition by R. Snusted
- Principles of genetics by Tamarin : 10th edition
- Principles of Plant genetics and breeding, second edition by GerorgeAcquaah, Willey-blackwell publishing groups
- An introduction to genetic analysis ,Eleven edition, by Griffith
- Molecular genetics of Bacteria , fourth edition by Dale
- Genetics ;A conceptual approach by Bemzamin A pierce
- Genetics , fourth edition by Brooker
- Genetics : laboratory investigation by Thomas R.Mertans
- Genetics: A conceptual approach (2nd edition, 2006) by B.A. Pierce ;W.H. Freeman and Co.

  Griffiths, Anthony J. F., Jeffrey H. Miller, David T. Suzuki, Richard C. Lewontin, and William M. *Gelbart. An Introduction to Genetic Analysis. 7th ed. New York: W. H.* Freeman, 2000. *ISBN: 978071673520*

MI761: MICROBIAL GENETICS

Credit (Theory): 03 **Semester VI**
Credit hours: 45

A. Objectives of the Course

- To help students to understand the
  - Basics of Microbial Genetics
  - Understand the concepts of Bacteria, Phage & Yeast Genetics
  - Understand the genetic re-arrangements in Microorganisms

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Essentials of Genetics and Microbial Genetics**	**18**
2	**Genetics of Bacteria and Phages**	**18**
3	**Genetic Re-arrangements and Fungal genetics**	**09**

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Essentials of Genetics and Microbial Genetics** Introduction to microbial genetics, Genetic nomenclature, Regulation of Gene Expression, DNA Replication, Damage and Repair, Mutagenesis, Mutations and Mutants, Reversions and Suppression.	**18**
2.	**Genetics of Bacteria and Phages** Plasmids, Bacterial Transformation, Bacterial Conjugation, and *Agrobacterium* Genetics: Ti-plasmid, Restriction Modification (RM) systems, Viral genetics: T4 and Lambda Phages, Transduction.	**18**
3.	**Genetic Re-arrangements and Fungal genetics** Genetic Rearrangements; Transposable elements, Transposition and Recombination. Yeast Genetics: Tetrad analysis and Mitotic recombination	**09**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- The students will be able to learn the basics of Microbial Genetics
- Students will be able to understand the concepts of genetic exchange in bacteria and phages: Conjugation, Transformation, and Transduction.
- Students will learn about the Transposable Elements, Genetic Recombination and Fungal Genetics

F. Recommended Study materials:

Text Books:

- Microbial Genetics by Stanly R. Maloy, John Cronan and David Freifelder
- Modern Microbial Genetics by Uldis Streips and Ronald Yasbin
- Molecular Genetics of Bacteria by Jeremy W. Dale and Simon F. Park
- Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness
- Genetics: Principles and Analysis by Daniel L. Hartl and Elizabeth W. Jones
- Guide to Yeast Genetics and Molecular and Cell Biology by C. Guthrie and G. R. Fink
- Principles of genetics by R. H. Tamarin

Reference books:

- Introduction to genetic analysis by Anthony J.F. Griffiths, Susan R. Wessler, Richard C. Lewontin, William M. Gelbart, David T. Suzuki, Jeffrey H. Miller
- Molecular Genetics by Stent and Calendar
- Principles of Genetics by Snustad and Simmons

BC 761 Bioenergetics and Metabolism

Credits (Theory): 03 **Semester II**
Credit hours: 45

A. Objectives of the Course.

To help students to understand the
- Importance of metabolic activity of in living cell
- Energy and thermodynamics importance in living cell
- Pathogen metabolism

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction, Enzymes in metabolism, Coenzymes and Cofactors in metabolism**	**10**
2.	**Metabolism of Primary metabolites**	**25**
3.	**Integration of Mammalian Metabolism and metabolic disorder**	**10**

C. Detailed syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction, Understand the fundamental energetic of Biochemical processes, Enzymes in metabolism,** Coenzymes and Cofactors in metabolism, Biological oxidation, Respiratory chain and oxidative phosphorylation. ATP, Creatine phosphate, Role and mechanism of action of NAD+/NADP+, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions with specific examples, Approaches for studying metabolism.	**10**
2.	**Metabolism of Primary metabolites and chemical logic of metabolic pathways** Carbohydrates metabolism: Glycolysis, Gluconeogenesis, TCA Cycle, Photosynthesis, Calvin cycle, Pentose phosphate pathway, Glycogen metabolism. Lipid Metabolism: Biosynthesis of membrane lipids, fatty acid metabolism Amino acid and nucleotide metabolism	**25**
3.	**Integration of Mammalian Metabolism and metabolic disorder** Tissue-specific metabolism. Specific functions of liver, adipose tissue, muscle, brain, blood Hormones: Communication among cells and tissues Hormonal regulation of fuel metabolism: epinephrine, glucagon, insulin Molecular mechanisms of signal transduction Second messengers: cyclic AMP, cyclic GMP, calcium Ion channels gated by ligands Protein phosphorylation and dephosphorylation, Hypoglycaemia, Hyperammonaemia, Hyperlipidaemia, Lactic Acidosis, Muscle Disease, Liver Disease, Inherited Metabolic Disease	**10**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- The students will be able to know the importance of metabolism, energy generation and requirement in living cell

- Students will be able to understand the problems in metabolic activity which leads to complications in cell.

F. Recommended Study materials

- Principles of Biochemistry by Albert Lehininger
- Harper's Biochemistry by Robert.KK.Murray 26/e, 2003.
- Fundamentals of Biochemistry by Debajyothi Das 11/e, 2002.
- Fundamentals of biochemistry- Life at the molecular level By: Voet, Voet and Pratt, 2nd edition, 2006.
- Human Biochemistry by James. M. Orten & Oho.W. Neuhaus
- Biochemistry by Lubert Stryer,
- Brock biology of microorganism by MT Madigan and JM Mart

M.Sc. Semester III (Biotechnology)

MS 811 Omics and Bioinformatics

Credits (Theory): 03 **Semester III**
Credit Hours: 45

A. Objectives of the Course

- To enable the students to learn concepts of 'omics' with special emphasis on genomics, transcriptomics, proteomics and metabolomics.
- To enable the students to understand the rapid advancements and applications of 'omics' technologies in the different areas of biological sciences.
- To enable the students to understand fundamentals of bioinformatics and its applications

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Genomics and transcriptomics technologies	**18**
2.	Proteomics and other 'omics' technologies	**15**
3.	Bioinformatics	**12**

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C. Detailed syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Genomics and transcriptomics technologies** Introduction to 'omics' technologies, Genome organization, Physical mapping of genomes, Construction of Genomic Libraries, Genome Sequencing (Chain-termination and High-Throughput Next Generation Sequencing platforms) and Genome sequence assembling strategies (Shotgun and Hierarchical/clone contig methods, sequence assembly softwares), Overview of Human Genome Project. Comparative Genomics, Metagenomics, Pharmacogenomics, Applications of genomics in identifying genetic disorders. Analysis of Transcriptome: Serial Analysis of Gene Expression (SAGE), DNA Microarrays and overview of RNA sequencing.	**18**
2.	**Proteomics and other 'omics' technologies** Introduction to proteomics, Proteome Separation, Characterization and Expression Profiling**:** 2D-PAGE (Two Dimensional Polyacrylamide Gel Electrophoresis), 2D-DIGE (Difference in Gel Electrophoresis), Multidimensional Liquid Chromatography, Mass spectrometry and Peptide mass fingerprinting, Quantitative approaches in proteomics: Isotope Coded Affinity Tag (ICAT) method, Enzymatic and Metabolic Stable Isotope Coding, Protein Microarrays.	**15**

	Protein-Protein Interactions: Genetic and Biochemical methods, Library based screening methods: Yeast Two Hybrid Systems and Phage Display. Tandem-affinity Purification. Introduction to Metabolomics and fluxomics.	
3.	**Bioinformatics** Introduction to bioinformatics- goals, scopes, limitations, applications of bioinformatics, introduction to biological databases, introduction to bioinformatics tools, scoring matrices, extraction of knowledge from resources, sequence based bioinformatics tools, sequence alignment studies, phylogenetic tree construction methods and programmes, protein structure analysis and validation, 3D structure, visualization of proteins, classification and comparison of protein 3D structure, overview of molecular docking.	**12**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome:

- The students will have the knowledge of genomics: genome projects and advanced high-throughput genome sequencing technologies and latest developments in the field of “Omics”.

- Students will learn different methods and approaches used in transcrptomics, proteomics and metabolomics research and their applications.

- Students will be able to understand basics of bioinformatics and its applications in biological sciences.

F. Recommended Study materials:

- S.B.Primrose, R.M.Twyman and R.W. Old. (2006) Principles of Gene Manipulation and Genomics. 6th Edition, Blackwell Science.
- B.R. Glick, J.J. Pasternak and C.L. Patten, (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition,
- Arthur M Lesk (2012) Introduction to Genomics. Oxford University Press

- T. A. Brown (2016) Gene Cloning and DNA Analysis: An Introduction, 7th Edition. John Wiley & Sons, Ltd
- Bernard R. Glick, Terry L. Delovitch, Cheryl L. Patten (2014) Medical Biotechnology. ASM Press
- Lehninger Principles of Biochemistry, Seventh Edition [2017] by David L Nelson; Michael M Cox, Publisher: New York W.H. Freeman © 2017
- R. M. Twyman (2008) Principles of proteomics. Taylor and Francis.
- Nawin Mishra (2010) Introduction to Proteomics: Principles and Applications. John Wiley & Sons, Inc.
- Leland H. Hartwell, Leroy Hood, Michael L. Goldberg, Ann E. Reynolds and Lee M. Silver (2011) Genetics From Genes to Genomes. Fourth Edition. The McGraw-Hill Companies, Inc.
- Pevsner, J. (2015). Bioinformatics and Functional Genomics. III Edition. John Wiley & Sons.
- Jin Xiong (2006) Essential Bioinformatics. Cambridge University Press.
- Jeremy Ramsden (2015) Bioinformatics: An Introduction, Third Edition. Springer.
- Jacques Izard, Maria C. Rivera (2015) Metagenomics for Microbiology. Elsevier.
- D. Barcello (2014) Fundamentals of Advanced Omics Technologies: From Genes to Metabolites (Comprehensive Analytical Chemistry Volume) Elsevier B.V.
- Edward F. Delong (2013) Microbial Metagenomics, Metatranscriptomics, and Metaproteomics (Methods in Enzymology Vol.) Elsevier Inc.
- Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics. John Wiley & Sons.
- Joel T. Dudley and Konrad J. Karczewski (2013) Exploring Personal Genomics
- Gary Walsh (2014) Proteins Biochemistry and Biotechnology Second Edition. John Wiley & Sons, Ltd.
- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons
  Inc.
- Ravindranath Duggirala, Laura Almasy, Sarah Williams-Blangero, Solomon F.D. Paul, Chittaranjan Kole (2015) Genome Mapping and Genomics in Human and Non-Human Primates. Springer-Verlag Berlin Heidelberg
- Debmalya Barh, Vasudeo Zambare, Vasco Azevedo (2013) OMICS: Applications in Biomedical, Agricultural, and Environmental Sciences. CRC Press.
- Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
- Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

MS812 Biostatistics

Credits (Theory): 02 **Semester III**
Credit Hours: 30

A. Objectives of the Course

- To introduce basic biostatistical techniques useful for analyzing data arising in Microbiology and other health science domains
- To emphasize statistical reasoning through problem solving and applications using hand calculation.

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Descriptive Statistics**	**04**
2.	**Probability and Probability distributions**	**04**
3.	**Estimation and Hypothesis Testing**	**06**
4.	**Analysis of Variance**	**06**
5.	**Analysis of categorical data**	**05**
6.	**Correlation and Regression**	**05**

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Descriptive Statistics** Types of data ,Tables and Graphs,Measures of central tendency,Measures of dispersion,Measures of skewness and kurtosis	**04**
2	**Probability and Probability distributions** Introduction to concepts, Binomial Probability distribution, Poisson Probability distribution, Normal Probability distribution	**04**
3	**Estimation and Hypothesis Testing** Estimating Means and Proportions,Central Limit Theorem, Confidence Interval Estimation,One sample and two sample tests, p-values,Powers, Sample size Estimation	**06**
4	**Analysis of Variance** One - Way Analysis of Variance, multi sample inference,Multiple comparisons and inference	**06**
5	**Analysis of categorical data** Chi-square test,Fisher's exact test,Relative risk and odds ratio	**05**

6	**Correlation and Regression** Pearson correlation coefficient,Spearman's rank correlation,Method of least squares; simple and multiple linear regression,Logistic regression	**05**

D. Instructional Methods and Pedagogy

At the starting of the course, delivery pattern and prerequisite of the subject will be discussed. Course materials will be provided to the students from various primary and secondary sources of information. Lectures will be conducted with the aid of Multi-Media projector, Black board, OHP etc. Attendance is compulsory in lectures and laboratory. Two internal exams will be conducted and average of the same will be converted to equivalent of 15 marks as a part of internal theory evaluation. Surprise tests/Quizzes/Seminar/ Assignments will be conducted which carries 5 marks as a part of internal theory evaluation. Unit Test may be conducted which carries 15 marks as a part of internal theory evaluation. In the lectures and laboratory discipline and **behaviour** will be observed strictly.al interactive problem solving sessions will be also.

E Student Learning Outcomes

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

- Interpret commonly used statistics
- Develop judgment about the application of statistical techniques in a given situation
- Implement basic statistical techniques, including descriptive and inferential (estimation and hypothesis testing) by hand

F. Recommended Study materials:

- Rosner, Bernard. Fundamentals of biostatistics. 7th Edition Bernard Rosner; Duxbury Thomson Learnin in Reading Materials, web materials with full citations:

http://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one

BT821 Plant and Animal Biotechnology

Credits (Theory): 04 credits **Semester III**
Credit Hours: 60

A. Objectives of the Course

- To make students understand about the plant development and pathology
- Make students aware about the basic techniques in plant tissue culture
- Exposure to Transgenic plant techniques and applications
- To make student understand about the applications of Plant Biotechnology
- To make students understand the concepts and applications of transgene technology and genetically engineered animals
- To train students on theoretical and practical aspects of animal cell culture.
- To introduce students how animals can be genetically improved for the benefit of humankind

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Plant Development and Pathology	10
2.	Plant Tissue Culture	10
3.	Transgenic Technology and applications of Plant Biotechnology	10
4.	Transgenic Animals and Marker Assisted Selection	20
5.	Animal Cell Culture and its Applications	10

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Plant Development and Pathology** Embryo sac development and double fertilization in plants, Embryogenesis, Establishment of symmetry in plants, Root, shoot, leaf and floral development, Senescence, Plant pathogens and common disease in plants, Isolation, identification and control of pathogens, Plant defense mechanism	10
2.	**Plant Tissue Culture** Laboratory organization of Plant tissue culture, Media in PTC, Common contamination in PTC, Micropropogation- Culture, initiation, shoot multiplication, rooting, Hardening, Callus culturing, single cell culture,	10

	cell suspension culture, Protoplast culturing- Isolation, fusion, Hybrid identification, Somatic embryogenesis and artificial seeds, Generation of Haploid- Anther, pollen and ovary, Somaclonal Variations, Applications of PTC	
3.	**Transgenic Technology and Applications of Plant Biotechnology** Gene targeting to specific organelles-concepts and strategies, Chloroplast transformation, DNA viruses as expression vector (Cauliflower mosaic virus, Gemini virus and Tobbaco mosaic virus), marker assisted selection GM technologies for Biotic stress, Abiotic stress, herbicide resistance, Increasing shelf life, Enhancing nutritional quality, Transgenic plants, Increased production, biofuels, plant nanotechnology, molecular pharming, Food Biotechnology, pathology, Alternative medicines	**10**
4.	**Transgenic Animals and Marker Assisted Selection** Introduction to transgene technology, transgenic animals; gene transfer strategies in animals, marker assisted breeding in animals, animal pharming, regulations for use of transgenic animals	**20**
5.	**Animal Cell Culture and its Applications** Primary culture and established cell line culture, equipment and materials used in animal cell culture, basic techniques in animal cell culture, applications of animal cell culture, organ culture, stem cell technology.	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

After the successful completion of the course a student will be able to

- Student will have insights into plant tissue culture
- Students will be made aware for plant development process and common plant disease
- Techniques to develop GM crops
- Applications of plant tissue culture.
- This syllabus aims to provide students with basic understanding of animal biotechnology
- Students will various aspects of animal cell culture, its application and various strategies used in the development of transgenic animals and their use in animal biotechnology
- Overall the program aims to ensure that students acquire essential knowledge in animal biotechnology for further study/ research.

F. Recommended Study materials:

- Plant tissue culture by Kalyan Kumar De
- Introduction to Plant Tissue Culture Paperback – by M. K. Razdan
- Plant tissue culture: Techniques and Experiment by Rober H Smith
- Plant Biotechnology and Agriculture by Denis Murphy
- Introduction to plant biotechnology by H.S. Chawla
- Experiments in Microbiology, plant pathology and Biotechnology by K.R. Aneja
- Principles of Gene Manipulation and Genomics by SB Primrose and RM Twyman
- Developmental Biology by Scott F. Gilbert
- Textbook of Biotechhbology by HK Das
- Biotechnology Expanding Horizons by BD Singh
- Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications by R. Ian Freshney
- Reproductive Biotechnology of Farm Animals by YG Dugwekar
- Stem Cell Technologies: Basics and Applications by Satish Totey and Kaushik Deb
- Principles of Gene Manipulation and Genomics by SB Primrose and RM Twyman,7th Ed., Blackwell Publishing, 2006
- Biotechnology-Expanding Horizons by BD Singh, Kalyani Publications, 2007
- Textbook of Biotechnology by HK Das, 4th Ed., Wiley India, 2010
- Textbook of Animal Biotechnology by Singh, Gautam, Chauhan and Singla, TERI Publications,2015

BT 822 Industrial Biotechnology

Credit (Theory): 03 **Semester III**
Credit hours: 45

A. Objectives of the course

- To help students to understand about the Scope of Biotechnology based products as compared to chemically derived products
- To introduce the role of regulatory, IPR and Biosafety issues concerning to the development of Biotechnology industry
- To introduce the concept of Bioentreprenuership and Biotechnology industry in India
- Exposure to types of Biotech products and companies

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Introduction to Business Biotechnology	**08**
2.	Regulations in Biotechnology	**08**
3.	Biotechnology products I	**07**
4.	Biotechnology products II	**22**

C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction to Business Biotechnology** Scope of Biotechnology based products, competition with chemical synthesis based products, economic regulatory and IPR issues, patenting of processes and products, Biotechnology companies – care and nurturing, Bio entrepreneurship, Overview of Biotech companies in India	**08**
2.	**Regulations in Biotechnology** Manufacturing facility for Biotechnology based products- Types of block flow diagram and conceptual layout, Concept of designing the facility, Good manugacturing guidelines and its imprortance, Principles of Quality assurance and Quality control, Types of validation- facility, equipment, materials, Treatment and disposal of waste	**08**
3.	**Biotechnology products I** Production of biofertilizers, biopesticides, Biomass-SCP, microalgae**,** probiotics, Neutraceuticals, Pigments	**07**

4.	**Biotechnololgy products II** Production and application of Xanthan gum, amino acids-lysine, glutamic acid, bioethanol, organic acids-gluconic acid, citric acid, lactic acid, vitamins-B12, enzymes-amylase, cellulase, protease, immunosuppressant-tacrolimus, Antibiotics-penicillin, rifampicin, daptomycin, vaccines, Flavours and Fragrances, Recombinant proteins-insulin, eryhthropoeitin, streptokinase	22

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

After the successful completion of the course a student will be able to

- Elaborate on the scope of biotechnology based products as compared to chemically derived products.
- Understand the role of regulatory, IPR and biosafety issues concerning the development of biotechnological industry.
- Understand the production of various primary and secondary metabolites, bioinoculants, recombinant proteins, probiotics and neutraceuticals.
- Obtain insights into regulations in application of biotechnology in industries
- Get overview of Bioentreprenerurship and Biotechnology industry in India

F. Recommended Study materials:

- Comprehensive Biotechnology by Murray Moo-Young, H.W. Blanch, S. Drew, D.I.C (Eds). Wang Pergamon Press Ltd.
- Biotechnology by H J Rehm and G Reed (Eds) Wiley-VCH (1985)
- Basic Biotechnology, 3rd edition, Colin Ratledge (Ed) Cambridge University Press (2006)
- Industrial Microbiology, L E Casida (2007), New Age International Ltd
- Quality in Manufacture of medicine and other health care products by John Sharp (2000)
- Industrial Microbiology by Prescott and Dunn

BT823: Environmental Biotechnology

Credits (Theory): 03 **Semester III**
Credit hours: 45

A. Objectives of the Course

This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

B. Outline of the Course

Sr. No	Title of the Units	Minimum numbers of hours
1	**Environment and pollution**	9
2	**Biodegradation of xenobiotics**	9
3	**Bioremediation**	9
4	**Design of reactors and processes for bioremediation**	9
5	**Biotechnology based environmental processes**	9

C. Detailed syllabus

Sr. No	Title of the units	Minimum numbers of hours
1	**Environment and pollution** Introduction to environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology.	**09**
2	**Biodegradation of xenobiotics**: xenobiotics and recalcitrant compounds, reasons for recalcitrance, biodegradation pathways for xenobiotic compounds e.g hydrocarbons, pesticides, dyes etc. cometabolism	**09**

3	**Bioremediation:** Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT *etc.*), technological aspects of bioremediation (*in situ*, *ex situ*). Application of bacteria and fungi in bioremediation: White rot fungi *vs* specialized degrading bacteria: Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization).	**09**
4	**Design of reactors and processes for bioremediation** Criteria for design of bioreactors, bioreactor configurations used for bioremediation of wastes and their design, suspended and attached growth processes	**09**
5	**Biotechnology based environmental processes** Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.	**09**

D. Instructional Methods and Pedagogy:

- The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations.
- The topics will taught using numerical problems, case studies, simulations, animations, softwares.
- Interactive problem solving sessions will be also conducted by respective faculty members on regular basis.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Unit tests, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.
- Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self study.
- Industrial visits/tours will be conducted for providing on-site understanding of the concepts of bioprocess engineering and technology gained during the theory and practical sessions.
- Mini-projects and/or dissertation project in the subject area of bioprocess technology will be carried out.

E. Student learning outcome

On completion of course, students will be able to understand the applications of biotechnology environmental protection and useful processes

F. Recommended Study materials:

- M. Evans and J. C. Furlong (2003), *Environmental Biotechnology: Theory and Applications*, Wiley Publishers.
- B. Ritmann and P. L. McCarty, (2000), *Environmental Biotechnology: Principle & Applications*, 2nd Ed., McGraw Hill Science.
- Scragg A. (2005) *Environmental Biotechnology*. Pearson Education Limited.
- J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), *Biofiltration for Air Pollution Control*, CRC Press.
- H. J. Rehm and G. Reed, (2001), *Biotechnology – A Multi-volume Comprehensive Treatise*, Vol. 11, 2nd Ed., VCH Publishers Inc.
- S. Peavy, D. R. Rowe and G. Tchobanoglous, (2013), *Environmental Engineering*, McGraw-Hill Inc.

BT825 Agricultural Biotechnology

Credit (Theory): 02 **Semester III**
Credit hours: 30

A. Objectives of the course.

- To help students to understand the Concept of Agricultural Biotechnology
- Molecular mechanism of various processes
- Basic tissue culture techniques
- Concept of Plant molecular markers

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Plant Molecular Biology**	10
2.	**Plant Genetic Engineering**	10
3.	**Molecular Markers and Genomics**	10

C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Molecular basis of plant function** Photoregulation and phytochrome regulation of nuclear and chloroplastic geneexpression. Molecular mechanism of nitrogen fixation. Molecular biology of variousstresses, *viz.* abiotic stresses like drought, salt, heavy metals and temperature; andbiotic stresses like bacterial, fungal and viral diseases. Signal transduction and itsmolecular basis, molecular mechanism of plant hormone action mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storageproteins and starch synthesis	10
2	**Plant Genetic Engineering** Isolation of genes of economic importance. Gene constructs for tissue-specificexpression. Different methods of gene transfer to plants, *viz.* direct and vectormediated. Molecular analysis of transformants. Potential applications of plant geneticengineering for crop improvement, i.e. insect-pest resistance (insect, viral, fungal andbacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, Current status of transgenics,biosafty norms and controlled field trials and release of transgenics (GMOs).	10

3	**Molecular Markers and Genomics** DNA molecular markers: Principles, type and applications; restriction fragment lengthpolymorphism (RFLP), amplified fragment length polymorphism (AFLP), randomlyamplified polymorphic DNA sequences (RAPD), Simple sequence repeats (SSR), Single nucleotide polymorphism (SNP), Structural and functional genomics, gene mapping, genome mapping, gene tagging and comparative genomics and application of genomics	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

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

- Elaborate on the scope of Agriculture biotechnology
- Understand the role of major molecular marker used in Biotechnology
- Student will be able to understand the basic techniques of tissue culture and genomics

F. Recommended Study materials:

- Plant physiology by Teiz and Zeigar
- Agricultural Biotechnology (Books in Soils, Plants, and the Environment 1997 by Arie Altman)
- Textbook of Agriculture Biotechnology by Ahuindra Nag 2008 , PHI Learning Pvt Ltd

BT826 FORENSIC BIOTECHNOLOGY

Credits (Theory): 02 credits **Semester: III**
Credit Hours: 30

A. Objectives of the Course

- Introduction to basic of inheritance, the role of inheritance in development of human.
- To develop the understanding of methods used in genetic analysis.
- To develop the analytical skills in analyzing the complex genetic interaction of forensic cases.

B. Outline of the Course

Sr. No	Title of the Units	Minimum numbers of hours
1.	**Introduction to Forensic biotechnology**	**10**
2.	**Biology in Forensics-I**	**10**
3.	**Biology in Forensics-II**	**10**

C. Detail Syllabus

Sr. No	Title of the Units	Minimum numbers of hours
1.	**Introduction to Forensic biotechnology** Introduction to Forensic Science, Forensic Biotechnology, Forensic Genetics, Forensic Agriculture, DNA fingerprinting / DNA Profiling / DNA Testing; History of DNA fingerprinting; Ethics, Rules and Procedures; Genetic linkage mapping; Physical mapping of the genome; BAC end sequencing; Extract DNA from blood and biological material; and other tests for DNA; DNA Testing Tool, Kits and Equipments	**10**
2.	**Biology in Forensics-I** Recognition of Biological evidences encountered in various cases, Search and Collection of Biological evidences, Estimation of Age, Sex and Race, Bite mark analysis	**10**
3.	**Biology in Forensics-II** Next Generations sequencing platforms and its application in Forensics, Methods for DNA fingerprinting, Molecular markers for forensics, Method for DNA quantification, Application of Monoclonal antibodies in forensics, Forensic challenges: degraded DNA mxtures	**10**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Animation and tutorials will be given for in-depth understanding of the subject.

E. Student learning outcome

After the successful completion of the course a student will be able to

- Describe various theoretical models of the creative process, capable to analyze the scientific concepts with observational mind and logical analysis of problems.
- Able to understand the modern techniques of Animal and Plant breeding
- The main objective of this study to develop concepts on fundamentals of heredity.
- Development of novel skills for enhancing the scientific knowledge of society.

F. Recommended Study materials:

- Principles of genetics, third edition by R. Snusted
- Principles of genetics by Tamarin : 10^{th} edition
- Principles of Plant genetics and breeding, second edition by GerorgeAcquaah, Willey-blackwell publishing groups
- An introduction to genetic analysis ,Eleven edition, by Griffith
- Molecular genetics of Bacteria , fourth edition by Dale
- Genetics ;A conceptual approach by Bemzamin A pierce
- Genetics , fourth edition by Brooker
- Genetics : laboratory investigation by Thomas R.Mertans
- Genetics: A conceptual approach (2nd edition, 2006) by B.A. Pierce ;W.H. Freeman and Co.
- Griffiths, Anthony J. F., Jeffrey H. Miller, David T. Suzuki, Richard C. Lewontin, and William M. Gelbart. *An Introduction to Genetic Analysis*. 7th ed. New York: W. H. Freeman, 2000. ISBN: 9780716735205
- Gurubachan S Miglani, Developmnetal Genetics, I K international Publishing house
- Sally A Moody, principles of Developmental genetics [2014]
- John M Butler, Forensic DNA Typing; Biology, Technology, and Genetics of STR Markers, Elsewire Academic Press
- Forensic DNA Biology: A Laboratory Manual By Kelly M. Elkins, Academic press

BT827 Ecology and Conservation Biotechnology

Credit (Theory): 02 **Semester III**
Credit hours: 30

A. Objectives of the course

- Help student understand the Scope of Ecology
- Understand the basic biotic and abiotic interactions
- Understand the concept of Habitat, Niche, Population and community ecology
- Help them preparing for competitive exams

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction to Ecology and Environment**	10
2.	**Habitat and Niche**	05
3.	**Population and community ecology**	05
4.	**Conservation and Applied ecology**	10

C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction to Ecology and Environment** Introduction to Ecology and Environment, Scope of Ecology The Environment: Physical environment; biotic environment; biotic and abiotic interactions. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).	10
2.	**Habitat and Niche** Concept of Habitat and Niche, Niche width and overlap, Fundamental and realized Niche, resource Partitioning, Character displacement	5
3.	**Population and community ecology** Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations Community ecology: Nature of communities; community	5

	structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological succession: Types; mechanisms; changes involved in succession; concept of climax	
4.	**Conservation and Applied ecology** Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India. Conservation biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves). Applied ecology: Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Methods in field biology: Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization-ground and remote sensing methods.	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

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

- Elaborate on the scope of Ecology
- Understand Applications of Ecology and methods of field biology
- Know types of biotic interactions
- Understand the concept of Population and community ecology as well as Habitat and Niche
- May help student in clearing competitive exam

F. Recommended Study materials:

- UGC-CSIR NET (JRF & LS) Life Science (English, Paperback, Nagesh A, Kumar P, Hossain C
- Campbell Biology (10th Edition) 10th Edition By Reece, Urry, Cain, Waseermen, Minorsky and Jackson
- Cell Biology, Genetics, Molecular Biology, Evolution & Ecology by PS Verma and BK Agarwal. S Chand Publication
- Community Ecology and Environment By V K Prabhakar. Anmol Publisher

M.Sc. Semester III (Microbiology)

MS 811 Omics and Bioinformatics

Credits (Theory): 03 **Semester III**
Credit Hours: 45_

B. Objectives of the Course

- To enable the students to learn concepts of 'omics' with special emphasis on genomics, transcriptomics, proteomics and metabolomics.
- To enable the students to understand the rapid advancements and applications of 'omics' technologies in the different areas of biological sciences.
- To enable the students to understand fundamentals of bioinformatics and its applications

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Genomics and transcriptomics technologies	**18**
2.	Proteomics and other 'omics' technologies	**15**
3.	Bioinformatics	**12**

C. Detailed syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Genomics and transcriptomics technologies** Introduction to 'omics' technologies, Genome organization, Physical mapping of genomes, Construction of Genomic Libraries, Genome Sequencing (Chain-termination and High-Throughput Next Generation Sequencing platforms) and Genome sequence assembling strategies (Shotgun and Hierarchical/clone contig methods, sequence assembly softwares), Overview of Human Genome Project. Comparative Genomics, Metagenomics, Pharmacogenomics, Applications of genomics in identifying genetic disorders. Analysis of Transcriptome: Serial Analysis of Gene Expression (SAGE), DNA Microarrays and overview of RNA sequencing.	**18**
2.	**Proteomics and other 'omics' technologies** Introduction to proteomics, Proteome Separation, Characterization and Expression Profiling**:** 2D-PAGE (Two Dimensional Polyacrylamide Gel Electrophoresis), 2D-DIGE (Difference in Gel Electrophoresis), Multidimensional Liquid Chromatography, Mass spectrometry and Peptide mass fingerprinting, Quantitative approaches in proteomics: Isotope Coded Affinity Tag (ICAT) method, Enzymatic and Metabolic Stable Isotope Coding, Protein Microarrays.	**15**

	Protein-Protein Interactions: Genetic and Biochemical methods, Library based screening methods: Yeast Two Hybrid Systems and Phage Display. Tandem-affinity Purification. Introduction to Metabolomics and fluxomics.	
3.	**Bioinformatics** Introduction to bioinformatics- goals, scopes, limitations, applications of bioinformatics, introduction to biological databases, introduction to bioinformatics tools, scoring matrices, extraction of knowledge from resources, sequence based bioinformatics tools, sequence alignment studies, phylogenetic tree construction methods and programmes, protein structure analysis and validation, 3D structure, visualization of proteins, classification and comparison of protein 3D structure, overview of molecular docking.	**12**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- The students will have the knowledge of genomics: genome projects and advanced high-throughput genome sequencing technologies and latest developments in the field of “Omics”.
- Students will learn different methods and approaches used in transcrptomics, proteomics and metabolomics research and their applications.
- Students will be able to understand basics of bioinformatics and its applications in biological sciences.

F. Recommended Study materials:

- S.B.Primrose, R.M.Twyman and R.W. Old. (2006) Principles of Gene Manipulation and Genomics. 6th Edition, Blackwell Science.
- B.R. Glick, J.J. Pasternak and C.L. Patten, (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition,

- Arthur M Lesk (2012) Introduction to Genomics. Oxford University Press
- T. A. Brown (2016) Gene Cloning and DNA Analysis: An Introduction, 7^{th} Edition. John Wiley & Sons, Ltd
- Bernard R. Glick, Terry L. Delovitch, Cheryl L. Patten (2014) Medical Biotechnology. ASM Press
- Lehninger Principles of Biochemistry, Seventh Edition [2017] by David L Nelson; Michael M Cox, Publisher: New York W.H. Freeman © 2017
- R. M. Twyman (2008) Principles of proteomics. Taylor and Francis.
- Nawin Mishra (2010) Introduction to Proteomics: Principles and Applications. John Wiley & Sons, Inc.
- Leland H. Hartwell, Leroy Hood, Michael L. Goldberg, Ann E. Reynolds and Lee M. Silver (2011) Genetics From Genes to Genomes. Fourth Edition. The McGraw-Hill Companies, Inc.
- Pevsner, J. (2015). Bioinformatics and Functional Genomics. III Edition. John Wiley & Sons.
- Jin Xiong (2006) Essential Bioinformatics. Cambridge University Press.
- Jeremy Ramsden (2015) Bioinformatics: An Introduction, Third Edition. Springer.
- Jacques Izard, Maria C. Rivera (2015) Metagenomics for Microbiology. Elsevier.
- D. Barcello (2014) Fundamentals of Advanced Omics Technologies: From Genes to Metabolites (Comprehensive Analytical Chemistry Volume) Elsevier B.V.
- Edward F. Delong (2013) Microbial Metagenomics, Metatranscriptomics, and Metaproteomics (Methods in Enzymology Vol.) Elsevier Inc.
- Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics. John Wiley & Sons.
- Joel T. Dudley and Konrad J. Karczewski (2013) Exploring Personal Genomics
- Gary Walsh (2014) Proteins Biochemistry and Biotechnology Second Edition. John Wiley & Sons, Ltd.
- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons
  Inc.
- Ravindranath Duggirala, Laura Almasy, Sarah Williams-Blangero, Solomon F.D. Paul, Chittaranjan Kole (2015) Genome Mapping and Genomics in Human and Non-Human Primates. Springer-Verlag Berlin Heidelberg
- Debmalya Barh, Vasudeo Zambare, Vasco Azevedo (2013) OMICS: Applications in Biomedical, Agricultural, and Environmental Sciences. CRC Press.
- Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
- Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

MS812 Biostatistics

Credits (Theory): 02 **Semester III**
Credit Hours: 30

A. Objectives of the Course

- To introduce basic biostatistical techniques useful for analyzing data arising in Microbiology and other health science domains
- To emphasize statistical reasoning through problem solving and applications using hand calculation.

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers s of hours
1.	Descriptive Statistics	04
2.	Probability and Probability distributions	04
3.	Estimation and Hypothesis Testing	06
4.	Analysis of Variance	06
5.	Analysis of categorical data	05
6.	Correlation and Regression	05

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Descriptive Statistics** Types of data ,Tables and Graphs,Measures of central tendency,Measures of dispersion,Measures of skewness and kurtosis	**04**
2	**Probability and Probability distributions** Introduction to concepts, Binomial Probability distribution, Poisson Probability distribution, Normal Probability distribution	**04**
3	**Estimation and Hypothesis Testing** Estimating Means and Proportions,Central Limit Theorem, Confidence Interval Estimation,One sample and two sample tests, p-values,Powers, Sample size Estimation	**06**
4	**Analysis of Variance** One - Way Analysis of Variance, multi sample inference,Multiple comparisons and inference	**06**
5	**Analysis of categorical data** Chi-square test,Fisher's exact test,Relative risk and odds ratio	**05**

6	**Correlation and Regression** Pearson correlation coefficient,Spearman's rank correlation,Method of least squares; simple and multiple linear regression,Logistic regression	**05**

D. Instructional Methods and Pedagogy

At the starting of the course, delivery pattern and prerequisite of the subject will be discussed. Course materials will be provided to the students from various primary and secondary sources of information. Lectures will be conducted with the aid of Multi-Media projector, Black board, OHP etc. Attendance is compulsory in lectures and laboratory. Two internal exams will be conducted and average of the same will be converted to equivalent of 15 marks as a part of internal theory evaluation. Surprise tests/Quizzes/Seminar/ Assignments will be conducted which carries 5 marks as a part of internal theory evaluation. Unit Test may be conducted which carries 15 marks as a part of internal theory evaluation. In the lectures and laboratory discipline and **behaviour** will be observed strictly.al interactive problem solving sessions will be also.

