PONDICHERRY UNIVERSITY

SCHOOL OF LIFE SCIENCES

DEPARTMENT OF BIOCHEMISTRY & MOLECULAR BIOLOGY

CBCS REGULATIONS (2017-18 onwards)

&

COURSES OF STUDIES FOR M.Sc. PROGRAMME

In

Biochemistry & Molecular Biology

2019-20 onwards

PONDICHERRY UNIVERSITY

CHOICE BASED CREDIT SYSTEM

REGULATIONS

(EFFECTIVE FROM 2017-18 ONWARDS)

CONTENTS

CHOICE BASED CREDIT SYSTEM

REGULATIONS

1. PREAMBLE

The Choice Based Credit System (CBCS) enables a student to obtain a degree by accumulating required number of credits prescribed for that degree. The number of credits earned by the student reflects the knowledge or skill acquired him / her. Each course is assigned with a fixed number of credits based on the contents to be learned. The student also has choice in selecting courses out of those offered by various departments. The grade points earned for each course reflects the student's proficiency in that course.

The CBCS enables the students to earn credits across departments and provides flexibility in duration to complete a Programme of study. The CBCS facilitates transfer of credits earned in different Departments/Centers of other recognized / accredited universities or institutions of higher education in India and abroad. In this System student representatives take part in designing the curriculum for a Programme of Study and facilitate in running the academic Programmes.

2. SCOPE AND COVERAGE

1) The CBCS is applicable to all full-time Post Graduate and Five year integrated Post Graduate study approved by the Academic Council
2) It is also applicable to any other Programme of study approved by the Academic Council that has been prescribed to follow the CBCS pattern
3) The learning and evaluation is on Semester pattern
4) Eligibility, qualifications and admission procedure for each Programme of study is as approved by the Academic Council and specified in Information Brochure of the University.

3. CREDITS AND COURSES

3.1. Contact hours

1) One credit shall mean one period of teaching for theory or two periods for laboratory / practical course per week in a semester (of 16 weeks)

2) One teaching period shall be for 60 minutes duration including 10 minutes for discussion/movement;
3) One credit shall be assigned to one week of field training Programme where the students spend the entire duration in the field along with the faculty member(s);
4) Up to two credit shall be assigned to one month of Internship undergone in a Company/ Organization/Institutions approved by the Faculty Advisor / Head of the Department;
5) One Tutorial hour per week may be conducted in addition to regular contact hours for both Hard core and Soft core theory Courses.

3.2. Number of credits

1) The core credits for any M. A. / M. Sc.,/ MBA Programme (inclusive of Hard-core, Soft-core and Project work) shall be in the range specified in Table 1 given below.
2) A candidate who has successfully completed all the Hard Core courses and a Project work, if any, and accumulated not less than minimum number of Credits prescribed shall be eligible to receive the Degree.
3) The normal duration of any PG Programme is 4 semesters. However students have the flexibility to complete the PG Programme of Study within minimum of 3 semesters and maximum of 8 semesters. Integrated 5 year PG Programme students shall be permitted to graduate in 8 semesters and not more than 16 semesters.
4) The minimum credits required for the award of degree in various PG Programmes are given in the Table 1.

Table I

S.No	Program	Hard-core Courses credits	Soft-core Courses credits	Total (Minimum credits required for award of the degree)
1	M. A. / M.Sc. / All M. Tech. **except M.Tech (ECE)** / Any other 2 year P.G. Programme not mentioned below	48 to 60	12 to 24	**72**
2	M.Com.,	68 to 78	12 to 24	**90**
3	All MBA programmes	72 to 86	14-28	**100**
4	M.C.A.	72 to 90	18 to 36	**108**
5	5 year Integrated P.G.	148 to 162	30 to 44	**192**
5.1	Exit option for UG degree in 5 year Integrated P.G.			**120**
6	M.Tech (Electronics & Communication Engineering)	59	15	**74**

3.3. Courses

1) The courses offered under a Programme of Study are designated as Hard Core and Soft Core.

2) A course designated as Hard Core for a particular Programme of Study must invariably be completed by the student to receive the degree in that Programme. The Hard Core Course cannot be substituted by any other course. Any other paper chosen by the candidate either within department or outside department will be treated as softcore course with respective credit assigned to the paper.

3) A student needs to earn certain number of minimum credits by successfully completing Soft core courses to receive the degree (Please see Table I).

4) The soft core courses are to be chosen from (a) a list of courses marked as Soft core courses for a particular Programme of Study and (b) any course offered by a Centre/Department/School under CBCS as Soft-core Course with the advice of his/her Faculty Advisor.

5) Dropping of soft-core courses shall be accepted within a period of three weeks only. Afterwards the student has no option to drop it. If, the Department is not offering that specific soft-core paper, the Programme Committee may take a decision on this issue.

6) The courses offered for Integrated 5 year PG and other PG programmes shall carry 2 or 3 or 4 credits. Normally no theory course shall have more than 4 credits.

7) Project Work of PG programmes may carry 4 or 5 credits. Up to 12 credits can be assigned if an entire semester is assigned for Project work. The Project includes submission of a written Project Report and a Viva-voce examination (one credit is assigned for the Viva-voce).

8) While choosing the soft core the student can keep in mind that the chosen paper is
    a. Supportive to the discipline of study.
    b. Providing an expanded scope
    c. Enabling an exposure to some other discipline/ domain
    d. Nurturing student's proficiency/skill

4. REGISTRATION

1) Each student, on admission shall be assigned to a Faculty Advisor.
2) With the advice and consent of the Faculty Advisor the student shall register for a set of courses he/she plans to take up in each Semester.
3) The student has to seek the consent of each teacher offering the courses for registration.
4) No student shall be permitted to register for courses exceeding 30 credits per semester. However, registration for Repeat courses is allowed in excess of this limit.
5) A student, to retain his status, should register for at least a minimum of 12 credits in a semester.
6) Students shall have to register for the courses within first week of a semester.
7) The maximum number of students to be registered in each course shall depend upon the physical facilities available.
8) The information on list of all the courses offered in every department specifying the credits, the prerequisites, a brief description of syllabus or list of topics, the faculty who is offering the course and the time slot may be made available in the University website.
9) In any department, preference for registration shall be given to those students of that department for whom the course is a Hard core course.

10) The registration for the soft core course shall be on first come first served basis, provided the student fulfills prerequisites for that course, if any. The number of students to be registered shall be based on the class room and laboratory capacity. Every effort shall be made by the Department/Centre to accommodate as many students as possible.

11) No soft core course shall be offered unless a minimum of 5 students are registered.

5. INTRODUCTION OF COURSES

5.1 Course Structure and Syllabus

1. The Course Structure shall prescribe the minimum eligibility, Semester wise list of courses, total credits for each Programme of Study, including, Theory, Practical, Field-work, Project work and Viva- voce examinations, etc.
2. Detailed syllabus for all courses offered by the Department shall be prepared in a specific number of units along with full details of Text Books, Reference Books, Web based resources, Reference of papers, e-Books, Published Reports, Monographs, etc. relevant to the course and made available to teachers and students. Each course shall have a title and course code. The course code shall consist of four alphabets representing the Department /Centre, and three numerals. The first numeral stands for level of the course, the second numeral stands for odd or even semester and third numeral is the serial number of the course.
3. The Course Structure and Syllabus of each PG programme shall be approved and recommended by the Programme Committee to Board of Studies (BOS) and School Board and then the Academic Council.
4. New hard-core or soft-core course proposed by a Faculty member is to be first considered and approved in the Programme Committee of the Department and BOS and then to be placed before the School Board and Academic Council for approval.
5. The syllabi of courses need to be revised to keep in tune with recent developments in knowledge and inventions. Minor revision of the already approved Syllabus of any course with proper justification shall be considered and recommended by the Programme Committee through the Chairperson of School Board to the Academic Council. However, the Chairperson of the Academic Council may approve the revisions to facilitate implementation of the revised syllabi in a timely manner.