E Student Learning Outcomes

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

- Interpret commonly used statistics
- Develop judgment about the application of statistical techniques in a given situation
- Implement basic statistical techniques, including descriptive and inferential (estimation and hypothesis testing) by hand

F. Recommended Study materials:

- Rosner, Bernard. Fundamentals of biostatistics. 7th Edition Bernard Rosner; Duxbury Thomson Learnin in Reading Materials, web materials with full citations:

http://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one

MI821 Industrial Microbiology

Credits (Theory): 04 **Semester III**
Credit Hours: 60

A. Objectives of the Course.

- To help students to understand the
    - Scope of microbial products as compared to chemically derived products.
    - To understand the production of various primary and secondary metabolites, bioinoculants, recombinant proteins, probiotics and recombinant products.
    - To provide insights into application of microbiology in industries

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1	Introduction Industrial Microbiology	**05**
2	Microbial Products and their manufacturing	**12**
3	Primary Metabolic Products	**10**
4	Secondary Metabolic Products	**09**
5	Biomass	**07**
6	Biotransformations	**07**
7	Production of Recombinant Products	**09**

C. Detailed syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
	Introduction Industrial Microbiology Scope of microbial products, competition with chemical synthesis based products, economic regulatory and IPR issues, patenting of processes and products,	**05**
•	**Microbial Products and their manufacturing** Over view of fermentations, Good manufacturing practices- cGMP guidelines, Containment, principles of quality assurance and quality control, validation of facility, equipment and materials, bio-waste treatment and disposal	**10**
•	**Primary Metabolic Products** Organic acids, Solvents, amino acids Biofuels, enzymes, vitamins	**10**
•	**Secondary Metabolic Products** Antibiotics, pigments, bioactive compounds, Polyaromatic hydrocarbons	**09**
•	**Biomass** Bioinoculants, starter cultures, probiotics, mushroom, spirulina, , SCP, SCO.	**07**

•	**Biotransformations** Organic synthesis, steroid transformation, semisynthetic antibiotics, metal transformations	**07**
•	**Production of Recombinant Proteins** Introduction to Recombinant Proteins, Systems for Producing Recombinant Proteins. Strategies for Recovery and purification of products Production of Enzymes and other recombinant products: vaccines, - insulin, eryhthropoeitin, streptokinase	**10**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Elaborate on the scope of biotechnology based products as compared to chemically derived products.
- Understand the role of regulatory, IPR and biosafety issues concerning the development of biotechnological industry.
- Understand the production of various primary and secondary metabolites, bioinoculants, recombinant proteins, probiotics and neutraceuticals.
- Obtain insights into regulations in application of microbiology in industries
- To elaborate the various methods available for recovery and purification of biotechnological products

F. Recommended Study materials

- Industrial Microbiology by Prescott and Dunn
- Industrial Microbiology by A H Patel
- Industrial Microbiology, L E Casida (2007), New Age International Ltd.
- Basic Biotechnology, 3rd edition, Colin Ratledge (Ed) Cambridge University Press (2006)
- Comprehensive Biotechnology 1st edition by Murray Moo-Young, H.W. Blanch, S. Drew, D.I.C (Eds). Wang Pergamon Press Ltd.
- *Biotechnology by H J Rehm and G Reed (Eds) Wiley-VCH (1985)*
- Comprehensive Biotechnology second edition, Edited by Murray Moo-Young Elsevier (2011)

MI822 Medical Microbiology

Credits (Theory): 03 **Semester III**
Credit Hours: 45

A. Objectives of the Course

- To introduce the concepts of Human anatomy and Microbial infections
- To enable the students to understand the interactions of human body and microorganisms
- To enable the students to understand classical and advanced diagnostic techniques and preventive measures

B. Outline of the Course

Sr. No.	Title of Unit	Minimum Number of Hours
1	**Anatomical and epidemiological basis of human diseases**	**08**
2	**Bacterial and Fungal infections**	**15**
3	**Viral, Protozoal and vector-borne infections**	**18**
4	**Nosocomial infections and multidrug resistance**	**04**

B. Detailed Syllabus

Sr. No.	Title Title of the Units	Minimum numbers of hours
1	**Anatomical and epidemiological basis of human diseases** Human body as microbial habitats, Molecular basis of Virulence and Pathogenicity (mechanism of attachment and entry into the host cells), strategies employed by bacterial pathogens to evade host immune response, Principles of epidemiology	**08**
2	**Bacterial and Fungal infections** **Bacterial infections:** **Molecular basis of infection**: Antimicrobial mechanisms of phagocytes and bacterial evasion strategies (*Mycobacterium tuberculosis* and *Leisteria monocytogenes*). **Pathogenicity islands(PAI)**: Definition, characteristics of PAI. PAI in enteric bacteria with special reference to EPEC, EHEC and UPEC, cag A pathogenicity island of *H.pylori* **Molecular basis of Toxins**- Cholera, diphtheria Botulinum, Actinomycetes (Athlete's foot) **Fungal infections:** Cutaneous & Sub cutaneous and Systemic Mycosis; Lab diagnosis of fungal Infections; Opportunistic mycosis.	**15**
3	**Viral, Protozoal and vector-borne infections** **Viral diseases transmitted via air**: Influenza, SARS; **Viral diseases of childhood**: Measles, Mumps;	**18**

	Viruses transmitted via food or water: Rotavirus, Polio, Hepatitis A; Other viruses - Herpes virus, Rabies virus, Oncogenic viruses; Human immunodeficiency virus: AIDS **Protozoal diseases** - Malaria, Leishmaniasis, Dysentery.	
4	**Nosocomial infections and multidrug resistance** Causes of nosocomial infections, Role of biofilms in infection prevelance and strategies to overcome biofilm mediated infection, Major classes of antibiotics, mode of action abs mechanism of resistance, Introduction to multi-drug resistance.	**04**

E. Student learning outcome

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

- Understand the human physiology
- Understand various microbial infections
- Understand classical and advanced diagnostic techniques

F. Recommended Study materials

- Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication
- Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication
- Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier
- Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition Appleton-Centuary-Crofts publication
- Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education

MI823 Environmental Microbiology

Credits (Theory): 03 **Semester III**
Credit Hours: 45

A. Objectives of the Course

- To help students to understand the-
- Concepts of microbial niche, habitat and community structure, including biofilm formation and microbial interactions in the environment.
- Microbial communication systems. Environmental sample collection and environmental monitoring using biosensors.
- Advanced molecular techniques to study environmental microbial communities.
- Concepts in biodegradation and biotransformation of organic and metal pollutants and microbial remediation technologies applied to polluted sites.

B. Outline of the Course:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Concepts of Microbial Ecosystems	10
3.	Methods to Study Microbial Communities	09
4.	Environmental Sample Collection and Monitoring	06
5.	Biodegradation and Biotransformation of Organic and Metal Pollutants:	08
6.	Microbial Remediation Technologies	12

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C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Concepts of Microbial Ecosystems** Microbial Niche and Habitats, Microbial Diversity in Natural Systems, Microbial community structure, dynamics and succession. Planktonic microorganisms, Surfaces and Biofilms and Microbial Mats Microbial Interactions: Microbe-Microbe Interactions, Plant-Microbe and Animal-Microbe Interactions. Microbial Communication: Introduction to Quorum Sensing in Gram Negative and Signaling in Gram Positive Bacteria	10
3.	**Methods to Study Microbial Communities** Cultivation-dependent and Cultivation Independent Methods: Conventional and Molecular methods. Overview of Microbial Diversity Indices.	09
4.	**Environmental Sample Collection and Monitoring** Sampling Strategies and Methods to collect Soil, Air and Water samples. Overview of Environmental Monitoring: Biosensors and other methods	06

5.	**Biodegradation and Biotransformation of Organic and Metal Pollutants:** Contaminant Structure, Bioavailability, Toxicity and Biodegradability, Environmental Factors Affecting and Mechanisms of Biodegradation and Biotransformation.	**08**
6.	**Microbial Remediation Technologies** Solid and Liquid Waste Treatment, *In-situ* and *Ex-situ* Bioremediation of Polluted sites.	**12**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome:

- The students will be able to learn the basic concepts of microbial ecosystems and communication.
- Students will be able to understand various conventional and advanced techniques to explore environmental microbial communities.
- The students will be able to learn various applied aspects of Environmental Microbiology.

F. Recommended Study materials

- Ian L. Pepper, Charles P. Gerba, Terry J. Gentry (2015) Environmental Microbiology. Third edition, Elsevier
- Jean-Claude Bertrand, Pierre Caumette, Philippe Lebaron, Robert Matheron, Philippe Normand, Telesphore Sime-Ngando. Environmental Microbiology: Fundamentals and Applications (2015). Springer
- Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA.
- Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
- Environmental Microbiology (2010) Wiley-Blackwell. Edited by Ralph Mitchell and Ji-Dong Gu.
- Brock Biology of Microorganisms, 14th Edition, 2015. Publisher: Pearson
- Prescott's Microbiology (10 th Edition) by Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton (2017) Publisher: McGraw-Hill.
- Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York

4. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg
5. Standard Methods for the Examination of Water and Wastewater 20th Edition (1999) Edited by Lenore S. Clesceri, Arnold E. Greenberg, Andrew D. Eaton. American Public Health Association, Water Environment Federation, American Water Works Association.

MI 825 Applied Microbiology

Credits (Theory): 02 **Semester III**
Credit Hours: 30

A. Objectives of the Course

- To help students to understand the
- Understand various applied aspects relating to industries, medical fields and healthcare
- Understand bioenergy generations and recent advancements
- Understand pros and cons of microbes in Environmental Microbiology
- Understand industrial policies and Governmental regulations alongside intellectual property rights

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Microbes in health and therapy	**07**
2.	Bioenergy	**08**
3.	Biodeterioration and Bioremediation	**10**
4.	Industrial regulations and IPR	**05**

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C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Microbes in health and therapy** Probiotics, Prebiotics, Phage Therapy and CRISPR-Cas system.	**07**
2.	**Bioenergy** First, second and third generations of biofuels, Bioethanol, Consolidated bioprocessing, Biodiesel, Biohydrogen and Biomethane.	**08**
3.	**Biodeterioration and Bioremediation** Biodeterioration of textile, food, leather and rubber; Recalcitrant compounds, Biodegradation pathways of dyes, petroleum products, pesticides, insecticides and PAHs by bacteria and Fungi; Phytoremediation strategies.	**10**
4.	**Industrial regulations and IPR** Guidelines to work with clones, aseptic packaging, food and dairy products; IPR and Patents.	**05**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcome

- The students will be able to learn applied aspects of medical, industrial and environmental microbiology.
- Students will be able to understand the industrial rules and regulations with IPR.

F. Recommended Study materials

- Applied Microbiology: Saxena, S., 2015; Springer publications.
- Advances in applied microbiology: Laskin, A.I., Bennett, J.W. and Gadd, G.M., 2003, Academic Press.
- A textbook of basic and applied microbiology: Aneja, K.R., 2008, New Age International.

MI 826 AGRICULTURAL MICROBIOLOGY

Credits (Theory): 02 **Semester: III**
Credit Hours: 30

A. Objectives of the Course

- To understand physical and chemical characteristics and ecology of soil.
- To impart knowledge of distribution and availability of nutrients in soils and its effect on soil fertility.
- To provide awareness about the plant diseases caused by microorganisms.
- To introduce the concept and role of bio-inoculants in soil amendment.

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Concepts of soil microbiology**	6
2.	**Plant – microbe interactions**	8
3.	**Plant diseases caused by microbes**	6
4.	**Bio-inoculants**	10

C. Detailed Syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Concepts of soil microbiology** Soil structure and composition: Soil physico- chemical properties, soil organic matter and humus. Soil fertility: Soil microbial communities, role of microorganisms in composting, humus formation and Nitrogen, Phosphorus and Sulphur cycles in soil. Rhizosphere: Rhizosphere effect, nutrient exchange, rhizosphere microbes and their significance. Waste land and degraded land reclamation	6
2.	**Plant – microbe interactions** Interactions on above and below the ground parts: Positive interactions (symbiotic/non-symbiotic, endophytic/epiphytic bacteria and phyllospheric/phylloplane bacteria) and negative interactions (microbial pathogens and nematodes). Concepts and mechanisms of rhizobium-legume symbiosis and Mycorrhizal symbiosis.	8
3.	**Plant diseases caused by microbes** Symptoms, transmission and control of viral, bacterial and fungal diseases.	6

4.	**Bio-inoculants** Concept of plant growth promoting bacteria, organic farming and vermicompost. Use of microorganisms as biofertilizers: Advantages, types of biofertilizers, mechanisms and methods of application of biofertilizers, field performance of biofertilizers; methods of application. Use of microorganisms as bio-control agents (bio-pesticides, bio-fungicides, bio-nematocides, entamopahtogenic fungi): Adverse effects of chemical pesticides, fungicides and nematocides. Types and mechanisms of bio-control agents. Quality control and Indian standards for biofertilizers and bio-control agents.	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- The students shall be aware of the physical and chemical characteristics ecological nature of soils
- Understand major biogeochemical processes occurring in natural soils
- Shall have the knowledge of distribution and availability of nutrients in soils and be capable of evaluating soil fertility
- Have knowledge about the plant diseases caused by microorganisms
- Understanding the applications of microorganisms for sustainable agriculture.

F. Recommended Study materials:

- Agricultural Microbiology by G. Rangaswami and D. Bagyaraj
- Introduction to Soil Microbiology, Alexander M, (1977),2nd edn, Wiley Eastern Ltd.
- Biofertilizers in Agriculture and Forestry, Subbarao N S, (1993), 3rd edn, Oxford and IBH.
- Principles of Microbiology. . Atlas R M, (1997), 2nd edn, Wm. C. Brown Pub, USA.
- Plant Pathology, . Mehrotra R and Aggarwal A, (2003), 2nd edn, Tata Mcgraw-Hill Publisher
- A textbook of microbiology R. C Dubey and D.K. Maheswari, S. Chand and Company.

MI 827 Microbial Ecology and Diversity

Credits (Theory): 02 **Semester III**
Credit Hours: 30

B. Objectives of the Course

To help students to understand

- To provide a framework for understanding the relationships between and role of microorganisms in ecological communities.
- To impart understanding of abiotic and biotic interactions within microbial communities and with plants and animals.
- To introduce to the underlying principles that drive microbial community structure and dynamics.
- To apply knowledge about Microbial Ecology and Diversity for the exploitation of bacterial, fungal and viral diversity.

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Basics of Microbial Ecology	**07**
2.	Algal and Protozoan diversity and its role in ecosystem	**08**
3.	Viral diversity and its role in ecosystem	**09**
4.	Bioprospecting	**06**

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C. Detailed Syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Basics of Microbial Ecology** Present status and scope of microbial ecology, sources of information for microbial ecologist, significance of microbial biodiversity in environmental processes. Microbial ecosystems: introduction to community structure in microorganisms, effect of sudden change in environmental factors on community structure, development of microbial communities, population selection within communities- r and k strategies, succession in microbial	**07**

	communities. Sessile and Planktonic communities. Conservation of microbial diversity.	
2.	**Algal and Protozoan diversity and its role in ecosystem** Salient features, diversity and significance of various groups of algae and protozoa.	**08**
3.	**Viral diversity and its role in ecosystem** Overview of bacterial, animal and plant Viruses; Significance in environment/ ecology and subviral entities.	**09**
4.	**Bioprospecting** Bioprospecting of enzymes (amylase, cellulase, protease, lipase), antibiotics, organic acids and vitamins; iChip technology and Single cell isolation.	**06**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcome

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

- Understand the relationships between and role of microorganisms in ecological communities.
- Learn the underlying principles that drive microbial community structure and dynamics.
- Exploit bacterial, fungal and viral diversity in various fields of biotechnology.

F. Recommended Study materials

- Microbial Ecology: Fundamentals and Applications, Atlas and Bartha, Pearson Education.
- Molecular Microbial Ecology: A Mark Osborn; Cindy J Smith, 2005, Taylor & Francis.
- Environmental Microbiology: Raina M. Maier, Ian L. Pepper, Charles P. Gerba, 2000, Academic Press.
- Introduction to Environmental Microbiology: R. Mitchell, Prentice-Hall publishers.

M.Sc. Semester III (Biochemistry)

MS 811 Omics: Technologies and Bioinformatics

Credits (Theory): 03 **Semester III**
Credit Hours: 45

C. Objectives of the Course

- To enable the students to learn concepts of 'omics' with special emphasis on genomics, transcriptomics, proteomics and metabolomics.
- To enable the students to understand the rapid advancements and applications of 'omics' technologies in the different areas of biological sciences.
- To enable the students to understand fundamentals of bioinformatics and its applications

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Genomics and transcriptomics technologies**	18
2.	**Proteomics and other 'omics' technologies**	15
3.	**Bioinformatics**	12

C. Detailed syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Genomics and transcriptomics technologies** Introduction to 'omics' technologies, Genome organization, Physical mapping of genomes, Construction of Genomic Libraries, Genome Sequencing (Chain-termination and High-Throughput Next Generation Sequencing platforms) and Genome sequence assembling strategies (Shotgun and Hierarchical/clone contig methods, sequence assembly softwares), Overview of Human Genome Project. Comparative Genomics, Metagenomics, Pharmacogenomics, Applications of genomics in identifying genetic disorders. Analysis of Transcriptome: Serial Analysis of Gene Expression (SAGE), DNA Microarrays and overview of RNA sequencing.	18
2.	**Proteomics and other 'omics' technologies** Introduction to proteomics, Proteome Separation, Characterization and Expression Profiling**:** 2D-PAGE (Two Dimensional Polyacrylamide Gel Electrophoresis), 2D-DIGE (Difference in Gel Electrophoresis), Multidimensional Liquid Chromatography, Mass spectrometry and Peptide mass fingerprinting, Quantitative approaches in proteomics: Isotope Coded Affinity Tag (ICAT)	15

	method, Enzymatic and Metabolic **Stable Isotope Coding, Protein Microarrays.** Protein-Protein Interactions: Genetic and Biochemical methods, Library based screening methods: Yeast Two Hybrid Systems and Phage Display. Tandem-affinity Purification. Introduction to Metabolomics and fluxomics.	
3.	**Bioinformatics** Introduction to bioinformatics- goals, scopes, limitations, applications of bioinformatics, introduction to biological databases, introduction to bioinformatics tools, scoring matrices, extraction of knowledge from resources, sequence based bioinformatics tools, sequence alignment studies, phylogenetic tree construction methods and programmes, protein structure analysis and validation, 3D structure, visualization of proteins, classification and comparison of protein 3D structure, overview of molecular docking.	**12**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome:

- The students will have the knowledge of genomics: genome projects and advanced high-throughput genome sequencing technologies and latest developments in the field of “Omics”.

- Students will learn different methods and approaches used in transcrptomics, proteomics and metabolomics research and their applications.

- Students will be able to understand basics of bioinformatics and its applications in biological sciences.

F. Recommended Study materials:

- S.B.Primrose, R.M.Twyman and R.W. Old. (2006) Principles of Gene Manipulation and Genomics. 6th Edition, Blackwell Science.
- B.R. Glick, J.J. Pasternak and C.L. Patten, (2010) Molecular Biotechnology:

Principles and Applications of Recombinant DNA, 4th Edition,

- Arthur M Lesk (2012) Introduction to Genomics. Oxford University Press
- T. A. Brown (2016) Gene Cloning and DNA Analysis: An Introduction, 7th Edition. John Wiley & Sons, Ltd
- Bernard R. Glick, Terry L. Delovitch, Cheryl L. Patten (2014) Medical Biotechnology. ASM Press
- Lehninger Principles of Biochemistry, Seventh Edition [2017] by David L Nelson; Michael M Cox, Publisher: New York W.H. Freeman © 2017
- R. M. Twyman (2008) Principles of proteomics. Taylor and Francis.
- Nawin Mishra (2010) Introduction to Proteomics: Principles and Applications. John Wiley & Sons, Inc.
- Leland H. Hartwell, Leroy Hood, Michael L. Goldberg, Ann E. Reynolds and Lee M. Silver (2011) Genetics From Genes to Genomes. Fourth Edition. The McGraw-Hill Companies, Inc.
- Pevsner, J. (2015). Bioinformatics and Functional Genomics. III Edition. John Wiley & Sons.
- Jin Xiong (2006) Essential Bioinformatics. Cambridge University Press.
- Jeremy Ramsden (2015) Bioinformatics: An Introduction, Third Edition. Springer.
- Jacques Izard, Maria C. Rivera (2015) Metagenomics for Microbiology. Elsevier.
- D. Barcello (2014) Fundamentals of Advanced Omics Technologies: From Genes to Metabolites (Comprehensive Analytical Chemistry Volume) Elsevier B.V.
- Edward F. Delong (2013) Microbial Metagenomics, Metatranscriptomics, and Metaproteomics (Methods in Enzymology Vol.) Elsevier Inc.
- Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics. John Wiley & Sons.
- Joel T. Dudley and Konrad J. Karczewski (2013) Exploring Personal Genomics
- Gary Walsh (2014) Proteins Biochemistry and Biotechnology Second Edition. John Wiley & Sons, Ltd.
- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
- Ravindranath Duggirala, Laura Almasy, Sarah Williams-Blangero, Solomon F.D. Paul, Chittaranjan Kole (2015) Genome Mapping and Genomics in Human and Non-Human Primates. Springer-Verlag Berlin Heidelberg
- Debmalya Barh, Vasudeo Zambare, Vasco Azevedo (2013) OMICS: Applications in Biomedical, Agricultural, and Environmental Sciences. CRC Press.
- Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
- Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

MS812 Biostatistics

Credits (Theory): 02 **Semester III**

Credit Hours: 30

A. Objectives of the Course

- To introduce basic biostatistical techniques useful for analyzing data arising in Microbiology and other health science domains
- To emphasize statistical reasoning through problem solving and applications using hand calculation.

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Descriptive Statistics**	**04**
2.	**Probability and Probability distributions**	**04**
3.	**Estimation and Hypothesis Testing**	**06**
4.	**Analysis of Variance**	**06**
5.	**Analysis of categorical data**	**05**
6.	**Correlation and Regression**	**05**

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Descriptive Statistics** Types of data ,Tables and Graphs,Measures of central tendency,Measures of dispersion,Measures of skewness and kurtosis	**04**
2	**Probability and Probability distributions** Introduction to concepts, Binomial Probability distribution, Poisson Probability distribution, Normal Probability distribution	**04**
3	**Estimation and Hypothesis Testing** Estimating Means and Proportions,Central Limit Theorem, Confidence Interval Estimation,One sample and two sample tests, p-values,Powers, Sample size Estimation	**06**
4	**Analysis of Variance** One - Way Analysis of Variance, multi sample inference,Multiple comparisons and inference	**06**
5	**Analysis of categorical data** Chi-square test,Fisher's exact test,Relative risk and odds ratio	**05**

6	**Correlation and Regression** Pearson correlation coefficient,Spearman's rank correlation,Method of least squares; simple and multiple linear regression,Logistic regression	**05**

D. Instructional Methods and Pedagogy

At the starting of the course, delivery pattern and prerequisite of the subject will be discussed. Course materials will be provided to the students from various primary and secondary sources of information. Lectures will be conducted with the aid of Multi-Media projector, Black board, OHP etc. Attendance is compulsory in lectures and laboratory. Two internal exams will be conducted and average of the same will be converted to equivalent of 15 marks as a part of internal theory evaluation. Surprise tests/Quizzes/Seminar/ Assignments will be conducted which carries 5 marks as a part of internal theory evaluation. Unit Test may be conducted which carries 15 marks as a part of internal theory evaluation. In the lectures and laboratory discipline and **behaviour** will be observed strictly.al interactive problem solving sessions will be also

E Student Learning Outcomes

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

C. Interpret commonly used statistics
D. Develop judgment about the application of statistical techniques in a given situation
E. Implement basic statistical techniques, including descriptive and inferential (estimation and hypothesis testing) by hand

F. Recommended Study materials:

- Rosner, Bernard. Fundamentals of biostatistics. 7th Edition Bernard Rosner; Duxbury Thomson Learnin in Reading Materials, web materials with full citations:

http://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one

BC821 Plant Biochemistry and Physiology

Credits (Theory): 04 **Semester-III**
Credit Hours: 60

A. Objectives of the Course.

- To understand the biochemistry of plant species and its unique metabolic and physiological differences as compared to other living systems.
- To understand how light energy is captured and used to provide chemical forms of energy to power the functions of cells and whole plants.
- To learn about rich diversity of secondary metabolites and their widespread applications in Natural Products-based industries and therapeutics

B. Outline of the Course

Sr. No.	Title of the Units	Minimum number of hours
1	**Introduction to Plant cell structure**	5
2	**Photosynthesis and Carbon assimilation**	11
3	**Respiration**	11
4	**Nitrogen metabolism**	12
5	**Regulation of plant growth and defense mechanisms**	6
6	**Secondary metabolites**	9
7	**Plant tissue culture**	6

C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Introduction to Plant cell structure** Specialized plant cell organelles - cell plate, cell walls, plasmodesmata, importance of vacuoles and tonoplast membrane, peroxisomes, plastids; characteristics of meristematic cells, Overview of plant cell metabolic compartments	5
2	**Photosynthesis and Carbon assimilation** Structure of PSI and PSII complexes, Light reaction, Cyclic and non-cyclic photophosphorylation, Calvin cycle and regulation; C4 cycle and	11

	Crassulacean acid metabolism (CAM), Photorespiration, sucrose and starch as storage metabolites-structure, biosynthesis and breakdown, glycerolipids as carbon stores	
3	**Respiration** Overview of plant glycolysis and its regulation, Alternative reactions of glycolysis, Translocation of metabolites across mitochondrial membrane, TCA cycle, metabolic functions of mitochondria in plant cells, Alternative NAD(P)H oxidative pathways; Cyanide resistant respiration.	**11**
5	**Nitrogen metabolism** Biological Nitrogen fixation by free living and in symbiotic association, structure and function of enzyme Nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by Glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway, storage proteins	**12**
6	**Regulation of plant growth and defense mechanisms** Introduction to plant hormones and their effect on plant growth and development, Regulation of plant morphogenetic processes by light, Defense system in plants.	**6**
7	**Secondary metabolites** Representatives alkaloid group and their amino acid precursors, function of alkaloids, Examples of major phenolic groups; simple phenylpropanoids, Coumarins, Benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics, Classification of terpenoids and representative examples from each class, biological functions of terpenoids, Scopes of industrial applications of plant secondary metabolite	**9**
8	**Plant tissue culture** Overview of plant stem cells, Cell and tissue culture techniques, types of cultures: organ and explants culture, callus culture, cell suspension culture and protoplast culture. Plant regeneration pathways: organogenesis and somatic embryogenesis. Applications of cell and tissue culture	**6**

- **Instructional Methods and Pedagogy:**

The topics will be discussed in interactive class room sessions using classical blackboard teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

- **Student learning outcome**
  - **After the successful completion of the course a student will be able to:**
- understand plant cell structure and organization and apply specific biochemical functions to all components of plant cell structure
- understand about the Biochemistry of plant and how is it different from other living forms. Students will be able to understand the unique metabolic basis of photosynthetic CO_2 fixation.
- appreciate the plants' ability to accumulate a variety of phytochemicals and learn scopes of its applications.
- understand various techniques in plant biotechnology and its potential applications.

- **Recommended Study materials:**

  - Plant Biochemistry by Heldt and Heldt (2005)
  - Plant Biochemistry by Bowsher, Steer and Tobin (2008)
  - Plant Biochemistry by Shamsher S Narwal and R. Bogatek, 2009
  - Biochemistry & Molecular Biology of Plants By B. Buchanan, W. Gruissem, R.
  - Jones, American Society of Plant Physiologist, 2000
  - Plant Biochemistry by P. M. Dey and J. B. Harborne, Harcourt Aria PTE Ltd. Singapore.
  - Plant Physiology by Salisbury and Ross, 4th Edition (2004).
  - Plant Physiology Biochemistry and Biotechnology by H S Srivastava, Rastogi publications (2009)

BC822 ENZYMOLOGY

Credits (Theory): 03 **Semester -III**
Credit hours: 45

A. Objectives of the Course.

- To build the fundamentals of specificity and mechanism enzyme catalysis
- To integrate the practical aspects of enzymology with the kinetic theories and regulatory mechanisms
- To describe principles and methods of enzyme purification, optimization and structure analysis
- To provide an overview of the key enzymes currently used in large scale industrial, clinical and environmental processes
- To compare the historical aspects of enzymology and the currently employed enzyme technology for diverse applications
- To emphasize the importance of enzymology in modern biosciences.

B.Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hpurs
1	Enzymes, Coenzymes, and Catalysis	**5**
2	Mechanism of enzyme action	**7**
3	Methods in Enzymology	**5**
4	Enzymes kinetics	**9**
5	Enzyme Regulation	**9**
6	Advances in Enzymology	**3**
7	Enzyme technology	**7**

C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Enzymes, Coenzymes, and Catalysis** Historical aspects, Nomenclature and classification of enzymes, Thermodynamics of catalysis, Energy of activation, Coupled reactions in metabolic pathways, metal and vitamin cofactors, enzyme specificity, activation energy and transition state theory, reaction rates, , Catalytic power and specificity of enzymes (concept of active site), review of Fischer's lock and key hypothesis and Koshland's induced fit hypothesis	**5**

2	**Mechanism of enzyme action** Active site, Types of catalysis: acid-base, transition state, covalent intermediates analysis, proximity and orientation effects, covalent catalysis, strain or distortion, metal activated enzymes and metallo-enzymes [using suitable examples]	**7**
3	**Methods in Enzymology** Methods to isolate and purify enzymes, Assays, Activity Units, criteria of purity, Experimental approaches to study enzyme active site and enzyme mechanisms	**5**
4	**Enzymes kinetics** Uni-substrate reaction kinetics: single-substrate reactions and their rates, Michaelis-Menten's equation and its significance, enzyme turnover, analysis of kinetic data, Factors affecting catalysis-pH, temperature, pressure, enzyme and substrate concentration, Bi-substrate reaction kinetics.	**9**
5	**Enzyme Regulation** Inhibition mechanisms and kinetics, Allostery and co-operativity: Theoretical models, Hill equation, Reversible and irreversible activation of enzymes (pro-enzymes, phosphorylation), Control of metabolic pathways: Amplification of signals, substrate cycles and Interconvertible enzyme cycles; Multienzyme complex	**9**
6	**Advances in Enzymology** Convergent and divergent evolution of enzymes, Enzyme engineering and biotransformations, Single cell enzymology, Biocatalysis in non-conventional media	**3**
7	**Enzyme technology** Immobilized Enzymes, Enzyme Technology-Overview of production, recovery, stability and formulation of bacterial and fungal enzymes-using examples, Enzyme/cell electrodes, Industrial application of enzymes, Enzymes in bioremediation, Enzymes as healthcare and clinical diagnosis	**7**

B Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical blackboard teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory. Standard protocols and analytical tools will be employed to integrate theoretical knowledge with the practical observations. Experiments will be performed and analyzed by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

C Student learning outcome

- Students will gain insight into wide range application of enzymes and will be able to appreciate the need for in-depth study of both fundamental and applied aspects of the subject.
- Students shall be able to compare and contrast the historical methods of studying enzymes with current advances in enzyme technology
- Students shall gain insights into experimental design, analysis and evaluation of enzyme kinetic data and methods to study mechanisms of enzyme actions
- Student shall be able to understand and calculate the effects of various factors that influence the enzyme efficiency.
- Students shall be able to describe and select appropriate method for enzyme purification and optimization for diverse applications.
- Student shall be well versed with a variety of important enzyme applications, along with an overview of the technology involved.

D Recommended Study materials

5. Enzymes: Biochemistry, Biotechnology, Clinical chemistry. Trevor Palmer, First Eastwest press edition 2004
6. Fundamentals of Biochemistry. Life at the molecular level. D Voet and J G. Voet, Fourth Edition, Wiley
7. Fundamentals of Enzymology by N C Price and L Stevens, Second Edition, Oxford science publications
8. Geoffrey Zubay (1993) Biochemistry, 3rd edition, Wm. C. Brown, Oxford (1993).
9. Methods in Enzymology, Vol. 182 (1990) Protein Purification.
10. Enzyme Technology by Ashok Pandey, Colin Webb, MARCELO FERNANDES, Christian Larroche, Springer; 2006 edition
11. Handbook of Enzyme Biotechnlogy by Wiseman, A. Ellis Horwood Publication

BC823 Human Physiology and disorders

Credits (Theory): 03 **Semester-III**
Credit hours: 45

A. Objectives of the Course.

- To provide a basic introduction to human physiology: the study of the functions of the human body and its constituent parts.
- To make the students understand how different systems in body coordinate to make the human body work

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Blood**	**6**
2	**Chemistry of respiration**	**6**
3	**Digestive system**	**9**
4	**Excretory system**	**9**
5	**The Muscular System**	**4**
6	**Nervous System**	**5**
7	**Hormones**	**6**

C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Blood:** Blood composition, plasma proteins and their diseases, blood counting and its significance, leucocyltes, thrombocytes and erythrocytes. Blood coagulation, clotting factors, mechanism of coagulation, fibrinolysis, laboratory test to measurecoagulation and thrombolysis, abnormal hemoglobin‟s, Hemoglobinopathies, thalassemias and anemias, Fibronectin.	**6**
2	**Chemistry of respiration** Gas transport and pH regulation, need for a carrier of oxygen in blood, transport of oxygen, carbon dioxide and H by Hb, buffer systems of plasma, interstitial fluid, carbon dioxide-bicarbonate buffer system, acid- base balance and it‟s maintenance, compensatory mechanisms, measures of acid base imbalance, significance of Anion gap.	**6**
3	**Digestive system** Composition, functions and regulation of saliva, gastric, pancreatic intestinal and bile secretions – digestion and absorption of carbohydrates, lipids, proteins nucleic acids, minerals and vitamins. Disorders related to digestive system	**9**

4	**Excretory system** The kidney: Structure of nephron, Formation and acidification of urine, glomerular filteration, GFR, tubular reabsorption of glucose, abnormalities of acid- base balance regulation by kidney, mechanism of action of diuretics. Disorders related to excretory system.	**9**
5	**The Muscular System** Types of muscles and their functions. Disoders related to muscular systems.	**4**
6	**Nervous System** Structure of neuron, function and organization of nervous system, Nerve impulse transmission. Disorders related to nervous system.	**5**
7	**Hormones** Communication among cells and tissues. Hormone- General mechanism of action of hormones. Chemistry, functions, synthesis of steroid hormones, polypeptide hormones, and thyroid hormones. Chemistry and functions of hormones of pancreas and parathyroid. Local hormones. Clinical disorders of hormones, Hormone receptors. Hormonal disorders.	**6**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- A detailed working knowledge of human physiology with particular emphasis on the digestive, muscular, respiratory and excretory systems.
- Integration of the organ systems to maintain constancy of the internal environment Regulation of homeostasis by neuronal and endocrine messengers.
- Participated in a variety of experiments in human physiology, gaining first-hand experience of different experimental conditions and methodologies.

F. Recommended Study materials:

- Text book of Medical Physiology by A. C. Guyton and J. E. Harcourt.
- Text book of Medical Physiology by Garong.
- Text book of Biochemistry and Human Biology by Talwar.
- Principles of anatomy and physiology by Tortora Grabowski, 10th edition
- Principles of Biochemistry, Lehninger C Rs. Publ. (1982).
- Biochemistry, L. Stryer, W.H. Freeman, San Francisco.

BC 825 Neurochemistry

Credits (Theory): 02 **Semester - III**
Credit Hours: 30

A. Objectives of the Course.

- To provide an overview of the elements of neurochemistry
- To prepare a platform for understanding of the basic biochemistry of the brain
- To emphasize the importance of fundamental neurochemistry in brain disorders.

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Cellular Neurochemistry and Membrane**	5
2	**Intracellular Signaling**	5
3	**Metabolism**	5
4	**Sensory transduction**	5
5	**Neuronal Processing and behavior**	5
6	**Neurological disorders**	5

C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1	**Cellular Neurochemistry and Membrane** Neurocellular anatomy; Cell membrane structures and functions; Lipids; Myelin formation, Structure and Biochemistry;Membrane transport; Ion Channels; Cell adhesion molecules, the cytoskeletons of Neurons and Glia; Intracellular Trafficking	5
2	**Intracellular Signaling** Synaptic Transmission (Acetylcholine,Catecholamines, Serotonin, Histamine, Glutamate, GABA and Glycine, Purinergic system and neuropetides); and Cellular Signaling(G proteins, Phosphoinositide, cyclic nucleotides, Calcium signaling, Serine and Threonine Phosphorylation, Tyrosine phosphorylation, Transcription and Growth factors)	5
3	**Metabolism** Energy metabolism of the brain; Brain Glycogen, lactate and ketones as alternative fuels; Hypoxic-Ischemic injury and oxidative stress;Ecosanoids,Docosanoids; Platelet activating factor and Inflammation; Metabolic Encephalopathies; Apoptosis and Necrosis; Metabolic basis of neuroimaging (fMRI and PET).	5

4	**Sensory transduction** Molecular biology of Five sensory systems (Vision, Hearing, Olfaction, Touch, Gustation and Tatse)	5
5	**Neuronal Processing and behavior** Endocrine effects on the Brain and their relationship to behavior, Neurochemistry of Learning and Memory, Biochemistry of anxiety,aggression, depression, mood disorders, addictions and pain.	5
6	**Neurological disorders** Biochemistry of Schizophrenia, Autism, ADHD, Alzheimer's disease.	5

➢ **Instructional Methods and Pedagogy:**

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory, using standard protocols. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

➢ **Student learning outcome**

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

a. Biochemical basis of neuronal cell structures
b. Biochemical basis of signal transduction
c. Metabolism of brain and its importance neuroimaging
d. Importance of neurotransmission in signaling and function
e. Neurochemical basis of neurological disorders

F. Recommended Study materials

➢ Basic Neurochemistry. 8th Edition. Principles of Molecular, Cellular, and Medical Neurobiology. Editors: Scott Brady George Siegel R. Wayne Albers Donald Price.

BC826 Protein Engineering

Credits (Theory): 2 credits **Semester: IV**
Credit Hours: 30

A. Objective of the course

- To enable the students to gain insights about amino acids functional classification
- To understand the insight information about super secondary structure of proteins
- To enable the students to design the research project to develop custom design of proteins (Enzymes)
- To understand the mechanism of action of different class of enzymes
- To enable the students learn the techniques to generate site directed mutagenesis

B. Outline of the Course

Sl. No.	Title of Unit	Minimum no of hours
1.	Protein Structure elements and their role in protein function	6
2.	Protein folding and flexibility	7
3.	Enzymes: Catalytic mechanisms and kinetics	6
4.	Protein Engineering- concepts and methods	5
5.	Design of protein structure	6

C. Detailed Syllabus

Protein Structure elements and its role in protein function
Functional classification of amino acids, Secondary structure formation and bonding pattern, α-helix, β- sheet, loop regions, Super secondary structure such as Hairpin β–motif, Greek Key Motif, αβα-motif.
Protein folding and flexibility
Kinetic factors for protein folding, Burying of hydrophobic side chain, molten globule, Single and multiple folding pathway, Assistance to protein folding
Enzymes: Catalytic mechanisms and kinetics
Involvement of amino acids in catalytic mechanism, understanding of charge exchange of protons and electrons, electrophiles, nucleophiles, Control of reaction, rate limiting steps in enzymatic reactions
Protein Engineering- concepts and methods
Applications of protein engineering, Methods involved in generating mutants, Analysis of protein database file (PDB). Protein crystallized structure analysis using software (PyMol)
Design of protein structure
Homologus protein, Homology modeling, improving the physical parameters of enzymes, Improving the catalytic properties of enzymes.

E. Student Learning Outcomes / objectives:

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

- Understand the amino acids propensity for different function in proteins.
- Clarify the concepts of protein mechanism of actions
- Design the research proposal for protein engineering

F. Reference Books:

1. Introduction to protein structure – Carl Branden and John Tooze
2. Biochemistry by Voet and Voet
3. Protein Ligand Interaction by R. Mannhold, H. Kubinyi and G. Folkers

M.Sc. Semester IV (Biotechnology)

MS 861: Research Methodology

Credits (Theory): 02 **Semester IV**
Credit Hours: 30

A. Objectives of the Course:

➢ This course is designed to provide students the basic understanding of:

- Research methodology in doing science research and along with the theoretical background for independent analysis of research findings.
- Research process—including selecting problem, defining research problem, developing hypothesis, selecting techniques involved in research, interpretation, and communication of research findings—and enabling students to design a research project addressing specific research problem.
- To develop the skills necessary to conduct, interpret, analyze, review and communicate biological science research.

B. Outline of the Course:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction to Research Methodology**	06
2.	**Defining the research problem and research design**	06
3.	**Scientific literature**	06
4.	**Scientific communications and reports**	06
5.	**Regulations, Safety and Ethics in Biotechnological research**	06

C. Detailed syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction to Research Methodology** Meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus methodology, research and scientific method, importance of knowing how research is done, research process, criteria of good research, problems encountered by researchers in India	06
2.	**Defining the research problem and research design** What is a research problem? Selecting the problem, necessity of defining the problem, technique involved in defining the problem; meaning, need and features of research design, statistical issues	06

3.	**Scientific literature** Features of scientific literature, Identification of scientific publications (ISBN, ISSN, DOI), literature collection, literature citation, Bibliometric measures (Impact factor & h-index), patent literature	**06**
4.	**Scientific communications and reports** Peer-review process, Types of research publications, Basic structure of a Research Article: IMRAD format, formatting, typing the thesis, grant proposals, Plagiarism, plagiarism detection softwares.	**06**
5.	**Regulations, Safety and Ethics in Biotechnological research** Laboratory safety, ethics in human research, ethics in use of laboratory animals, handling and disposal of biomedical wastes, handling, containment and disposal of genetically modified organisms, international regulations, treaties and conventions	**06**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome:

By the end of this course, students will be able to:

- Read, interpret, and critically evaluate research.
- Identify, explain, and apply the basic concepts of research and scientific method.
- Understand how define a research problem and develop a hypothesis.
- Recognize the ethical issues involved in biomedical research, and practice ethical research standards.
- Identify and explain the difference between quantitative, qualitative research approaches and explain different types of research.
- Understand literature citation and publication metrics Construct a coherent research proposal that includes an abstract, introduction, literature review, research questions, ethical considerations, and methodology

F. Suggested readings

Text Books:

- Research Methodology- Methods and Techniques by C. R. Kothari (2004) Published by New Age International (P) Ltd., Publishers, New Delhi.
- Research in Medical and Biological Sciences: From Planning and Preparation to Grant Application and Publication. Edited by Petter Laake, Haakon Breien Benestad, Bjorn Reino Olsen. (2015) Publisher: Elsevier Ltd.
- Practical Research Methods by Catherine Dawson (2002). UBS Publishers, New Delhi.
- Research Methodology-A Step-by-Step Guide for Beginners (2nd.ed.) by Ranjit Kumar (2005). Singapore, Pearson Education
- Writing and Publishing Science Research Papers in English: A Global Perspective by Karen Englander © The Author(s) 2014, Publisher: Springer.
- Introduction to Scientific Publishing: Backgrounds, Concepts, Strategies by Andreas Öchsner (2013) Publisher: Springer.
- Mastering Scientific and Medical Writing A Self-Help Guide (Second Edition) by Silvia M. Rogers, © Springer-Verlag Berlin Heidelberg 2014.
- Writing Dissertation and Grant Proposals: Epidemiology, Preventive Medicine and Biostatistics by Lisa Chasan-Taber © 2014 by Taylor & Francis Group, LLC.
- Laboratory biosafety manual. – 3rd ed. (2004) World Health Organization.
- Guidelines for care and use of animals in scientific research by Indian National Science Academy (INSA), New Delhi.
- Test and post-release monitoring of genetically modified organisms (GMOs) by Oliver Brandenberg, Alessandra Sensi, Kakoli Ghosh and Andrea Sonnino. Food and Agriculture Organization of the United Nations Rome, 2011.
- WIPO Patent Drafting Manual by World Intellectual Property Organization (WIPO).
- Biological Safety: Principles and Practices, 4th Edition. Editors: Diane O. Fleming, Debra L. Hunt (2006) ASM Press.

Reference books:

- Research Design and Methods: A Process Approach (Ninth Edition) by Kenneth S. Bordens and Bruce B. Abbott, Published by McGraw-Hill Education © 2014.

BT 862 Developmental Genetics

Credits (Theory): 02 **Semester: IV**
Credit Hours: 30

A. Objectives of the Course

- To develop the understanding of students in the novel field of Developmental genetics

B. Outline of the Course

Sr. No.	Title of Unit	Minimum numbers of hours
1.	**The impact of genetic and genomic tools in study of developmental biology**	**10**
2.	**Introduction to Stem cells theory**	**10**
3.	**Epigenetics and roles of genes in aging**	**10**

C. Detailed Syllabus

Sr. No.	Title of Unit	Minimum number of hours
1.	**The impact of genetic and genomic tools in study of developmental biology** Introduction to Developmental Genetics **Tools:** Chemical and functional genomics approach to study stem cell biology and regeneration, Application of deep sequencing, Developmental synexpression analysis, ineractome mapping, RNAi and its role in study of developmental genetics	**10**
2.	**Introduction to Stem cells theory** Stem cells- types, Approaches for derivation and maintenance of human Embryonic stem cells, Stem cell therapy	**10**
3.	**Epigenetics and roles of genes in aging** History of epigenetic, Epigenetic in Saccharomyces, Fungal model for epigenetic research, epigenetic of ciliates, epigenetic regulation in plants, Genetics of aging, Apoptosis	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Student will get insight in the new field of Stem cell research
- This introductory course will give insight on roles of genes in development of organisms

F. Recommended Study materials: :

- Handbook of Stem Cells, Essentials of Stem Cell Biology, Robert Lanza, John Gearhart, Brigid Hogan, Douglas Melton, Roger Pedersen, E. Donnall Thomas, James A. Thomson, Ian Sir Wilmut. Academic Press
- Principles of Developmental Genetics, Second Edition, Sally A. Moody Academic Press
- Epigenetics, C. David Allis. CSHL Press

BT863 Cancer Biology

Credits (Theory): 02 **Semester IV**
Credit Hours: 30

A. Objectives of the Course

- To provide basic knowledge about cancer biology to the students
- To make student acquainted with various mechanism of carcinogenesis
- To make students aware on various cancer prevention and treatment strategies

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Cancer Epidemiology and Etiology	**7**
2.	Cellular and Molecular Biology of Cancer	**15**
3.	Cancer Prevention, Diagnosis and Treatment	**8**

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Cancer Epidemiology and Etiology** Worldwide cancer incidence, mortality, trends, viral and bacterial infection, radiations, tobacco and alcohol consumption.	**7**
2.	**Cellular and Molecular Biology of Cancer** Cancer cell cycle and cellular immortalization, signalling in normal and cancer cells, role of oncogenes and tumor suppressor genes, cancer, polymorphism and cancer, invasion and metastasis, hereditary cancers.	**15**
3.	**Cancer Prevention, Diagnosis and Treatment** Primary and secondary cancer prevention, imaging techniques in cancer diagnosis, treatment strategies and drug resistance in cancer.	**8**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

After the successful completion of the course a student will be able to

- Gain basic understanding of cancer in general, its causes and genesis
- Gain in-depth knowledge of cellular and molecular biology of cancer
- Obtain knowledge on various cancer prevention and detection methods as well as currently available cancer therapeutic strategies

F. Recommended Study materials:

- The Biology of Cancer 2nd Ed., by Robert A Weinberg, Garland Science, 2014
- Introduction to Cancer Biology by Robin Hesketh, Cambridge University Press 2013
- Introduction to the Cellular and Molecular Biology of Cancer 4th Ed., by Margaret Knowles and Peter Selby, Oxford University Press, 2005
- 52 Simple Ways to Prevent, Control and Turn off Cancer by Man Mohan Sharma, S Chand and Company, 2012

BT864 Plant Pathology

Credits (Theory): 02 **Semester IV**
Credit Hours: 30

A. Objectives of the course.

- To make students understand about the diseases in plants
- Causes for the diseases and way to control the diseases
- Mechanism of Host – pathogen interaction

B. Outline of the Course

Sr. No.	Title of the Uits	Minimum numbers of hours
1.	**Introduction to plant pathology**	4
2.	**Types of pathogen and diseases in plants**	16
3.	**Disease Resistance in plants**	05
4.	**Crop Protection**	05

C. Detailed syllabus

Sr.No	Title of the Units	Minimum numbers of hours
1.	**Introduction to plant pathology** History of plant pathology, Scope of plant pathology, Interaction of host and pathogen, Disease development	4
2.	**Types of pathogen and diseases in plants** Bacterial pathogens and diseases, Fungal pathogens and diseases, viral pathogens and diseases, Insect pathogens and diseases, nematodes and diseases in Plants. Symptoms related to diseases	16
3.	**Disease Resistance in plants** Morphological, Biochemical and anatomical changes in plants against pathogens, Basal Resistance, Systemic acquired resistance, Induced resistance, R and Avr interaction, Genetic engineering and resistant plants	05
4.	**Crop Protection** Strategies for crop protection- eradication, exclusion, fungicides, bacteriscides, pestiscides, organic and inorganic control measures, case studies of crop protection and diseases	05

D. Instructional Methods and Pedagogy

- Topic will be discussed in the interactive class room sessions using black board teaching and power point presentations.
- For better understanding appropriate examples and case studies will be discussed.
- Special interactive problem solving sessions will also be conducted.
- Course material will be provided to the students from various primary and secondary information
- Unit test will be conducted regularly as part of continuous evaluation and students will be counseled to improve their performance

E. Student learning outcomes

After successful completion of course,

- Student will have insights of plant pathology and scope of plant pathology
- Common plant pathogens and symptoms
- Plant defense mechanism
- Various control measures for diseases

F. Recommended Study materials:

- Alexopoulus 0, Mims CW and Blakwell M. 1996. Introductory Mycology, John
- Wiley & Sons, Inc.

- Introduction to plant biotechnology by H.S. Chawla
- Experiments in Microbiology, plant pathology and Biotechnology by K.R. Aneja
- Plant pathology by J Lucas

BT865 Bioentrepreneurship

Credits (Theory): 02 **Semester IV**
Credit Hours: 30

A. Objectives of the course

- To explain the phenomenon of innovation and entrepreneurship and the creation of life science companies and projects.
- To identify market need, competition and opportunities bases on intellectual property protection
- To learn creation and management of bioscience based companies from the successes and failures of entrepreneurs

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	Innovation and Bioentrepreneurship	**05**
2.	The entrepreneurial process-I	**07**
3.	The entrepreneurial process-II	**07**
4.	Basics of marketing of products and services	**06**
5.	Start-up cases	**05**

C. Detailed syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Innovation and Bioentrepreneurship** bioeconomy, biotechnology based products and services innovation as strategy a in Biotech Companies, technology acquisition/development/licensing and protection, IP issues in bioentrepreneurship, biosafety and other legal issues, barriers to entrepreneurship	**05**
2.	**The entrepreneurial process-I** Idea to product, the entrepreneurial opportunity, market structure and strategies of entry, entrepreneur/entrepreneurial team (traits, types and roles), resources (requirements, sources and allocation), organisational context (legal format; venture team; management team; value chain)	**07**
3.	**The entrepreneurial process-II**	**07**

	Revenue streams and models, key players, Planning a business venture- translation of business model to business plan, development of business plan for biotech business idea, entrepreneurial ecosystems	
4.	**Basics of marketing of products and services** Concepts of marketing management, the value proposition and how value is created for selected market segments via effective channels, Customer relationship management (CRM)	**06**
5.	**Start-up cases**	**05**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations. The topics will taught using numerical problems, case studies, simulations, animations, softwares. Interactive problem solving sessions will be also conducted on regular basis. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self-study. The course consists of lectures, seminars, interactive workshops, a case exercise and a team and an individual project.

E. Student learning outcomes

By the end of this course, students will

- Gain knowledge regarding bioentrepreneurship and regulatory issues
- Understand the entrepreneurial process and marketing
- Learn entrepreneurship from successful cases

F. Recommended Study materials:

- Entrepreneurship by Hisrich
- S. N. Jogdand, *Entrepreneurship and Business of Biotechnology,* Himalaya Publishing Home, 2007.
- C. B. Gupta and S. S. Khanka, *Entrepreneurship and Small Business Management,* 1996.
- R Oliver, *The coming biotech age: The business of biomaterials*. New York: McGraw Hill, 2000.
- S. Shaleesha. Bioethics, *Wisdom educational service*, Chennai, 2008.

M.Sc. Semester IV (Microbiology)

MS 861 Research Methodology

Credit: 02 **Semester IV**
Credit Hours: 30

A. Objectives of the Course:

➢ This course is designed to provide students the basic understanding of:

- Research methodology in doing science research and along with the theoretical background for independent analysis of research findings.
- Research process—including selecting problem, defining research problem, developing hypothesis, selecting techniques involved in research, interpretation, and communication of research findings—and enabling students to design a research project addressing specific research problem.
- To develop the skills necessary to conduct, interpret, analyze, review and communicate biological science research.

B. Outline of the Course:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction to Research Methodology**	**06**
2.	**Defining the research problem and research design**	**06**
3.	**Scientific literature**	**06**
4.	**Scientific communications and reports**	**06**
5.	**Regulations, Safety and Ethics in Biotechnological research**	**06**

C. Detailed syllabus:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction to Research Methodology** Meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus methodology, research and scientific method, importance of knowing how research is done, research process, criteria of good research, problems encountered by researchers in India	**06**
2.	**Defining the research problem and research design** What is a research problem? Selecting the problem, necessity of defining the problem, technique involved in defining the problem; meaning, need and features of research design, statistical issues	**06**

3.	**Scientific literature** Features of scientific literature, Identification of scientific publications (ISBN, ISSN, DOI), literature collection, literature citation, Bibliometric measures (Impact factor & h-index), patent literature	**06**
4.	**Scientific communications and reports** Peer-review process, Types of research publications, Basic structure of a Research Article: IMRAD format, formatting, typing the thesis, grant proposals, Plagiarism, plagiarism detection softwares.	**06**
5.	**Regulations, Safety and Ethics in Biotechnological research** Laboratory safety, ethics in human research, ethics in use of laboratory animals, handling and disposal of biomedical wastes, handling, containment and disposal of genetically modified organisms, international regulations, treaties and conventions	**06**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome:

By the end of this course, students will be able to:

- Read, interpret, and critically evaluate research.
- Identify, explain, and apply the basic concepts of research and scientific method.
- Understand how define a research problem and develop a hypothesis.
- Recognize the ethical issues involved in biomedical research, and practice ethical research standards.
- Identify and explain the difference between quantitative, qualitative research approaches and explain different types of research.
- Understand literature citation and publication metrics Construct a coherent research proposal that includes an abstract, introduction, literature review, research questions, ethical considerations, and methodology

F. Suggested readings:

Text Books:

- Research Methodology- Methods and Techniques by C. R. Kothari (2004) Published by New Age International (P) Ltd., Publishers, New Delhi.
- Research in Medical and Biological Sciences: From Planning and Preparation to Grant Application and Publication. Edited by Petter Laake, Haakon Breien Benestad, Bjorn Reino Olsen. (2015) Publisher: Elsevier Ltd.

- Practical Research Methods by Catherine Dawson (2002). UBS Publishers, New Delhi.
- Research Methodology-A Step-by-Step Guide for Beginners (2nd.ed.) by Ranjit Kumar (2005). Singapore, Pearson Education
- Writing and Publishing Science Research Papers in English: A Global Perspective by Karen Englander © The Author(s) 2014, Publisher: Springer.
- Introduction to Scientific Publishing: Backgrounds, Concepts, Strategies by Andreas Öchsner (2013) Publisher: Springer.
- Mastering Scientific and Medical Writing A Self-Help Guide (Second Edition) by Silvia M. Rogers, © Springer-Verlag Berlin Heidelberg 2014.
- Writing Dissertation and Grant Proposals: Epidemiology, Preventive Medicine and Biostatistics by Lisa Chasan-Taber © 2014 by Taylor & Francis Group, LLC.
- Laboratory biosafety manual. – 3rd ed. (2004) World Health Organization.
- Guidelines for care and use of animals in scientific research by Indian National Science Academy (INSA), New Delhi.
- Test and post-release monitoring of genetically modified organisms (GMOs) by Oliver Brandenberg, Alessandra Sensi, Kakoli Ghosh and Andrea Sonnino. Food and Agriculture Organization of the United Nations Rome, 2011.
- WIPO Patent Drafting Manual by World Intellectual Property Organization (WIPO).
- Biological Safety: Principles and Practices, 4th Edition. Editors: Diane O. Fleming, Debra L. Hunt (2006) ASM Press.

Reference books:

- Research Design and Methods: A Process Approach (Ninth Edition) by Kenneth S. Bordens and Bruce B. Abbott, Published by McGraw-Hill Education © 2014.

MI852 QUALITY CONTROL AND ASSURANCE IN INDUSTRIES

Credits (Theory): 02 **Semester IV**
Credit Hours: 30

A. Objectives of the Course

- To enable the students to have an idea about industrial rules and standards applied in QA- QC
- To enable the students to make SOPs for procedures used in Quality testing of products and raw materials.
- To appreciate the role of GMP and GLP for acquiring ISO certification
- To enable students to have an understanding of microbiological techniques used for testing raw materials and finished pharmaceutical products
- To enable students to learn about International standards for biosafety and validation

B. Outline of the Course

Sr. No.	Title of Unit	Minimum numbers of hours
1.	Overview of Pharmaceutical Quality control and Assurance	**12**
2.	Testing Regime for QA and QC in Food and Pharmaceutical Industries	**9**
3.	The Application of Pharmaceutical Microbiology	**9**

C. Detailed Syllabus

Sr. No.	**Title**	**Minimum numbers of hours**
1.	**Overview of Pharmaceutical Quality control and Assurance** Quality control and Quality assurance, Concept and philosophy of TQM, GMP, ICH and ISO 9000, GLP: Scope of GLP, Quality assurance unit, SOP, protocols for conduct of clinical & non clinical testing, control on animal house, report preparation and documentation. Disinfection and Cleansing	**12**
2.	**Testing Regime for QA and QC in Food and Pharmaceutical Industries** Testing of Starting Materials, in process quality control and finished products quality control for various formulation in pharma industry Quality control of radio pharmaceutical and radio chemical methods in analysis, Testing of Utilities and Environmental Monitoring Document maintenance in pharmaceutical industry: Batch	**9**

	Formula Record, Master Formula Record, Quality audit reports and documents, quality reports, distribution records, complaints and evaluation of complaints, Handling of return good, recalling and waste disposal.	
3.	**The Applications of Pharmaceutical Microbiology** Safe Microbiological Practices, Culture Media Used in Pharmaceutical Microbiology: Enumeration and Identification of Microorganisms Pharmacopeial Methods for the Detection of Specified Microorganisms Microbiology Laboratory Methods in Support of the Sterility Assurance System Antimicrobial Preservative Efficacy Testing and Water Activity, Microbiological Assay of Antibiotics, vitamins and enzymes in Pharmaceutical Preparations	**9**

D. Instructional Methods and Pedagogy:

- The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations.
- Practical sessions will be conducted in a highly equipped laboratory.
- Experiments will be carried out by students individually.
- Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Understand industrial rules and standards applied in QA- QC
- Make SOPs for procedures used in Quality testing of products and raw materials.
- Appreciate the role of GMP and GLP for acquiring ISO certification
- Understanding of microbiological techniques used for testing raw materials and finished pharmaceutical products
- Learn about International standards for biosafety and validation

F. Reference Books:

- Microbiology and Sterility Assurance in Pharmaceuticals and Medical Devices
- Editors: Madhu Raju Saghee, Tim Sandle and Edward C. Tidswell
- Industrial Pharmaceutical Microbiology: Standards & Controls - 2015 Edition. edited by Geoff Hanlon and Tim Sandle

MI853 INDUSTRIAL WASTE TREATMENT

Credits (Theory): 02 **Semester IV**
Credit Hours: 30

A. Objectives of the Course

- To enable the students to have an idea about industrial waste management and the role of Pollution control board
- To enable the students about the characteristics of wastes generated by various industries and its potential to cause pollution
- To learn about various ways of pollution prevention and treatment of wastes

B. Outline of the Course

Sr. No.	Title of Unit	Minimum numbers of hours
1.	**Management of Industrial Wastes: Solids, Liquids, and Gases**	10
2.	**Treatment and Disposal of Solid Wastes from Industry**	10
3.	**Pollution Prevention and methods of treatment of effluent**	10

C. Detailed Syllabus

Sr. No.	Title of Unit	Minimum numbers of hours
1.	**Management of Industrial Wastes: Solids, Liquids, and Gases** Understanding hazardous waste and its risks to environment Role of pollution control board in prevention of pollution, Management of Industrial Wastewater O&M Costs, Management of Discharges to the Air, Reduction at the Source Containment Treatment Physical, Chemical and Biological Methods of treatment	10
2.	**Treatment and Disposal of Solid Wastes from Industry** Characterization of Solid Wastes Solid Waste Incineration The Process of Composting Industrial Wastes Solidification and Stabilization of Industrial Solid Wastes. The Solid Waste Landfill Case Studies	10
3.	**Pollution Prevention and methods of treatment of industrial effluent** General Approach, Source Reduction Waste Equalization Physical, Chemical and biological methods of liquid waste treatment The Waste Audit Benefits of Pollution Prevention Case Studies	10

D. Instructional Methods and Pedagogy:

- The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations.
- Practical sessions will be conducted in a highly equipped laboratory.
- Experiments will be carried out by students individually.
- Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Appreciate the importance of industrial waste management and the role of Pollution control board
- Learn about the characteristics of wastes generated by various industries and its potential to cause pollution
- Learn about various ways of pollution prevention and treatment of wastes

F. Recommended Study materials:

- Industrial Waste Treatment Handbook by Frank Woodard 2001 Publisher Butterworth–Heinemann
- Industrial Waste Treatment Handbook Hardcover – 9 Jan 2006 by Woodard & Curran Inc
- Industrial Solid Wastes by A. D. Patwardhanb (Author)
- Water and Air Effluents Treatment Handbook by NPCS Board of Consultants & Engineers (Author)
- Industrial Waste Treatment: Contemporary Practice and Vision for the Future By Nelson Leonard Nemerow
- Handbook of Industrial and Hazardous Wastes Treatment edited by Lawrence K. Wang, Yung-Tse Hung, Howard H. Lo, Constantine Yapijakis
- Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes, Second Edition Pradyot Patnaik
- Biological Wastewater Treatment, Third Edition C. P. Leslie Grady, Jr., Glen T. Daigger, Nancy G. Love, Carlos D. M. Filipe

MI 864 MICROBIOLOGY BASED ENTREPRENEURSHIP

Credits (Theory): 02 credits **Semester IV**
Credit Hours: 30

A. Objectives of the Course

- To enable the students to imbibe the concepts of bio-based entrepreneurship
- To enable the students to understand the opportunities and risks associated with entrepreneurship
- To make the students aware about Market research and IPR
- To make the students aware about current scenario of bio-entrepreneurship in India

B. Outline of the Course

Sl. No.	Title of Unit	Minimum numbers of Hours
1.	Foundations of entrepreneurship and introduction to bio-entrepreneural skills	**10**
2.	Bio-entrepreneurship development platforms	**8**
3.	Market research and IPR	**8**
4.	Bio-entrepreneurs of India	**4**

C. Detailed Syllabus

Sl. No.	Title of Unit	Minimum numbers of Hours
1.	**Foundations of entrepreneurshipand introduction to bio-entrepreneural skills** Concept of entrepreneur, characteristics of entrepreneur, role of entrepreneur, risks and charms of entrepreneurship, types of entrepreneur, intrapreneurs, ultrapreneurs, role of entrepreneurship in economic development, barriers to entrepreneurship, entrepreneurship with microbiology, factors affecting bio-entrepreneurship Bio-entrepreneural skills - Innovation aptitude, principles of effective communication, body language, public speaking, presentations, business proposal writing, market opportunistic attitude, leadership qualities, organization qualities	**10**
2.	**Bio-entrepreneurship development platforms** Role of government and schemes, financial institutions in fostering bio-entrepreneurship, concept of venture capitalists, concept of bio-incubators	**8**
3.	**Market research and IPR** General market research methodology, seizing and segmentation of markets, drivers and hurdles, introduction to referral chain Intellectual property commercialization and technology transfer, financial and non-financial terms of license agreement	**8**
4.	**Bio-entrepreneurs of India** Case studies of successful and unsuccessful bio-entrepreneurs	**4**

D. Instructional Methods and Pedagogy:
The topics will be discussed in an interactive class room sessions using conventional blackboard teaching to power-point presentations. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests and surprise quizzes will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome
After the successful completion of the course a student will be able to:
- Understand the opportunities lying with bio-entrepreneurships
- Understand the funding opportunities for bio based entrepreneurs
- Know the implications of market research onto the performance of an enterprise
- Imbibe the significance of intellectual property rights in entrepreneurship

F. Reference books:

- S. S. Mehta (2008) Commercializing successful biomedical technologies. Cambridge University Press, New Delhi
- V. Havinal (2009) Management and entrepreneurship New age international Ltd. Publishers, New Delhi

M.Sc. Semester IV (Biochemistry)

MS 861 Research Methodology

Credits (Theory): 02 **Semester IV**
Credit Hours: 30

A. Objectives of the Course:

- This course is designed to provide students the basic understanding of:
  - Research methodology in doing science research and along with the theoretical background for independent analysis of research findings.
  - Research process—including selecting problem, defining research problem, developing hypothesis, selecting techniques involved in research, interpretation, and communication of research findings—and enabling students to design a research project addressing specific research problem.
  - To develop the skills necessary to conduct, interpret, analyze, review and communicate biological science research.

B. Outline of the Course:

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Introduction to Research Methodology**	06
2.	**Defining the research problem and research design**	06
3.	**Scientific literature**	06
4.	**Scientific communications and reports**	06
5.	**Regulations, Safety and Ethics in Biotechnological research**	06

C. Detailed syllabus:

Sr. No.	Title of the Units	Minimum no. of hours
1.	**Introduction to Research Methodology** Meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus methodology, research and scientific method, importance of knowing how research is done, research process, criteria of good research, problems encountered by researchers in India	06
2.	**Defining the research problem and research design** What is a research problem? Selecting the problem, necessity of defining the problem, technique involved in defining the problem; meaning, need and features of research design, statistical issues	06
3.	**Scientific literature** Features of scientific literature, Identification of scientific publications (ISBN, ISSN, DOI), literature collection, literature citation, Bibliometric measures (Impact factor & h-index), patent	06

	literature	
4.	**Scientific communications and reports** Peer-review process, Types of research publications, Basic structure of a Research Article: IMRAD format, formatting, typing the thesis, grant proposals, Plagiarism, plagiarism detection softwares.	**06**
5.	**Regulations, Safety and Ethics in Biotechnological research** Laboratory safety, ethics in human research, ethics in use of laboratory animals, handling and disposal of biomedical wastes, handling, containment and disposal of genetically modified organisms, international regulations, treaties and conventions	**06**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome:

By the end of this course, students will be able to:

- Read, interpret, and critically evaluate research.
- Identify, explain, and apply the basic concepts of research and scientific method.
- Understand how define a research problem and develop a hypothesis.
- Recognize the ethical issues involved in biomedical research, and practice ethical research standards.
- Identify and explain the difference between quantitative, qualitative research approaches and explain different types of research.
- Understand literature citation and publication metrics Construct a coherent research proposal that includes an abstract, introduction, literature review, research questions, ethical considerations, and methodology

F. Suggested readings:

Text Books:

- Research Methodology- Methods and Techniques by C. R. Kothari (2004) Published by New Age International (P) Ltd., Publishers, New Delhi.
- Research in Medical and Biological Sciences: From Planning and Preparation to Grant Application and Publication. Edited by Petter Laake, Haakon Breien Benestad, Bjorn Reino Olsen. (2015) Publisher: Elsevier Ltd.
- Practical Research Methods by Catherine Dawson (2002). UBS Publishers, New Delhi.
- Research Methodology-A Step-by-Step Guide for Beginners (2nd.ed.) by Ranjit Kumar (2005). Singapore, Pearson Education

- Writing and Publishing Science Research Papers in English: A Global Perspective by Karen Englander © The Author(s) 2014, Publisher: Springer.
- Introduction to Scientific Publishing: Backgrounds, Concepts, Strategies by Andreas Öchsner (2013) Publisher: Springer.
- Mastering Scientific and Medical Writing A Self-Help Guide (Second Edition) by Silvia M. Rogers, © Springer-Verlag Berlin Heidelberg 2014.
- Writing Dissertation and Grant Proposals: Epidemiology, Preventive Medicine and Biostatistics by Lisa Chasan-Taber © 2014 by Taylor & Francis Group, LLC.
- Laboratory biosafety manual. – 3rd ed. (2004) World Health Organization.
- Guidelines for care and use of animals in scientific research by Indian National Science Academy (INSA), New Delhi.
- Test and post-release monitoring of genetically modified organisms (GMOs) by Oliver Brandenberg, Alessandra Sensi, Kakoli Ghosh and Andrea Sonnino. Food and Agriculture Organization of the United Nations Rome, 2011.
- WIPO Patent Drafting Manual by World Intellectual Property Organization (WIPO).
- Biological Safety: Principles and Practices, 4th Edition. Editors: Diane O. Fleming, Debra L. Hunt (2006) ASM Press.

Reference books:

- Research Design and Methods: A Process Approach (Ninth Edition) by Kenneth S. Bordens and Bruce B. Abbott, Published by McGraw-Hill Education © 2014.

BC862 ANIMAL CELL CULTURE AND TECHNOLOGY

Credits (Theory): 02 credits **Semester: IV**
Credit Hours: 30

A. Objectives of the Course

- To enable the students to gain insights about basic techniques of animal cell culture
- To understand the principles of animal cell culture and its application
- Describe the Equipments used on tissue culture.

B. Outline of the Course

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Laboratory requirements for animal cell culture**	3
2.	**Cell culture Media and reagents:**	5
3.	**Cell culture techniques**	8
4.	**Stem cell research: An Overview**	7
5.	**Gene transfer technology in animals**	7

C. Detailed Syllabus

Sr. No.	Title of the Units	Minimum numbers of hours
1.	**Laboratory requirements for animal cell culture** Sterile handling area. Sterilization of different materials used in animal cell culture, Aseptic concepts. Instumentation and equipments for animal cell culture. History of cell culture. Primary and secondary cell culture.	3
2.	**Cell culture Media and reagents** Types of cell culture media, Ingredients of media, Physiochemical properties, Antibiotics, growth supplements, Foetal bovine serum; Serum free media, Trypsin solution, Selection of medium and serum, Conditioned media, Other cell culture reagents, Preparation and sterilization of cell culture media, serum and other reagents.	5
3.	**Cell culture techniques** Different types of cell cultures, Trypsinization, Cell separation, Continuous cell lines, Suspension culture, Organ culture. Development of cell lines, Characterization and maintenance of cell lines, stem cells, Cryopreservation, Common cell culture contaminants.	8

4.	**Stem cell research: An Overview** Current status and application in medicine. Application of animal cell culture for in vitro testing of drugs; Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins. Production of recombinant hemoglobin, blood substituents, Artificial blood, General account of in vitro regulation of blood cells production.	**7**
5.	**Gene transfer technology in animals** Viral and non-viral methods, Production of transgenic animals and molecular pharming, current status of production of transgenic animals. Animal cloning: Techniques, relevance and ethical issues.	**7**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes / objectives

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

- Understand the basic principles and techniques used in animal cell tissue culture.
- Able to use the equipments used for tissue culture.
- Understand the safety procedures need for tissue culture.

F. Recommended Study materials:

C. Freshney, Culture of Animal Cells, 5th Edition, Wiley-Liss, 2005
D. Ed. John R.W. Masters, Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press, 2000.
E. Ed. Martin Clynes, Animal Cell Culture Techniques., Springer, 1998.
F. B.Hafez, E.S.E Hafez, Reproduction in Farm Animals, 7th Edition, Wiley- Blackwell, 2000.
G. Louis-Marie Houdebine, Transgenic Animals: Generation and Use, 1st Edition, CRC Press, 1997.

BC863 Clinical Biochemistry

Credits (Theory): 02 **Semester-IV**
Credit hours: 30

A. Objectives of the Course

- To give students a sound knowledge of the underlying scientific and technological principles of clinical biochemistry.
- To provide students a sound knowledge of the clinical principles underlying the application of clinical biochemistry investigations in human disease.
- To foster an interest in quality control measurements, research and development an Good Clinical Practices in the discipline
- To provide a basic information about automation in clinical laboratory.

B. Outline of the Course

Sr. No.	Title of the Units	Minimum number of hours
1.	Disorders of Carbohydrate metabolism	**4**
2.	Disorders of Lipids	**4**
3.	Disorders of liver and kidney	**6**
4.	Gastric disorders	**3**
5.	Electrolytes and acid-base balance	**3**
6.	Diagnostic Enzymes	**3**
7.	Abnormalities in Nitrogen metabolism	**3**
8.	Automation in Clinical Biochemistry	**4**

C. Detailed syllabus

Sr.No	Title of the units	Minimum numbers of hours
1	**Disorders of Carbohydrate Metabolism** Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia	4
2	**Disorders of Lipids** Plasma lipoproteins, cholesterol, triglycerides and phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher"s disease, Tay-Sach"s and Niemann-Pick disease, ketone bodies, Abetalipoproteinemia	4
3	**Disorders of liver and kidney** Jaundice, fatty liver, normal and abnormal functions of liver and kidney. Liver function tests and Renal function tests	6
4	**Gastric disorders** Disorders of gastric function, method of evaluation, pancreatic diseases, Steatorrhoea	3
5	**Electrolytes and acid-base balance** Regulation of electrolyte content of body fluids and maintenance of pH, reabsorption of electrolytes	3
6	**Diagnostic Enzymes** Enzymes in health and diseases. Biochemical diagnosis of diseases by enzyme assays – SGOT, SGPT, CPK, cholinesterase, LDH	3
7	**Abnormalities in Nitrogen Metabolism** Uremia, hyperuricemia, porphyria and factors affecting nitrogen Balance	3
8	**Automation in Clinical Biochemistry** Instrumental concept, Selection of Instrument, Quality assurance, Control of pre-analytical and analytical variables, External and internal quality control measurements. Good Clinical Practices: Basics and principles	4

D.Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- Understand the role of clinical biochemistry in clinical diagnosis.
- Be proficient in the interpretation of results of routine clinical biochemistry investigations.
- Have developed problem-solving skills relevant to the practice of clinical biochemistry.
- Be familiar with the literature in Clinical Biochemistry and able to extract and present relevant information.
- Discuss the biochemistry associated with tests performed in a clinical biochemistry laboratory.
- Describe the principals of the analytical instruments in use in the routine clinical laboratory.
- Have an understanding of the importance of quality control and assurance to diagnostic work.