5.2.1 Hard core course

1. A Hard core subject may be a Theory, Practical, Field based or Project Work based subject which is a compulsory component in the Course Structure. Based on the quantum of time required for teaching – learning the number of credits for each subject is to be decided within the prescribed limit (please see 3.3 (6 & 7)).
2. Registration for Hard Core courses is also open to students of other departments provided they meet the prerequisites.
3. A Course may be treated as a Hard core or Soft Core Course for students of other department as per the requirement of Programme of Study.

5.2.2 Soft core course

1. A Soft core course may be a Theory, Practical, Field based or Project Work, which is optional for the students to register.
2. Students can exercise their choice among a set of Soft core courses from the list of Soft core courses specified for each Programme of study.
3. Students have a choice to register for Soft Core Courses offered by any Department under the advice of the Faculty Advisor.
4. Students may be advised to choose Soft Core
   (a) Supportive to the discipline of study
   (b) Providing an expanded scope
   (c) Enabling an exposure to some other discipline/domain
   (d) Nurturing student's proficiency/skill
5. Students can be allowed to register to audit a course for knowledge enhancement if they wish to learn. Auditing refers to having the required attendance but an exemption from internal assessment and end semester examinations. Such Courses can be marked as AUD in grade card to indicate that student has audited.
6. Based on students' requirements a department could request or float a foundation course which could be a non-credit course. For example if a PG programme of a department requires a basic course in a language, such a course could be offered by the department or the department can request the relevant language department to offer the course. The performance of students in non-credit Foundation Course shall be graded as Satisfactory or Unsatisfactory instead of the letter grade and this will not be counted for the computation of SGPA/CGPA. (page 5 of UGC guidelines)

5.3 Teachers work load

1. Every faculty member shall be assigned workload as per the UGC norms.
2. In addition to regular handling of classes, teachers are required to participate in preparation of detailed Syllabus, designing Teaching plan, Evaluation of answer papers of examination, preparation of grades, etc.
3. Teachers shall undertake to associate with organizing practical Lab sessions, Field visits, Industrial Tours and guide Project Work.
4. Faculty Members of the Department shall actively involve in all the academic activities of the department such as organizing National Events, Seminars, Guest Lectures, etc.

6. EVALUATION

6.1 Breakup of Internal/ End Semester Exams:

1. All theory courses in a PG programme shall carry an Internal Assessment component of 40 marks and End Semester component of 60 marks.
2. In case of practical courses involving Laboratory/Field/Project work, appropriate distribution of marks for Practical Record/ Project Report, Practical end-Semester exam, Viva etc. may be decided by the respective Programme Committee.

6.2. Break up of Internal Assessment Marks

Each teacher shall organize a continuous assessment of each of the courses assigned to him/her. The internal assessment marks shall be given as per the following breakup:

Internal Assessment Tests / Term Papers / Quizzes (Minimum two)	= 30 marks
Seminars/ Assignments/ Case Demos/ Presentations/ Write ups/ Viva, etc.	= 10 marks
Internal Total	= 40 marks

6.3. Internal Assessments

A schedule of Internal Assessment tests may be prepared at the beginning of each semester. Internal Assessment marks shall be displayed a week before the conduct of end

semester examination and all corrected answer papers shall be given back to students with comments, if any. It is mandatory for all students to participate in all the Internal Assessment tests and in various course-work related activities for award of the above marks.

6.4. End- semester examinations and Evaluation

1. End Semester examination shall be conducted for all courses offered in the department. The duration of the end semester examination shall be 3 hours.
2. A schedule of End Semester examinations will be prepared and displayed by the department at least one month ahead of the conduct of the examination.
3. No student who has less than 70% attendance in any course shall be permitted to attend the end-semester examination and he/she shall be given grade of FA – failure due to lack of attendance. He/she shall be required to repeat that course. The HOD shall ensure that the candidate is informed about lack of attendance before the commencement of examination and confirm that such candidates are not permitted to write the exam.
4. End-semester Examination shall be conducted by the Department by assigning the responsibility of question paper setting, invigilation and valuation of answer papers to the course teachers. Wherever project/viva-voce evaluation is involved, a nomination may be obtained from the Dean concerned. The Dean may nominate a faculty from the sister departments / any other department in the University. Each teacher shall prepare the question paper, which should cover all the units of syllabus.
5. The Dean of the concerned school in consultation with HOD shall at Random scrutinize the question paper of the End Semester Examinations to ensure consistency and quality in the Academic Standards of the Questions and coverage of the syllabus.

6.5. Consolidation of Marks

Programme Committee consisting of VC's nominee and other members shall take up the consolidation of Internal Assessment marks and End-Semester marks and prepare a consolidated Marks Statement.

In order to declare the pass, a Student should get

a) A minimum of 40% marks in end-semester exam, and
b) A minimum of 50% marks in aggregate when Internal Assessment and End-Semester marks are added.

6.6. Supplementary Exam

a) A failed student who meets the attendance requirement and has a minimum of 40% in internal assessment mark may be permitted to register for the next end-semester examination in the following semester itself or in any semester of his/her choice.

b) Students who have failed due to insufficient attendance and / or less than 40 % Internal Assessment marks should repeat the course as and when it is offered.

7. PROGRAMME COMMITTEE

Every academic department of the University shall have a Programme Committee for implementing and monitoring the CBCS. The Programme Committee shall consist of a nominee of the Vice Chancellor who will be from a related disciple/department, all teachers offering the Hard and Soft core-courses for the Programmes of study and one student representative per class. The Head of the Department shall be the ex-officio Chair person.

7.1. Activities of the Programmme Committee

Duties and Responsibilities

1. It shall be the duty and responsibility of Programme Committee to implement the CBCS guidelines in all Programmes of Study prescribed in a Department. It reviews and monitors the implementation of BOS approved Course structure, Coverage of syllabus, Time Table, Distribution of workload of faculty, Conduct of classes, Internal Assessments and End-semester examinations.
2. Programme Committee shall review and recommend infrastructure requirements for smooth conduct of teaching-learning activities and to carryout research in every Department.
3. Programme Committee provides an opportunity for individual teachers to initiate steps to float new courses, new methods of teaching, ICT implementation, etc.

4. Programme Committee may give recommendations on the Non-plan Budget requirements for each Programme of Study under different heads like, a) Teaching aids, b) Invited Lecture, c) Field studies, d) Software subscriptions and renewals, e) Study Tour/ Industrial Visits, etc.

7.2. Frequency of Meetings

The Committee shall meet at least thrice in every semester. At first, in the beginning of the semester to chalk out Time Table, list of courses to offer, etc. Second time, at middle of the Semester to review the progress of academic activities. Last meeting of the Programme Committee shall finalize and recommend the grades for all the courses offered by the department in that semester. In this meeting student members shall not take part.

8. SCHOOL BOARD

1. The Dean, who is Chairperson of the respective School Board is the overall in-charge of implementing CBCS in all Programmes of study offered in different departments of the School.
2. Dean, being the Chairman of the School Board shall suggest certain uniform academic practices across all the departments in each School.
3. Dean also gives his approval for Grades and Results.
4. Dean of the respective School shall periodically review the Academic activities of Departments, resolve any issues in conduct of academic Programmes under CBCS regulations.

9. GRADING AND GRADE CARD

The Programme Committee shall prepare two copies of the results, one with marks to be sent to the University Office and another for the Department. Grades shall be awarded as indicated below (**Section 9.1**) in a meeting of the Programme Committee to be held at the earliest, not later than 15 days after the last day of semester examinations.

The department shall display the provisional grades approved by Programme Committee within a week after the meeting. If a student wishes to look at the evaluated answer script, he/ she can approach the concerned teacher within a week of declaration of the provisional results. Students can approach the Grievance Committee for issues relating to award of Marks/Grade. The Grievance Committee shall consist of the Dean, the HOD and an external subject expert and the decision by the Grievance committee after examing the paper shall be the final. Thereafter the results shall be communicated to the Dean for approval.

9.1. Letter Grades

Performances of students in each paper are expressed in terms of marks as well as in Letter Grades. In case of fractions the marks shall be rounded off to nearest integer. The class interval for the purpose of awarding the grades can be arrived at by dividing the difference between the highest mark secured and the minimum pass mark by 6 as there are six passing grades. The formula is given below:

$$K = (X-50)/6$$

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

The grades may be awarded as given in the following Table II.

Table II

Range of Marks in %	**Letter Grade**	**Points for Calculate of CGPA**
X to (X-K)+1	O	10
(X-K) to (X-2K)+1	A+	9
(X-2K) to (X-3K)+1	A	8
(X-3K) to (X-4K)+1	B+	7
(X-4K) to (X-5K)+1	B	6
(X-5K) to 50	C	5
Below 50	F	0
Failure due to lack of attendance	FA	0

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

In courses where the number of students who have secured 50 marks and above is less than 10 then grading may be given based on the Table III.

Table III

Range of Marks in %	Letter Grade	Points for Calculate of CGPA
81-100	O	10
71-80	A+	9
66-70	A	8
61-65	B+	7
56-60	B	6
50-55	C	5
Below 50	F	0
Failure due to lack of attendance	FA	0

The GPA and CGPA will be calculated as weighted average of points secured by the student in all the papers registered by him /her. The weights are the number of credits for each paper. For example, a student getting in A+ grade in 4 credit course, A grade in 2 credit course, O grade in a 3 credit course and F grade in a 3 credit course will have a GPA as (9x4 + 8x2 +10x3 + 0x3)/ (4+2+3+3)=(36+16+30+0)/12=82/12 = 6.83 out of 10.0; GPA = 6.83. The CGPA shall also be calculated in similar lines taking all subjects taken by the students in all semesters.

Students with a CGPA of 9.0 and above and did not fail in any of the courses taken by him / her shall be awarded Distinction.

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

Student who has secured less than 50% marks in any paper gets F Grade and he is treated as failed in that paper.

Model Grade Sheet

Example 1 - Average performance			Example 2 - Good performance			Example 3 - Skipping of grade	
Marks	Grade		Marks	Grade		Marks	Grade
78	O		86	O		85	O
72	A+		80	A+		83	O
70	A+		80	A+		80	O
68	A		80	A+		80	O
67	A		79	A+		71	A

64	A		78	A+		71	A
64	A		77	A+		70	A
62	B+		76	A+		70	A
62	B+		76	A+		69	A
62	B+		76	A+		68	B+
62	B+		75	A		67	B+
61	B+		74	A		67	B+
61	B+		74	A		65	B+
61	B+		73	A		64	B+
61	B+		73	A		64	B+
61	B+		71	A		62	B
58	B		70	A		61	B
58	B		69	A		60	B
58	B		68	B+		59	B
57	B		68	B+		59	B
56	B		67	B+		59	B
55	B		67	B+		59	B
55	B		67	B+		59	B
55	B		66	B+		58	B
55	B		66	B+		57	B
54	C		66	B+		57	B
54	C		66	B+		56	C
53	C		65	B+		54	C
53	C		64	B+		53	C
53	C		64	B+		53	C
53	C		64	B+		53	C
53	C		63	B+		53	C
51	C		62	B		52	C
50	C		62	B		50	C
50	C		60	B		46	F
50	C		60	B		45	F
50	C		60	B			
50	C		60	B			
50	C		60	B			
50	C		59	B			
50	C		58	B			
50	C		58	B			
50	C		57	B			
20	F		57	B			
K=4.67			K=6			K=5.83	

Marks	Grade	Marks	Grade	Marks	Grade
78 -74	O	86 - 81	O	85 - 80	O
73 - 70	A+	80 - 75	A+	79 – 74	A+
69 - 65	A	74 - 69	A	73 – 69	A
64 - 60	B+	68 - 63	B+	68 – 63	B+
59 - 56	B	62 - 57	B	62 – 57	B
55 - 50	C	56 - 50	C	56 - 50	C
< 50	F	< 50	F	< 50	F

9.2. Grade Card

1. The University Office shall issue a Grade card for the students, containing the marks and grades obtained by the student in the previous semester and Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA).

2. The grade card shall list:
   a. The title of the courses taken by the student.
   b. The credits associated with the course.
   c. The marks and grade secured by the student.
   d. The total credits earned by the student in that semester
   e. The GPA of the student.
   f. The total credits earned by the students till that semester.
   g. The CPGA of the student.

10. EXIT OPTION IN 5 YEAR INTEGRATED PROGRAMME

(1) The Exit Option shall be allowed at the end of 3rd year of all 5 year Integrated Programmes with the exception of M.P.Ed Programme and subject to fulfilling mandatory conditions.

(2) It is mandatory to complete the courses such as English, MIL Communcation, Environmental Sciences and Public Administration.

(3) The Concerned Co-ordinators have to frame the course structure and to arrange classes for the compulsory papers which are to be offered to fulfil the mandated requirements for consideration to issue Bachelor Degree.

(4) The minimum number of credits to be completed for a 3 year UG degree is 120, including mandatory courses.

(5) The students should be successful in all the courses (both hard and soft core).

(6) The students are permitted to exercise Exit Option any time after 3 years. However, the students should have completed minimum required credit for a UG Programme by that time.

(7) The respective Board of Studies will suggest the nomenclature of appropriate UG degree to the students who are exercising Exit Option.

(8) Integrated/Dual Degree (name of the first degree - name of the final degree) will be awarded to all students on successful completion of 5 year Integrated Programme.

11. POWER TO MODIFY AND REMOVE DIFFICULTIES

1. Notwithstanding anything contained in the foregoing, the Chairman, Academic Council shall have the power to issue directions or orders to remove any difficulty.
2. Nothing in the foregoing limits the power the A.C. to amend, modify or repeal any or all of the above.

PONDICHERRY UNIVERSITY

SCHOOL OF LIFE SCIENCES

DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY

MASTER OF SCIENCE
IN
BIOCHEMISTRY AND MOLECULAR BIOLOGY

PROGRAMME OBJECTIVES

The M.Sc. programme in Biochemistry and Molecular Biology will:

(1) provide training and understanding of basic concepts as well as cutting edge advancement in the field of Biochemistry and Molecular Biology,

(2) impart practical skills through laboratory courses and understanding of modern scientific techniques,

(3) enhance analytical, statistical and validation skills through hands on training,

(4) expose students to various aspects of research through dissertation, and

(5) introduce applications of Biochemistry and Molecular Biology in order to prepare highly trained and skilled workforce for teaching, research and entrepreneurship.

PROGRAMME OUTCOMES

By the end of the programme students will:

(1) have an in-depth understanding of the basic and recent developments in the field of Biochemistry and Molecular Biology,

(2) acquire skills of critical, analytical and problem solving in order to enable them to be successful in various national and international examinations,

(3) possess skills for independent thinking and in writing scientific proposal and presentations, and

(4) capable of becoming successful academicians/researchers and/or entrepreneurs.

PONDICHERRY UNIVERSITY

SCHOOL OF LIFE SCIENCES

DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY

SYLLABUS FOR M.Sc. BIOCHEMISTRY AND MOLECULAR BIOLOGY

2019-20 onwards

Online Courses recognized by UGC can be opted for with the approval of the Department.