F.Recommended Study materials:

- Tietz Textbook of Clinical Chemistry, Carl A. Burtis, Edward R. Ashwood, Harcourt Brace & Company Aisa Pvt. Ltd.
- Textbook of Medical Laboratory Technology (Set of 2 Volumes) : Clinical Laboratory Science and Molecular Diagnosis 3rd Edition, Darshan P. godkar & Praful B. Godkar, Bhalani Book U.
- Satyanarayana, Biochemistry, Books and Allied (P) Ltd., Calcutta, Latest Edition. Dinesh Puri. Text book of medical biochemistry, 3rd Edition, 2011 – Elsevier.
- Biochemistry: 7th Edition, (2012), Jeremy Berg, Lubert Stryer, W.H.Freeman and company, NY.
- Lehninger , Principles of Biochemistry. 5th Edition (2008), David Nelson & Michael Cox, W.H. Freeman and company, NY.
- Textbook of Medical Laboratory Technology, Sood Ramnik, Jaypee brothers medical publishers (p) ltd.

ACADEMIC REGULATIONS & SYLLABUS

Faculty of Applied Sciences

Dual Degree (BSc + MSc) Programme
2017

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY

Education Campus – Changa, (ECC), hitherto a conglomerate of institutes of professional education in Engineering, Pharmacy, Computer Applications, Management, Applied Sciences, Physiotherapy and Nursing, is one of the choicest destinations by students. It has been transformed into **Charotar University of Science and Technology (CHARUSAT)** through an Act by Government of Gujarat. CHARUSAT is permitted to grant degrees under Section-22 of UGC- Govt. of India.

The journey of CHARUSAT started in the year 2000, with only 240 Students, 4 Programmes, one Institute and an investment of about Rs.3 Crores (INR 30 million). At present there are seven different institutes falling under ambit of six different faculties. The programmes offered by these faculties range from undergraduate (UG) to Ph.D. degrees. These faculties, in all offer 64 different programmes. A quick glimpse in as under:

Faculty	**Institute**	**Programmes Offered**
Faculty of Technology & Engineering	Charotar Institute of Technology	B. Tech M. Tech MTM Ph. D
Faculty of Pharmacy	Ramanbhai Patel College of Pharmacy	B. Pharm M. Pharm MPM PGDCT/ PGDPT Ph. D
Faculty of Management Studies	Indukaka Ipcowala Institute of Management	M.B.A PGDM Dual Degree BBA+MBA Ph.D
Faculty of Computer Applications	Smt. Chandaben Mohanbhai Patel Institute of Computer Applications	M.C.A/MCAL M.Sc (IT) Dual Degree BCA+MCA Ph. D
Faculty of Applied Sciences	P D Patel Institute of Applied Sciences	M.Sc Dual Degree B.Sc+M.Sc

		Ph.D
Faculty of Medical Sciences	Ashok and Rita Institute of Physiotherapy ManikakaTopawala Institute of Nursing Charotar Institute of Paramedical Sciences	B.PT M.PT Ph.D B.Sc (Nursing) M.Sc PGDHA PGDMLT GNM Ph.D

The development and growth of the institutes have already led to an investment of over Rs.125 Crores (INR 1250 Million). The future outlay is planned with an estimate of Rs.250 Crores (INR 2500 Million).

The University is characterized by state-of-the-art infrastructural facilities, innovative teaching methods and highly learned faculty members. The University Campus sprawls over 105 acres of land and is Wi-Fi enabled. It is also recognized as the Greenest Campus of Gujarat.

CHARUSAT is privileged to have 360 core faculty members, educated and trained in IITs, IIMs and leading Indian Universities, and with long exposure to industry. It is also proud of its past students who are employed in prestigious national and multinational corporations.

From one college to the level of a forward-looking University, **CHARUSAT** has the vision of entering the club of premier Universities initially in the country and then globally. **High Moral Values like Honesty, Integrity and Transparency** which has been the foundation of ECC continues to anchor the functioning of **CHARUSAT**. Banking on the world class infrastructure and highly qualified and competent faculty, the University is expected to be catapulted into top 20 Universities in the coming five years. In order to align with the global requirements, the University has collaborated with internationally reputed organizations like Pennsylvania State University – USA, University at Alabama at Birmingham – USA, Northwick Park Institute –UK, ISRO, BARC, etc.

CHARUSAT has designed curricula for all its programmes in line with the current international practices and emerging requirements. Industrial Visits, Study Tours, Expert Lectures and Interactive IT enabled Teaching Practice form an integral part of the unique **CHARUSAT** pedagogy.

The programmes are credit-based and have continuous evaluation as an important feature. The pedagogy is student-centred, augurs well for self-learning and motivation for enquiry and research, and contains innumerable unique features like:

- Participatory and interactive discussion-based classes.
- Sessions by visiting faculty members drawn from leading academic institutions and industry.
- Regular weekly seminars.
- Distinguished lecture series.
- Practical, field-based projects and assignments.
- Summer training in leading organizations under faculty supervision in relevant programmes.
- Industrial tours and visits.
- Extensive use of technology for learning.
- Final Placement through campus interviews.

Exploration in the field of knowledge through research and development and comprehensive industrial linkages will be a hallmark of the University, which will mould the students for global assignments through technology-based knowledge and critical skills.

The evaluation of the student is based on grading system. A student has to pursue his/her programme with diligence for scoring a good Cumulative Grade Point Average (CGPA) and for succeeding in the chosen profession and life.

CHARUSAT Welcomes You For A Bright Future

CHAROTAR UNIVERSITY OF SCIENCE & TECHNOLOGY
Faculty of Applied Sciences

ACADEMIC REGULATIONS
Dual Degree (BSc + MSc) Programmes in Biological Sciences

Charotar University of Science and Technology (CHARUSAT)
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2017

CHARUSAT

FACULTY OF APPLIED SCIENCES

ACADEMIC RULES AND REGULATIONS
[Bachelor's Degree (BSc) Component of the Dual Degree Programme in Biological Sciences]

Faculty of Applied Sciences

The following are the academic rules and regulations for the **under graduate programmes in biological sciences** wherein the duration of the course, eligibility criteria and mode of admission, credit requirement and system of examination and other related aspects are laid down.

1. Nomenclature of the degree

The programme shall be called Bachelor of Science (BSc) with specialization in Biotechnology, Microbiology and Biochemistry.

2. System of Education

- The Semester system and choice based credit system of education shall be followed.
- Duration of each semester will be of at least 90 working days.
- Every student requires to do a specified course work in the chosen program of specialization and also to complete project/dissertation/industrial training/specialized training if any.
- **Medium of instruction will be English.**

3. Duration of Programme

Undergraduate programme (BSc) 6 semesters (3 academic years)

Maximum time allowed for completion of the BSc programme shall not be more than 12 semesters.

4. Eligibility for admission

For the admission to BSc programs in Biological Sciences, a candidate must have successfully passed the higher secondary examination with science subjects from a state or central or international school education boards etc.

5. Mode of admission

Admission to BSc programme will be based on merit.

6. ***Course structure***

A student admitted to the program should study the prescribed courses and earn credits specified in the course structure. Courses in a programme will be of three kinds: (a) Core, (b) Core allied and (c) Foundation.

(a) **Core courses**: These are the courses which should compulsorily be studied by a candidate and are called "Core compulsory". This category also includes laboratory courses.

(b) **Core allied**: These are the courses where choice or an option for the candidate is available. The student can choose the courses from the sister/allied disciplines which supports the main discipline.

(c) **Foundation courses**: These are the courses based upon the content that leads to knowledge enhancement and/or skill enhancement. These are mandatory for all disciplines but choices are available to the candidate from the defined courses.

The courses offered during the first two semesters are basic and introductory courses in Biology, Chemistry, and Statistics. These are mandatory for all the students and are meant to give a flavour to the various approaches and analyses used in these disciplines and to prepare the students for advanced courses in later years of study. In addition, there will be Interdisciplinary as well as Trans-disciplinary Courses. These are communication skills, computational skills, mathematical methods, scientific inquiry, critical thinking, liberal arts, languages, values culture and wisdom, critical thinking and, logic, society, governance and international studies and conceptual inquiry.

From the third semester onwards students **have the freedom to choose advanced courses in their choice of specialization i.e. biotechnology, microbiology and biochemistry based on their interest and inclination.**

In addition, these students are also exposed to industrial training, field investigations. By availing this, a student can work in an experimental lab or visit industries or sanctuary and national parks. This is meant to help the student to gain required personality traits for working in an industrial environment.

Credit scheme

- The BSc programme shall have 22-24 **credits/semester** and the total minimum **credits to earn a degree is 140.**
- **A candidate has to register for minimum prescribed credits in a semester.**

7. ***Attendance***

- All activities prescribed under these regulations and listed by the course faculty members in their respective course outlines are compulsory for all students pursuing the courses.
- Minimum attendance required is 80%.

8. *Course Evaluation*

- The performance of every student in each course will be evaluated as follows:
- Continuous and Comprehensive assessment is an integral part of CBCS of CHARUSAT. A continuous assessment system in semester system (also known as internal assessment/comprehensive assessment) is spread through the duration of course and is done by the teacher(s) teaching the course.
- Internal evaluation by the course faculty member(s) based on continuous assessment for 30% of the marks for the course; and Final examination 70% of the marks for the course.
- The assessment is done through various means including: Written tests, MCQ based quizzes, Presentations, Mini-projects, Projects, dissertation, Field visits, industry visits, Seminars, assignments, group discussions/activities, Viva-voce etc.as prescribed by the concerned teacher and decided by the Faculty of Applied Sciences. (**Refer annexure-I)**
- In "Continuous evaluation" of practical's students shall be evaluated in a continuous manner for their involvement in the practical, aptitude for learning, completion of practical related assignments, regularity in the laboratory and record keeping.
- The end examination for 70% of the evaluation for the course will be through written paper or practical test or oral test or presentation by the student or a combination of any two or more of the above.
- In order to earn the credit in a course a student has to obtain grade other than FF.

9. Grading

Grading Scheme: Relative grading based on ten point scale will be adopted.

Letter Grade	AA	AB	BB	BC	CC	CD	DD	FF
Grade Point	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**0**

- The student's performance in any semester will be assessed by the Semester Grade Point Average (SGPA). Similarly, his performance at the end of two or more consecutive semesters will be denoted by the Cumulative Grade Point Average (CGPA). The SGPA and CGPA are calculated as follows:

(i) SGPA $= \sum C_i G_i / \sum C_i$ where C_i is the number of credits of course i

G_i is the Grade Point for the course i and i = 1 to n,

n = number of courses in the semester

(ii) CGPA $= \sum C_i G_i / \sum C_i$ where C_i is the number of credits of course i

G_i is the Grade Point for the course I and i = 1 to n,

n = number of courses of all semesters up to which CGPA is computed.

(iii) In addition the student has to complete the required formalities as per the regulatory bodies.

In case, a student, of undergraduate programme or diploma, gets less than 40% marks in end-semester examination and less than 45% marks overall (combining continuous evaluation and end-semester examination) in a particular course, he / she will not be graded in that course till he / she reappears in said course and obtains specified minimum marks .

10. Grading Procedure

The committee will be constituted for finalising the Grading.

1. Provost Nominee
2. Dean
3. Expert Member(s)

11. Award of Degree

Every student will be eligible for the award of the degree if she/he **should have earned minimum required credits (140 credits)** as prescribed in a program.

12. Provision for Appeal

There shall be a provision for Appeal for a candidate who may be dissatisfied with the Grade he/she has been awarded. He/she can approach the University with the written submission.

13. Award of Class

The class awarded to a student in the programme is decided by the final CGPA as per the following scheme:

Award of Class	**CGPA Range**
First Class with Distinction	CGPA $\geq$ 7.50
First class	7.50 > CGPA $\geq$ 6.50
Second Class	6.50 > CGPA $\geq$ 5.50
Pass Class	5.50 > CGPA $\geq$ 4.00

14. Transcript

The transcript will be issued to the student only after successful completion of the course by earning required number of credits for B.Sc. degree. Transcript will contain a consolidated record of all the courses taken, credits earned, grades obtained, SGPA, CGPA, class obtained, etc.

Annexure-I

Policy for distribution of Internal marks

Particulars	Marks	Marks distribution for 2 credit course	Marks distribution for 3 or 4 credit course
All the internal test/other continuous assessment tool	**15 / 30 Marks** Sum of average marks obtained by the student from internal test + marks of other assessment components	10 (Should be converted in to 10 at the end of semester)	20 (Should be converted in to 20 at the end of semester)
Assignment Or Seminar	**3 /Course**	3	6
Attendance	**2/Course**	2	4
	Total	**15**	**30**

Annexure III

Teaching scheme for B.Sc. Biotechnology /Microbiology/Biochemistry

Course Code

BT: B Sc (Biotechnology) specific courses

MI: B Sc (Microbiology) specific courses

BC: B Sc (Biochemistry) specific courses

BS: Common courses for all three branches

BE: Common elective courses for the all the three branches

B. Sc. Biotechnology/Microbiology/Biochemistry (Semester I)

	Semester I						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute (Internal)**	**University (External)**	**Total-I**	**Institute (Internal)**	**University (External)**	**Total -II**	**Total I+II**
	Core Compulsory												
BS108	Biochemistry	3	-	-	3	3	30	70	100	-	-	-	100
BS109	Chemistry	3	-	-	3	3	30	70	100	-	-		100
BS110	Plant Sciences	3	-	-	3	3	30	70	100	-	-		100
  BE112 BE113	**Core-allied Electives** **(any one to be selected)** Biotechnology and Human Welfare Scope of Microbiology	3	- -	- -	3	3 3	30 30	70 30	100 100	- -	- -	- -	100 100
  HS101.01 HS102.01 HS103.01 HS104.01 HS105.01 HS106.01 HS107.01 HS108.01 HS109.01 HS110.01 HS132E	**Liberal Arts Courses** **(any one to be selected)** Liberal arts –Painting Liberal arts –Photography Liberal arts –Sculpturing Liberal arts –Pottery and Ceramic Art Liberal arts –Media and Graphic Design Liberal arts –Arts and Crafts Liberal arts –Fashion Designing Liberal arts–Interior Designing Liberal arts –Dramatics Liberal arts–Contemporary Dance Academic English		2	-	2	2	–	–	–	30	70	100	100
BS112	Laboratory- I		16	-	16	8	-	-	-	50	100	150	150
	Library	**-**	**-**	**-**	**2**	**0**	–	–	–	–	–	–	**-**
	Total	**14**	**16**	**-**	**30+2=32**	**22**	–	–	–	–	–	–	**650**

B.Sc. Biotechnology/Microbiology/Biochemistry (Semester II)

	Semester II						Theory Evaluation			Practical Evaluation			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute (Internal)**	**University (External)**	**Total–I**	**Institute (Internal)**	**University (External)**	**Total–II**	**Total I+II**
	Core Compulsory												
BS208	General Microbiology	3	–	–	3	3	30	70	100	–	–	–	100
BS209	Animal Sciences	3	–	–	3	3	30	70	100	–	–	–	100
BS210	Analytical Techniques in Biology	3	–	–	3	3	30	70	100	–	–	–	100
BS211	Biostatistics	3	–	–	3	3	30	70	100	–	–	–	100
HS126.01	Communication Skills–1	2	–	–	2	2	30	70	100	–	–	–	100
BS212	Laboratory–II		16	–	16	8	–	–	–	50	100	150	150
	Library	–	–	–	**2**	**0**	–	–	–	–	–	–	
	Total	**14**	**16**		**30+2=32**	**22**	–	–	–	–	–	–	**650**

B.Sc. Biotechnology/Microbiology/Biochemistry Semester III

	Semester III						Theory Evaluation			Practical Evaluation			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute (Internal)**	**University (External)**	**Total-I**	**Institute (Internal)**	**University (External)**	**Total-II**	**Total I+II**
	Core Compulsory												
BS309	Molecular Biology	3			3	3	30	70	100	-	-	-	100
BS310	Genetics	3			3	3	30	70	100	-	-	-	100
BS311	Cell Biology	3			3	3	30	70	100	-	-	-	100
BT301 MI301 BC301	Enzyme Technology Bacteriology and Virology Metabolism	3			3	3	30	70	100	-	-	-	100
HS122E	Values and Ethics	2			2	2	30	70	100	-	-	-	100
	University Elective I	2			2	2	30	70	100	-	-	-	100
BT312 MI312 BC312	Biotechnology Laboratory- III Microbiology Laboratory- III Biochemistry Laboratory-III		16		16	8	-	-		50	100	150	150
	Library	**-**	**-**	**-**	**2**	**0**							
	Total	16	16		**32+2=34**	**24**							**750**

B.Sc. Biotechnology/Microbiology/Biochemistry Semester IV

	Semester IV						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute (Internal)**	**University (External)**	**Total-I**	**Institute (Internal)**	**University (External)**	**Total-II**	**Total I+II**
	Core Compulsory												
BS405	Immunology	3			3	3	30	70	100	-	-	-	100
BS406	Genetic Engineering	3			3	3	30	70	100	-	-	-	100
BT405 MI405 BC405	Plant Biotechnology Mycology and Phycology Membrane Biology and Bioenergetics	3			3	3	30	70	100	-	-	-	100
BT406 MI406 BC406	Bioprocess Technology Microbial Physiology Enzymology	3			3	3	30	70	100	-	-	-	100
HS133E	Creativity, Problem solving and innovation		2		2	2	-	-	-	30	70	100	100
	University Elective II		2		2	2	-	-	-	30	70	100	100
BT410 MI410 BC410	Biotechnology Laboratory-IV Microbiology Laboratory-IV Biochemistry Laboratory-IV		16		16	8	-	-	-	50	100	150	150
	Library	-	-	-	**2**	**0**							
		16	16		**32+2=34**	**24**							**750**

B.Sc. Biotechnology/Microbiology/Biochemistry Semester V

	Semester V						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total-II**	**Total I+II**
	Core Compulsory												
BS503	Bioinformatics	2			2	2	15	35	50	-	-	-	50
BT505 MI505 BC505	Industrial Biotechnology Food and Dairy Microbiology Human Physiology	3			3	3	30	70	100	-	-	-	100
BT506 MI506 BC506	Animal Biotechnology Environmental Microbiology Neurochemistry	3			3	3	30	70	100	-	-	-	100
BT507 MI507 BC507	Entrepreneurship and IPR Plant Pathology Nutritional Biochemistry	3			3	3	30	70	100	-	-	-	100
	Core-allied Elective (any one to be selected)												
BE510	Bioethics and Biosafety	3			3	3	30	70	100	-	-	-	100
BE511	Microbial Enzymes	3			3	3	30	70	100	-	-	-	100
BE512	Management of Human Microbial Diseases	3			3	3	30	70	100	-	-	-	100
BE513	Agricultural Biotechnology	3			3	3	30	70	100	-	-	-	100
BE514	Drug Designing	3			3	3	30	70	100	-	-	-	100
HS124E.01	Professional Communication		2		2	2				30	70	100	100
BT508 MI508 BC508	Biotechnology Laboratory- V Microbiology Laboratory -V Biochemistry Laboratory-V		**16**		**16**	**8**				**50**	**100**	**150**	**150**
	Library	**-**	**-**	**-**	**2**	**0**							
		16	**16**		**32+2=34**	**24**							**700**

B.Sc. Biotechnology/Microbiology/Biochemistry Semester VI

	Semester VI						**Theory Evaluation**			**Practical Evaluation**			
Course Code		**L**	**P**	**T**	**Contact hours**	**Total Credits**	**Institute**	**University**	**Total-I**	**Institute**	**University**	**Total-II**	**Total I+II**
	Core Compulsory												
BT605 MI609 BC609	Omics and Synthetic Biology Medical Microbiology Hormones: Biochemistry and Functions	3			3	3	30	70	100	-	-	-	100
BT606 MI606 BC606	Environmental Biotechnology Advances in Microbiology Plant Biochemistry	3			3	3	30	70	100	-	-	-	100
BT607 MI607 BC607	Developmental Biology Industrial Microbiology Clinical Biochemistry	3			3	3	30	70	100	-	-	-	100
BT608 MI608 BC608	Medical and Forensic Biotechnology Microbes in sustainable Agriculture Molecular Basis of Diseases	3			3	3	30	70	100	-	-	-	100
	Core-allied Electives (any one to be selected)												
BE608	Animal Cell Culture Techniques	2			2	2	15	35	50				50
BE609	Pharmaceutical Quality Control and Quality Assurance	2			2	2	15	35	50				50
BE610	Food and Dairy Biotechnology	2			2	2	15	35	50				50
BE611	Microbiological Analysis of Air and Water	2			2	2	15	35	50				50
BE612	Extremophiles and their Applications	2			2	2	15	35	50				50
BE613	Protein Purification Techniques	2			2	2	15	35	50				50
BE614	Glycobiology	2			2	2	15	35	50				50
HS134E	Contributor personality development		2		**2**	**2**	-	-	-	30	70	100	100
BT610 MI610 BC610	Biotechnology Laboratory-VI Microbiology Laboratory-VI Biochemistry Laboratory-VI		**16**		**16**	**8**	-	-	-	**50**	**100**	**150**	**150**
	Library	**-**	**-**	**-**	**2**	**0**	-	-	-				
		14	16		**30+2=34**	**24**							**700**

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B.Sc. Semester I

Detailed Syllabus

BS108 BIOCHEMISTRY

Credit (Theory): 03 **Semester I**
Credit Hours: 45

A. Objectives of the course

- To help students to understand the
  - chemical foundations of life
  - basis of macromolecules and their structure.
  - how and why biological molecules are built the way they are and how this makes life possible.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**The foundations of biochemistry, water**	4
2.	**Carbohydrates and glycobiology**	12
3.	**Lipids**	11
4.	**Amino acids**	7
5.	**Nucleic acids**	7
6.	**Vitamins**	4

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C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**The foundations of biochemistry** Cellular and chemical foundations of life **Water** Unique properties, weak interactions in aqueous systems, ionization of water, buffers, wateras a reactant and fitness of the aqueous environment.	4
2.	**Carbohydrates and glycobiology** Monosaccharides - structure of aldoses and ketoses, ring structure of sugars, conformations ofsugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and nonreducing disaccharides. Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). Carbohydrates as informational molecules, working with carbohydrates.	12
3.	**Lipids** Building blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes. Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Plant steroids. Lipids as signals, cofactors and pigments	11
4.	**Amino acids** Structure and classification, physical, chemical and optical properties of amino acids	7

5.	**Nucleic acids** Nucleotides - structure and properties. Nucleic acid structure – Watson-Crick model of DNA. Structure of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry- UV absorption, effect of acid and alkali on DNA. Other functions of nucleotides - source of energy, component of coenzymes, second messengers.	**7**
6.	**Vitamins** Structure and active forms of water soluble and fat soluble vitamins, deficiency diseases and symptoms, hypervitaminosis	**4**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- The students will know the chemical structures and chemistry of biological polymers and their monomers.
- Students will be able to understand the roles of these biological molecules in living cells.

F. Recommended study materials

- Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H.
  Freeman and Company (New York), ISBN:13: 978-1-4641-0962-1 / ISBN:10:1-4292-
  3414-8.
- Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John
  Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4.
- Harper's Biochemistry by Robert .KK. Murray 26/e, 2003.
- Fundamentals of biochemistry- Life at the molecular level By: Voet, Voet and Pratt, 2nd edition, 2006.
- Human Biochemistry by James.M. Orten & Oho.W.Neuhaus
- Biochemistry by Lubert Stryer
- Fundamentals of Biochemistry by Debajyothi Das 11/e, 2002.

BS109 CHEMISTRY

Credit (Theory): 03 **Semester I**
Credit Hours: 45

A. Objectives of the course

The objectives of the course is:

- To introduce the basic concepts of chemistry to the undergraduate students of biological sciences.
- To demonstrate the basic principles chemistry at the chemistry laboratory.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Fundamentals of Physical Chemistry** **i. Mathematical foundation of Physical Chemistry** **ii. Chemical Thermodynamics** **iii. Chemical Kinetics**	15
2.	**Fundamentals of Inorganic Chemistry** **i. Periodic tables and its properties** **ii. Chemical Bonding** **iii. Acids and Bases**	18
3.	**Fundamentals of Organic Chemistry** **i. Basic concepts of Organic Chemistry** **ii. Stereochemistry**	12

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1	**Fundamentals of Physical Chemistry** **i. Mathematical foundations of physical chemistry** Applications of mathematics in physical chemistry, use of Equation of a straight line, intercept and slope, differentiation, and Integration. **ii. Chemical thermodynamics** System and surroundings, heat and work, internal energy, first law of thermodynamics, entropy and enthalpy, temperature dependence of entropy and enthalpy, exothermic and endothermic reactions, Hess's law, Gibbs free energy, second law of thermodynamics, heat capacities. Numerical problems. **iii. Chemical kinetics** Equilibrium and equilibrium constant. Rate and order of chemical reaction. Reaction mechanism and elementary process, 1^{st} order chemical reactions, Half-life, activation of energy, Arrhenius law.	15
2	**Fundamentals of Inorganic Chemistry** **i. Periodic table and its properties** Periodic Table, Ionization Energy, Electron affinity, Atomic Size and Electronegativity	18

	ii. Chemical Bonds The Lewis Theory, Sidgwick- Powell Theory, Valence Shell Electron Pair Repulsion (VSEPR) Theory, Valence Bond Theory (VBT), Hybridization, Molecular Orbital Theory (MOT). **iii. Acids and Bases** Arrhenius theory of Acids and Bases, The Lowry – Bronsted Concept, Strength of Acids and Bases, The Lewis concept, The pH Scale, Self Ionization of Water	
3	**Fundamentals of Organic Chemistry** **i. Basic Concepts of Organic Chemistry** Tetravalent carbon atom, Hybridization, Functional groups, Nomenclature of organic molecules, Types of bond, Fission of bond, Inductive effect, Electromeric effect, Resonance Effect, Hyper conjugation **ii. Stereochemistry:** Classification of Stereoisomers, Enatiomers, Diasteromers, Absolute configuration (R & S Nomenclature), Geometrical isomerism	**12**

D. Instructional Methods and Pedagogy

The topics will be discussed in an interactive class room sessions using conventional blackboard teaching to power-point presentations. Numerical problem solving sessions will be conducted for better understanding of the subject. Course materials and question bank will be provided to the students from various primary and secondary sources of information. Internal exams and surprise quizzes will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Practical sessions, related to the basic principle of the topics, will be conducted in a highly equipped chemistry laboratory. Experiments will be performed and analyzed by students individually.

E. Student Learning Outcomes

- The Programme aims at providing students with the methodological concepts and tools needed to acquire skills in the field of chemical sciences
- Ensuring that students acquire sound knowledge base for future study/research.

F. Recommended study materials

- Physical Chemistry for the life sciences by Peter Atkins, Oxford University Press.
- Essential of Physical Chemistry by Bahl, Bahl, and Tuli, S. Chand and Co.
- Advanced Inorganic Chemistry Volume I, Satyaprakash, G D Tuli, S K Basu, R D Madan
- Concise Inorganic Chemistry, 5th Edition, J D Lee
- Organic Chemistry 6th Edition by R. T. Morrision and R. N. Boyd; Prentice Hall
- Stereochemistry Conformation and Mechanism 7th Edition by P.S. Kalsi; New Age International (P) Ltd.

BS110 Plant Sciences

Credit (Theory): 03 **Semester I**

Credit Hours: 45

A. Objectives of the course

To make students understand about

- The basics of plant sciences
- Plant morphology and anatomy
- Structure and function of plant parts
- Plant physiology

B. Outline of the Course

Sr. No	Title	Minimum number of hours
1	**Introduction to Systematics and morphogenesis**	10
2	**Histology and anatomy**	10
3	**Physiology**	10
4	**Cryptogams, Gymnosperms and Angiosperms**	15

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to systematics and morphology** Introduction to plant sciences, nomenclature, systems of classification, their basis and Development Plant Morphology: roots, stem, leaf, inflorescence, flower, pollination, fertilization, seeds, fruits, dispersion of seeds and fruits	10
2.	**Histology and Anatomy** Cell, tissue-simple and complex, tissue system, anatomy of root, leaves, stem, secondary growth	10
3.	**Physiology** Chemical composition of Plants, Mineral Nutrients Absorption and Movements of water, Photosynthesis, Nitrogen Metabolism and special modes of nutrition Translocation and storage of food, Respiration and Fermentation, growth, transpiration, Growth hormones, enzymes and vitamins Movement, Reproduction, abiotic and biotic stress, aging, senescence and death	10
4.	**Cryptogams, Gymnosperms and Angiosperms** Cryptogams: Algae, Bacteria, Fungi, Lichens, Bryophyta, Pteridophyta Gymnosperms: Cycadales, Coniferales, Gnetales Angiosperms: Principles and systems of classifications, Dicotyledons, Monocotyledons	15

D. Instructional Methods and Pedagogy

- Topic will be discussed in the interactive class room sessions using black board teaching and power point presentations.
- Special interactive problem solving sessions will also be conducted.
- Course material will be provided to the students from various primary and secondary information
- Internal exam will be conducted regularly as part of continuous evaluation and students will be counseled to improve their performance

E. Student learning outcome/objective

After successful completion of course,

- Student will have basic understanding of important aspects of plant sciences
- Taxonomy and systematic of plants
- Various cell and tissue type of plants
- Physiological factors influencing plants

F. Recommended study materials

- Nagesh Ashish, Prashant Kumar and Hussian Kushal Life Sciences UGC CSIR NET/SET. Arihant publication ISBN: 9789350750483
- Dutta AC (2013) Botany for degree students. 6th Edition, Oxford University Press ISBN: 13:978-0-819-563748-9
- Kumar A (2001) Botany in Forestry and Environment, 1st Edition. Avichal Press

BE112 Biotechnology and Human welfare

Credit (Theory): 03 **Semester I**
Credit Hours: 45

A. Objectives of the course

To help students to understand the

- Biotechnology types
- Use of Biotechnology in Industry, Agriculture, Forensic science and Health
- Products of Biotechnology and its effect on Human welfare

B. Outline of the Course

Sr. No.	Title	Minimum no. of hours
1	**Introduction to Biotechnology**	5
2	**Biotechnology in Industry**	8
3	**Biotechnology in Agriculture**	8
4	**Biotechnology in Forensic sciences**	8
5	**Biotechnology in Enviornment**	8
6	**Biotechnology in Human Health**	8

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Biotechnology** What is Biotechnology? Types of Biotechnology, Steps in any biotechnological process, Scope of Biotechnology	5
2.	**Biotechnology in Industry** protein engineering; enzyme and polysaccharide synthesis, activity and secretion, alcohol and antibiotic formation.	8
3.	**Biotechnology in Agriculture** Agriculture: N2 fixation: transfer of pest resistance genes to plants; interaction between plants and microbes; qualitative improvement of livestock	8
4.	**Biotechnology in Environment** Environments: e.g. chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers such as PHB.	8
5.	**Biotechnology in Forensic Sciences** Forensic science: e.g. solving violent crimes such as murder and rape; solving claims of paternity and theft etc. using various methods of DNA finger printing.	8

6.	**Biotechnology in Health** Health: e.g. development of non-toxic therapeutic agents, recombinant live vaccines, gene therapy, diagnostics, monoclonal in *E.coli*, human genome project.	**8**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and student will be counselled to improve their performance.

E. Student learning outcome

- Augment their knowledge related to Biotechnology and its scope
- Students will have knowledge of applications of Biotechnology in Human health, Environment, forensic sciences, Agriculture

F. Recommended study materials

- Biotechnology by B D Singh
- Basic Biotechnology by Ratledge
- Biotechnology by HK Das
- Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
- Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New Age international publishers

BE113 Introduction and Scope of Microbiology

Credit (Theory): 03 **Semester I**
Credit Hours: 45

A. Objectives of the course

- To provide intuition into historical developments in the field of Microbiology
- To provide comprehensive idea about the distribution of diverse groups of microorganisms in various environments
- To make them learn the methods of cultivation and observation of bacteria in laboratory.
- To help them identify the impact of microbes on life at the individual and ecological and application levels
- To provide insight into types of symbiotic interactions between microbes and other organisms

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Scope and History of Microbiology**	15
2.	**Overview of bacteriology**	15
3.	**Overview of Environmental, Industrial and Medical Microbiology**	15

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Scope and History of Microbiology** Historical developments of Microorganisms; Characterization, Classification and Identification of Microorganisms; Microscopic examinations	15
2.	**Overview of Bacteriology** Morphology and Fine structure of Bacteria; Bacterial cultivation and reproduction; Sterilization	15
3.	**Overview of Environmental, Industrial and Medical Microbiology** Microbe-Microbe and Host-Microbe Interactions; Biopesticides and Biofertilizers; Biodeterioration and bioremediation Fundamentals of fermentation; Bioreactors; Use of Microbes to produce various primary and secondary metabolites Normal Microbial flora of a Healthy human host; Pathogenic microorganisms; Vaccines and immunology; antibiotics	15

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

The students shall have intuition into historical developments in the field of Microbiology

- The students shall have comprehensive idea about the distribution of diverse groups of microorganisms in various environments
- The students shall learn the methods of cultivation and observation of bacteria in laboratory.
- The students shall be able to identify the impact of microbes on life at the individual and ecological and application levels
- The students shall have insight into types of symbiotic interactions between microbes and other organisms

F. Recommended study materials

- Pelczar M.J., Chan E.C.S., Krieg N.R. (1996) Microbiology. TATA MaGraw-Hill Edition
- Ingraham J. L. and Ingraham C.A. (2004). Introduction to Microbiology. 3rd Edition. Thomson Brooks/ Cole
- Tortora G.J., Funke B.R., Case C.L. (2006). Microbiology: An Introduction. 8th Edition. Pearson Education Inc
- Stanier R.Y., Adelberg E.A. and Ingraham J.L. (1987) General Microbiology, 5th Edition. Macmillan Press Ltd.
- Introductory Mycology by Alexopoulos. Wiley
- Madigan M.T., Martinko J.M. (2006). Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.

B.Sc. Semester II

Detailed Syllabus

BS208 General Microbiology

Credit (Theory): 03 **Semester II**
Credit Hours: 45

A. Objectives of the course

- To provide intuition into historical developments in the field of Microbiology
- To provide comprehensive idea about the distribution of diverse groups of microorganisms in various environments
- To provide insight into the nutritional types, pattern of growth of microorganisms
- To make them learn the methods of cultivation and observation of microorganisms in laboratory.
- To understand and implement the control of microorganisms in laboratory and in environment using various techniques.
- To help them identify the impact of microbes on life at the individual and ecological and application levels
- To provide insight into types of symbiotic interactions between microbes and other organisms

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	**Introduction to microbial life**	7
2	**Techniques to observe Microorganisms**	5
3	**Nutrition, cultivation, and preservation of Microorganisms**	9
4	**Growth of Microorganisms**	9
5	**Control of Microorganisms**	10
6	**Microbes in environment and health**	5

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to microbial life** Overview of microbial world (General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and Protozoa); History and scope of Microbiology; Comparison between Prokaryotes, Eukaryotes and Archaea	7
2.	**Techniques to observe Microorganisms** Microscopic techniques, Stains, Dyes, their types and Staining techniques (Differential, Structural and Special staining technique)	5
3.	**Nutrition, cultivation, and preservation of Microorganisms** Major nutritional types of microorganisms, Macronutrients (Carbon, Oxygen, Nitrogen, Phosphorous, Sulfur and others); Micronutrients; Nutrient uptake mechanism; Concept of media preparation and their types; Enrichment techniques; Pure culture and cultural characteristics; Preservation of strains; Culture	9

	collection centres	
4.	**Growth of Microorganisms** Microbial growth; Cell division; Microbial growth curve; Calculation of generation time and growth rate; Measurement of growth, cell mass and cell activity; Synchronous growth; Diauxic growth; Continuous culture: Chemostat and Turbidostat; Influence of environmental factors on growth- Solutes and water activity, pH, Temperature, Oxygen concentration, Pressure and Radiations	**9**
5.	**Control of Microorganisms** Definitionsof terms - sterilization, disinfectant, antiseptic, sanitizer, germicide, microbioidal agents, microbiostatic agents and antimicrobial agent Control of microorganisms by physical and chemical methods; Antimicrobial agents; Evaluation of antimicrobial and chemical agents	**10**
6.	**Microbes in environment and health** Distribution of Microorganisms: Soil, Air and Water; Study of microbes in their environment; Microbes in Extreme environments Microbial associations (Parasitism symbiosis, commensalism, antagonism, predator and Competition); Succession in microbial populations Applications of Microbiology: Significance of normal flora and probiotics in human health; Microbes as Biofertilizers and Biocontrol Agents; Microbes in Health: diseases and probiotics	**5**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- The students shall have intuition into historical developments in the field of Microbiology
- The students shall have comprehensive idea about the distribution of diverse groups of microorganisms in various environments
- The students shall have insight into the nutritional types, pattern of growth of microorganisms
- The students shall learn the methods of cultivation and observation of microorganisms in laboratory.
- The students shall understand and implement the control of microorganisms in laboratory and in environment using various techniques.
- The students shall be able to identify the impact of microbes on life at the individual and ecological and application levels
- The students shall have insight into types of symbiotic interactions between microbes and other organisms

F. Recommended study materials

- Ingraham J. L. and Ingraham C.A. (2004). Introduction to Microbiology. 3rd Edition. Thomson Brooks/ Cole
- Tortora G.J., Funke B.R., Case C.L. (2006). Microbiology: An Introduction. 8th Edition. Pearson Education Inc
- Stanier R.Y., Adelberg E.A. and Ingraham J.L. (1987) General Microbiology, 5th Edition. Macmillan Press Ltd.
- Introductory Mycology by Alexopoulos. Wiley
- Madigan M.T., Martinko J.M. (2006). Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.

BS209 Animal Sciences

Credit (Theory): 03 **Semester II**
Credit Hours: 45

A. Objectives of the course

To help students to understand the

- systematics and animal classification
- concept of evolution
- various aspects of animal behavior
- animal physiology associated with various body systems
- process of reproduction in selected vertebrates and invertebrates

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	**Animal Diversity**	10
2	**Animal Evolution**	8
3	**Animal Behaviour**	7
4	**Animal Physiology**	10
5	**Animal Reproduction**	10

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Animal Diversity** Principles of Systematics and animal classification in Chordates and Non-chordates with characters and examples	10
2.	**Animal Evolution** Concept of Evolution: Origin of Life, Variations, Mutations, Isolation, Species and Speciation, Darwin's Natural Selection Theory, Mimicry, Population Genetics and Evolution	8
3.	**Animal Behaviour** Introduction of Ethology, Branches, History, Significance, Patterns of Behaviour, Study of Behaviour, Genetics of Behaviour, Reproductive Behaviour	7
4.	**Animal Physiology** Tissues, Organs and Systems, Feeding and Digestion, Absorption, Metabolism, Respiration, The Blood and Circulatory System, Excretion, Muscle Contraction, Nervous System, Endocrine Glands	10
5.	**Animal Reproduction** Reproduction in selected vertebrates and invertebrates	10

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and student will be counselled to improve their performance.

E. Student learning outcome

- Augment their knowledge related to diversity in animal kingdom and its importance
- Improve their awareness about various aspects of animal behaviour
- Learn and understand the process of animal physiology and reproduction and their importance

F. Recommended study materials

- Textbook of Invertebrates by RL Kotpal, Rastogi Publication, Meerut
- Textbook of Vertebrates, RL Kotpal, Rastogi Publications, Meerut.
- Chordate Zoology, PS Dhami and JK Dhami, S Chand & Co., Delhi.
- Invertebrate Zoology, Jordan and Verma, S Chand & Company, Delhi
- Instant notes in Animal Biology by Richard D Jurd. Vivi Books Pvt Ltd, New Delhi
- Evolution and Behaviour by ReenaMathur, SP Singh and BS Tomar 1st Ed., 2013 Rastogi Publication, Meerut
- Evolutionary Biology by BS Tomar and SP Singh. 9th Ed. 2013-14, Rastogi Publications, Meerut
- A Textbook of Animal Physiology by AK Berry, Emkay Publications, Delhi
- Animal Physiology by VK Agarwal and PS Verma. Reprint Edition: (2012), S Chand &Co.,Delhi.
- Animal Physiology by KA Goel and KV Sastry, 6th Ed 2012-13, Rastogi Publications, Meerut
- Animal Physiology and Biochemistry by KV Sastry, 2nd Ed. 2012-13, Rastogi Publications, Meerut
- Instant notes in Animal Biology by Richard D Jurd. Vivi Books Pvt Ltd, New Delhi
- A Manual of Practical Zoology: Invertebrates, By: V.K. Aggarwal, Dr. P. S. Verma. S Chand and Co.
- Practical Zoology Invertebrates by Dr. S. S. Lal, 2013, Rastogi Publications
- A Manual of Practical Zoology Chordates byDr. P. S. Verma, S Chand and Co.
- Practical Zoology vertebrates by SS Lal, Rastogi Publications.

BS210 Analytical Techniques in Biology

Credit (Theory): 03 **Semester II**
Credit Hours: 45

A. Objectives of the course

- To help students to understand the
  - Basic techniques used in Biology
  - Understand the instrumentation and methods
  - Understand the applications of bioanalytical techniques

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	**Microscopic Techniques**	**7**
2	**Spectroscopy Techniques**	**8**
3	**Chromatographic Techniques**	**10**
4	**Electrophoresis and Centrifugation**	**5**
5	**Molecular Biology Techniques**	**15**

C. Detailed syllabus:

Sr. No.	Title	Minimum number of hours
1.	**Microscopic Techniques** Conventional light microscopy, phase contrast microscopy, florescence and introduction to electron microscopy	**7**
2.	**Spectroscopy Techniques** Principle, Instrumentation and Applications of Colorimetry, UV-Visible spectroscopy, Spectoflourimetry, Atomic Absorption spectrophotometry, Flame Photometry and IR spectroscopy	**8**
3.	**Chromatographic Techniques** Chromatography- Principle, types and Applications Paper chromatography, Thin layer chromatography, Gel filtration, Ion exchange, affinity, HPLC and GC	**10**
4.	**Electrophoresis and Centrifugation** Electrophoresis- Principle, types, instrumentation and applications Centrifugation – Principle, types, Instrumentation and applications	**5**
5.	**Molecular Biology Techniques** Techniques for Protein, DNA, RNA – Isolation & Applications Western Blotting, Southern Blotting, Northern Blotting, Polymerase Chain Reaction (PCR)	**15**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- The students will be able to learn the basic techniques used to separate and analyze biomolecules

- Students will be able to understand the instrumentation and applications of a range of bioanalytical techniques

F. Recommended study materials

Text Books

- Bioanalytical Techniques by Abhilasha Shourie and Shilpa S. Chapadgaonkar
- Fundamentals of Bioanalytical Techniques and Instrumentation by Sabri Ghoshal and A. K. Shrivastava
- Biophysical Chemistry Principles And Techniques by Upadhyay, Upadhyay and Nath.
- Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker
- Gene cloning: An introduction by TA Brown

Reference books

- Bioanalytical Chemistry by Susan R. Mikkelsen, Eduardo Corton
- Bioanalytical Chemistry by Andreas Manz, Petra S Dittrich, Nicole Pamme, Dimitri Iossifidis
- Molecular Biology of the Cell by Bruce Alberts
- Biotechnology Exploartions : Applying the fundamentals By Judith A Scheppler, Pattricia E Cassin and Rosa M Gambler

BS211 BIOSTATISTICS

Credit (Theory): 03 **Semester II**
Credit Hours: 45

A. Objectives of the Course

The Aim of this course is to

- acquaint students with some basic concepts of Statistics used in Biological Sciences.
- Students will be introduced to some elementary statistical methods of analysis of data.

B. Outline of the course

Sr. No	Title	Minimum number of hours
1	**Introduction to Biostatistics, Population and Sample**	15
2	**Descriptive Statistics and Presentation**	15
3	**Regression and Correlation**	15

C. Detailed Syllabus

Sr. No	Title	Minimum number of hours
1	**Introduction to Biostatistics, Population and Sample** Scope of Biostatistics, Population and Sample, types of data, Concept of Population in Biostatistics, Sampling Methods	15
2	**Descriptive Statistics and Presentation** Classification, Graphical Presentation, Measures of Central Tendency, Measures of Dispersion	15
3	**Regression and Correlation** Introduction to Regression, Linear Regression, Concept and types of correlation, Computation of Correlation Coefficients	15

D. Instructional Method and Pedagogy

- At the start of course, the course delivery pattern, prerequisite of the subject will be discussed.
- Lectures will be conducted with the aid of multi-media projector, black board etc.
- Attendance is compulsory in lectures which will contribute to final results.
- Continuous evaluation will be carried out through unit test/quiz/assignment.

E. Student Learning Outcomes

- Summarize and Tabulate statistical data in descriptive forms
- Learn Graphical techniques for interpretation
- Compute different types of summary statistics
- Compute Correlation coefficient in case of bivariate data and interpret it.
- Compute linear regression coefficients and interpret it

F. Recommended study materials

- Robert R. Sokal and F. James Rohlf: Introduction to Biostatistics, Dover Publications
- Olive Jean Dunn and Virginia A Clark: Basic Statistics, A primer for the Biomedical Sciences,*Fourth Edition, John Wiley \& Sons.
- Wayne W. Daniel: Biostatistics, A foundation for Analysis in the Health Sciences,*Eighth Edition, John Wiley & Sons
- Bernard Rosner: Fundamentals of Biostatistics, Duxbury, Thomson Learning, *Fifth Edition

B.Sc. Semester III

Detailed Syllabus

BS309 Molecular Biology

Credits (Theory): 03 **Semester III**
Credit Hours: 45

A. Objectives of the course

- To introduce basic concepts of molecular biology to the undergraduate students of biological sciences.
- To make students understand the importance of nucleic acids and familiarise them with DNA and RNA structure was well as genome organization
- To augment students' knowledge on the mechanism of replication, recombination and Repair
- To provide information on RNA and protein synthesis and make them understand how gene expression is regulated

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Nucleic Acids as Genetic Material**	4
2.	**Nucleic Acids' Structure and Genome Organization**	11
3.	**DNA Replication, Recombination and Repair**	11
4.	**RNA and Protein Synthesis**	11
5.	**Regulation of Gene Expression**	8

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Nucleic Acids as Genetic Material** DNA as a genetic material: Griffith's experiment, Avery–MacLeod–McCarty experiment Hershey–Chase experiment, RNA as genetic material in viruses, Difference between molecular biology and biochemistry	4
2.	**Nucleic acids' Structure and Genome Organization** DNA, mRNA, rRNA, tRNA and miRNA structure; genome organization in prokaryotes and eukaryotes, structure of chromatin and chromosomes, heterochromatin and euchromatin, gene clusters, mobile DNA, unique and repetitive DNA, C-value paradox, DNA topology, super-coiling and topoisomerases, gene clusters, continuous, interrupted and overlapping genes, gene mutation	11

3.	**DNA Replication, Recombination and Repair** DNA replication in prokaryotes and eukaryotes; enzymes involved and mechanism of replication, replication models, overview of regulation of replication, end replication problem, extrachromosomal replicons, mechanism of recombination and repair	**11**
4.	**RNA and Protein Synthesis** Types of RNA polymerases, genetic code and wobble hypothesis, transcription unit, fundamentals of transcription in prokaryotes and eukaryotes, post-transcriptional modifications, role of ribosome and tRNA in protein synthesis, basics of translation in prokaryotes and eukaryotes, post-translational modifications	**11**
5.	**Regulation of Gene Expression** Operon concept, *lac* and *trp* operons, promoter, operator and enhancer sequences, repressor and activator proteins, overview of regulation of gene expression by miRNA, Molecular switch of Phage lambda	**8**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- Understand the basic concept of molecular biology which include DNA replication, recombination, repair, RNA and protein synthesis as well as regulation of gene expression.
- Acquire fundamental knowledge of molecular biology for further detailed study in master program
- Students will gain hands-on training in molecular biology experiments such as DNA isolation, agarose gel electrophoresis etc.

F. Recommended Study Material

- Essential of Molecular Biology by David Freifelder, 2015
- Principles of Genome Analysis by SB Primose, 2002
- Genes XI by Benjamin Lewin, 2012
- Genomes 3 by TA Brown, 2006
- Molecular Biology of the Cell by Bruce Alberts, 2008
- DNA Science by David A. Micklos, 2007

BS310 Genetics

Credits (Theory): 03 **Semester III**
Credit Hours: 45

A. Objectives of the course

- Introduction to basics of genetics like gene structure and functions.
- To develop the understanding of methods used in genetic analysis.
- Comparative genetics of microbes, plant and eukaryotic genetics.
- To develop the perceptive of population genetics.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**History of genetics, gene structure and functions**	12
2.	**Gene linkage and various methods to study the genetics**	11
3.	**Basic cytogenetics, breeding and population genetics**	12
4.	**Basic microbial genetics**	10

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**History of genetics, Gene structure and Functions** Terminology of the genetics, brief history, DNA as genetic material, central dogma of life, branches of genetics and their importance: classical, molecular and evolutionary genetics, Mendel's principles and extensions of Mendel's law, continuous and discontinuous variation, segregation and independent assortment, multiple alleles and incomplete dominance, epistasis and co-dominance, probability and statistics, overview of structure and functions of gene	12
2.	**Gene linkage and various methods to study the genetics** Gene linkage and crossing over, complementation test, mutations and their role in genetic analysis, introduction to molecular markers	11
3.	**Basic cytogenetics, breeding and population genetics** Chromosomal theory of heredity, mitosis and meiosis in plants and animals, variation in chromosome structure and number, polyploid plants, principles of plant breeding, principles of population genetics, Pedigree analysis	12

4.	**Basic microbial genetics** Introduction to microbial genetics, methods of gene transfer in bacteria: transformation, Transduction and Conjugation, mitotic recombination	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Animation and tutorials will be given for in-depth understanding of the subject.

E. Student learning outcomes

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

- Describe various theoretical models of the creative process, capable to analyze the scientific concepts with observational mind
- Apply a variety of creativity enhancing modes in a team setting; evaluate the practical importance of study.
- Understanding their own personal style of learning and how this relates to leadership and thoughtful development of Science.
- Development of novel skills for enhancing the scientific knowledge of society.

F. Recommended study materials

- Principles of genetics, third edition by R. Snusted
- Principles of genetics by Tamarin : 10th edition
- Principles of Plant genetics and breeding, second edition by Gerorge Acquaah, Willey-blackwell publishing groups
- An introduction to genetic analysis ,Eleven edition, by Griffith
- Molecular genetics of Bacteria , fourth edition by Dale
- Genetics ;A conceptual approach by Bemzamin A pierce
- Genetics , fourth edition by Brooker
- Genetics : laboratory investigation by Thomas R.Mertans
- Genetics: A conceptual approach (2nd edition, 2006) by B.A. Pierce ;W.H. Freeman and Co.
- Griffiths, Anthony J. F., Jeffrey H. Miller, David T. Suzuki, Richard C. Lewontin, and William M. Gelbart. An Introduction to Genetic Analysis. 7th ed. New York: W. H. Freeman, 2000. ISBN: 9780716735205

BS311 Cell Biology

Credits (Theory): 03 **Semester III**
Credit Hours: 45

A. Objectives of the course

- Differentiate between prokaryotic and eukaryotic cells and understand their functional compartmentalization
- Understanding cell-cell interactions underlying tissue organization and physiological processes
- To develop understanding of cell division cycle and cell death mechanism along with itsimplications in cancer
- To introduce methods employed to study cell organelles and cellular processes
- To build a fundamental that would enable the understanding of complex molecular basisof cellular mechanisms

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Cell as a Basic Unit of Life**	4
2.	**Bio-membranes of Cells**	6
3.	**Cell Organelles and Special of cells**	9
4.	**Cytoskeleton and Extracellular matrix**	6
5.	**Cell-cell interactions**	7
6.	**Cell cycle, cell death and cell renewal**	8
7.	**Tools and Techniques of Cell Biology**	5

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Cell as a Basic Unit of Life** Overview of cellular evolution and cell theory, comparison of prokaryotic and eukaryotic cells- cell size, shape and structural differences, special cells like neurons and muscle cells; basic molecules of a cell, fundamental functions of cells	4
2.	**Bio-membranes of Cells** Structural organization of cell membrane and Fluid-Mosaic model, Lipid composition, Protein components and basic functions, Membrane carbohydrates and their role	6

3	**Cell Organelles and Special of cells** Structure, function and organization of nuclear envelope and nucleus complex, ER, Golgi apparatus, Lysosomes; concepts of vesicular transport and Protein sorting; Structure and functions of mitochondria, chloroplasts and peroxisomes; special structures like Cilia, flagella, vacuoles, glyoxysomes, centrioles, Cell Wall	9
4	**Cytoskeleton and Extracellular matrix** Basic functions of cytoskeleton, Structure and organization of actin filaments, intermediate filaments; microtubules; Assembly, organization and movement of cilia and flagella, components of Extracellular Matrix, their organization and their interaction with cells	6
5	**Cell-cell interactions** Cell junctions, principles of cell signaling, Signaling molecules and their receptor types, amplification of signals; bacterial and plant signaling	7
6	**Cell cycle, cell death and cell renewal** Eukaryotic Cell Cycle and its regulation, Cell division, Cell division, Apoptosis and necrosis - brief outline and correlation with cancer, Oncogenes and Tumor Suppressor genes, Introduction to stem cells,	8
7	**Tools and Techniques of Cell Biology** Use of microscopy, Analytical techniques for cell count and cell viability, cell staining, cell disruption, Sub-cellular fractionation-differential and density gradient centrifugation	5

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical blackboard teaching to power-point presentations. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be performed and analyzed by students individually. Course materials will be provided to the students from various primary and secondary sources of information along with extra reference material. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- Students will gain insight into wide range of basic concepts in cell biology.
- Students shall develop appreciation towards the intricacies of cell structure and function, their dynamic properties and their co-ordination for the functioning of the whole organism and its development.
- Students will acquire an understanding of hierarchical organization of cellular interactions and communication
- Students shall gain insights into understanding of tools and techniques used to study cell organization and function.

F. Recommended Study Material

- Raven's Biology, 10th Edition, McGraw-Hill Higher Education
- Cell and Molecular Biology' 8th Edition by E.D.P. De Robertis
- Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc
- Cell Biology, Genetics, Molecular Biology: Evoloution and Ecology P S Verma and V K Agarwal, S Chand publications, 2004
- Cell Biology 2nd Edition, by Seong S. Han, Ruth Ashley, Gary Hann Rastogi publications
- Essentials of Cell and Molecular Biology: by de Robertis E. D. P. and E. M. F. , Holt Saunder's International Edition (new edition)

BT301 Enzyme Technology

Credits (Theory): 03 **Semester III**
Credit Hours: 45

A. Objectives of the Course

The course will provide an overview of the use of enzymes in large scale industrial processes. An overview of industrial scale protein production will be presented, including an introduction to applicable microbial expression hosts, downstream processing and purification methods, and enzyme optimization through enzyme discovery and engineering. A number of case studies highlighting the use of enzymes in modern industries will be explored.
After passing the course, the student should be able to:

- explain the key structural and energetic factors which give rise to increased enzyme stability important for industrial application,
- summarize current processes involved in industrial enzyme production, from protein production to purification and formulation,
- describe methods for selection and optimisation of industrial enzymes using genetic and biochemical techniques,
- describe the principles and methods of metabolic engineering of (micro)organisms to produce industrial chemicals.
- compare and contrast the historical uses of enzyme technology with current applications in a diverse range of industries.
- research a contemporary application of enzyme technology or metabolic engineering and present the results in a well-structured oral presentation.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Basics of enzymes**	**10**
2.	**Enzyme kinetics**	**10**
3.	**Structure and Regulation of enzymes**	**05**
4.	**Large scale production and technological aspects of enzymes**	**10**
5.	**Enzyme engineering**	**10**

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Basics of enzymes** Historical background, Enzymes vs Chemical catalyst, structure and properties of enzymes, Cofactors and coenzymes. Enzyme nomenclature and classification (rationale, overview and specific examples) Zymogens and their activation (Proteases and	**10**

	Prothrombin). Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Isolation, crystallization and purification of enzymes, test of homogeneity of enzyme preparation, methods of enzyme analysis. Units of activity	
2.	**Enzyme kinetics** Kinetics of enzyme activity, Michaelis-Menten equation and its derivation, Different plots for the determination of Km and Vmax and their physiological significance, factors affecting initial rate, E, S, temp. & pH. Collision and transition state theories, Significance of activation energy and free energy. Two substrate reactions (Random, ordered and ping-pong mechanism) Enzyme inhibition types of inhibition, determination of Ki, suicide inhibitor.	**10**
3.	**Structure and Regulation of enzymes** Allosteric enzymes with special reference to aspartate transcarbomylase and phosphofructokinase, Isoenzymes– multiple forms of enzymes with special reference to lactate dehydrogenase. Multienzyme complexes. Ribozymes. Multifunctional enzyme-eg Fatty Acid synthase. Mechanism of enzyme action: General mechanistic principle, factors associated with catalytic efficiency Techniques for studying mechanisms of action specific examples-: chymotrypsin, Iysozyme, GPDH, aldolase, RNase, Carboxypeptidase and alcohol dehydrogenase. Enzyme regulation: Product inhibition, feedback control, covalent modification. Structure function relationship in enzymes, structural motifs and enzyme evolution.	**05**
4.	**Large scale production and technological aspects of enzymes** Enzyme industry in India, scope for entrepreneurship in enzyme industry, Methods for large scale production of enzymes. Immobilized enzyme and their comparison with soluble enzymes, Methods for immobilization of enzymes. Immobilized enzyme reactors. Improvement of enzymes, Thermal stability and catalytic efficiency of enzyme, introduction to enzyme engineering site directed mutagenesis and enzyme engineering– selected examples	**10**
5.	**Applications of enzymes** Application of Immobilized and soluble enzyme in health and industry. Application to fundamental studies of biochemistry. Enzyme electrodes.	**10**

D. Instructional Methods and Pedagogy

- The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations.
- The topics will taught using numerical problems, case studies, simulations, animations, softwares.
- Interactive problem solving sessions will be also conducted by respective faculty members on regular basis.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Internal exams, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.
- Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self-study.
- Industrial visits/tours will be conducted for providing on-site understanding of the concepts of bioprocess engineering and technology gained during the theory and practical sessions.
- Mini-projects and/or dissertation project in the subject area of bioprocess technology will be carried out.

E. Student learning Outcomes

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

- Appreciate the scope and future of enzyme technology.
- Understand the sources of enzymes and their exploitation
- Understand the large scale production of enzymes and their purification
- Delineate process design and reactors for enzymatic reactions
- Understand the kinetics of enzyme reactions and reaction stoichiometry, mass balances, basic modeling of enzyme mediated bioprocesses
- Understand the applications of enzymes in industrial and other processes

F. Recommended Study Materials

- Principles of Enzyme Technology (2015) by M. Y. Khan and Farha Khan
- Enzyme Technology: Pacemaker of Biotechnology (2011) by Prasad N.K
- Enzyme Technology (2012) by S. Shanmugam and T. Sathish kumar
- Biocatalysts and Enzyme Technology (2012) by Klaus Buchholz and Volker Kasche
- Enzyme Technology (2009) by Anusha Bhaskar and V. G. Vidhya

MI301 Bacteriology and Virology

Credit (Theory): 03 **Semester III**
Credit Hours:45

A. Objectives of the course:

- To make students know about the cell organization in bacteria
- To provide comprehensive idea about diverse groups of microorganisms
- To provide information about the salient features of various viral groups
- To provide a contemporary understanding of how viruses are built, how they infect and replicate in procaryotic and eucaryotic organisms.
- To generate insight into the evolution of various viruses and the concept of emerging viral diseases
- To develop a foundation for continued learning in microbiology.

B. Outline of the Course

Sr. No.	Title of Unit	Minimum of hours
1.	**Cell organization**	9
2.	**Bacterial Systematics and Taxonomy**	9
3.	**Introduction to Viruses**	9
4.	**Replication and Multiplication of viruses**	9
5.	**Role of Viruses in Disease and its prevention**	9

C. Detailed Syllabus:

Sr. No.	Title of Unit	Minimum of hours
	MI 301 Bacteriology and Virology	
1.	**Cell organization** Morphology: Cell size, shape and arrangements, Specialized structures: capsule, flagella and pili, spores, inclusions. Cell wall: Composition, structure and functions of bacteria and archaea. Cell membranes: Structure, chemical composition and functions of bacteria and archaea. Cell components: Ribosomes, nucleoid, plasmids, other special structures	**8**
2.	**Bacterial Systematics and Taxonomy** Taxonomy, nomenclature, systematics, types of classifications. Morphology, ecological significance and economic importance of the following groups: Archaea; Deinococci, Mollicutes, and Nonproteobacterial Gram-Negative Bacteria; Proteobacteria; Firmicutes, Actinobacteria; Hyperthermophilic Bacteria ; Other Bacteria	**11**
3.	**Introduction to Viruses** History, Theories of viral origin and general properties of viruses. Structural and morphological characters: Capsid symmetry and shapes of viruses. Classification and nomenclature of viruses. Giant Viruses, subviral particles; viroids, prions and their importance. Role of viruses in environment and its evolution. Isolation and cultivation of viruses	**10**

4.	**Replication and Multiplication of viruses** Viral replication and multiplication: Lytic and lysogenic cycle Description of important viruses: Bacteriophages (T4 & Lambda); Plant (TMV & Cauliflower Mosaic Virus), Human (HIV & Hepatitis viruses) Viral Genetics: Influenza	**9**
5.	**Role of Viruses in Disease and its prevention** Viral pathogenesis (Plant: TMV or Cauliflower Mosaic Virus, Human: HIV or Hepatitis viruses). Prevention and control of viral diseases: vaccines, interferon and antiviral compounds.	**7**

D. Instructional Methods and Pedagogy:

- The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations.
- Practical sessions will be conducted in a highly equipped laboratory.
- Experiments will be carried out by students individually.
- Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes / objectives:

- ➢ After successful completion of the course the student will be able to:
    - know about the cell organization in bacteria
    - have comprehensive idea about diverse groups of microorganisms
    - understand the salient features of various viral groups
    - have contemporary understanding of how viruses are built, how they infect and replicate in procaryotic and eucaryotic organisms.
    - have insight into the evolution of various viruses and the concept of emerging viral diseases
    - develop a foundation for continued learning in microbiology.

F. Suggested Study materials
Text Books:

1. Microbiology: an introduction- Tortora, G.J., Funke, B.R. and Case, C.L.
2. General Microbiology- Stanier, R.Y.
3. Microbiology- Pelczar, M.T.
4. Virology: Principles and Applications Carter J and Saunders V 2nd edition. John Wiley and Sons.
5. Principles of Molecular Virology, Fifth Edition Alan J. Cann

Reference Books

1. Brock biology of microorganisms / Michael T. Madigan. . . [*et al*.]. — Fourteenth edition. ISBN 978-0-321-89739-8 Pearson
2. Prescott's Microbiology, Ninth Edition Mcgraw-Hill,

BC301 Metabolism

Credits (Theory): 03 **Semester III**
Credit Hours: 45

A. Objectives of the course

- To help students to understand the importance of metabolic activity of in living cell
- Energy and thermodynamics importance in living cell
- Pathogen metabolism

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Basic design of metabolism**	2
2.	**Carbohydrate Metabolism**	10
3.	**Fatty acid Metabolism**	11
4.	**Amino acid and Protein metabolism**	12
5.	**Nucleotide metabolism**	5
6.	**Integrated Metabolism**	5

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Basic design of metabolism** Autotrophs, heterotrophs, metabolic pathways, catabolism, anabolism, ATP as energy currency, reducing power of the cell.	2
2.	**Carbohydrate Metabolism** Glycolysis - a universal pathway, reactions of glycolysis, fermentation, fates of pyruvate, feeder pathways for glycolysis, galactosemia. Gluconeogenesis and pentose phosphate pathway. Synthesis of glucose from non-carbohydrate sources, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway and its importance. Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases. Production of acetyl CoA, reactions of citric acid cycle, anaplerotic reactions, amphibolic role, regulation of citric acid cycle, glyoxalate pathway, coordinated regulation of glyoxalate and citric acid pathways. Calvin cycle, regulation of calvin cycle, regulated synthesis of starch and sucrose, photorespiration, C4 and CAM pathways, synthesis of cell wall polysaccharides, integration of carbohydrate metabolism in plant cell.	10

3.	**Fatty acid Metabolism** Digestion, mobilisation and transport of cholesterol and triacyl glycerols, fatty acid transport to mitochondria, β oxidation of saturated, unsaturated, odd and even numbered and branched chain fatty acids, regulation of fatty acid oxidation, peroxisomal oxidation, ω oxidation, ketone bodies metabolism, ketoacidosis. Fatty acid synthase complex. Synthesis of saturated, unsaturated, odd and even chain fatty acids and regulation. Synthesis of prostagladins, leukotrienes and thromboxanes. Synthesis of cholesterol, regulation of cholesterol synthesis. Synthesis of steroids and isoprenoids. Synthesis of membrane phospholipids in prokaryotes and eukaryotes, respiratory distress 17 syndrome, biosynthesis of triacylglycerol, biosynthesis of plasmalogens, sphingolipids and glycolipids, lipid storage diseases.	**11**
4.	**Amino acid and protein metabolism** Nitrogen cycle, incorporation of ammonia into biomolecules. Metabolic fates of amino groups. Digestion and absorption of dietary proteins. Protein calorie malnutrition - Kwashiorkar and Marasmus. Nitrogen balance, transamination, role of pyridoxal phosphate, glucose-alanine cycle, Kreb's bicycle, urea cycle and inherited defects of urea cycle. Catabolic pathways of individual amino acids. Glucogenic and ketogenic amino acids. Metabolism of one carbon units. Disorders of amino acids metabolism, phenylketonuria, alkaptonuria, maple syrup urine disease, methylmalonic acidemia (MMA), homocystinuria and Hartnup's disease. Overview of amino acid synthesis. Biosynthesis of non-essential amino acids and its regulation. Biosynthesis of creatine and creatinine, polyamines (putresine, spermine, spermidine), catecholamines (dopamine, epinephrine, norepinephrine) and neurotransmitters (serotonin, GABA). Porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.	**12**
5.	**Nucleotide metabolism** Biosynthesis of purine and pyrimidine nucleotides No. of Hours: 8 De novo synthesis of purine and pyrimidine nucleotides, regulation and salvage pathways. Biosynthesis of deoxyribonucleotides and its regulation, conversion to triphosphates, biosynthesis of coenzyme nucleotides. Digestion of nucleic acids, degradation of purine and pyrimidine nucleotides. Inhibitors of nucleotide metabolism. Disorders of purine and pyrimidine metabolism – Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency.	**5**
6.	**Integrated Metabolism** Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways), tissue specific metabolism (brain, muscle, and liver).	**5**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- The students will be able to know the importance of metabolism, energy generation and requirement in living cell
- Students will be able to understand the problems in metabolic activity which leads to complications in cell.

E. Recommended study materials

- Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
- Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4 / BRV ISBN: 978-0-470- 60152-5.
- Biochemistry (2010) 4th ed., Garret, R. H. and Grisham, C.M., Cengage Learning (Boston), ISBN-13:978-0-495-11464-2.
- Principles of Biochemistry (2008) 3rd ed., Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons, Inc. (New York), ISBN:13: 978-0470-23396-2
- Human Biochemistry by James.M.Orten & Oho.W.Neuhaus
- Biochemistry by Lubert Stryer
- Brock biology of microorganism by MT Madigan and JM Martinko

B.Sc. Semester IV

Detailed Syllabus

BS405 Immunology

Credits (Theory): 03 **Semester IV**
Credit Hours: 45

A. Objectives of the course

- To know the historical background of the development of immunology
- Understand immune system, identify the major cellular and tissue components which comprise the innate and adaptive immune system e.g. antigens, antibodies
- Develop a basic understanding of fundamental immunological processes.
- Learn how highly variable lymphocyte receptors are generated from a limited amount of genetic information.
- Acquire a basic understanding of the fundamental of the Major Histocompatibility Complex
- Understand the processes of hypersensitivity, autoimmunity and immunity against tumours
- Know the immunity against infections and principles and practice of immunization

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to immune system**	10
2.	**Immune response-I**	10
3.	**Immune response-II**	10
4.	**Immunity to infection and Autoimmunity**	10
5.	**Vaccines, Vaccination and immunodiagnostics**	05

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to immune system** An overview, components of mammalian immune system, molecular structure of Immunoglobulins	10
2.	**Immune response-I** Humoral and Cellular immune responses, T lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination.	10

3.	**Immune response-II** Regulation of immunoglobulin gene expression – clonal selection theory, allotypes and idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity. Major Histocompatibility complexes – class I & class II MHC antigens, antigen processing.	**10**
4.	**Immunity to infection and Autoimmunity** pathogenic attributes of microorganisms, principles of epidemiology, immunity to different organisms, pathogen defense strategies, avoidance of recognition. Autoimmune diseases, Immunodeficiency-AIDS.	**10**
5.	**Vaccines, Vaccination and immunodiagnostics** adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics – RIA, ELISA.	**05**

D. Instructional Methods and Pedagogy

- The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations.
- The topics will taught using numerical problems, case studies, simulations, animations
- Interactive problem solving sessions will be also conducted on regular basis.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Internal exams, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.
- Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self-study.

E. Student learning outcomes

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

- understand the functioning of immune system and immune processes, its disorders and use in immunization against infectious diseases.

F. Recommended Study Materials

- Basic Immunology: Functions and Disorders of the Immune System by Abbas, Lichtman and Shiv Pillai
- Kuby Immunology by Kindt, Goldsby and Osborne, 7th Edition, Mac Millan Education
- Textbook of Immunology. A. Basir. Phi Learning Private Limited (2012)
- Immunology by Raj Khanna. Oxford University Press
- Immunology by Kuby

- How the immune system works. Lauren Sompayrac. Wiley Blackwell
- A text book of immunology and immunotechnology by Annaduri. S Chand and Co, New Delhi (2010)
- Basic Immunology: functions and disorders of the immune system. Abu Abbas, Andrew Lichtman and Shiv Pillai. Elsevier
- The elements of Immunology by Fahim Ali Khan
- Immunology-Introductory textbook by Nandini Shetty, Wiley Eastern Limited
- Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6 th
- edition Saunders Publication, Philadelphia.
- Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th
- edition Wiley-Blackwell Scientific Publication, Oxford.
- Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H.
- Freeman and Company, New York.
- Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland
- Science Publishers, New York.
- Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition
- Churchill Livingstone Publishers, Edinberg.
- Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication

BS406 Genetic Engineering

Semester IV

Credits (Theory): 03
Credit Hours: 45

A. Objectives of the course

- To gain a thorough understanding of the basic principles of molecular biology. To understand the tools of DNA technology.
- To be able to read and interpret scientific papers.
- To design approaches to addressing questions in molecular biology and to interpret experimental data in molecular biology.
- To become proficient with a number of advanced and basic tools in molecular biology
- To interpret and design experiments.
- To keep a laboratory notebook, to gain the confidence and skills necessary to be able to attempt new laboratory procedures and troubleshoot their implementation.
- To be competitive for employment in an introductory laboratory research position.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Principle, Tools and Concept of Gene Cloning**	15
2.	**Cloning Vectors and Host Strains**	15
3.	**Methods of Gene Manipulation and Selection of Clones**	08
4.	**Applications of Genetic Engineering**	07

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Principle, Tools and Concept of Gene Cloning** Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, Electroporation, Ultrasonication, Principle and applications of Polymerase chain reaction (PCR), primer-design, and RT-(Reverse transcription) PCR	15
2.	**Cloning Vectors and Host Strains** Plasmid based vectors, Phage based vectors, Cosmids, Phagemids, BACs and yeast based vectors. Salient features of Host strains	15
3.	**Methods of Gene Manipulation and Selection of Clones**	08

	Screening and selection of clones, Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis,Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two)	
4.	**Applications of Genetic Engineering** Genetic engineering in plants: Use of Agrobacterium tumefaciens and A. rhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors. Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each).	**07**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

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

- describe various theoretical models of the creative process.
- Identify and interact with creative pockets in the community to continue to re-energize their skills.
- Develop understanding about the molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes
- Gain basic concepts of synthetic biology and its applications
- Interpret and critique data from primary research articles.

F. Recommended Study Materials

- Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
- Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.
- Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington
- Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
- Sambrook J, Fritsch EF and Maniatis T. (2001). Molecular Cloning-A Laboratory Manual. 3rdedition. Cold Spring Harbor Laboratory Press.