Total credit requirements 72

BCMB 430 - ANALYTICAL BIOCHEMISTRY AND BIOPHYSICS

3 Credits

COURSE OBJECTIVES: *To understand the principles of physical sciences that form the basis of the techniques and instrumentation used in biological science*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Electrochemical techniques & Photometry 11h

Basic principles of electrochemistry - pH electrode- ion-selective- gas- sensing and oxygen electrodes - Elementary details of Biosensors. Principles and techniques of colorimetry & spectrophotometry- Beer-Lambert's Law - instrumentation - hypo and hyperchromicity - Fluorimetry – Flow cytometry - Atomic absorption spectrometry- Circular Dichroism- Optical rotary Dispersion-Nuclear Magnetic Resonance Spectroscopy – Infra Red Spectroscopy

UNIT- II – Microscopy 7h

Microscopy- basic principles and applications– Light– Compound– Phase contrast– Dark Field- Fluorescence Microscopy Scanning Electron Microscopy - Transmission Electron Microscopy (TEM) - Scanning Tunneling Microscopy- (STM) – Confocal Microscopy.

UNIT- III – Centrifugation 6h

Basic principles of Centrifugation – instrumentation, centrifugation units - Types of centrifuges – rotors, accessories - centrifugation methods - sedimentation velocity - sedimentation equilibrium – colloids - cell fractionation methods.

UNIT- IV – Chromatography 10h

Types of chromatography - column, thin layer, paper, adsorption, partition, gas liquid ion exchange, affinity, High Performance Liquid Chromatography -principles of each type- instrumentation and accessories- detection methods & systems – qualitative and quantitative aspects – applications;

UNIT- V –Electrophoresis 6h

Types of Electrophoresis – paper and gel – agarose and PAGE – pulsed field – capillary – isoelectric focusing – blotting techniques: western, Southern & northern. Applications

Text Books

1. James, P. Allen. (2008). Biophysical Chemistry, Wiley Blackwell, New Jersey.
2. Wilson, K. and Walker, J. (2010) Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, Cambridge.

Suggested Reading

1. Horst, F. (2010) Basic One and Two-dimensional NMR Spectroscopy, Wiley-VCH, New Jersey.
2. Murphy, D.B. and Davidson, M. W. (2012) Fundamentals of Light Microscopy and Electron Imaging, Wiley-Blackwell, New Jersey.
3. Freifelder, D.M. (1983) Physical Biochemistry- Application to Biochemistry and Molecular Biology, W.H. Freeman, New York

COURSE OUTCOME: *Students will know the physical basis of appropriate strategies and instrumentation for analysis of different biological sample types.*

BMB 431 - BIOMOLECULES AND BIOENERGETICS

3 Credits

COURSE OBJECTIVES: *To provide basic understanding of physical & chemical properties of macromolecules and principles of bioenergetics*

Pre-requisite*:* Bachelor's level course in Life Sciences.

UNIT- I– Biomolecules concepts and Bioenergetics 8h

General concepts of biomolecules, bonding and interactions. Bioenergetics: First and second laws of thermodynamics– entropy, enthalpy, standard free energy changes, standard reduction potentials, membrane potential. Mobile electron-carriers and role of electron transport chain in electron capture – Role of Fe-S clusters in proton gradient – ATP and high-energy phosphate compounds – Thermodynamics of coupled reaction. Energy terms and balance in intermediary metabolism (outline of glycolysis, tricarboxylic acid cycle, electron transport chain).

UNIT- II – Carbohydrates 8h

Monosaccharides – stereochemistry, optical activity – Disaccharides – Oligosaccharides – N-linked, O-linked and GPI linked Oligosaccharides – Sugar derivatives. Homo- and hetero- polysaccharides. Glycoproteins – Proteoglycans – Glycosaminoglycans – structures and biological functions. Blood group substances and Sialic acid. Sugar code - Lectins types and functions.

UNIT- III – Proteins and Amino acids 9h

Amino acids classification and chemistry. Proteins– primary structure – secondary – tertiary – quaternary – super secondary structures. Sequence determination – Ramachandran plot – peptide synthesis (automated solid phase). Globular and fibrous proteins (triple helix collagen and hemoglobin structure). Protein folding and dynamics– Molecular chaperones – heat shock proteins. Protein denaturation (pH, temperature, chaotropic agents) – refolding.

UNIT- IV– Lipids 8h

Lipids classification – structure and chemical properties – saturated and unsaturated fatty acids. Essential and non-essential fatty acids. Structure and functions of phospholipids – glycolipids – sphingolipids – lipid soluble vitamins. Lipoproteins types transport and functions. Biological functions of steroids and carotenoids.

UNIT- V– Nucleic acids 7h

Nucleic acids types (A, B and Z forms) – Chemistry and structural organization – supercoiling – triple helix of DNA. Denaturation and renaturation of DNA – hyper and hypochromicity – Tm. Structure and functions of t-RNA – hnRNA – and non-coding regulatory RNAs (siRNA– miRNA, etc.).

Text Books

1. Nelson, D.L. and Cox, M.M. (2012) Lehninger's Principle of Biochemistry, W.H. Freeman, New York.
2. Voet, D. and Voet, J.G. (2010) Biochemistry. John Wiley and Sons Inc., New Jersey.

Suggested Reading

1. Garrett, R.H. and Grisham, C.M. (2016). Biochemistry, Cengage Learning, Mason. Ohio.
2. Berg, J.M., Tymoczko, J.L., Stryer, L. (2011) Biochemistry,W. H. Freeman, New York.
3. Harris, D.A. (1995) Bioenergetics at a glance. Willey J. and Sons Inc., New Jersey.

COURSE OUTCOME

The course will ensure basic understanding of physical, chemical and functional properties of macromolecules and principles of bioenergetics.

BCMB 432 - CELL BIOLOGY

3 Credits

COURSE OBJECTIVES: *To understand structural and functional aspects of cells and basic mechanisms underlying cell signaling and cell division.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT-I - Cellular evolution **6h**

Assembly of macromolecules and origin of life, endosymbiotic theory, RNA world hypothesis - structural organization of prokaryotic and eukaryotic cells - different cell types in tissues.

UNIT-II – Bio-membranes and cell signaling **9h**

Structural organization, models of plasma membrane, membrane permeability- transport across cell membranes. The cytoskeleton - microtubules, microfilaments and intermediate filaments. The extracellular matrix - collagen, integrin, elastin, fibrillin, fibronectin, laminin and proteoglycans. Basics of cell signaling- transmembrane, cytosolic and nuclear receptors, integrin and tyrosine kinase signaling, GPCRs role of secondary messengers.

UNIT-III - Mitochondria **8h**

Molecular organization and function - components of respiratory chain- chemiosmotic theory- ATP formation- uncouplers of oxidative phosphorylation- mitochondrial DNA and semiautonomy; autophagy and necrosis. **Ribosomes**- biogenesis, structural organization and functions.

UNIT-IV - Endomembrane system **9h**

Structure and function of endoplasmic reticulum and Golgi complex- post translational modifications, protein sorting, targeting and secretion; importance of proteasomes. Microbodies- peroxisomes, glyoxysomes, lysosomes, and their functions; **Nucleus** - internal organization- nuclear pore complex and transport- nucleosomes and chromatin organization.

UNIT-V – Cell division **8h**

Stages of mitosis and meiosis- cohesins and condensins in chromosomes segregation, structure and functions of kinetochore, centrosomes and its functions, regulation of cell cycle- cyclin, CDKs, check points in cell cycle.

Text Books:

1. Alberts, B., Bray, D., Hopkin, K., Johnson, A.D., Morgan, D. Raff, M., Roberts, K., Walter, P. (2018) Essential Cell Biology, W. W. Norton and Company, San Francisco.
2. Raven, P.H., Johnson, G.B., Mason, K.A., Losos, J., Singer, S. (2016) Biology, McGraw Hill Education, St. Louis.

Suggested Reading:

1. Campbell, N.A. and Reece J.B. (2008) Biology, Pearson Benjamin Cummings, San Francisco.

COURSE OUTCOME: *Students will understand the fundamentals of cell biology and cell signaling.*

BCMB 433 - ENZYMOLOGY

3 Credits

COURSE OBJECTIVES: *To understand the principles of physical sciences in the techniques and instrumentation used in biological science*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Introduction to Enzymes **10h**

Historical perspective- Nomenclature and classification of enzymes – properties of enzymes, enzyme activity and units, specific activity, factors affecting enzyme activity - catalytic power and specificity, Hill's plot - Scatchard plot - Theories of specificity and catalysis - lock and key theory, induced fit model, transition state theory, strain theory of enzyme action. Enzyme kinetics- Michaelis-Menten equation- catalytic efficiency - analyses of kinetic data- Lineweaver-Burk plot- Eadie Hofstee, Hanes Woolf and Cornish Bowden plots - Haldane relationship.

UNIT- II – Bisubstrate reactions and enzyme inhibition **7h**

Bi-substrate reactions- Sequential – Ping-Pong reactions- rate equations, examples – Differentiating Bi-substrate mechanisms. Enzyme inhibition- Irreversible- Reversible- Competitive- Uncompetitive – Mixed and Non-Competitive inhibition- graphical analysis – Determination of Ki, enzyme inhibitors as drugs – Basic concepts of structure based/rational drug design - Properties of a lead compound – Lipinski's Rule of Five - IC50, TD50, LD50, ED50 – Therapeutic Index - Structure activity relationships – Fragment based lead discovery - Quantitative structure activity relationships - Phases of clinical trials.

UNIT- III – Enzyme Catalysis **10h**

Acid-Base catalysis - Covalent catalysis - Metal ion catalysis - Electrostatic catalysis - Catalysis through proximity and orientation effects - Catalysis by transition state binding. Catalysis in model enzymes – ribonuclease A, chymotrypsin, carbonic anhydrase, carboxypeptidase A, lysozyme.

Coenzymes – $NAD(P)^+$, FMN & FAD, CoA.SH, TPP, PLP, Biotin, THF, methylcobalamin, ascorbate, menaquinone - structure & function.

UNIT- IV – Regulation of enzyme activity **7h**

Regulation by availability, importance of compartmentalization. Isoenzymes – Isoenzymes of clinical importance. Regulation by reversible covalent modification - proteolytic activation.

Allosteric enzymes- allosteric binding in feedback regulation - Monod, Wyman and Changeux Model - Koshland, Nemethy & Filmer Model of allosteric enzymes - subunit interaction and regulation of enzyme activity in aspartate transcarbamoylase.

UNIT- V – Applications of Enzymology **6h**

Enzyme purification – methods and strategies. Test for catalytic activity – active site titrations – Overview of enzyme engineering - Immobilized enzymes- methods and applications in industry-medicine - enzyme electrodes in biosensors.

Text Books

1. Voet, D. and Voet, J.G. (2010) Biochemistry. John Wiley and Sons Inc., New Jersey.
2. Nelson, D.L. and Cox, M.M. (2013) Lehninger's Principle of Biochemistry, W.H. Freeman, New York.

Suggested Reading

1. Nicholas, P. and Lewis, S. (1999) Fundamentals of Enzymology: Cell & Molecular Biology of Catalytic Proteins. Oxford University Press.
2. Palmer T. and Bonner P. (2007) Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. Horwood Publishing Ltd., United Kingdom.

COURSE OUTCOME: *Basic understanding of enzyme kinetics, inhibition, mechanisms of action, enzyme regulation and applications.*

BCMB 434 – MOLECULAR BIOLOGY

3 Credits

COURSE OBJECTIVES: *To demonstrate knowledge and understanding of the molecular machinery of living cells. This course will introduce the principles that govern the synthesis of macromolecules: DNA, RNA and protein and chromatin organization.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Introduction **8h**

Discovery of DNA - The genomes of bacteria, viruses, plasmids, mitochondria and chloroplast- Gene transfer in microorganisms- conjugation- transformation, transduction – protoplasmic fusion.

UNIT- II – Organization of genome **9h**

Components of eukaryotic chromatin - chromatin and chromosome structure- DNA-supercoiling - linking number- Cot curve, C- value paradox - satellite DNA - possible functions - repetitive sequences – transposons.

UNIT- III – DNA replication **9h**

Prokaryotic and eukaryotic DNA replication – mechanism of replication, enzymes and necessary proteins in DNA replication, telomeres, telomerase and end replication, role of telomerase in aging and cancer. DNA Mutation and Repair - mutation subtypes, mismatch, base-excision, nucleotide-excision and direct repair. DNA recombination - homologous, non - homologous and site-specific. DNA transposition.

UNIT- IV – Transcription **6h**

Prokaryotic and eukaryotic transcription - RNA polymerases - general and specific transcription factors- regulatory elements. Mechanism of transcription regulation and transcription termination. Post-transcriptional modification - 5' cap formation- 3'end processing and polyadenylation- splicing-editing- nuclear export of mRNA- mRNA stability. Inhibitors of transcription

UNIT- V – Translation **8h**

Genetic code - Prokaryotic and eukaryotic translation - translational machinery. Mechanism of initiation - elongation and termination. Regulation of translation. Inhibitors of translation.

Text Books

1. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2014) Molecular Biology of Gene. Cold Spring harbor, New York.
2. Nelson, D.L. and Cox, M.M. (2012) Lehninger's Principle of Biochemistry. W.H. Freeman, New York.

Suggested Reading

1. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K.C. (2016) Molecular Cell Biology. W.H. Freeman, New York.
2. Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. (2014) Lewin's Gene XI. Jones and Bartlett Learning, Massachusetts.

COURSE OUTCOME: *Students will be able to understand the central dogma of molecular biology and fundamentals of biogenesis of macromolecules.*

BMB 480 - ANALYTICAL BIOCHEMISTRY LAB

1 Credit

1. Buffers: Basic principles, Concept of pH, buffering capacity and pKa, Preparation of different biological buffers in the laboratory, Calculations based on Henderson- Hassel Balch equation Use of pH meters. Handling of buffers and storage concerns.

2. UV- Visible Spectroscopy: Basic Principles, Concept of extinction co efficient, absorption spectra of nucleic acids, amino acids and proteins.

3. Separation of biomolecules by precipitation techniques

4. Separation of biomolecules by extraction techniques - Partition chromatography, adsorption chromatography

5. Biomolecule separation by ion exchange chromatography

6. Separation of Biomolecules by Size exclusion chromatography

7. Determination isoelectric point of proteins

8. Electrophoretic separation of proteins

9. Subcellular fractionation by centrifugation

Reference:

Hofman A. and Clokle S. (2010) Wilson and Walker's Principle and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge.

BCMB 481- BIOMOLECULES LAB

1 Credit

1. Comparative estimation of reducing sugar by Benedict's & dinitrosalicylic acid (DNSA) method – sensitivity & specificity.
2. Comparative of protein quantification methods – Biuret & Lowry – sensitivity, specificity and interference
3. Estimation of DNA by diphenylamine method (DPA) – significance of deoxyribose.
4. Estimation of RNA by orcinol method – significance of ribose.
5. Estimation of cholesterol.
6. Estimation of inorganic phosphate.
7. Estimation of free proline.
8. Isolation and estimation of casein in milk.
9. Isolation of cholesterol and lecithin from egg.

Reference:

Hofman A. and Clokle S. (2010) Wilson and Walker's Principle and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge.