BT405 Plant Biotechnology

Credits (Theory): 03 **Semester IV**
Credit Hours: 45

A. Objectives of the course

- To make student understand about basic techniques of plant biotechnology
- Types of plant tissue culture techniques
- Importance of plant tissue culture
- Transgenic plants
- Plant based technology and products products and its importance

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Plant biotechnology**	3
2.	**Plant tissue culture**	10
3.	**Transgenic plants**	7
4.	**Plant Based technology**	15
5.	**Plant microbe interaction**	10

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Plant biotechnology** History and development of Plant biotechnology, Scope of Plant Biotechnology and Applications of Plant Biotechnology	3
2.	**Plant tissue culture** Totipotency, Laboratory organization of Plant tissue culture, General techniques of plant tissue culture-Media Preparation, selection of explant, sterilization techniques in PTC (explant, glassware and media), Inoculation and culture conditions, Specialized techniques in plant tissue culture-callus culture, shoot culture, root culture, embryo culture, protoplast culture, somaclonal variations, ovary culture, pollen culture, somatic hybridization etc. Application of Plant tissue culture	10

3.	**Transgenic technology** Introduction, genetic manipulation of plants, Methods of gene transfer in plants, Introduction to *A. tumefaciens*, application of transgenic technology	**7**
4.	**Plant Based technology** Food technology, neutraceuticals, Plant based biofertilizers, plant based biopestiscides, Herbal technology, Plant Nanobiotechnology, Phytoremediation, Forestry – wood and timber biotechnology, Plant – herbivore interaction	**15**
5.	**Plant microbe interaction** Concept of Plant Growth Promoting microorganisms, Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation, Biocontrol of pathogens, Growth promotion by free-living bacteria	**10**

D. Instructional methods and pedagogy

- Topic will be discussed in the interactive class room sessions using black board teaching and power point presentations.
- Special interactive problem solving sessions will also be conducted.
- Course material will be provided to the students from various primary and secondary information
- Internal exam will be conducted regularly as part of continuous evaluation and students will be counseled to improve their performance

E. Student learning outcomes

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

- understand of plant tissue culture techniques
- Understand the applications of plant tissue culture and transgenic plants
- Types and importance of plant based technology

F. Recommended Study Materials

- Introduction to plant tissue culture by kalian Kumar De
- Plant tissue culture by Bhojwani and Razdan
- Plant Biotechnology by B D singh
- Plant Biotechnology by HS Chawla
- Pharmacognocy Dr C K Kokate, Nirali prakashan

MI 405 Mycology and Phycology

Credits (Theory): 3 **Semester IV**
Credit Hours: 45

A. Objectives of the course

- To enable students to understand the basic concepts in mycology
- To enable student appreciate the fungal diversity and classification
- To enable student understand the different association of fungi with algae and higher plants.
- To enable students to understand the algal diversity and classification

B. Outline of the course

Sr. No.	Title	Minimum number of hours
1.	**Basic Concepts in Mycology**	6
2.	**Fungal reproduction and classification of true fungi**	17
3.	**Fungal classification & associations**	12
4.	**Phycology**	10

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Basic Concepts in Mycology** Importance of Mycology; History, General characteristics of fungi; habitat; nutrition and growth; fungal cell ultra- structure, thallus, organization and aggregation, fungal cell- wall structure, mycotoxins.	6
2.	**Fungal reproduction and classification of true fungi** Reproduction in fungi : Asexual reproduction, Sexual reproduction, Heterokaryosis and parasexuality; Sexual compatibility, factors affecting sporulation, spore dispersal, spore dormancy and germination Fungal diversity: general characteristics, thallus organization, ecology, reproduction and life cycle of fungi belonging to the different fungal groups: ➢ *Zygomycota: Rhizopus.* ➢ *Ascomycota: Saccharomyces, Penicillium, Aspergillus* ➢ *Basidiomycota: Puccinia, Agaricus*	17
3.	**Fungal classification & associations** Fungal diversity: general characteristics, thallus organization, ecology, Life cycle of fungi belonging to the different fungal groups: ➢ *Oomycota: Phytophthora* ➢ *Deuteromycota: Fusarium, Colletotrichum,*	12

	➢ General features and typical life cycle of the *Genus Myxomycota*. Lichen Biology: Occurrence; nature of of algal and fungal association Overview of growth forms and range of thallus organization; Reproduction. Mycorrhiza: Salient features, Types, Ecological and economic significance.	
4.	**Phycology** Endosymbiont theory of algal evolution, General characteristics of algae including occurrence, thallus organization, algae cell ultra-structure, pigments, flagella, eyespot food reserves. Vegetative, asexual and sexual reproduction. Different types of life cycles in algae: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles. Detailed life cycle of Chlamydomonas and Spirogyra	**10**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Learn the basics of mycology and phycology
- Understand the fungal classification and importance of fungal association.

F. Recommended study material

- Alexopolous, C. J., Mims, C. W., Blackwell, M. Introductory Mycology. (4^{th}ed); John Wiley& Sons; 2007.
- Webster, J. and Weber, R. Introduction to Fungi. (3^{rd}ed), Cambridge University Press, Cambridge; 2007
- Kumar HD. Introductory Phycology. (2^{nd} ed) Affiliated East Western Press., New Delhi;1990

BC405 Bioenergetics

Credits (Theory): 03 **Semester IV**
Credit Hours: 45

A. Objectives of the course

- To enable the students to understand the bioenergetics principles of cell
- To understand the students to the ATP production and utilization

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to bioenergetics**	15
2.	**Oxidative Phosphorylation**	15
3.	**Photophosphorylation**	15

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to bioenergetics** Laws of thermodynamics, state functions, equilibrium constant, coupled reactions, energy charge, ATP cycle, phosphorylation potential, phosphoryl group transfers. Chemical basis of high standard energy of hydrolysis of ATP, other phosphorylated compounds and thioesters. Redox reactions, standard redox potentials and Nernst equation. Universal electron carriers. Role of Vitamins in bioenergetics.	15
2.	**Oxidative Phosphorylation** Mitochondria. Electron transport chain - its organization and function. Inhibitors of ETC and uncouplers. Peter Mitchell's chemiosmotic hypothesis. Proton motive force. F_o F_1ATP synthase, structure and mechanism of ATP synthesis. Metabolite transporters in mitochondria. Regulation of oxidative phosphorylation. ROS production and antioxidant mechanisms. Thermogenesis. Alternative respiratory pathways in plants.	15
3.	**Photophosphorylation** General features of photophosphorylation, historical background, Hills reaction, photosynthetic pigments, light harvesting systems of plants and microbes and resonance	15

	energy transfer. Bacterial photophosphorylation in purple bacteria, Green sulfur bacteria and *Halobacterium salinarum*. Photophosphorylation in plants - structure of chloroplast, molecular architecture of Photosystem I and Photosystem II, Z-scheme of photosynthetic electron flow, oxygen evolving complex and action of herbicides. Cyclic photophosphorylation and its significance. Photo inhibition. Evolution of oxygenic photosynthesis.	

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- Understand the basic principles of Bioenergetics and enrgy flow in the living cell
- Understand the ATP production through Oxidative and Photophosphorylation

E. Recomanded study materials

- Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
- Molecular Cell Biology (2013) 7th ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., W.H. Freeman & Company (New York), ISBN:13:978-1-4641-0981-2.
- Biochemistry (2010) 4th ed., Garret, R. H. and Grisham, C.M., Cengage Learning (Boston), ISBN-13:978-0-495-11464-2.
- Principles of Biochemistry (2008) 3rd ed., Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons, Inc. (New York), ISBN:13: 978-0470-23396-2

BT406 Bioprocess Technology

Credits (Theory): 03 **Semester IV**
Credit Hours: 45

A. Objectives of the course

- To introduce to the scope and future of bioprocess technology
- To learn how microorganisms can be screened for production of metabolites and activities.
- To understand how process fluids, air and equipments can be sterilized
- To know the importance of aseptic conditions and control of contaminations
- To understand on what basis cultivation methods are decided for a particular bioprocess.
- To know the types of bioreactor configurations available and their use and operation
- To understand the role of transport processes in bioprocess
- To introduce to various methods of cultivation of microbial, plant and animal cells.
- To understand the need and methods for control of bioprocesses
- To elaborate the various methods available for recovery and purification of biotechnological products
- To appreciate the economic considerations involved in bioprocess industry

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Basics of bioprocess technology**	15
2.	**Bioreactors- design, operation and control**	13
3.	**Basics of bioprocess design**	5
4.	**Advanced cultivation methods**	8
5.	**Downstream processing of fermentation products**	4

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Basics of bioprocess technology** History, Scope and future of bioprocess technology, chemical v/s bioprocesses, stages in bioprocesses, process organisms, screening for microorganisms/activities, cultivation media, sterilization of process fluids, air and utilities, inoculum development, Cultivation methods-batch, fed-batch and continuous culture; improvement in productivity of processes, biosafety considerations in bioprocesses	15

2.	**Bioreactors- design, operation and control** Mechanically and non-mechanically agitated reactors, immobilized enzyme and cell reactors, transport phenomena in bioprocesses, aeration and mixing, aseptic operation, detection and control of contamination, control of bioprocesses: sensors and probes, importance of rheology of fermentation broths	**13**
3.	**Basics of bioprocess design** Stoichiometry and energetics of microbial growth and product formation, bioprocess kinetics, process economics	**5**
4.	**Advanced cultivation methods** Cultivation of algal, plant and animal cells, suspension cultures, comparison with cultivation of microbial cells, products of animal cell cultures, solid substrate cultivation, immobilized enzymes and cells	**8**
5.	**Downstream processing of fermentation products** Strategies to recover and purify products, purity requirements, separation of cells, insoluble products and soluble products	**4**

D. Instructional Methods and Pedagogy

- The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations.
- The topics will taught using numerical problems, case studies, simulations, animations, softwares.
- Interactive problem solving sessions will be also conducted by respective faculty members on regular basis.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Internal exams, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.
- Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self-study.
- Industrial visits/tours will be conducted for providing on-site understanding of the concepts of bioprocess engineering and technology gained during the theory and practical sessions.
- Mini-projects and/or dissertation project in the subject area of bioprocess technology will be carried out.

E. Student learning outcomes

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

- be introduced to the scope and future of bioprocess technology
- learn how microorganisms can be screened for production of metabolites and activities.
- understand how process fluids, air and equipments can be sterilized
- know the importance of aseptic conditions and control of contaminations
- understand on what basis cultivation methods are decided for a particular bioprocess.
- know the types of bioreactor configurations available and their use and operation
- understand the role of transport processes in bioprocess

- introduce to various methods of cultivation of microbial, plant and animal cells.
- understand the need and methods for control of bioprocesses
- know to elaborate the various methods available for recovery and purification of biotechnological products
- appreciate the economic considerations involved in bioprocess industry

F. Recommended Study Materials

- Principles of Fermentation Technology By F. Stanbury
- Industrial Microbiology By Casida Jr.
- An introduction to industrial microbiology by P K Shivakumar, M M Joe and K Sukesh
- Introduction to biochemical Engineering by D G Rao
- Biochemical engineering by Aiba, Humphrey and Millis
- Bioprocess Engineering by Shuler and Kargi
- Algal Bioprocess Technology By Lele and Kumar
- Comprehensive Biotechnology volume I, II, III and IV By Moo Young
- Manual of Industrial Microbiology and Biotechnology Davies, Arnold L. Demain
- Fermentation Microbiology and Biotechnology By El-Mansi
- Bioprocess engineering principles By P. Doran
- Process Biotechnology By S. N. Mukhopadhyay
- Bioprocess Engineering: System, Equipment And Facilites, (English) By Lyderson. Wiley India Pvt Ltd.
- Bioprocess Engineering by Biswajit Mukherjee, 2013 Black Prints
- Bioprocess Engineering by Liu
- Bioprocess Engineering: An introductory Engineering and Life Science Approach By K G Clarke
- Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited
- Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi

MI406 Microbial Physiology

Credits (Theory): 03 **Semester IV**
Credit Hours: 45

A. Objectives of the course

- To understand the unique physiological functioning of microbial cells
- To understand the behaviour of microbes under stress conditions and to learn the mechanism used by microbes to combat the stress
- To understand the cell division in gram negative as well as gram positive bacteria

B. Outline of the course

Sr. No.	Title	Minimum number of hours
1	**Bioenergetics and enzyme kinetics**	10
2	**Physiological diversity in microorganisms**	15
3	**Physiological adaptation of microbes**	08
4	**Microbial development**	12

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Bioenergetics and enzyme kinetics** Nutrition and Culture of microorganisms, Bioenergetics, Laws of thermodynamics, Concept of Gibbs's free energy, Entropy, Enthalpy, Oxidation–Reduction, Proton motive force, Energy-rich compounds, over view of enzymes and enzyme kinetics	**10**
2.	**Physiological diversity in microorganisms** Physiological diversity of microbes: Chemolithotrophy (metabolism of inorganic compounds), Autotrophy and nitrogen fixation, Fermentations, Bacterial photosynthesis (oxygenic and anoxygenic photosynthesis), Anaerobic respiration, Aerobic chemo-organotrophic processes, Unique metabolic processes of microbes – stickland reaction	**15**
3.	**Physiological adaptation of microbes** Types of stress – osmotic, oxidative, pH, thermal, radiation; survival strategies under stress, Extremophiles	**08**
4.	**Microbial development** Introduction to bacterial development-, sporulation in *Bacillus subtilis*, cell division in bacteria. Differentiation in *Caulobacteria*, *Myxobacteria* spp, Heterocyst formation	**12**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Understand the functioning of microbial cells, with respect to unique metabolic and physiological processes
- Know how the microorganisms withstand and survive under stressful environmental conditions
- Understand the mechanism of cell division and differentiation among different types of microbes

F. Recommended study materials

- Microbial physiology (4th ed.) Moat, A.G., Foster, J,W., and Spector, M. P. Wiley-Liss.New York; 2002.
- Bacterial Metabolism. (2nd ed.) Gerhardt, G. Springer, 1986.
- Lehninger's Principles of Biochemistry. (4th ed.) Nelson, D.L. & Cox, M. M. W. H. Freeman & Co. NY; 2005.
- Brock's Biology Microorganisms (14th ed.) Madigan, M.T., Martinko, J. M., Bender, K.S., Buckley, D.H., Stahl, D. A., Benjamin Cummings
- Biochemistry and Physiology of microorganisms (3rd ed.) David White. Oxford University Press; 2007.
- Bacterial Physiology and Metabolism. Sokatch, J. R. Academic Press, New York: 1969.

BC406 Enzymology

Credits (Theory): 03 **Semester IV**
Credit Hours: 45

A. Objectives of the course.

- To build the fundamentals of specificity and mechanisms of enzyme catalysis
- To inculcate the practical perspective of enzymology based on the theoretical background
- To prepare a platform for understanding the advanced aspects in the subject
- To emphasize the importance of enzymes and its biochemical aspects in development of modern biosciences and related technology.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	Introduction to enzymes	8
2	Enzyme catalysis	8
3	Mechanism of enzyme action	4
4	Enzymes kinetics	8
5	Enzyme Regulation	8
6	Concepts of enzyme assay and enzyme purification	3
7	Applications of enzymes	6

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1	**Introduction to enzymes** History, Definition of enzymes, Nature of enzymes - protein and non-protein (ribozyme), differences between biocatalysts and chemical catalysts, Holoenzymes and apoenzymes, cofactors, coenzymes, prosthetic groups, metal and vitamin cofactors	8
2	**Enzyme catalysis** Basic thermodynamic principles of enzymatic reactions- collision theory, activation energy and transition state theory, reaction rates, , Catalytic power and specificity of enzymes (concept of active site), Fischer's lock and key hypothesis, Koshland's induced fit hypothesis	8
3	**Mechanism of enzyme action:** General features - proximity and orientation, strain and distortion, acid base and covalent catalysis, Metal activated enzymes and metalloenzymes	4

4	**Enzyme kinetics** Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant-unisubstrate reactions, maximum velocity, Michaelis constant, Michaelis- Menten equation, double reciprocal plot, Significance of K_M & V_{max}, turnover number, Factors influencing enzyme activity [Substrate concentration, enzyme concentration, pH, temperature, time, metal ions], Types of bi bi reactions (sequential – ordered and random, ping pong reactions)	8
5	**Enzyme Regulation** Reversible and irreversible inhibition mechanisms, feedback inhibition, regulation by covalent modification (phosphorylation), regulation by proteolytic cleavage of protein (zymogens) Isozymes: Definition and basis of difference, multienzyme complex [each based on suitable examples]	8
6	**Concepts of enzyme assay and enzyme purification:** Enzyme activity units (Katal & Specific activity), significance, Introduction to enzyme isolation and purification methods	3
7	**Applications of enzymes** Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases), enzyme immunoassay (HRPO), enzyme therapy (Streptokinase). Concept of immobilized enzymes.	6

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory, using standard protocols. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- Students will gain insight into the mechanistic aspects of enzyme action.
- Students shall gain insights into experimental aspects of enzyme activity measurements and their significance.
- Student shall be able to understand and calculate the effects of various factors that influence the enzyme efficiency.
- Student shall be well versed with a variety of important enzymes, their roles and applications.

- Students shall be able to appreciate the wide spectrum of scopes available for applying the knowledge on enzymology.

F. Recommended Study Material

- Lehninger principles of biochemistry. Lehninger, Nelson and Cox. [4^{th} ed. and above] W.H. Freeman and Company
- Biochemistry: Jeremy M. Berg, John L. Tymoczko and Lubert Stryer [5^{th} ed and above] W. H. Freeman
- Fundamentals of Enzymology by N C Price and L Stevens, Second Edition, Oxford science publications

B.Sc. Semester V

Detailed Syllabus

BS503 Bioinformatics

Credits: 02 **Semester V**
Credit hours: 30

A. Objectives of the course

- To make students understand the concept of bioinformatics
- To enable the students learn various bioinformatics tools and techniques used in research
- To provide students hand-on training on bioinformatics tools

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Bioinformatics and Biological Databases**	**04**
2.	**Bioinformatics Tools**	**07**
3.	**Structural Bioinformatics**	**09**
4.	**Molecular Phylogenetics**	**05**
5.	**Bioinformatics tools training through class activity**	**05**

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to bioinformatics and biological database** Fundamental of bioinformatics-goals, scope, applications and limitations, introduction to biological databases-primary, secondary and specialized databases, Human genome project	**04**
2.	**Bioinformatics tools** Data-mining, Sequence analysis and Structure display tools, Homology/ Similarity search tools, transcription and translation tools.	**07**
3.	**Structural bioinformatics** Protein 3D structure evaluation, visualization, comparison and classification	**09**
4.	**Molecular Phylogenetics** Introduction to molecular phylogenetics, tree topologies, methods and in brief about programs of tree constructions and evalualtion	**05**
5.	**Bioinformatics tools training through class activity** Data base searching, Restriction site analysis, primer designing, sequence alignment (BLAST, Clustal Omega), molecular graphics visualization (RasMol).	**05**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

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

- Understand bioinformatics and its importance.
- Perform scientific literature search and nucleotide and protein sequence analysis.
- Understand the methods and programs used for 3D structure analysis of proteins.
- Understand molecular phylogenetics and learn the use of DNA or protein sequences in developing evolutionary relationship.

F. Suggested study materials

Essential Bioinformatics by Jin Xiong, Cambridge University Press, 2006

- Bioinformatics-An introduction, J.J.Ramsden, Springer, 2009.
- Introduction to bioinformatics by A. Lesk, Oxford University Press, 2008.
- Bioinformatics Methods And Applications: : Genomics Proteomics and Drug
- Discovery by SC Rastogi, Mendiratta and P Rastogi, 4th Ed. PHI Learning 2013
- A practical guide to the analysis of genes and proteins by Andreas Baxevanis and Francis Ouellette, Wiley Interscience, 2nd Ed. 2001

BT505 Industrial Biotechnology

Credits: 03 **Semester V**
Credit hours: 45

A. Objectives of the course

To make student understand

- About scope of Industrial Biotechnology
- Regulations in BT industries
- Biotechnology products and processes

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction and scope of Industrial Biotechnology**	10
2.	**Regulations in biotechnology industries**	3
3.	**Biotechnology products-I**	15
4.	**Biotechnology products-II**	7
5.	**Biotechnology based processes**	10

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction and scope of Industrial Biotechnology** Brief History of Industrial Biotechnology, Types of BT industries and their location-site selection, Society and IBT, Scope of IBT, Examples of products and processes	10
2.	**Regulations in biotechnology industries** GMP, Safety norms, Norms for construction, overview of QC and QA	3
3.	**Biotechnology Products-I** Organic acid (Citric/Lactic), Alcohol (Ethanol), Antibiotics (Penicillin/Cephalosporin), Biofertilizer (Azotobacter), Mushroom, Vitamin (B12)	15
4.	**Biotechnology Products-II** Insulin, Mycorhizzae, Pigments, vaccines, sweeteners, drugs	7
5.	**Biotechnology based Processes** Biogas production, Microbial leaching, MEOR, Biohydrogen, Biofuel	10

D

D. Instructional methodology and Pedagogy

Topic will be discussed in the interactive class room sessions using black board teaching and power point presentations. Special interactive problem solving sessions will also be conducted. Course material will be provided to the students from various primary and secondary information. Internal exam will be conducted regularly as part of continuous evaluation and students will be counseled to improve their performance

E. Student learning outcomes

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

- understand of scope of Biotech industries, types of BT industries, Products and processes of Biotechnology industries

F. Recommended Study Materials

B. Basic Industrial Biotechnology by S M Reddy, S Ram Reddy, G Narendra Babu. New Age International Publisher

C. Industrial Biotechnology by PR Yadav and Rajiv Tyagi (2005) Discovery publishing house

D. Plant Product Biotechnology by PR Yadav and Rajiv Tyagi Discovery publishing house

E. Crop Biotechnology by PR Yadav (2006) Discovery publishing house

F. Industrial Microbiology, L E Casida (2007), New Age International Ltd

MI505 Food and Dairy Microbiology

Credits: 03 **Semester V**
Credit Hours: 45

A. Objectives of the course

- To develop insights into different types of foods and fermented foods
- To enable the students to understand food spoilage and its control mechanisms
- To enable the students to understand the concept of dairy microbiology

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Microbiology of Food and Food preservation**	10
2.	**Fermented Foods, Beverages and Dairy products**	12
3.	**Food spoilage and food poisoning**	13
4.	**Food sanitization, control and inspection**	10

C. Detailed Syllabus

Sr. No.	Title	Hours
1.	**Microbiology of Food and Food preservation** Significance of micro-organisms in food, microbiological examination of foods, microorganisms in fresh foods, foods produced by micro-organisms, principles of food preservation	10
2.	**Fermented Foods, Beverages and Dairy products** Fermented foods: dosa, sauerkraut, soy sauce and tampeh; Composition of Milk, Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market, Beverages and fermentation process: wine and beer	12
3.	**Food spoilage and food poisoning** Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins; Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, *Salmonellosis*, *Shigellosis*, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*	13
4.	**Food sanitization, control and inspection** Microbiology in Food Sanitation, Food control, International Microbiological Specifications, HACCP, Cultural and rapid detection methods of food borne pathogens in foods and introduction to Predictive Microbiology, Dye reduction test	10

	– MBRT and Resazurin Test, Total bacterial count, Brucella ring test and test for mastitis, Pasteurization of milk, Methods of pasteurization – LHT, HTST, UHT, tests for determination of efficiency of pasteurization, spoilage of milk	

D. Instructional methodology and Pedagogy

Topic will be discussed in the interactive class room sessions using black board teaching and power point presentations. Special interactive problem solving sessions will also be conducted. Course material will be provided to the students from various primary and secondary information. Internal exam will be conducted regularly as part of continuous evaluation and students will be counseled to improve their performance

E. Student Learning Outcomes

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

- Understand the principles and techniques of food preservation and food handling
- Imbibe the concepts of food spoilage and food poisoning and its control
- To understand the methods used for milk pasteurization and other dairy products
- Understand the need for food inspection and advanced packaging technologies in food and dairy industries

F. Recommended Study Materials

- Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
- Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
- Frazier WC and Westhoff DC. (2005). Food Microbiology. 5th edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
- Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
- Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
- Lund BM, Baird Parker AC, and Gould GW. (2000). The Microbiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication, Gaithersberg, MD
- Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education

BC505 Human physiology

Credits: 03 **Semester V**
Credit Hours: 45

B. Objectives of the course

- To enable the students to learn or to know the biological, physiological activities along with the mechanism of action of various organs
- To impart understanding of functioning of various systems in human body
- To clear the basic concepts of physiology
- To make the students understand how different systems in body coordinate to make the human body work

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	**Blood and body buffers**	8
2	**Digestive System**	7
3	**Respiratory System**	7
4	**Excretory system.**	7
5	**Reproductive physiology**	8
6	**Nervous System**	8

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Blood and Body buffers** Composition and function, Red blood cells, Hemoglobin, white blood cells and platelets. Blood coagulation, blood groups and blood transfusion. Body buffers.	8
2.	**Digestive system** Secretion of digestive juices, digestion and absorption of carbohydrates, proteins and fats. Gastro intestinal hormones.	7
3.	**Respiratory system** Diffusion of gases in lungs, transport of oxygen from lungs to tissues through blood, factors influencing the transport of oxygen. Transport of CO_2 from tissues to lungs through blood, factors influencing the transport of CO_2.	7
4.	**Excretory System** Mechanism of formation of urine, composition of urine, Micturition. Renal regulation of acid balance, hormone of the kidney.	7

5.	**Reproductive physiology** Sex determination and differentiation. Development of female and male genital tracts. Spermatogenesis, capacitation and transport of sperm, blood testis barrier. Ovarian function and its control. Uterine changes, fertilization and implantation. Placenta as a feto- maternal unit, gestation and parturition.	8
6.	**Nervous System** Organization of the Nervous System, Basic function of synapses, and neurotransmitters, Sensory receptors, Neuronal circuits for processing information, The chemical senses.	8

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Understood clearly on major systems of human body Students will be able to understand the roles of these biological molecules inliving cells.
- Learnt more specific on the digestive, respiratory, excretory and nervous systems.
- Learnt the body fluids and its composition

F. Recommended Study Material

- Text-book of Biochemistry with clinical correlations by Thomas M. Devlin, 2nd Edition, J. Wiley and Sons (1986).
- Human Physiology by C.C. Chatterjee.
- Textbook of Medical Physiology by Guyton. A.C., H. Sanders Philadelphia. 1988.
- Vander's Human Physiology (2008) 11th ed., Widmaier, E.P., Raff, H. and Strang, K.T., McGraw Hill International Publications (New York), ISBN: 978-0-07-128366-3.
- Harper's Biochemistry (2012) 29th ed., Murray, R.K., Granner, D.K., Mayes and P.A., Rodwell, V.W., Lange Medical Books/McGraw Hill. ISBN:978-0-07-176-576-3.

BT506 Animal Biotechnology

Credits: 03 **Semester V**
Credit Hours: 45

A. Objectives of the course

- To make students understand the concepts and applications of animal biotechnology and genetically engineered animals
- To train students on theoretical and practical aspects of animal cell culture.
- To familiarize students with the concept of In-vitro fertilization, embryo transfer , cryopreservation and artificial insemination
- To provide overview of marine biotechnology and the importance of economically important animals

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Animal Biotechnology**	03
2.	**Animal Cell Culture Technology**	05
3.	**In-vitro Fertilization and Embryo Transfer**	10
4.	**Cryopreservation and Artificial Insemination**	10
5.	**Transgenic Animals**	07
6.	**Marine Biotechnology and Economically Important Livestock**	10

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Animal Biotechnology** Overview of animal biotechnology, its scope, applications, opportunities and challenges	**03**
2.	**Animal Cell Culture Technology** Basics of cell culture technology and its applications, sterilization methods and equipments used in animal tissue culture	**05**
3.	**In-vitro Fertilization and Embryo Transfer** Principle, procedure and applications of IVF, embryo transfer in cattle, applications of embryo transfer technology	**10**
4.	**Cryopreservation and Artificial Insemination** Principle and procedure of cryopreservation, different methods and importance of cryopreservation, methods of artificial insemination (AI),	**10**

	advantages and disadvantages of AI	
5.	**Transgenic Animals** Introduction to transgenic animals and transgenic technology, strategies used for gene transfer, applications of transgenic animals, animals ethics	**07**
6.	**Marine Biotechnology and Economically Important Livestock** Overview of marine biotechnology, therapeutic and other useful compounds obtained from marine resources, economically important animals, their uses and intervention of animal biotechnology	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

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

- Understand the importance of animals biotechnology its goals and application and
- limitations
- Imbibe the basic understanding of animal cell culture, cryopreservation, artificial insemination and embryo transfer techniques used in animal biotechnology
- Gain knowledge that how transgenic animals are produced and what are their applications
- Gain knowledge on marine biotechnology and various economically important animals and the involvement of animal biotechnology in their development.

F. Recommended study materials

- Principles of Gene Manipulation and Genomics by SB Primrose and RM Twyman,7th Ed., Blackwell Publishing, 2006
- Biotechnology-Expanding Horizons by BD Singh, Kalyani Publications, 2007
- Textbook of Biotechnology by HK Das, 4th Ed., Wiley India, 2010
- Textbook of Animal Biotechnology by Singh, Gautam, Chauhan and Singla, TERI Publications, 2015

MI506: Environmental Microbiology

Credit: 03 **Semester V**
Credit Hours: 45

A. Objectives of the course.

To help students to understand the

- Understand the microbial ecology of various habitats (including terrestrial, aquatic, air and extreme habitats) and microbial community structure function
- Interactions within a single microbial populations and between two microbial populations and microbial interactions between animal and plant hosts
- Roles of microorganisms in biogeochemical cycles
- Treatment of liquid and solid wastes and concepts of bioremediation

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Microorganisms and their Habitats**	08
2.	**Microbial Interactions**	09
3.	**Biogeochemical Cycling**	07
4.	**Water Potability**	07
5.	**Waste Management**	08
6.	**Microbial Bioremediation**	06

C. Detailed syllabus:

Sr. No.	Title	Minimum number of hours
1.	**Microorganisms and their Habitats** Microbial Communities, Structure and function of microbial ecosystems: Terrestrial Environment, Aquatic Environment, Aeromicroflora and dispersal of airborne microbes, Microbes associated with human body (Microbiome). Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high osmotic pressures, salinity, & low nutrient levels.	08
2.	**Microbial Interactions** Microbe-microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation Symbiotic and non-symbiotic: Plant-Microbe and Animal-Microbe interactions.	09
3.	**Biogeochemical Cycling** Role of microorganisms in Carbon cycle, Nitrogen cycle, Phosphorus cycle, Sulphur cycle, Other elemental cycles: Iron and manganese	07
4.	**Water Potability** Microbial indicators of fecal contamination of potable water. Methods to detect potability of water samples: (a) Presumptive test/MPN test,	07

	confirmed and completed tests for total and faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests. Drinking (potable) Water Treatment/Disinfection.	
5.	**Waste Management** Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment. Solid Waste management: Sources and types of solid waste, Methods of solid waste treatment and disposal (composting and sanitary landfill).	**08**
6.	**Microbial Remediation** Concepts of bioremediation and biodegradation, Overview of Xenobiotic/recalcitrant pollutants-Biomagnification, Biodegradation mechanism of specific organic pollutants. Bioremediation of heavy metals, Phytoremediation systems.	**06**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome/objective

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

- The students will be able to learn the basic concepts of microbial ecology, diversity and role of microbes in maintenance of ecological balance.
- Students will have an overview of environment microbiological applications for sustainable treatment of water pollution and solid waste management.
- Students will understand microbiological standards of water potability and learn concepts of biodegradation of recalcitrant environmental pollutants.

F. Recommended study materials

- Prescott's Microbiology (9th Edition) by Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton (2013) Publisher: McGraw-Hill.
- Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
- Encyclopedia of Environmental Microbiology, Gabriel Bitton (Editor) (2002), Publisher: Wiley
- Textbook of Environmental Microbiology (2008) by Pradipta K. Mohapatra. Publisher: I. K. International.
- Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA

- Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
- Microbiology Paperback by Michael Pelczar, E.C.S. Chain, Noel R. Kreig (2001). Publisher: McGraw Hill.
- Brock Biology of Microorganisms, 14th Edition, 2015. Publisher: Pearson
- Environmental Microbiology by RG Buckley (2015) Publisher: CBS.
- Ananthanarayan and Paniker's Textbook of Microbiology Tenth edition (2017) by Reba Kanungo (Editor). Publisher: Universities Press.

BC506 Neurochemistry

Credits (Theory): 3 **Semester-V**
Credit Hours: 45

A. Objectives of the course.

- To provide overview of the elements of neurochemistry.
- To prepare a platform for understanding of the basic biochemistry of the brain.
- To emphasize the importance of fundamental neurochemistry in brain disorders.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	Brain and behavior, Nerve cells and behavior	6
2.	Anatomical organization	8
3.	Neurotransmitters	8
4.	Receptors	8
5.	Learning and memory	8
6.	Neurological disorders	7

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**The Nervous System and Behavior**: Brain and behavior, Nerve cells and behavior	6
2.	**Anatomical organization:** Central nervous system, spinal cord, different regions of the brain, peripheral and autonomic nervous system afferent and efferent pathways.	8
3.	**Neurotransmitters:** Synthesis, storage, uptake degradation and action of neurotransmitters. Acetyl choline, GABA, Serotonin, Dopamine, Glutamate Aspartate, Nitrous Oxide etc., Neuropeptides.	8
4.	**Receptors:** Types of receptors, properties of receptors, sensory modalities and sensory circuits. Sensory perception, Cerebrospinal fluid, blood- brain barrie	8

5.	**Learning and memory:** Mechanism of short term memory and long term potentiation. NMDA and AMPA glutamate receptors. Retrograde messengers in synaptic transmission. Role of CAM kinase II, Calcium, Protein kinase, CAMP, No, Calpain and other proteins in memo	8
6.	**Neurological disorders :** Biochemistry of Schizophrenia, Autism, ADHD, Alzheimer's disease.	7

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory, using standard protocols. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Biochemical basis of neuronal cell structures
- Biochemical basis of signal transduction
- Importance of neurotransmission in signaling and function
- Neurochemical basis of neurological disorders

F. Recommended Study Materials

- Basic Neurochemistry. 8th Edition. Principles of Molecular, Cellular, and Medical Neurobiology. Editors: Scott Brady George Siegel R. Wayne Albers Donald Price.

- Neuroscience. 2nd edition. Purves D, Augustine GJ, Fitzpatrick D, et al., editors. Sunderland (MA): Sinauer Associates; 2001.

BT507 Entrepreneurship and IPR

Credits: 03 **Semester V**
Credit Hours: 45

A. Objectives of the course

- Student will have a basic idea of how a Biotech company works
- What is necessary to start a company
- What product to select
- How important is IPR for any company

B. Outline of the Course

Sr. No	Title	Minimum number of hours
1.	**Introduction to Business Biotechnology**	**10**
2.	**Strategies for business Development**	**10**
3.	**Case studies- Biotech Product based companies**	**8**
4.	**Intellectual property rights**	**7**
5.	**Regulations in Biotechnology**	**10**

C. Detailed syllabus

Sr. No	Title	Minimum number of hours
1.	**Introduction to Business Biotechnology** Scope of Business Biotechnology, Characteristics of biotechnology business, Concepts of Entrepreneurship, People involved in Bioentrepreneurship, qualities of Bioentrepreneur, product selection and development, Market survey techniques,	**10**
2.	**Strategies for Business development** business models, Business plan, raising money and generating finance for business establishment, Special government schemes for Biotech business marketing, managing people, social entrepreneurship, Corporate-social responsibility	**10**
3.	**Case studies- Biotech Product based companies** Biotech product based companies in India and Abroad- case studies, Success and failure stories of Biotech industries	**8**

4.	**Intellectual property Rights** IPR and its types, Importance of IPR protection of IPR, Plant breeder's right, Case Studies- patenting of Basmati, revocation of turmeric and neem patent	**7**
5.	**Regulations in Biotechnology** Bioethics, biosafety rules, regulatory authorities and governing bodies forming regulations, regulations for biotechnology business	**10**

D. Instructional methodology and Pedagogy

Topic will be discussed in the interactive class room sessions using black board teaching and power point presentations. Special interactive problem solving sessions will also be conducted. Course material will be provided to the students from various primary and secondary information. Internal exam will be conducted regularly as part of continuous evaluation and students will be counseled to improve their performance.

E. Student learning outcomes

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

- Student will have basic understanding of Bioentrepreneurship
- What are the needs for startups? How to manage a company?
- Types of IPR and its importance

F. Recommended Study Materials

- Ratledge, C., Kristiansen, B. (Eds.). (2001). Basic biotechnology. Cambridge University Press.
- Manual of Industrial Microbiology and Biotechnology by Demein and Davies. American Society of Microbiology press
- Hine, D., Kapeleris, J., Innovation and Entrepreneurship in Biotechnology, An International Perspective. Concepts, Theories and Cases. Edgar Elgar Publishing Limited. ISBN-10:1 84376 584 5 (2006)
- Dobers, P., Wikader, S., Bionova: Building a Biotech Company. Student literature. ISBN: 9144037767 (2004)
- David B. Resnik, The Ethics of Science: An Introduction (1998), Routledge Publication, UK
- Ganguli Prabuddh, Intellectual Property Rights (2001), Tata McGraw-Hill Publishing Company Ltd., Delhi

MI 507 Plant Pathology

Credits: 03 **Semester: V**
Credit hours: 45

A. Objectives of the course.

- To make students understand the concept of plant pathology
- To enable the students learn about plant pathogens, plant defense mechanisms.
- To enable the students learn about different approach to control plant disease.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Plant pathology**	**06**
2.	**Plant pathogenesis**	**09**
3.	**Characteristics of Plant Pathogens and plant diseases**	**12**
4.	**Plant defence mechanisms**	**09**
5.	**Control of Plant Diseases**	**09**

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Plant pathology** History, principles, classification and significance of plant diseases; economic losses and social impact of plant diseases.	**06**
2.	**Plant pathogenesis** Infection, infection process or disease development, virulence factors-enzymes, toxins, *Avr* gene proteins and R gene proteins. Physiological, cellular and molecular changes in diseased plant, environment and nutrition in relation to disease development.	**09**
3.	**Characteristics of Plant Pathogens and plant diseases** Morphology, nutrition, and classification of plant pathogenic fungi, bacteria, viruses and other causal agents (protozoa, viriods, nematodes). Types, symptoms and pathogenesis of major plant diseases.	**12**
4.	**Plant defence mechanisms** Concepts of constitutive defense mechanisms in plants, inducible structural defenses (histologicalcork layer, abscission layer, tyloses, gums), inducible biochemical defenses [hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones, oxidative bursts].	**09**
5.	**Control of Plant Diseases** Principles and methods of plant disease control, Biotechnological approach to control plant diseases. Post-harvest diseases-control measures.	**09**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

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

- Understand about plant disease impact on plant productivity.
- Identify plant disease and its causing organisms.
- Understand the methods and programs used for the controlling of plant disease.

F. Recommended study materials

- Fundamentals of Plant Pathology By V.N Pathak
- A text book of Plant Pathology by A.V.S.S. Sambamurty
- Plant Pathology by Agrios. G. N. (Elsevier academic press).