BCMB 482 - CELL BIOLOGY LAB

1 Credit

1. Observation of eukaryotic cells with the help of light microscope.
2. Permanent slide preparation and preparation of slide for dicot leaf section.
3. Cell counting and viability (yeast/bacteria).
4. Mitosis and the cell cycle in onion root-tip cell.
5. Isolation of mitochondria and assay for function.
6. Isolation of peroxisomes and assay for function.
7. Determination of osmotic fragility of cell (goat erythrocyte).
8. Isolation of goat erythrocyte plasma membrane and estimation of Na^+/K^+ ATPase.
9. Karyotyping
10. Mammalian Cell culture (demonstration and report only)

Reference:

Hardin, J. and Bertoni, G. P. (2016) The World of the Cell, Pearson, Madison.

BCMB 483 - ENZYMOLOGY LAB

1 Credit

1. Estimation of enzyme activity (serum alkaline phosphatase) by endpoint assay.
2. Estimation of enzyme activity (serum alkaline phosphatase/lactate dehydrogenase/horse radish peroxidase) by continuous monitoring assay.
3. Estimation of enzyme (serum aspartate transaminase) activity by coupled assay.
4. Effect of pH on enzyme (horse gram urease/ alkaline phosphatase) activity.
5. Effect of Temperature on enzyme (horse gram urease/alkaline phosphatase) activity.
6. Effect of substrate concentration on enzyme (serum alkaline phosphatase/urease) activity.
7. Determination of K_m & V_{max} of an enzyme (horse gram urease/alkaline phosphatase).
8. Partial purification of enzyme and determination of specific activity.
9. Determination of catalytic efficiency.
10. Enzyme inhibition studies and determination of Ki (cadmium chloride on alkaline phosphatase).

Reference:

Bisswanger, H. (2011) Practical Enzymology. John Wiley & Sons, New Jersey.

BCMB 484 - MOLECULAR BIOLOGY LAB

1 Credit

1. Extraction of genomic DNA
2. Extraction of plasmid DNA
3. Spectrophotometric analysis of purity of isolated DNA
4. Agarose gel electrophoresis of genomic and plasmid DNA
5. Restriction digestion of chromosomal DNA
6. Restriction digestion of plasmid DNA
7. Isolation of DNA fragment from agarose gel
8. Isolation of RNA
9. Analysis of RNA by formaldehyde – agarose electrophoresis.

Reference:

Green, M. R. and Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual Vol 1, 2 & 3, CSHL Press. New York.

BCMB 435 - BIOSTATISTICS AND SCIENTIFIC WRITING

3 Credits

COURSE OBJECTIVES: *The objective of the course is to learn basic statistics and scientific communication.*

Pre-requisite: Bachelor's level course in Life Sciences

UNIT- I – Central Tendency and Dispersion of Data **12h**

Introduction- definition of statistics-population and universe- the sample and population- statistical inference- parameter and statistics

Handling of bulky data- construction a histogram- interpretation of histogram- the normal distribution- the mean-mode-and standard deviation- uncertainties in estimating a mean.

UNIT- II – Chi Square and Poisson's Distribution **6h**

Proportion data- Examples of Proportion data- MPM- sterility testing of medicines- animal toxicity- infection and immunization studies e.g., LD50, ED50, PD50 statistical treatment to proportion data- Chi-square test- goodness of fit to normal distribution.

Count data- Examples of count data (bacterial cell count, radioactivity count, colony and plaque count, etc.). Statistical treatment to count data- Poisson's distribution- standard error- confidence limits of counts.

UNIT- III - Test of significance **6h**

Analysis of variance- Introduction –procedure-F and t test.

UNIT- IV – Correlation and Regression **8h**

Correlation regression and line fitting through graph points- standard curves- correlation- linear regression (fitting the best straight line through series of points)- standards curves and interpolations of unknown y-values thereon.

UNIT- V – Scientific Writing & Communication **8h**

Methodology for writing science report and oral presentation- compilation of experimental record- program of writing- use of vocabulary- use of good english-art of illustration- report writing- editing and correcting- technique of oral presentation.

Text Book:

1. Glover. T. and Mitchell, K. (2015) Introduction to Biostatistics. McGraw –Hill Science.

Suggested Reading:

1. Zar. J.H. (2010) Biostatistical Analysis, Pearson Education, New Jersey.
2. Matthews, J.R. and Matthews, R.W. (2007) Successful Scientific writing: A step-by- step Guide for Biomedical Scientists, Cambridge University Press, Cambridge.
3. Snedecor, G. W. and Cochran, W. G. (1989).Statistical methods. Iowa State Press, Iowa.
4. Green, R. H. (1979) Sampling Design and Statistical Methods for Environmental Biologists, John Wiley & Sons, New Jersey.

COURSE OUTCOME: *At the end of the course the students will be able to apply appropriate statistical test for their analysis and will be able to effectively communicate scientifically.*

BCMB 436 - GENOMICS

3 Credits

COURSE OBJECTIVES: *To get an overview of genomics, its functional aspects and understanding of genome analysis.*

Pre-requisite – Master's level course in Molecular Biology.

UNIT- I - Overview of Genomics **6h**

Introduction to Genomics, number of genes and complexity of genomes, Structural genomics, Comparative genomics, Organelle genome: nuclear genome, mitochondria and chloroplast, Concepts of Metagenomics, Conservation and diversity of genomes.

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UNIT- II – The Genome project **10h**

History, organization and goals of human genome project, Strategies for sequencing genomes, Genetic and physical map, DNA segment nomenclature, Organization of human genome: Mitochondrial genome, Gene density, CpG islands, RNA-encoding genes, functionally identical/similar genes, Diversity in size and organization of genes, Annotation. Human genome diversity, Human Microbiome Project, 16S rRNA analysis.

UNIT- III – Functional genomics **8h**

Functional genomics of microbes, plants and animals; transcriptome analysis methods, microarrays and serial analysis of gene expression. Basic concepts of identification of disease genes, gene silencing, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling, identification of SNPs.

UNIT- IV – Molecular markers in genome analysis **8h**

Tools for genome analysis- RFLP, RAPD, AFLP, SSLPs, STR, EST and SNPs, Disease monitoring, Linkage and Pedigree, disease prognosis, genetic counseling.

UNIT- V – Pharmacogenomics 8**h**

Pharmacogenetics, cancer genomics, immunogenomics, somatic cell Genomics, biochemical genomics, single cell analysis, Genetics of globin triplet repeat Disorders, polygenic inheritance, Effects of drugs in individual and susceptibility, Personalized medicine, Synthetic Genomes. Ethics and issues of synthetic.

Text Books

1. Lesk, A.M. (2012) Introduction to Genomics, Oxford University Press Inc., New York.
2. Pevsner, J. (2015) Bioinformatics and Functional Genomics, John Wiley and Sons, Inc., Hoboken.

Suggested reading

1. Zdanowicz, M.M. (2010) Concepts in Pharmacogenomics, American Society of Health-System Pharmacists, Bethesda.
2. Dale, J.W., Schantz, M.V., Plant, N. (2012) Concepts and Applications of DNA Technology. John Wiley & Sons, Ltd, Chichester.

COURSE OUTCOME: *The course will impart understanding of comparative genomics, construction of protein interaction maps and outline the various experimental methods used to identify transcribed parts of a genome.*

BCMB 437 - METABOLISM AND REGULATION

3 Credits

COURSE OBJECTIVES*: To provide an overview of cellular metabolism, organization of metabolic networks and regulatory mechanisms.*

Pre-requisite – Master's level course in Biomolecules and Enzymology.

UNIT- I - General Introduction **10h**

Metabolism – Anabolism – Catabolism - Xenobiotic metabolism. Metabolism of carbohydrates: glycolytic pathway, gluconeogenesis pathway, reciprocal regulation of gluconeogenesis and glycolysis. Pentose phosphate pathway - Citric acid cycle and its regulation - Glycogen synthesis and degradation - Regulation of glycogen metabolism - Cori's cycle.

UNIT- II - Metabolism of Lipids **8h**

Oxidation of fatty acids - beta oxidation, alpha oxidation and omega oxidation, oxidation of fatty acids with odd number of carbon atoms. Ketogenesis. Biosynthesis of saturated fatty acids and unsaturated fatty acids, regulation of fatty acid biosynthesis. Biosynthesis of tri-acylglycerol and phospholipids. Cholesterol - biosynthesis, transport and excretion, regulation of cholesterol biosynthesis.

UNIT- III - Metabolism of Amino acids **7h**

Overview of biosynthesis of non-essential amino acids from amphibolic intermediates – α - ketoglutarate, oxaloacetate, 3-phosphoglycerate. Glucose - alanine cycle, Urea cycle reactions.

UNIT-IV - Metabolism of Porphyrins **8h**

Biosynthesis and catabolism of Porphyrins – heme, bile pigments. Metabolism of Purines and Pyrimidines**:** biosynthesis and catabolism of purines and pyrimidines, regulation of purine and pyrimidine biosynthesis.

UNIT- V - Dietary Minerals **7h**

Biological roles of magnesium, sodium, potassium and phosphate trace elements. Metabolism of iron: absorption, storage, transport and excretion, iron deficiency and overload. Genetic errors of metabolism: representative examples– galactosemia, phenylketonuria, alkaptonuria, albinism.

Text Books

1. Nelson, D.L. and Cox, M.M. (2013) Lehninger's Principle of Biochemistry, Macmillan, London.
2. Murray, R.K., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2006) Harper's Biochemistry, McGraw Hill, New York.

Suggested Reading

1. Voet, D., Voet, J.G., Pratt, C.W (2016) Fundamentals of Biochemistry. Life at the molecular level, Wiley-VCH, New Jersey.
2. Berg, J.M., Tymoczko, J.L, Stryer, L. (2012) Biochemistry, H. Freeman and Company, Canada.

COURSE OUTCOME: *Understanding of different regulatory mechanisms in metabolic pathways, the key regulatory points in metabolic pathways and molecular mechanisms underlying major inherited diseases of metabolism.*

BMB 438 - MOLECULAR ENDOCRINOLOGY

3 Credits

COURSE OBJECTIVES:

To provide basic understanding of organization, physiology and regulation of endocrine glands along with biological functions and control mechanisms.

Pre-requisite – Bachelor's level course in Life Sciences.

UNIT- I – Introduction to Endocrinology 8h

Definition and scope of Endocrinology – historical and anatomical aspects of mammalian endocrine system. Definition of a hormone – chemical nature of mammalian hormones – types of hormone receptors. Secondary messenger systems – General mechanism of signaling by G protein coupled receptors, receptor tyrosine kinase and ion channels. General mechanism of peptide and non-peptide hormone action. Axis and feed-back regulation of endocrine system.

UNIT - II – Brain and gut hormones 8h

Brain as endocrine organ – Hypo-physiotropic hormones – significance of hypophyseal portal system. Pituitary gland and its hormones – chemistry and biochemical functions. Neuro-hormones – the brain-renin angiotensin. Concept of central and peripheral regulation of endocrine system. Gut hormones and brain axis – Neuropeptides – roles in obesity. Pineal gland hormones – chemistry – mechanism of action. Melatonin and circadian rhythm.

UNIT- III – Thyroid and Parathyroid gland hormones 8h

Thyroid gland hormones chemistry – biochemical functions – mechanism of action. Regulation of thyroid function. Disorders of thyroid hormone – Concept and etiology of primary, secondary, tertiary hypothyroidism and peripheral resistance – Hashimoto's thyroiditis – thyrotoxicosis – Graves' disease. Thyroid function test. Parathyroid glands – biochemical functions. Hormones involving in calcium metabolism – chemistry – molecular mechanism of action. Somatostatin.

UNIT - IV– Adrenal gland and Adipose tissue hormones 8h

Adrenal gland – hormones of adrenal cortex and medulla – chemical nature, functions and regulation of secretions of the adrenal cortical hormones. Cushing's syndromes and Addison's disease. Biosynthesis and catabolism of catecholamines – biochemical functions. Phaechromocytoma. Pancreatic hormones – Insulin and glucagon chemistry, biochemical functions, mechanism of action. Diabetes mellitus. Hormones of the adipose tissue – Leptin and adiponectin biological functions.

UNIT- V– Reproductive Endocrinology 8h

Hormones of testes and ovary – Ovarian steroid hormones chemistry, biosynthesis and transport. Endocrine functions of testis – synthesis, chemistry and metabolism of androgens. Dynamics of sex hormone production and mechanisms of action. Testicular and ovarian determining genes – Mullerian inhibiting substance genes. Molecular basis of male and female contraception.

Text Books:

1. Rodwell, V., Bender, D., Weil, P.A., Kennelly, P., Botham, K. (2015) Harpers Illustrated Biochemistry, McGraw-Hill Education / Medical, New York.
2. Melmed, S., Polonsky, K.S., Larsen, P.R., Kronenberg, H.M. (2015) Williams Textbook of Endocrinology, Elsevier, New York.

Suggested Reading:

1. Hadely, M.E. and Levine, J.E. (2006) Endocrinology, Benjamin Cummings, San Francisco.
2. Wass, J.A.H., Stewart, P.M., Amiel, S.A., Davies, M.J. (2011) Oxford Textbook of Endocrinology and Diabetes, OUP, Oxford.

COURSE OUTCOME

Development of understanding of organization and functions of endocrine glands, feedback regulations, mechanisms of actions of hormones and clinical importance.

BCMB 439 – MOLECULAR GENETICS

3 Credits

COURSE OBJECTIVES: *The course will focus on the fundamental concepts in genetics and techniques used to predict genetic outcomes.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Introduction to Genetics **10h**

Molecular Evolution: History of Genetics and Evolutionary biology, Neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; origin of new genes and proteins; Gene duplication and divergence.

Mendelian and non-Mendelian principles: Laws of Inheritance, autosomal inheritance, Chi square analysis, Phenocopy, Inheritance of mitochondrial and chloroplast genes, X- linked Inheritance, Maternal Effect - Sex influenced and sex determined traits.

UNIT- II – Genome Mapping **7h**

Mapping in Bacteria, bacteriophages and yeast: - Mapping genes by interrupted mating, deletion mapping

Chromosomal Mapping in Eukaryotes: Linkage maps, - Physical Mapping- restriction mapping, mapping with molecular markers, somatic cell hybrids. Linkage mapping in haploid organisms - tetrad analysis, development of mapping population in plants.

UNIT- III – Developmental Genetics **8h**

Genetics of drosophila embryo development, axes and pattern formation in drosophila, Homeotic induction, Floral development in plants, Sex determination, Dosage compensation and X-inactivation in human female, Genomic imprinting.

Epigenetic regulation and inheritance – Chromatin modification, Euchromatin, Heterochromatin-DNA methylation, histone acetylation, histone methylation, non-coding RNAs in chromosomal remodeling and gene activity.

UNIT- IV – Human Genetics **9h**

Human genetics: Genetic disorders- Autosomal Dominant, Recessive and X- Linked and other Maternally inherited Diseases- Pedigree analysis- Genetic testing –Direct testing, – Karyotyping, Prenatal diagnosis - Gene tracking, Detection of Single Nucleotide Polymorphism. Haplotype and Linkage Equilibrium, Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping, LOD score for Linkage testing.