BC507 Nutritional Biochemistry

Credits: 3 **Semester V**

Credit Hours: 45

A. Objectives of the course.

- To build the fundamentals of nutrition and energy metabolism.
- To inculcate the practical perspective of human nutrition based on the theoretical background
- To prepare a platform for understanding the advanced aspects in the subject
- To emphasize the importance of nutritional biochemistry and its biochemical aspects in development of modern biosciences and related technology.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	**Introduction to Nutrition and Energy Metabolism**	7
2	**Dietary carbohydrates and health**	6
3	**Dietary lipid and health**	6
4	**Dietary Proteins and health**	6
5	**Fat and water soluble Vitamins**	6
6	**Minerals**	8
7	**Assessment of Nutritional status**	3
8	**Food and drug interactions and Nutraceuticals**	3

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1	**Introduction to Nutrition and Energy Metabolism** Defining Nutrition, role of nutrients. Unit of energy, Biological oxidation of foodstuff. measurement of energy content of food, Physiological energy value of foods, SDA. Measurement of energy expenditure. Direct and Indirect Calorimetry, factors affecting thermogenesis, factors affecting energy input - hunger, appetite, energy balance Energy expenditure in man. Estimating energy requirements, Recommended Dietary Allowances for different age groups.	7
2	**Dietary carbohydrates and health** Review functions of carbohydrates. Digestion, absorption ,utilization and storage, hormonal regulation of blood glucose. Dietary requirements and source of carbohydrates, Dietary fiber, role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.	6
3	**Dietary lipid and health** Review of classification, sources, functions, digestion, absorption, utilization and storage. Essential Fatty Acids; Functions of EFA, RDA, – excess and deficiency of EFA. Lipotropic factors, role of saturated	6

	fat, cholesterol, lipoprotein and triglycerides. Importance of the following: a) Omega – fatty acids. Omega 3/ omega 6 ratio b) Phospholipids c) Cholesterol in the body d) Mono, Polyunsaturated and Saturated Fatty Acids. Dietary implications of fats and oils	
4	**Dietary Proteins and health** Review of functions of proteins in the body, Digestion and absorption. Essential and Non-essential amino acids. Amino Acid Availability Antagonism, Toxicity and Imbalance, Amino acid Supplementation. Effects of deficiency. Food source and Recommended Dietary Allowances for different age group. Amino acid pool. NPU, Biological Value , Nitrogen balance. PEM and Kwashiorkor.	6
5	**Fat and water soluble Vitamins** Vitamin A, C, E, K and D Dietary sources, RDA, Adsorption, Distribution, Metabolism and Excretion (ADME), Deficiency diseases; Dietary source, RDA, absorption, metabolic role Biochemical basis for deficiency symptoms.	6
6	**Minerals** Calcium, Phosphorus and Iron - Distribution in the body digestion, Absorption, Utilization , Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA. Calcium: Phosphorus ratio, Role of iron in prevention of anemia. Iodine and iodine cycle. Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Molybdenum Distribution in the human body, Physiology, Function, deficiency, Toxicity and Sources.	8
7	**Assessment of Nutritional status** Anthropometric measurements; Z scores, BMI, Biochemical assessment; Basal metabolic panel, Comprehensive metabolic panel, Urine Analysis, Assessment of Anemia, ROS assessment, Differential diagnosis of B12 and folate.	3
8	**Food and drug interactions and Nutriceuticals** Nutrient interactions affecting ADME of drugs, Alcohol and nutrient deficiency, Anti-depressants, psychoactive drugs and nutrient interactions, Appetite changes with drug intakes and malnutrition. Food as medicine.	3

F. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory, using standard protocols. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- Students will gain insight into the mechanistic aspects of nutrition and energy metabolism
- Students shall gain insights into experimental aspects of functions of Biomolecules, digestion, absorption ,utilization and storage .
- Student shall be able to understand Vitamin A, C, E,K and D Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion(ADME), Deficiency.
- Student shall be well versed with a variety of important minerals like Calcium, Phosphorus and Iron - Distribution in the body digestion, Absorption, Utilization, Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA.Students shall be able to appreciate the wide spectrum of scopes available for applying the knowledge on enzymology.
- Students will gain insight into the mechanistic aspects of Assessment of Nutritional status and also Food and drug interactions and Nutriceuticals.

F. Recommended Study Materials

- Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
- Nutrition for health, fitness and sport (2013) ; Williams.M.H,Anderson,D.E, Rawson,E.S. McGraw Hill international edition. ISBN-978-0-07-131816-7.
- Krause’s Food and Nutrition Care process.(2012); Mahan, L.K Strings,S.E, Raymond,J. Elsevier’s Publications. ISBN- 978-1-4377-2233-8.
- The vitamins, Fundamental aspects in Nutrition and Health (2008); G.F. Coombs Jr. Elsevier’s Publications. ISBN-13- 978-0-12- 183493-7.
- Principles of Nutritional Assessment (2005) Rosalind Gibson. Oxford University Press.

BE510 Bioethics and Biosafety

Credits: 03 **Semester V**

Credit Hours: 45

A. Objectives of the Course

To introduce students the concepts of biosafety and bioethics and its application in use of biotechnology for welfare of life forms

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Bioethics**	10
2.	**Basic concepts of Biosafety**	10
3.	**Biosafety in laboratory and manufacturing**	10
4.	**GMOs and LMOs**	10
5.	**Biosafety and bioethics in practice**	05

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Basic concepts of Bioethics** – Necessity of Bioethics, different paradigms of Bioethics – National & International. Ethical issues against the molecular technologies. Animal ethics, human ethics, committees for animal and human ethics, regulations for use of animals in research	10
2.	**Basic concepts of Biosafety**: Introduction; biosafety issues in biotechnology; Biosafety of Genetically Engineered Products, Biosafety Guidelines: Biosafety guidelines and regulations (National and International); Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms, health hazards concerning biotechnology.	10
3.	**Biosafety in laboratory and manufacturing-**Concept of containment level and Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP). AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions.	10

4.	**GMOs and LMOs-**GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.	**10**
5.	**Biosafety and bioethics in practice-**NGOs for Biosafety and Bioethics, Web-based Information of Biosafety on GMO, Case Studies in IPR and Biosafety	**05**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations. The topics will taught using numerical problems, case studies, simulations, animations, softwares. Interactive problem solving sessions will be also conducted by respective faculty members on regular basis. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self-study. Industrial visits/tours will be conducted for providing on-site understanding of the concepts of bioprocess engineering and technology gained during the theory and practical sessions. Mini-projects and/or dissertation project in the subject area of bioprocess technology will be carried out.

E. Student learning Outcomes

After successful completion of the course the student will be able to under the concepts of biosafety and bioethics and its application in use of biotechnology for welfare of life forms.

F. Recommended Study Materials

- Goel D and Prashar S (2013). IPR, Biosafety and Bioethics.
- Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management. Jasen Publications, Tiruchirappalli, India.
- Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
- Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers

BE511 Microbial Enzymes

Credits: 03 **Semester V**
Credit Hours: 45

A. Objectives of the course

- To develop insights into various classes of enzymes and their role
- To enable the students to understand enzyme kinetics and inhibition
- To enable the students to understand the concept of applications of microbial enzymes
- To enable the students to understand the concept of enzyme immobilizations techniques and their industrial applications

B. Outline of the Course

Sr. No.	Title	Minimum Number of hours
1.	**Enzymes – General Introduction**	07
2.	**Enzyme kinetics and inhibitions**	10
3.	**Significance and applications of enzymes**	19
4.	**Enzyme Immobilization and engineering**	09

C. Detailed Syllabus

Sr. No.	Title	Minimum Number of hours
1.	**Enzymes – General Introduction** Salient features of enzymes, Basic concepts of Cofactors and Coenzymes, Classification and Nomenclature. General overview of enzymes derived from plants, animals and microbes, Enzyme purification	07
2.	**Enzyme kinetics and inhibition**. Concepts and significance of enzyme kinetics, Michaelis menten equation, Enzyme inhibition: types-competitive, non-competitive and mixed, Allosteric enzymes, Feedback regulation	10
3.	**Significance and applications of enzymes** Enzymes from bacteria and fungi Ribozymes, restriction endonucleases, DNA polymerases used in PCR, Role of enzymes as virulence factors to spread pathogenesis, e.g. SAPs in candidiasis and HIV infections, exotoxins v/s endotoxins, toxoids Applications of proteases, amylases, cellulases, lipases and pectinase in Industry, Biofuel production, Non-aqueous Enzymology	19

4.	**Enzyme Immobilization and engineering** Concept of Cell v/s Enzyme immobilization, Techniques of Enzyme Immobilization, Operational stability, Applications of immobilized enzymes at commercial scale Over view of enzyme engineering	**09**

E. Student Learning Outcomes / objectives:

After the successful completion of the course a student will be able to understand

- the salient properties of biocatalysts and their purification
- the enzyme kinetics and inhibitions
- the significance of microbial enzymes
- the enzyme immobilization techniques for commercial viability

F. Recommended Study Materials

- Price, N.C. and Stevens, L., 1989. Fundamentals of enzymology (Vol. 205). Oxford: Oxford University Press.
- Palmer, T. and Bonner, P.L., 2007. Enzymes: biochemistry, biotechnology, clinical chemistry. Elsevier.
- Walsh, G., 2002. Proteins: biochemistry and biotechnology. John Wiley & Sons.
- Cornish-Bowden, A. and Cornish-Bowden, A., 2012. Fundamentals of enzyme kinetics.
- Fersht, A., 1999. A guide to enzyme catalysis and protein folding. Structure and mechanism in protein science, 508-539.

BE512 Management of Human Microbial Diseases

Credits: 03 **Semester V**
Credit Hours: 45

A. Objectives of the course

- To develop insights into various contagious and non-contagious infections/ diseases
- To enable the students to understand principles and methods of epidemiology
- To enable the students to understand various microbial diseases and their prevention
- To enable the students to understand the contemporary developments in vaccination and cancer biology

B. Outline of the Course

Sr. No.	Title	Minimum Number of hours
1.	**Overview of Human Diseases**	10
2.	**Epidemiology**	12
3.	**Microbial Diseases, Diagnostics and treatment**	12
4.	**Microbial diseases and societal issues**	06
5.	**Cancers**	05

C. Detailed Syllabus

Sr. No.	Title	Minimum Number of hours
1.	**Overview of Human Diseases** Outline about process of infection, Infectious and non-infectious diseases, Deficiency diseases, occupational diseases, Incubation period, mortality rate, nosocomial infections, biomedical waste disposal	10
2.	**Epidemiology** Principles and methods of Epidemiology, Air borne, water borne, Food borne and Sexually transmitted diseases. Preventive measures (mass immunization and herd immunity) and mode of action of antibiotics	12
3.	**Microbial Diseases, Diagnostics and treatment** Respiratory, gastrointestinal, Nervous system, skin, eye, urinary tract diseases, Sexually transmitted diseases. Study of recent outbreaks of human diseases (SARS/ Swine flu/Ebola) – causes, spread and control. Mosquito borne disease – Types and prevention	12
4.	**Cancers** Types, causes, prevention, detection and treatment, use of nanotechnology in cancer biology	06
5.	**Infectious diseases and societal issues** Importance of personal hygiene (Typhoid Marry), judicious use of antibiotics, emergence of antibiotic resistance	05

E. Student Learning Outcomes / objectives:
After the successful completion of the course a student will be able to:

- Understand various human microbial diseases
- Understanding of possible preventive measures during outburst of any microbial infection
- Understand significance of antibiotic resistance and antibiotic misuse
- Understand vaccination and advanced techniques in Cancer biology

F. Recommended study materials

- Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
- Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
- Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
- Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
- Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition

BE513 Agricultural Biotechnology

Credits: 03 **Semester V**
Credit hours: 45

A. Objectives of the course

To help students to understand the

- Concept of Agricultural Biotechnology
- Basics of plant breeding
- Concepts and applications of microorganisms for development of Biofertilizers, Biofungicides and Biopesticides
- About the GMO's and their implications

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Agricultural biotechnology**	5
2.	**Plant breading**	12
3.	**Biofertilizer, Biofungicides and Biopesticides**	15
4.	**Application of Genetically Modified Plants for crop improvment**	13

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Agricultural biotechnology** Introduction- Soil nutrition for the plant growth, Physical chemical properties of soil; Major Problems due to Abiotic and Biotic stress, Application Agricultural biotechnology.	5
2.	**Plant breading** Introduction to Plant Breeding, History of Plant Breeding, Conventional Plant breeding Techniques; Use of induced mutation in Plant Breeding, Molecular marker aided breeding, DNA molecular markers: Principles, type and applications (RFLP, RAPD, AFLP etc.); Marker assisted selection , IPR related to plant breeding	12
3.	**Biofertilizer, Biofungicides and Biopesticides** Concept of plant growth promoting bacteria and organic farming, Use of microorganisms as biofertilizers: Types of biofertilizers, composts, mechanisms and methods of application of biofertilizers, field performance	15

	of biofertilizers; method of application Plant diseases caused by microbes, Microorganisms used as Biofungicides and Biopesticides, quality control and Indian Standards for biofertilizers and biopesticides	
4.	**Application of Genetically Modified Plants for crop improvement** Application of plant transformation for productivity and performance- Development of Biotic and Abiotic stress resistance in plants; Delay of fruit ripening; improvement in oil quality trait etc. Molecular farming: Production of antibodies, polymers, vaccines and Bioplastics.	**13**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

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

B Elaborate on the scope of Agriculture biotechnology
- Understand the basics of plant breeding
- Know the importance of microorganisms for development of Biofertilizers, Biofungicides and Biopesticides
- Understand the implications and applications of GMO’s

F. Recommended study materials

- Plant Pathology, Mehrotra R and Aggarwal A, (2003), 2nd edn, Tata Mcgraw-Hill Publisher
- Agricultural Biotechnology (Books in Soils, Plants, and the Environment 1997 by Arie Altman
- Agricultural Microbiology by G. Rangaswami and D. Bagyaraj
- Plant Biotechnology by B D singh
- Plant Biotechnology by Hs Chawla
- Text Book of Microbiology by R.C. Dubey

BE514 Drug designing

Credits: 03 **Semester V**
Credit Hours: 45

A. Objectives of the Course

This course aims to impart knowledge of rational drug design process and various techniques used in rational drug design process.

Broad Objectives of the course is to provide basic knowledge regarding the following:

- Design and discovery of lead molecules
- The role of drug design in drug discovery process
- The concept of QSAR and docking
- Various strategies to develop new drug like molecules.
- The design of new drug molecules using molecular modeling software

B. Outline of the Course

Sr. No	Title	Minimum number of hours
1.	**Introduction to drug discovery and development**	10
2.	**Quantitative Structure Activity Relationship (QSAR)**	10
3.	**Molecular Modeling and virtual screening techniques**	10
4.	**Informatics and Methods in drug design**	10
5.	**Molecular Modeling**	05

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to drug discovery and development** Stages of drug discovery and development Lead discovery and Analog Based Drug Design Rational approaches to lead discovery based on traditional medicine, Random screening, Non-random screening, serendipitous drug discovery, lead discovery based on drug metabolism, lead discovery based on clinical observation. **Analog Based Drug Design:** Bioisosterism, Classification, Bioisosteric replacement. Any three case studies	10

2.	**Quantitative Structure Activity Relationship (QSAR)** SAR versus QSAR, History and development of QSAR, Types of physicochemical parameters, experimental and theoretical approaches for the determination of coefficient, Hammet's Hansch analysis, Free Wilson analysis, 3D-QSAR approaches like COMFA and COMSIA.	**10**
3.	**Molecular Modeling and virtual screening techniques** **Virtual Screening techniques:** Drug likeness screening, Concept of pharmacophore mapping and pharmacophore based Screening, **Molecular docking**: Rigid docking, flexible docking, manual docking, Docking based screening. *De novo* drug design	**10**
4.	**Informatics & Methods in drug design** Introduction to Bioinformatics, chemoinformatics. ADME databases, chemical, biochemical and pharmaceutical databases.	**10**
5.	**Molecular Modeling:** Introduction to molecular mechanics and quantum mechanics. Energy Minimization methods and Conformational Analysis, global conformational minima determination.	**05**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations.The topics will taught using numerical problems, case studies, simulations, animations, softwares. Interactive problem solving sessions will be also conducted by respective faculty members on regular basis. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self study. Industrial visits/tours will be conducted for providing on-site understanding of the concepts of bioprocess engineering and technology gained during the theory and practical sessions. Mini-projects and/or dissertation project in the subject area of bioprocess technology will be carried out.

E. Student learning Outcomes

Upon completion of the course, the student shall be able to understand

- Design and discovery of lead molecules
- The role of drug design in drug discovery process
- The concept of QSAR and docking
- Various strategies to develop new drug like molecules.
- The design of new drug molecules using molecular modeling software

F. Recommended Study Materials

- Robert GCK, ed., “Drug Action at the Molecular Level” University Prak Press Baltimore.
- Martin YC. “Quantitative Drug Design” Dekker, New York.
- Delgado JN, Remers WA eds “Wilson & Gisvolds’s Text Book of Organic Medicinal & Pharmaceutical Chemistry” Lippincott, New York.
- Foye WO “Principles of Medicinal chemistry ‘Lea & Febiger.
- Koro lkovas A, Burckhalter JH. “Essentials of Medicinal Chemistry” Wiley Interscience.
- Wolf ME, ed “The Basis of Medicinal Chemistry, Burger’s Medicinal Chemistry” John Wiley & Sons, New York.
- Patrick Graham, L., An Introduction to Medicinal Chemistry, Oxford University Press.
- Smith HJ, Williams H, eds, “Introduction to the principles of Drug Design” Wright Boston.

Silverman R.B. “The organic Chemistry of Drug Design and Drug Action” Academic Press New York

B.Sc. Semester VI

Detailed Syllabus

BT605 Omics and Synthetic Biology

Credits (Theory): 03 **Semester VI**
Credit Hours: 45

A. Objectives of the course

- To keep a laboratory notebook, to gain the confidence and skills necessary to be able to attempt new laboratory procedures and troubleshoot their implementation.
- To be competitive for employment in an introductory laboratory research position. describe how naturally occurring organisms regulate the expression of their genes
- describe how biotechnology can alter regulation of the genes
- describe how biotechnology can alter the properties of the cell
- explain, evaluate and report on practical applications of synthetic biology
- plan and carry out a laboratory project aimed at creating replicating systems with new properties that can be regulated

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Genomics**	20
2.	**Introduction to Proteomics**	15
3.	**Concept of Synthetic Biology**	10

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Genomics** Introduction to Genomics, DNA sequencing methods – manual & automated: Maxam & Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods, Computer tools for sequencing projects: Genome sequence assembly software, Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organisms' Genomes and Databases	20
2.	**Introduction to Proteomics** Introduction to protein structure, Chemical properties of proteins. Physical interactions that determine the property of	15

	proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bond, Native page, 2D page, De novo sequencing using Mass spectrophotometric data.	
3.	**Concept of Synthetic Biology** Overview of Synthetic Biology, Principles and limitations, programming living bacteria, engineered riboswitches	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

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

- Describe various theoretical models of the creative process.
- Identify and interact with creative pockets in the community to continue to re-energize their skills.
- Gain basic concepts of synthetic biology and its applications
- Interpret and critique data from primary research articles.

F. Recommended study materials

- Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
- Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
- Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
- Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III,1989.
- Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and SonsInc.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
- Russell, P. J. (2009). *i*Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
- Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
- Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons.

MI609 Medical Microbiology

Credits: 03 **Credit Hours: 45**

A. Objectives of the course

- To introduce the concepts of medical microbiology
- To enable the students to understand the interactions of human body and microorganisms
- To enable the students to understand the control mechanisms of pathogens and diseases

B. Outline of the Course

Sr. No.	Title of Unit	Minimum Number of Hours
1	**Microorganisms and human body**	08
2	**Bacterial diseases and their control**	15
3	**Viral diseases and their control**	15
4	**Protozoal, fungal and other vector borne diseases**	07

C. Detailed Syllabus

Sr. No.	Unit	Hours
1	**Microorganisms and human body** Normal flora of human body - Skin, throat, gastrointestinal tract, urogenital tract; host pathogen interactions; Fundamentals of Epidemiology Process of infection, Generalized v/s Localized infection, Primary v/s Secondary infection, Opportunistic infections, Nosocomial infections, Invasion, Virulence factors, exotoxins and endotoxins, Bacteremia, Septicemia, shock, LD_{50} and MLD	08
2	**Bacterial diseases and their control** Enteric pathogens – *Vibrio cholerae*, *Salmonella*, *Shigella*, *E. coli* -diabetic ulcers: Extracellular pathogens –*Staphylococcus*, *Streptococcus*; *Yersinia*; Intracellular pathogens – *Bacillus*, *Clostridium*, *Mycobacterium*, *Chlamydia*, *Actinomyces*, *Rickettsia*, *Nisserria*, *Bordatella*, *Brusella*, Sexually transmitted diseases–Gonorrhea, Syphilis	15
3	**Viral diseases and their control** Viral diseases transmitted via air: Influenza, Rhinovirus, SARS; Viral diseases of childhood: Polio, Rotaviruses, Measles, Mumps; Viruses transmitted via food or water: Hepatitis A; Other viruses - Herpes virus, Rabies virus, Oncogenic viruses; Human immunodeficiency virus: AIDS	15
4	**Protozoal, fungal and other vector borne diseases** Protozoal diseases - Malaria, Leishmaniasis, Dysentery, Fungal infections- *Microsporum*, *Trichophyton*, Tripanosomias, Epidermophyton- Madura mycosis; *Candida albicans*, *Aspergillus*, *Mucor*; Fungal infections in AIDS Other vector borne diseases	07

E. Student Learning Outcomes / objectives:

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

- Understand the microbial world and its harmful impact on human society
- Understand various types of microbial infections, virulence factors and spread
- Understand the control mechanisms and preventive approaches for various diseases

F. Recommended Study materials

1. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication
2. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication
3. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier
4. 4. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition Appleton-Century-Crofts publication
5. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education

BC609 Hormones: Biochemistry and Functions

Semester VI

Credits (Theory): 03
Credit Hours: 45

A. Objectives of the course.

- To build the fundamentals of hormones and their regulation.
- To inculcate the practical perspective of different types of hormones based on the theoretical background
- To prepare a platform for understanding the advanced aspects in the subject
- To emphasize the importance of hormone mediated signaling and its biochemical aspects in development of modern biosciences and related technology.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	Introduction to endocrinology	5
2	Hormone mediated signaling	12
3	Hypothalamic and pituitary hormones	6
4	Thyroid hormone	4
5	Hormones regulating Ca^{2+} homeostasis	4
6	Pancreatic and GI tract hormones	4
7	Hormones of adrenals	4
8	Reproductive hormones	4
9	Growth factors	2

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1	**Introduction to endocrinology** Functions of hormones and their regulation. Chemical signalling - endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms. Chemical classification of hormones, transport of hormones in the circulation and their half-lives. Hormone therapy. General introduction to Endocrine methodology.	5
2	**Hormone mediated signalling** Hormone receptors - extracellular and intracellular. Receptor - hormone binding, Scatchard analysis. G protein coupled receptors, G proteins, second messengers - cAMP, cGMP, IP3, DAG, Ca^{2+}, NO. Effector	12

	systems - adenyl cyclase, guanyl cyclase, PDE, PLC. Protein kinases (PKA, PKB, PKC, PKG). Receptor tyrosine kinases - EGF, insulin, erythropoietin receptor; ras - MAP kinase cascade, JAK - STAT pathway. Steroid hormone/ thyroid hormone receptor mediated gene regulation. Receptor regulation and cross talk.	
3	**Hypothalamic and pituitary hormones** Hypothalamic - pituitary axis. Study the physiological and biochemical actions of hypothalamic hormones, pituitary hormones - GH, prolactin, TSH, LH, FSH, POMC peptide family, oxytocin and vasopressin, feedback regulation cycle. Endocrine disorders - gigantism, acromegaly, dwarfs, pigmies and diabetes insipidus.	6
4	**Thyroid hormone** Thyroid gland. Biosynthesis of thyroid hormone and its regulation; its physiological and biochemical action. Pathophysiology - Goiter, Graves disease, cretinism, myxedema, Hashimato's disease.	4
5	**Hormones regulating Ca^{2+} homeostasis** PTH, Vitamin D and calcitonin. Mechanism of Ca^{2+} regulation and pathways involving bone, skin, liver, gut and kidneys. Pathophysiology - rickets, osteomalacia, osteoporosis.	4
6	**Pancreatic and GI tract hormones** Regulation of release of insulin, glucagon, gastrin, secretin, CCK, GIP, adipolectin, leptin and ghrelin. Summary of hormone metabolite control of GI function. Physiological and biochemical action. Pathophysiology - diabetes type I and type II.	4
7	**Hormones of adrenals** Aldosterone, renin angiotensin system, cortisol, epinephrine and norepinephrine. Fight or flight response, stress response. Pathophysiology – Addison's disease, Conn's syndrome, Cushing syndrome.	4
8	**Reproductive hormones** Male and female sex hormones.Interplay of hormones during reproductive cycle, pregnancy, parturition and lactation. Hormone based contraception.	4
9	**Growth factors** PDGF, EGF, IGF-II, and erythropoietin.	2

G. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory, using standard protocols. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- Students will gain insight into the mechanistic aspects of hormones and their regulation.
- Students shall gain insights into experimental aspects of functions of Hormones and how it regulates Ca^{2+} homeostasis

F. Recommended Study Material:

- Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M. W.H. Freeman & Company (NewYork), ISBN:13: 978-1-4641-0962-1 / ISBN:10-14641-0962-1.
- Vander's Human Physiology (2008) 11th ed., Widmaier, E.P., Raff, H. and Strang, K.T. McGraw Hill International Publications, ISBN: 978-0-07-128366-3.
- Endocrinology (2007) 6th ed., Hadley, M.C. and Levine, J.E. Pearson Education (New Delhi), Inc. ISBN: 978-81-317-2610-5.
- The Cell: A Molecular Approach (2009) 5th Ed. Cooper, G.M. and Hausman, R.E. ASM Press & Sunderland, (Washington DC), Sinauer Associates. (MA). ISBN:978-0-87893-300-6.

BT606 Environmental Biotechnology

Credits (Theory): 03 **Semester VI**
Credit Hours: 45

A. Objectives of the Course

- This course aims to introduce fundamentals of Environmental Biotechnology.
- The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications.
- The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Role of biotechnology in environmental protection**	10
2.	**Basic concepts of biodegradation and bioremediation**	10
3.	**Treatment of municipal waste and Industrial effluents**	10
4.	**Biotechnological processes**	6
5.	**Environmental amelioration and GMOs**	9

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Role of biotechnology in environmental protection** Conventional fuels and their environmental impact – Firewood, Plant, Animal, Water, Coal and Gas. Modern fuels and their environmental impact – Methanogenic bacteria, Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol	10
2.	**Basic concepts of biodegradation and bioremediation** Bioremediation of soil and water contaminated with oil spills, heavy metals and detergents. Degradation of lignin and cellulose using microbes. Degradation of pesticides and other toxic chemicals by micro-organisms- degradation aromatic and chlorinates hydrocarbons and petroleum products.	10
3.	**Treatment of municipal waste and Industrial effluents**. Treatment strategies for wastewater and solid wastes	10

4.	**Biotechnological processes** Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium). MEOR, biosorption, green technologies	**6**
5.	**Environmental amelioration and GMOs** Phyto-remediation. Bio-fertilizers, Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Reclamation of degraded land Algal and fungal biofertilizers (VAM) Environmental significance of genetically modified microbes, plants and animals.	**9**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching and power-point presentations. The topics will taught using numerical problems, case studies, simulations, animations, softwares. Interactive problem solving sessions will be also conducted by respective faculty members on regular basis. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams, quizzes, group discussions, critical analyses sessions will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance. Assignments will form part of the learning and evaluation process in order to motivate students for critical thinking and self-study. Industrial visits/tours will be conducted for providing on-site understanding of the concepts of bioprocess engineering and technology gained during the theory and practical sessions. Mini-projects and/or dissertation project in the subject area of bioprocess technology will be carried out.

E. Student Learning Outcomes

By the end of this course, students will be able to understand the biotechnology use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

F. Recommended Study Materials

- Environmental Science, S.C. Santra
- Environmental Biotechnology, Pradipta Kumar Mohapatra
- Environmental Biotechnology – Concepts and Applications, Hans-Joachim Jordening and Jesef Winter Waste Water Engineering, Metcalf and Eddy, Tata McGraw hill
- Agricultural Biotechnology, S.S. Purohit
- Environmental Microbiology : Methods and Protocols, Alicia L. Ragout De Spencer, JohF.T. Spencer
- Introduction to Environmental Biotechnology, Milton Wainwright
- Principles of Environmental Engineering, Gilbert Masters
- Wastewater Engineering – Metcalf & Eddy G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
- B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.

- Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
- J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.
- H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.
- H. S. Peavy, D. R. Rowe and G. Tchobanoglous, (2013), Environmental Engineering, McGraw-Hill Inc.

BS606 Advances in Microbiology

Credit: 03 **Semester VI**
Credit Hours: 45

A. Objectives of the course.

- To help students to understand:
- Concepts of microbial Genomics and genome sequencing
- Concepts of metagenomics, systems and synthetic biology
- Concepts of microbial fuel cells and their applications
- Functions of human microbiota, host-microbe interactions and significance of microbial biofilms in healthcare.
- Antimicrobial resistance and mechanisms

B. Outline of the Course

Sr. No.	Title	Minimum no. of hours
1.	**Advances in Molecular Microbiology**	18
2.	**Advances in Environmental Microbiology**	14
3.	**Host-Microbe Interactions and Anti-microbial Resistance**	13

C. Detailed syllabus:

Sr. No.	Title	Minimum no. of hours
	BS 606	
1.	**Advances in Molecular Microbiology** Investigating Genomes: Introduction to Genomics and Sequencing Genomes, Introduction to Functional Genomics: Transcriptomics & Proteomics, Overview of Microbial genomes and genome evolution. Overview of systems and synthetic biology. Overview of CRISPR/CAS system	**18**
2.	**Advances in Environmental Microbiology** Metagenomics: Brief history and development of metagenomics, Understanding bacterial diversity using metagenomics approach, Enrichment of metagenome for desired applications, Prospecting genes of biotechnological importance using metagenomics Overview of Microbial Fuel Cell (MFC) systems, types and applications.	**14**
3.	**Host-Microbe Interactions and Anti-microbial Resistance** Mechanisms of Host-Microbe Interactions in plant and animal pathogenesis, Significance of human gut microbiota, microbiom dysbiosis and associated diseases. Biofilms: types of microorganisms, molecular aspects and significance in environment, health care, virulence and antimicrobial resistance	**13**

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Unit tests will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- The students will be able to learn the advanced concepts of molecular, environmental and medical microbiology

- Students will develop an understanding of current trends in microbiology

F. Suggested study materials

Text Books:

- Prescott's Microbiology (10 th Edition) by Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton (2017) Publisher: McGraw-Hill.
- Brock Biology of Microorganisms, 14^{th} Edition, 2015. Publisher: Pearson
- Lehninger Principles of Biochemistry, Seventh Edition [2017] by David L Nelson; Michael M Cox, Publisher: New York W.H. Freeman © 2017
- S.B.Primrose, R.M.Twyman and R.W. Old. (2006) Principles of Gene Manipulation and Genomics. 6th Edition, Blackwell Science.
- Microbial Fuel Cells, Bruce E. Logan, 2008 by John Wiley & Sons, Inc.
- Encyclopedia of Metagenomics: Environmental Metagenomics. Editors: Sarah K. Highlander, Francisco Rodriguez-Valera, Bryan A. White, Publisher: Springer (2015).
- Advances in Molecular and Cellular Microbiology: The Human Microbiota and Microbiome. Edited by Julian R. Marchesi, CAB International, 2014.
- Klipp E, Liebermeister W. Systems Biology – A Textbook, 2009, Wiley –VCH Verlag
- Quorum Sensing vs Quorum Quenching: A Battle with No End in Sight. Editor: Vipin Chandra Kalia, Publisher: Springer (2015).
- Synthetic Biology, Advances in Molecular Biology and Medicine, Edited by Robert A. Meyers, 2015 Wiley-VCH Verlag GmbH & Co.
- Klipp E, Liebermeister W. Systems Biology – A Textbook, 2009, Wiley –VCH Verlag.
- Springer Series on Biofilms, Series Editor: J. William Costerton, Springer-Verlag Berlin Heidelberg 2007.

- Bull AT. Microbial Diversity and Bioprospecting, 2004, ASM Press.

Reference books:

- Genomics and Evolution of Microbial Eukaryotes Edited by L. Katz and D. Bhattacharya, Oxford University Press 2006.
- Systems and Synthetic Biology, Editors: Vikram Singh, Pawan K. Dhar, Springer Science+Business Media Dordrecht 2015.
- Antimicrobial resistance: beyond the breakpoint. Volume editor, J. Todd Weber, Karger AG, Basel (Switzerland), 2010.

BC606 Plant Biochemistry

Credit (Theory): 03 **Semester-VI**

Credit Hours: 45

A. Objectives of the course.

- To understand the biochemistry of plant species and its unique cellular, metabolic and physiological differences as compared to other living systems.
- To understand how light energy is captured and used to provide chemical forms of energy to power the functions of cells and whole plants, through photosynthesis.
- To learn about rich diversity of secondary metabolites and their widespread applications in Natural Products-based industries and therapeutics
- To get an overview of physiological processes in plants

B. Outline of the Course

Sr.No	Title	Minimum no of hours
1	Introduction to Plant cell structure	4
2	Photosynthesis and Carbon assimilation	10
3	Mitochondrial respiration	5
4	Nitrogen metabolism	8
5	Role of minerals and phytohormones	5
6	Secondary metabolites	7
7	Overview of Plant tissue culture	6

C. Detailed syllabus

Sr. No.	Topics	Minimum no of hours
1	**Introduction to Plant cell structure** Specialized plant cell organelles and structures- cell plate, cell wall, plasmodesmata, vacuoles and tonoplast membrane, peroxisomes, plastids; characteristics of meristematic cells, overview of transport processes	4
2	**Photosynthesis and Carbon assimilation** History, Structure of PSI and PSII complexes, Light reaction-Hill reaction, Cyclic and non-cyclic photophosphorylation, Calvin cycle and regulation; C4 cycle and Crassulacean acid metabolism (CAM), Photorespiration, sucrose and starch as storage metabolites, biosynthesis and breakdown of other polysaccharides and storage forms	10
3	**Mitochondrial respiration** Overview of plant glycolysis, Translocation of metabolites across mitochondrial membrane, TCA cycle, metabolic functions of	5

	mitochondria in plant cells, Cyanide resistant respiration	
4	**Nitrogen metabolism** Nitrate assimilation, Nitrate and nitrite reductases, Biological nitrogen fixation, ammonia fixation GS-GOGAT pathway	8
5	**Role of minerals and phytohormones** Introduction to plant hormones and their effect on plant growth and development, polyamines; Role of different minerals; absorption and translocation of inorganic and organic substances; role of water, absorption, and transpiration, guttation, water balance and stress.	5
6	**Secondary metabolites** Terpenoids, phenolic compounds and nitrogen containing compounds, alkaloids, biological role and applications of secondary metabolites	7
7	**Overview of Plant tissue culture** Overview of plant stem cells, Cell and tissue culture techniques, types of cultures: organ and explants culture, callus culture, cell suspension culture and protoplast culture. Applications of cell and tissue culture	6

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using a combination of black-board and power-point presentations. Illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well-equipped laboratory, using standard protocols. Interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

Upon successful completion of this subject, students shall be able to

- understand specifics of plant cell structure and organization and apply specific biochemical functions to all components of plant cell structure
- understand about the distinct biochemistry and energetics of plants .
- appreciate the plants' ability to accumulate a variety of phytochemicals and learn scopes of its applications.
- understand various techniques in plant biotechnology and its potential applications.

F. Recommended Study Material

- Plant Biochemistry by Heldt and Heldt (2005)
- Plant Biochemistry by Bowsher, Steer and Tobin (2008)
- Plant Biochemistry by Shamsher S Narwal and R. Bogatek, 2009
- Biochemistry & Molecular Biology of Plants By B. Buchanan, W. Gruissem, R.
- Plant Biochemistry by P. M. Dey and J. B. Harborne, Harcourt Aria PTE Ltd. Singapore.
- Plant Physiology Biochemistry and Biotechnology by H S Srivastava, Rastogi publications (2009)
- Principles of Biochemistry, Lehninger C Rs. Publ. (Fi

BT607 Developmental Biology

Credits (Theory): 03 **Semester VI**

Credit Hours: 45

A. Objectives of the course

- To gain a thorough understanding of the basic principles of Developmental biology. To understand the tools of Developmental Biology. To be able to read and interpret scientific papers. To design approaches to addressing questions in Developmental biology and to interpret experimental data in developmental biology**.**
- To become proficient with a number of advanced and basic tools in developmental biology. To interpret and design experiments.
- To keep a laboratory notebook, to gain the confidence and skills necessary to be able to attempt new laboratory procedures and troubleshoot their implementation. To be competitive for employment in an introductory laboratory research position.

B. Outline of the Course

Sr. No.	**Title**	**Minimum number of hours**
1.	**Gametogenesis and Fertility**	**10**
2.	**Early embryonic development**	**13**
3.	**Embryonic Differentiation**	**12**
4.	**Organogenesis**	**10**

C. Detailed Syllabus

Sr. No.	**Title**	**Minimum number of hours**
1.	**Gametogenesis and Fertility** Definition, scope & historical perspective of development Biology, Gametogenesis – Spermatogenesis, Oogenesis Fertilization - Definition, mechanism, types of fertilization. Different types of eggs on the basis of yolk.	**10**
2.	**Early embryonic development** Cleavage: Definition, types, patterns & mechanism Blastulation: Process, types & mechanism Gastrulation: Morphogenetic movements– epiboly, emboly, extension, invagination, convergence, de-lamination. Formation & differentiation of primary germ layers, Fate Maps in early embryos.	**13**
3.	**Embryonic Differentiation**	**12**

	Differentiation: Cell commitment and determination- the epigenetic landscape: a model of determination and differentiation, control of differentiation at the level of genome, transcription and post-translation level Concept of embryonic induction	
4.	**Organogenesis** Fate of different primary germ layers Development of behaviour: constancy & plasticity, Extra embryonic membranes, placenta in Mammals	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcomes

- By the end of this course, students will be able to:
- Be able to describe various theoretical models of the creative process.
- Identify and interact with creative pockets in the community to continue to re-energize their skills.
- Develop understanding about the molecular mechanisms behind different modes of differentiation

F. Recommended study materials

- Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
- Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.

1. Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

MI 607 Industrial Microbiology

Credits (Theory): 03 **Semester VI**
Credit Hours: 45

A. Objectives of the course.

- To help students to understand the
- Design of fermenters and its applications
- Process of screening and improvement of industrially important microorganisms
- Scope of microbial products as compared to chemically derived products.
- To understand the production of various primary and secondary metabolites, bioinoculants, recombinant proteins, probiotics and recombinant products.
- To provide insights into application of microbiology in industries

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction Industrial Microbiology**	**12**
2.	**Isolation of Industrial Strains and Fermentation Medium**	**08**
3.	**Downstream processing**	**04**
4.	**Production of primary Metabolites**	**07**
5.	**Production of secondary metabolites, recombinant products and Biotransformation**	**08**
6.	**Production of Solvents and Bio-fuels**	**06**

C. Detailed syllabus:

Sr. No.	Title	Minimum number of hours
1.	**Introduction Industrial Microbiology** Brief history and developments in industrial microbiology Types of fermentation processes - solid state, liquid state, batch, fed-batch and continuous Types of fermenters – laboratory, pilot-scale and production fermenters Components of a typical continuously stirred tank bioreactor and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration Sterilization of fermenter and fermentation media	**12**
2.	**Isolation of Industrial Strains and Fermentation Medium** Sources of industrially important microbes, Primary and secondary screening, strain improvement Preservation and maintenance of industrial strains Inoculum Preparation Crude and synthetic media; molasses, cornsteep liquor, sulphite	**08**

	waste liquor, whey, yeast extract and protein hydrolysates	
3.	**Downstream processing** Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying	**04**
4.	**Production of primary Metabolites:** Organic acids: Citric acid, Lactic acid Amino acids: Glutamic acid, Lysine Enzymes: Protease, Amylase and Lipases, Cellulases Single cell proteins, Single cell Lipid	**07**
5.	**Production of secondary metabolites, recombinant products and Biotransformation:** Alkaloids and antibiotics Penicillin, Streptomycin Over view of steroid biotransformation and semisynthetic antibiotics Recombinant microbial production processes in pharmaceutical industries – Insulin and Streptokinase,	**08**
6.	**Production of Solvents and Bio-fuels:** Ethanol, Acetone- butanol, Methane	**06**

D. Instructional Methods and Pedagogy:

- The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations.
- Practical sessions will be conducted in a highly equipped laboratory.
- Experiments will be carried out by students individually.
- Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes / objectives:

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

- Comprehend about components of fermenter and its applications
- screen and improve industrially important microorganisms
- appreciate scope of microbial products as compared to chemically derived products.
- understand the production of various primary and secondary metabolites, bioinoculants, recombinant proteins, probiotics and recombinant products.
- have insights into application of microbiology in industries

F. Recommended study materials

- Industrial Microbiology by Prescott and Dunn
- Industrial Microbiology by A H Patel

BC607 Clinical Biochemistry

Credits (Theory): 03 **Semester VI**
Credit Hours: 45

A. Objectives of the course.

- The broad goal of the teaching of undergraduate students in diagnostic biochemistry is to make them understand the scientific basis of the diagnostic biochemical tests and to orient them towards the application of the knowledge acquired for disease diagnosis
- To understand the significance of diagnostic biochemistry.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction**	4
2.	**Evaluation of biochemical changes in diseases**	4
3.	**Biochemical analysis of body fluids**	7
4.	**Assessment of glucose metabolism in blood**	4
5.	**Lipid profile**	4
6.	**Liver function tests**	4
7.	**Renal function tests**	4
8.	**Gastric function tests and Pancreatic function test**	4
9.	**Enzymes: distribution and diagnostic significance**	6
10.	**Tests for cardiovascular diseases**	4

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1	**Introduction** Organization of clinical laboratory, Introduction to instrumentation and automation in clinicalbiochemistry laboratories safety regulations and first aid. General comments on specimen collection, types of specimen for biochemical analysis. Precision, accuracy, quality control, precautions and limitations.	4
2	**Evaluation of biochemical changes in diseases** Basic hepatic, renal and cardiovascular physiology. Biochemical symptoms associated with disease and their evaluation. Diagnostic biochemical profile.	4
3	**Biochemical analysis of body fluids**. Biochemical analysis of body fluids- blood, urine, saliva, csf	7
4	**Assessment of glucose metabolism in blood** Clinical significance of variations in blood glucose. Diabetes mellitus.	4
5	**Lipid profile**	4

	Composition and functions of lipoproteins. Clinical significance of elevated lipoprotein.	
6	**Liver function tests** Liver function tests - bile pigment metabolism, jaundice and its type, tests for liver function	4
7	**Renal function tests** Renal function tests – functions of kidney, disease of kidney, renal function tests	4
8	**Gastric function tests and Pancreatic function test** Gastric function tests– functions of stomach, tests for gastric function Pancreatic function test - functions of pancreas, tests for pancreatic function	4
9	**Enzymes: distribution and diagnostic significance** Enzymes: distribution and diagnostic significance. Clinical significance and interpretation of diagnostically important enzymes and isoenzymes: creatine kinase, lactate dehydrogenase, alanine- & aspartate aminotransferases, alkaline phosphatase, acid phosphatase, cholinesterase with a detailed account of the biochemical reactions catalysed by these enzymes and of their clinical significance.	6
10	**Tests for cardiovascular diseases.** Involvement of enzymes in diagnostics of heart disease including aspartate transaminase, isoenzymes of creatine kinase and lactate dehydrogenase and troponin.	4

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory, using standard protocols. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- This course would have made the students understand the significance of diagnostic bio-chemistry.
- Able to use the equipments used for clinical biochemistry tests.
- Understand the safety procedures need for clinical biochemistry work.

F. Recommended Study Material:

- Textbook Of Medical Laboratory Technology 2/e by Godkar Praful. B-English-Bhalani Publishing House Biochemistry by U Satyanarayana, Publisher-Elsevier Health Sciences, 2014
- Textbook of Biochemistry for Medical Students by M.D. Vasudevan D.M., M.D. S. Sreekumari, M.D. Vaidyanathan Kannan, Publisher-Jaypee Brothers Medical Publishers (P) Ltd
- Textbook of Medical Laboratory Technology by Sood, Publisher-Jaypee Brothers Publishers

BT608 Medical and Forensic Biotechnology

Credits (Theory): 03 **Semester VI**
Credit Hours: 45

A. Objectives of the course

- To keep a laboratory notebook, to gain the confidence and skills necessary to be able to attempt new laboratory procedures and troubleshoot their implementation.
- To be competitive for employment in an introductory laboratory research position.
- describe how naturally occurring organisms regulate the expression of their genes
- describe how biotechnology can alter regulation of the genes
- describe how biotechnology can alter the properties of the cell
- explain, evaluate and report on practical applications of synthetic biology
- plan and carry out a laboratory project aimed at creating replicating systems with new properties that can be regulated

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Forensic Science and Forensic Biotechnology**	**20**
2.	**Concepts and methods of Molecular Diagnostics**	**15**
3.	**Drug designing and drug delivery**	**10**

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Forensic Science and Forensic Biotechnology** Introduction and principles of forensic science, forensic science laboratory and its organization and service, tools and techniques in forensic science, branches of forensic science, causes of crime, role of modus operandi in criminal investigationPrinciple of DNA fingerprinting, application of DNA profiling in forensic medicine,Investigation Tools, eDiscovery, Evidence Preservation, Search and Seizure of Computers,Introduction to Cyber security.	**20**
2.	**Concepts and methods of Molecular Diagnostics** Overview, application of molecular dignostics, Hybridization and reverse hybridization based methods,Dignostics based on DNA chips and Microarray,Nucleic acid amplification-End-	**15**

	point PCR, Qualitative, Ligation assay: SNP detection by probe ligation and amplification (e. g. MLPA), Fluorescence *In situ* hybridization, chromosome Comparative Genomic Hybridization arrays	
3.	**Drug designing and drug delivery** Concept of virtual screening, molecular docking, Theory and practice for drug delivery, advances of nanotechnology for drug delivery, Various drug delivery systems, targeting potentials; systems used for delivery of biotechnological products (Liposomes, microspheres, nanoparticles, immobilization techniques, etc.)	**10**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- By the end of this course, students will be able to:
- Be able to describe various theoretical models of the creative process.
- Identify and interact with creative pockets in the community to continue to re-energize their skills.
- Gain basic concepts of synthetic biology and its applications
- Be able to Interpret and critique data from primary research articles.

F. Recommended study materials

- Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
- B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001). _
- M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002). _
- S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005). _
- W.G. Eckert and R.K. Wright in Introduction to Forensic Sciences, 2nd Edition, W.G.
- Eckert (ED.), CRC Press, Boca Raton (1997). _
- R. Saferstein, Criminalistics, 8th Edition, Prentice Hall, New Jersey (2004). _
- W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene
- Investigation, CRC Press, Boca Raton (2013).

MI608 Microbes in Sustainable Agriculture

Credits: 03 **Semester VI**
Credit Hours: 45

A. Objectives of the course

To enable the students

- To understand physical and chemical characteristics and ecology of soil.
- To know the crucial role of microorganisms in soil fertility and agriculture.
- To introduce the concept and role of bio-inoculants in soil amendment.
- To gain knowledge about microorganisms that can be used as bioinoculants.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	**Concepts of soil microbiology**	**10**
2	**Microbial activity in soil**	**05**
3	**Plant–microbe interactions**	**12**
4	**Microbes as biocontrol agents**	**10**
5	**Biofertilizers**	**08**

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
➢	**Concepts of soil microbiology** Soil structure and composition: Soil physico- chemical properties, soil organic matter and humus. Soil fertility: Soil microbial communities, role of soil microorganisms in composting, humus formation and mineralization of cellulose and lignin. Rhizosphere: Rhizosphere effect, nutrient exchange, rhizosphere microbes and their significance.	**10**
➢	**Microbial activity in soil and Greenhouse gases** Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control. Role of soil microorganisms in Nitrogen, Phosphorus and Sulphur cycles.	**05**
➢	**Plant–microbe interactions** Interactions on above and below the ground parts: Positive interactions (symbiotic/non-symbiotic, endophytic/epiphytic bacteria and	**12**

	phyllospheric/phylloplane bacteria) and negative interactions (microbial pathogens and nematodes). Plant growth promoting bacteria (PGPB). Concepts and mechanisms of rhizobium-legume symbiosis and Mycorrhizal symbiosis.	
➢	**Microbes as biocontrol agents** Adverse effects of chemical pesticides, fungicides and nematocides in agricultural soils. Types and mechanisms of bio-control agents. Use of microorganisms as bio-control agents: bio-pesticides, bio-fungicides, bio-insecticides, bio-nematocides and entamopahtogenic fungi.	**10**
➢	**Biofertilizers** Use of microorganisms as biofertilizers: Advantages, types of biofertilizers, mechanisms and methods of application of biofertilizers, field performance of biofertilizers; methods of application. Nitrogen fixers: Symbiotic (*Rhizobium, Frankia*) and Non-Symbiotic Nitrogen fixers (*Azospirillum, Azotobacter*), characteristics and significance. Phosphate Solubilizers: Characteristics and significance. Mycorrhizal Biofertilizers: Types, chracteristics and importance.	**08**

D. Instructional Methods and Pedagogy

- The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations.
- Practical sessions will be conducted in a highly equipped laboratory.
- Experiments will be carried out by students individually.
- Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- Gain knowledge of distribution and availability of nutrients in soils and its effect on soil fertility
- Basic concepts of plant microbe interactions and plant beneficial microbes.
- Understanding the applications of microorganisms for sustainable agriculture

F. Recommended study materials

- Agricultural Microbiology by G. Rangaswami and D. Bagyaraj
- Introduction to Soil Microbiology, Alexander M, (1977),2nd edn, Wiley Eastern Ltd.
- Biofertilizers in Agriculture and Forestry. Subbarao N S, 3rd edn, Oxford and IBH.
- Principles of Microbiology. Atlas R M, 2nd edn, Wm. C. Brown Pub, USA.
- Plant Pathology. Mehrotra R and Agarwal A, 2nd edn, Tata Mcgraw-Hill Publisher
- A textbook of microbiology. R. C Dubey & D.K. Maheswari, S. Chand& Company.

BC608: MOLECULAR BASIS OF DISEASE

Credits (Theory): 03
Credit Hours: 45 **Semester VI**

A. Objectives of the course.

- The broad goal of the teaching of undergraduate students in diagnostic biochemistry is to make them understand the scientific basis of the diagnostic biochemical tests and to orient them towards the application of the knowledge acquired for disease diagnosis
- To understand the significance of diagnostic biochemistry.

B. Outline of the Course

Sr.No	Title of the topics	Minimum number of hours
1	Classification of infectious agents	5
2	Overview of diseases caused by bacteria	8
3	Overview of diseases caused by Viruses	5
4	Overview of diseases caused by Parasites and other organisms	6
5	Nutritional disorders	4
6	Metabolic and Lifestyle disorders	4
7	Multifactorial complex disorders and Cancer	8
8	Diseases due to misfolded proteins	5

C. Detailed syllabus

Sr. No.	Topics	Minimum number of hours
1	**Classification of infectious agents** Bacteria, Viruses, protozoa and fungi. Past and present emerging and re-emerging infectious diseases and pathogens. Source, reservoir and transmission of pathogens, Antigenic shift and antigenic drift. Host parasite relationship, types of infections associated with parasitic organisms. Overview of viral and bacterial pathogenesis. Infection and evasion.	5

2	**Overview of diseases caused by bacteria** Detailed study of tuberculosis: History, causative agent, molecular basis of host specificity, infection and pathogenicity, Diagnostics, Therapeutics, inhibitors and vaccines. Drug resistance and implications on public health. Other bacterial diseases including Typhoid,Diphtheria, Pertussis, Tetanus, Typhoid and Pneumonia.	8
3	**Overview of diseases caused by Viruses**. Detailed study of AIDS, history, causative agent, pathogenesis, Diagnostics, Drugs and inhibitors. Other viral diseases including hepatitis, influenza, rabies, chikungunya and polio.	5
4	**Overview of diseases caused by Parasites and other organisms** Detailed study of Malaria, history, Diagnostics, Resistance, Vaccine development. Other diseases including leishmaniasis. Fungal diseases, General characteristics. Medical importance of major groups, pathogenesis, treatment.	6
5	**Nutritional disorders** Overview of major and minor nutrient components in the diet. Balanced diet and the concept of RDA. Nutrient deficiencies; Kwashiorkor and Marasmus, Scurvy, beri beri, pellagra and B12 deficiency, Night blindness, Vitamin D deficiency, Vitamin K deficiency.	4
6	**Metabolic and Lifestyle disorders** Obesity and eating disorders like Anorexia nervosa and Bullemia. Diabetes mellitus A, obesity, hypothyroidism and stress. Cardio vascular disorders, stages of disorder and the management of the condition. Irritable bowel syndrome-biochemistry behind the disorder and the influence of diet, stress and environment on the condition.	4
7	**Multifactorial complex disorders and Cancer** Understanding the definition of multifactorial diseases. Polygenic diseases and the relationship of environmental factors and genetic makeup in the onset of diseases. Cancer: characteristics of a transformed cell, causes and stages of Cancer, molecular basis for neoplastic growth and metastasis, Proto-oncogenes and tumor suppressor genes; Cancer causing mutations; Tumor viruses; Biochemical analysis of cancer; approaches to cancer treatment. Disorders of mood : Schizophrenia, dementia and anxiety disorders. Polycystic ovarian syndrome, Parkinson’s disease, ALS.	8

8	**Diseases due to misfolded proteins** Introduction to protein folding and proteosome removal of misfolded proteins; etiology and molecular basis for Alzheimer's, Prion diseases, Huntington's Chorea, sickle cell anemia, Thalassemia.	5

H. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory, using standard protocols. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- This course would have made the students understand the significance of different disease causing agents.
- Understand the mechanism of different life style and metabolic disorders and cancer.

F. Recommended Study Material:

- Prescott, Harley, Klein's Microbiology (2008) 7th Ed., Willey, J.M., Sherwood, L.M.,Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.
- Mandell, Douglas and Bennett.S, Principles and practices of Infectious diseases, 7thedition, Volume, 2. Churchill Livingstone Elsevier.
- Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
- Introduction to Human Physiology (2013) 8th edition; Lauralee Sherwood. Brooks/Cole, Cengage Learning.

BE608 Animal Cell Culture Techniques

Credits (Theory): 02 **Semester: VI**
Credit Hours: 30

A. Objectives of the course

- To enable the students to gain insights about basic techniques of animal cell culture.
- To understand the principles of animal cell culture and its application
- Describe the Equipments used on tissue culture.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Animal cell culture Techniques**	**3**
2.	**Laboratory requirements for animal cell culture**	**3**
3.	**Structure and organization of animal cells, tissues and biology of cultured cells.**	**3**
4.	**Introduction to the balanced salt solutions and growth medium**	**4**
5.	**Cell culture Media and reagents**	**5**
6.	**Cell culture techniques**	**6**
7.	**Primary and established cell line culture.**	**3**
8.	**Basic techniques of mammalian cell culture *in vitro***	**3**

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Introduction to Animal cell culture Techniques** Introductory history, Laboratory organization, Media, Aseptic manipulation.	**3**
2.	**Laboratory requirements for animal cell culture** Sterile handling area. Sterilization of different materials used in animal cell culture. Instrumentation and equipments for animal cell culture. History of cell culture.	**3**
3.	**Structure and organization of animal cells, tissues and biology of cultured cells.** General out-line of epithelial tissue, connective tissue, muscular tissue and nerve tissue. Cell adhesion; Junctions; Extracellular matrix; Cytoskeleton; Cell cycle; Differentiation; Cell signaling; Energy metabolism	**3**

4.	**Introduction to the balanced salt solutions and growth medium** Media –Physical properties, balance salt solutions, complete media, serum, Serum-Free media. Chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide. Role of serum and supplements. Serum and protein free media and their application.	**4**
5.	**Cell culture Media and reagents** Types of cell culture media, Ingredients of media, Physiochemical properties, Antibiotics, growth supplements, Foetal bovine serum; Serum free media, Trypsin solution, Selection of medium and serum, Conditioned media, Other cell culture reagents, Preparation and sterilization of cell culture media, serum and other reagents.	**5**
6.	**Cell culture techniques** Different types of cell cultures, Trypsinization, Cell separation, Continuous cell lines, Suspension culture, Organ culture. Development of cell lines, Characterization and maintenance of cell lines, stem cells, Cryopreservation, Common cell culture contaminants.	**6**
7.	**Primary and established cell line culture** Measurement of viability and cytotoxicity. Biology; Characterization and growth of the cultured cells; Disaggregation of tissue and primary culture; Maintenance of cell culture; Cell cloning and cell separation; Cell differentiation; Cell synchronization and transformation; Measurement of cell death and apoptosis.	**3**
8.	**Basic techniques of mammalian cell culture *in vitro*** Culture of specialized cells: Epithelia; Mesenchymal and connective tissues; Muscles;Neuroectoderm; Endocrine; Hematopoietic cells; Tumor cells, Embryonic stem cells stem cell culture and their applications. Embryo technology and transgenic animals.	**3**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal examinations will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- Understand the basic principles and techniques used in animal cell tissue culture.
- Able to use the equipments used for tissue culture.
- Understand the safety procedures need for tissue culture.

F. Recommended Study Material

- Freshney, Culture of Animal Cells, 5th Edition, Wiley-Liss, 2005
- Masters, J. R. W. (ed): Animal Cell Culture – Practical Approach, Oxford Univ. Press.
- Ed. John R.W. Masters, Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press, 2000.
- Ed. Martin Clynes, Animal Cell Culture Techniques., Springer, 1998.
- B.Hafez, E.S.E Hafez, Reproduction in Farm Animals, 7th Edition, Wiley-Blackwell, 2000.
- Louis-Marie Houdebine, Transgenic Animals: Generation and Use, 1st Edition, CRC Press, 1997.

BE609 Pharmaceutical Quality Control & Quality Assurance

Credits (Theory): 02 credits **Semester: VI**
Credit Hours: 30

A. Objectives of the course

- To enable the students to have an overview of industrial rules and standards applied in QA- QC
- To enable students to have an understanding of microbiological techniques used for testing raw materials and finished products
- To enable students to learn about International standards for biosafety and validation

B. Outline of the Course

Sl. No.	Title	Minimum number of hours
1.	**Industrial Rules and standards**	**8**
2.	**Detection and quantification of Compounds using Indian Pharmacopoeia**	**6**
3.	**Quality Control Tests of Pharmaceutical Products**	**6**
4.	**International Standards for Biosafety and Validation (WHO, ISI)**	**10**

C. Detailed Syllabus

Sl. No.	Title	Minimum numbers of hours
1.	**Industrial Rules and standards**	**8**
	Importance of Quality control and assurance , Introduction to IP, BP, USP, PFA Concept of pharmacopoeia Concept of regulatory authorities , Types of pharmaceutical products , Microbiological Q.C of foods and drugs	
2	**Detection and quantification of Compounds using Indian Pharmacopoeia:**	**6**
	Ascorbic acid, Vit. BI2 in tablets , Antibiotics - penicillin and streptomycin in drugs	
3	**Quality Control Tests of Pharmaceutical Products**	**6**
	Sterility test, Pyrogen test, Toxicity test , Carcinogenicity test, Mutagenicity test , Allergy test	

4	**International Standards for Biosafety and Validation (WHO, ISI)**	**10**
	Introduction of WHO, ISI standards. Concept of validation.- validation of moist heat sterilization in pharmaceuticals Biosafety in pharmaceuticals	

D. Instructional Methods and Pedagogy:

- The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations.
- Practical sessions will be conducted in a highly equipped laboratory.
- Experiments will be carried out by students individually.
- Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases.
- Course materials will be provided to the students from various primary and secondary sources of information.
- Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- Understand the importance of implementation of industrial rules and standards applied in QA- QC
- Understand microbiological techniques used for testing raw materials and finished products
- Learn about International standards for biosafety and validation

F. Recommended study materials

- Microbiology and Sterility Assurance in Pharmaceuticals and Medical Devices Editors: Madhu Raju Saghee, Tim Sandle and Edward C. Tidswell
- Industrial Pharmaceutical Microbiology: Standards & Controls - 2015 Edition edited by Geoff Hanlon and Tim Sandle ISBN 978-0-9573491-1-7 (Hb); ISBN 978-0-9573491-2-4 (Pb)
- Quality Assurance Guide by organization of Pharmaceutical Procedures of India, 3rd revised edition, Volume I & II, Mumbai, 1996.
- Good Laboratory Practice Regulations, 2nd Edition, Sandy Weinberg Vol. 69, Marcel Dekker Series, 1995.

- Quality Assurance of Pharmaceuticals- A compedium of Guide lines and Related materials Vol I & II, 2nd edition, WHO Publications, 1999.

- How to Practice GMP's – P P Sharma, Vandana Publications, Agra, 1991.

- The International Pharmacopoeia – vol I, II, III, IV & V - General Methods of Analysis and Quality specification for Pharmaceutical Substances, Excepients and Dosage forms, 3rd edition, WHO, Geneva, 2005.
- Good laboratory Practice Regulations – Allen F. Hirsch, Volume 38, Marcel Dekker Series, 1989.
- ICH guidelines ISO 9000 and total quality management
- The drugs and cosmetics act 1940 – Deshpande, Nilesh Gandhi, 4th edition, Susmit Publishers, 2006.
- QA Manual – D.H. Shah, 1st edition, Business Horizons, 2000.
- Good Manufacturing Practices for Pharmaceuticals a plan for total quality control – Sidney H. Willig, Vol. 52, 3rd edition, Marcel Dekker Series.

BE610 Food and Dairy Biotechnology

Credits (Theory): 02 **Semester VI**
Credit hours: 30

A. Objectives of the course.

- To make student understand about types of food
- Types of dairy products
- Genetically modified food and dairy products
- Technology related to food and dairy products

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1	**Introduction to food and Dairy Science**	5
2	**Food Biotechnology**	10
3	**Dairy Biotechnology**	7
4	**Food and Dairy technology**	8

C. Detailed syllabus

Sr.No	Title of the topics	Minimum number of hours
1	**Introduction to food and Dairy Science** Scope of Food and Dairy Biotechnology, Types of food and Dairy products, additives, Adulteration, Spoilage, Preservation, Packaging, quality control	5
2	**Food Biotechnology** Improvement of food resources eg. Golden rice, flavr savr tomatoes etc. Post harvest technology, Concept of nutrigenomics, Neutraceuticals, Probiotic, prebiotic, fermented food (Sauekraut, pickle, soy products), SCP (Spirulina, yeast)as food supplements, flavor enhancers: Nucleoside, nucleotides and related compounds	10
3	**Dairy Biotechnology** Genetic engineered milk, Genetic manipulation of starter culture, Probiotics, food grade biopreservative, Dairy enzyme eg recombinant chymosin, Accelerated cheese ripening, Biofilm and its control in dairy industry	7
4	**Food and dairy technology** Biosensors in Dairy and food industry, Enzymes in food and dairy industry, Membrane process in food and dairy, Biodetergents, Waste management, laws related to food and dairy Sciences	8

D

D. Instructional methodology and Pedagogy

- Topic will be discussed in the interactive class room sessions using black board teaching and power point presentations.
- Special interactive problem solving sessions will also be conducted.
- Course material will be provided to the students from various primary and secondary information
- Internal exam will be conducted regularly as part of continuous evaluation and students will be counseled to improve their performance

E. Student learning outcome

After successful completion of course,

- Student will have basic understanding of types of food and dairy products
- Processing, preservation and sampling of food and dairy products
- Role of Biotechnology in food and dairy industry

F. Recommended Study Materials

- 16th CAS course on applications of Biotechnology in food and dairy processing (4th Nov-24th Nov, 2003), NDRI, Karnal
- Food Microorganisms, Dr. H. A. Modi, - Aavishkar Publishers and Distributors,Jaipur
- Food Processing and preservations, B. Sivankar, - PHI, - first edition.
- Sukumar D E. Outlines of Dairy Technology, Oxford University Press.
- Eckles, Clarence, Henry Milk and Milk Products, Tata MCGraw Hill publishers
- Ananthakrishnan C P, Khan A Q, Padmanabhan P N. Technology of Milk Processing. Srilakshmi Publishers
- Mathlouthi, M Food Packaging and Preservation . Aspen
- Food Sciences and Food biotechnology- G.F.G. Lopez, G. Canaas, E.V.Nathan
- Genetically Modified Foods- M.Ruse, D. Castle (Eds.)
- Biotechnology of Food Crops in Developing Countries- T.Hohn and K.M. Leisinger (Eds.)

BE 611: Microbiological Analysis of Air and Water

Credits (Theory): 02 **Semester VI**
Credit Hours: 30

A. Objectives of the course.

- To help students to understand:
- Aeromicrobiology, airborne microorganisms and their sampling
- Dispersal mechanism of bioaerosols and control measures
- Water borne pathogens, indicator organisms and methods for detection of fecal contamination of potable water.
- Disinfection systems for treatment of drinking water.

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	Microbiological Analysis of Air	15
2.	Microbiological Analysis of Water	15

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C. Detailed syllabus:

Sr. No.	Title	Minimum number of hours
1.	**Microbiological Analysis of Air:** **Aeromicrobiology:** Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens. **Air Sample Collection and Analysis:** Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics **Control Measures:** Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration	15
2.	**Microbiological Analysis of Water:** **Water Microbiology:** Water borne pathogens, water borne diseases **Microbiological Analysis of Water:** Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests **Control Measures:** Precipitation, chemical disinfection, filtration, high temperature, UV light	15

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

- The students will be able to learn the basic concepts in aeromicrobiology and microbial contamination of water.

- Students will be able to understand the methods to detect, sample and analyze the microbial contamination of air and water.

- Students will learn the control measures to prevent microbial contamination of air and water.

F. Recommended study materials

Text Books:

- Prescott's Microbiology (9th Edition) by Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton (2013) Publisher: McGraw-Hill.
- Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
- da Silva N, Taniwaki MH, Junqueira VC, Silveira N, Nascimento MS, Gomes RAR (2012) Microbiological Examination Methods of Food and Water, A Laboratory Manual, CRC Press
- Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th
  edition. Benjamin/Cummings Science Publishing, USA
- Hurst CJ, Crawford RL, Garland JL, Lipson DA (2007) Manual of Environmental Microbiology, 3rd edition, ASM press.

BE612 Extremophiles And Their Applications

Credits (Theory): 02 **Semester VI**
Credit Hours: 30

A. Objectives of the course

- To introduce the concepts of ubiquity of microbes in extreme environments
- To enable the students to understand probable adaptive measures by extremophilic microbes
- To enable the students to understand commercial significance of extremophiles

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Life at Extreme conditions**	04
2.	**Concept of Archaea**	06
3.	**Adaptations and applications of thermophiles, psychrophiles and halophiles**	10
4.	**Adaptations and applications of acidophiles, alkaliphiles, piezophiles and radiation resistant microorganisms**	10

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Life at Extreme conditions** Range of extremities and related habitats: temperatures, pH, salt concentration and radiation; Life on other planets	04
2.	**Concept of Archaea** Difference between bacteria, archaea and eukaryotes, Classification and salient features of each archaeal group, Physiology, Genetics and Metabolic diversity	06
3.	**Adaptations and Applications of thermophiles, psychrophiles and halophiles** Thermophiles: Basic concepts, Classification, adaptations and significance Psychrophiles: Basic concepts, adaptations and significance Halophiles: Basic concepts, Classification, adaptations and significance	10
4.	**Adaptations and Applications of acidophiles, alkaliphiles, piezophiles and radiation resistant microorganisms** Acidophiles: Basic concept, Classification, adaptations and significance Alkaliphiles: Basic concept, Classification, adaptations and significance Piezophiles/ Barophiles : Basic concept, adaptations and significance Desiccation(Xerophiles) and Radiation resistant microbes (*Deinococcus radiodurans*) and applications	10

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in a highly equipped laboratory. Experiments will be carried out by students individually. Special interactive problem solving sessions will also be conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- Understand the microbial world with special reference to extremophiles
- Understand various classes of Archaea
- Understand significance and applications of extremophilic microbes

F. Recommended study materials

- Horikoshi K., Grant W. (1998) Extremophiles: Microbial Life in Extreme Environments. Wiley Publications
- Horikoshi, K., Antranikian, G., Bull, A.T., Robb, F.T., Stetter, K.O. (2011) Extremophiles Handbook. Springer Publications
- Rampelotto, Pabulo H (2016) Biotechnology of Extremophiles: Advances and Challenges. Springer Publications

BE 613 Protein Purification Techniques

Credits (Theory): 02 **Semester VI**
Credit Hours: 30

A. Objectives of the course

- To enable the students to gain insights about techniques used for protein purification techniques
- To understand the insight information about industrial level application of protein purification technology
- To enable the students to design the research project to develop custom design of proteins purification

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Sample preparation**	5
2.	**Purification strategies**	10
3.	**Protein purification methods**	5
4.	**Desalting, buffer exchange, and protein concentration**	5
5.	**Analysis and characterization**	5

C. Detailed Syllabus

Sr. No.	Title	Minimum number of hours
1.	**Sample preparation** Source materials, Cell harvesting and extraction Clarification, Protein stability—selection of conditions, Removal of specific impurities, Advances in methodology, chromatography media, Genomics and proteomics,	5
2.	**Purification strategies** Brief history of protein purification, Affinity chromatography, Immobilized metal ion affinity chromatography (IMAC), Gel filtration (GF) Ion exchange chromatography (IEX), Hydrophobic interaction chromatography (HIC), Chromatofocusing Reversed phase chromatography (RPC)	10

3.	**Protein purification methods** GF for desalting, removal of low-molecular-weight, substances, and buffer exchange, Other methods for desalting and buffer exchange, Protein concentration using ultrafiltration, Other methods for protein concentration	**5**
4.	**Desalting, buffer exchange, and protein concentration** Three-stage purification strategy (CIPP) Capture, Intermediate purification Polishing, Selection and combination of purification methods Chromatography media	**5**
5.	**Analysis and characterization** Target protein identity and quantitation, Total protein concentration Activity, Purity, Size, homogeneity and Other homogeneity issues Protein stability	**5**

D. Instructional Methods and Pedagogy

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations. Practical sessions will be conducted in highly equipped laboratories. Experiments will be carried out by students individually. Special interactive problem solving sessions will be also conducted by respective faculty members on weekly bases. Course materials will be provided to the students from various primary and secondary sources of information. Internal exams will be conducted regularly as a part of continuous evaluation and suggestions will be given to student in order to improve their performance.

E. Student Learning Outcomes

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

- Understand the basic principles of various techniques used in protein purification.
- Design experiments for their research work.

E. Recommended study material

- Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN:978-0-470-85602-4 / ISBN:978-0-470-85603-1.
- Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D., W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
- An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.
- Strategies for Protein Purification. GE Healthcare

BE 614 Glycobiology

Semester - VI

Credits (Theory): 2
Credit Hours: 30

A. Objectives of the course

- To provide overview of carbohydrates as essential class of biomolecules finding numerous biological functions and industrial as well as therapeutic applications
- To build and augment students' knowledge on carbohydrate structure-function relationships using various examples from animal, plant and microbial systems.
- To prepare a platform for understanding the advanced molecular and -omics aspects in the subject
- To emphasize the importance of fundamental biochemistry in developing major technology and applications based on glycans

B. Outline of the Course

Sr. No.	Title	Minimum number of hours
1.	**Structural Basis of Glycan Diversity**	**6**
2.	**Glycosylation and Glycoconjugates**	**7**
3.	**Glycoproteins and proteoglycans**	**5**
4.	**Glycolipids and Glycan binding proteins**	**5**
5.	**Glycans in Physiology and Disease**	**4**
6.	**Application of glycated biomolecules**	**3**

C. Detailed syllabus

Sr. No.	Title	Minimum number of hours
1.	**Structural Basis of Glycan Diversity** Historical background and introduction to glycobiology, monsaccharides as basic structural units: structure, configuration, conformation, and linkage, Glycan structure and diversity, examples from nature-plant and microbial cell walls and animal glycans	6
2.	**Glycosylation and Glycoconjugates** Subcellular localization of glycosylation process; Glycosylation precursors- activated and interconversion of monosaccharides, Enzymes involved in synthesis/cleavage of glycosides- glycosyl transferases, Glycoside hydrolases and transglycosidases, Polysaccharide lyases, Carbohydrate esterases; typical examples of glycasoconjugates	7
3.	**Glycoproteins and Proteoglycans** Biological roles, glycoroteins vs proteoglycans, biosynthesis, secretion and functions of N- and O-glycans, cellular localization of glycoproteins, example of Mucin	5

4.	**Glycolipids and Glycan binding proteins** Structure and biosynthesis of glycolipids, Glycosyl-Phosphatidyl-Inositol (GPI) anchors, Glycosylated glycerophospholipids, Glycosphingolipids, associated diseases, structural role in cell membranes; principles of glycan recognition, lectins	5
5.	**Glycans in Physiology and Disease** Glycoprotein quality control, glycans as signaling molecules, role in bacterial and viral infections, glyosylation- genetic and acquired disorders, cancer	4
6.	**Application of glycated biomolecules** Applications in food industry, biofuel from sugars, medical appliations-therapeutic glycoproteins, glycans as components of small molecule drugs, vaccine components	3

D. Instructional Methods and Pedagogy:

The topics will be discussed in interactive class room sessions using classical black-board teaching to power-point presentations and case studies. Animations, illustrative pictures and diagrams and other appropriate e-resources shall be employed as per requirement. Practical sessions will be conducted in well equipped laboratory, using standard protocols. Special interactive problem solving sessions will be also conducted by respective faculty members if required. Course materials will be provided to the students from various primary and secondary sources of information. Internal tests will be conducted regularly as a part of continuous evaluation. The question paper will be solved post-exam within the class, students will get a chance to go through their evaluated answer sheets and suggestions will be given to student in order to improve their performance.

E. Student learning outcome

Upon completion of the course, the student will be able to

- describe carbohydrate structure and its organization into various conjugates
- understand interaction of carbohydrates with other biopolymers
- understand the role and diversity of glycan related enzymes and binding proteins
- describe the subcellular biosynthetic events for N- and O-glycans and glycolipids
- understand various biotechnological applications of glycans scope of
- understand scope and importance of research related to biochemical aspects important for developing applications.

F. Recommended Study Materials

- Essentials of Glycobiology, 2nd edition. Ajit Varki Richard D Cummings, Jeffrey D Esko, Hudson H Freeze, Pamela Stanley, Carolyn R Bertozzi, Gerald W Hart, and Marilynn E Etzler. Cold Spring Harbor (NY)
- Lehninger principles of biochemistry. Lehninger, Nelson and Cox. [4th ed. and above] W.H. Freeman and Company
- Introduction to Glycobiology. Maureen E. Taylor and Kurt Drickamer. Oxford University Press
- Allen HJ, Kisailus EC, editors. Glycoconjugates: Composition, structure, and function. Marcel Dekker (1992) CRC Press.