Population Genetics: Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; Adaptive radiation; Isolating mechanisms; Speciation; Allopatricity and Sympatricity; Convergent evolution; Sexual selection; Human Impact in Genetic Variation, Co-evolution.

UNIT- V – Mutations and Genetics of Cancer **6h**

Mutations - molecular & phenotypic perspective. Chromosomal mutations- deletion, duplication, inversion, translocation, ploidy and their genetic implications.

Genetics of Cancer: Defects in DNA repair, oncogenes and proto-oncogenes, viral oncogenes, tumor suppressor genes, genes in cell cycle checkpoint regulation and cancer.

Text Books

1. Strachan, T. and Read, A. (2018) Human Molecular Genetics. Garland Science, CRC Press, Florida.

2. Griffiths, A.J.F., Wessler, R.S., Carroll, S.B., Doebley, J. (2015) Introduction to Genetic Analysis. W.H. Freeman and Company, New York.

Suggested Reading

1. Sudbery, P. and Sudbery, I. (2010) Human Molecular Genetics. Pearson, London.
2. Snustad, D.P. and Simmons, M.J. (2008) Principles of Genetics. John Wiley and Sons Inc, New Jersey.

COURSE OUTCOME: *Basic understanding of Mendelian /transmission genetics and mechanisms of non-Mendelian inheritance of traits, population and quantitative genetics and basic understanding of the genetic basis of development and cancer.*

BCMB 485 - GENERAL MICROBIOLOGY LAB

1 Credit

1. Introduction to sterilization techniques- sterilization of glass wares, autoclaving.
2. Preparation of liquid and solid media
3. Isolation of Bacteria and fungi from soil samples – serial dilution technique
4. Measurement of bacterial population
5. Pure culture techniques: spread plate, streak plate technique and pour plate
6. Determination of Bacterial growth curve
7. Identification of bacteria by morphological and Biochemical characteristics
8. Smear preparation and staining of bacteria: simple staining, Grams staining and spore staining
9. In vitro antibiotic sensitivity tests for selected bacterial cultures
10. Methods for preserving microbial cultures: slant, glycerol stock and lyophilization

Reference:

Sherman, N. and Cappuccino, J.G. (2004) Microbiology A Laboratory Manual, Benjamin-Cummings Publishing Company, San Francisco.

BCMB 486 - METABOLISM AND REGULATION LAB

1 Credit

1. Estimation of urea
2. Estimation of uric acid
3. Estimation of creatinine
4. Determination of bilirubin
5. Estimation of pyruvate
6. Precipitation of calcium and estimation of calcium
7. Assay of acid phosphatase enzyme activity
8. Determination of catalase activity from liver/serum
9. Assay of alcohol dehydrogenase/ glutamate dehydrogenase enzyme activity in liver/ serum
10. Determination of alanine transaminase enzyme activity

Reference:

Bisswanger, H. (2011) Practical Enzymology. John Wiley and Sons, New Jersey.

BCMB 536 - GENETIC ENGINEERING

3 Credits

COURSE OBJECTIVES: *To provide understanding of genetic manipulation and gene transfer in addition to providing insights into its success in living systems.*

Pre-requisite: Master's level course in Molecular Biology.

UNIT- I - Introduction to Genetic Engineering 10h

Enzymes used in rDNA technology (Restriction enzymes, nucleases, RNA polymerases, DNA polymerases, PNK, alkaline phosphatases, DNA ligases). Cloning Vectors for *E. coli:* Plasmids, Bacteriophage λ, Filamentous phage, Cosmids, Phagemids and other advanced vectors: BAC, YAC, P1-derived Artificial Chromosome, Shuttle vectors, Expression vectors.

UNIT- II – Gene Transfer Techniques 8h

Cloning Vectors for Eukaryotes: Vectors for cloning in yeast, Vectors for cloning in animal cells– adenoviral vector, adeno-associated viral vectors, retroviral vectors, baculovirus vectors for cloning in insect cells. Ligation of DNA fragments– using DNA ligases, homopolymer tailing, linkers and adaptors. Introduction of foreign DNA into prokaryotes - Natural gene transfer methods, calcium chloride mediated transformation, transfection with phage vectors. Introduction of foreign DNA into animal cells - lipofection, electroporation, microinjection, microprojectile.

UNIT- III - Gene Cloning Strategies 7h

Construction of genomic and cDNA libraries. Selection and screening of recombinant clones: Methods based on nucleic acid hybridization, finding specific clones by functional complementation. Reporter genes. Studying protein-protein interactions-Phage display libraries, yeast two hybrid systems.

UNIT- IV – Gene Manipulation Techniques 8h

DNA sequencing methods –Sanger's sequencing method, Next generation sequencing methods– pyrosequencing, Polony sequencing. Polymerase chain reaction and its applications, altering genes-Site-directed mutagenesis. DNA microarrays. Dot Blot and Slot Blot Hybridization, Fluorescence *in-situ* hybridization. Analysis of DNA protein interactions-Electrophoretic mobility shift assay, Filter-binding assay, Chromatin Immunoprecipitation (ChIP) assay, Methylation Interference assay.

UNIT- V – Expression of Engineered Proteins 7h

Engineering microbes for the production of therapeutic proteins - insulin and growth hormones. Concepts of gene knock out technique- Cre-loxP recombination. Production of transgenic mice and applications of transgenic mice. Gene Therapy: Gene silencing by RNA interference technology-Genome editing by CRISPR/Cas. Necessity of bioethics in rDNA technology.

Text Books

1. Brown, T.A. (2016) Gene Cloning and DNA Analysis, Wiley-Blackwell Publishers, New Jersey.
2. Primrose, S.B. and Twyman, R. (2006) Principles of Gene Manipulation and Genomics, Wiley-Blackwell Publishers, New Jersey.

Suggested Reading

1. Nicholl, D.S.T. (2010) An Introduction to Genetic Engineering, Cambridge University Press, United Kingdom.
2. Glick, B.R., Pasternak, J.J., Patten, C.L., (2012) Molecular Biotechnology: Principles and Applications of recombinant DNA, ASM Press, Washington DC.
3. Sambrook, J. and Russell, D.W. (2012) Molecular Cloning: A Laboratory Manual –a set of 3 volumes, CSHL Press, New York.

COURSE OUTCOME: *Understanding of basic cloning, gene transfer techniques and methods of identifying the successful clones and expression of the desired protein, concepts of knock-in, knock-out and gene therapy.*

BCMB 537 - IMMUNOLOGY

3 Credits

Course Objectives: *To understand the basic concepts in Immunology and techniques used in Immunology research*

Pre-requisite: Master's level course in Cell Biology and Molecular Biology.

UNIT- I -Historic perspectives and introduction to immunology - 8h

History and scope of immunology; Types of Immunity-Innate/basic immunity, Acquired immunity-natural, artificial, active and passive immunity; nature of antigens, immunogenicity, antigenicity, epitopes; PAMPs, DAMPs; PRRs-Toll like receptors, acute phase proteins; functions of cells of myeloid and lymphoid lineage- granulocytes, dendritic cells, macrophages, T and B lymphocyrtes; Inflammatory response; Pathways of complement activation and its regulation

UNIT- II -Functions of Lymphoid organs- 6h

Primary and Secondary lymphoid organs; development of T and B lymphocytes in Thymus and Bone marrow-positive and negative selection; MHC restriction- types and significance of MHC molecules; antigen processing and presentation to T cells- endogenous and exogenous pathways; Formation of effecter T and B lymphocytes in the secondary lymphoid organs; Lymphocyte recirculation

UNIT- III – Humoral Immunity and Immunological Techniques- 8h

Immunoglobulins-structure, types and biological functions; Primary and Secondary immune response; Molecular basis of antibody diversity-multiple germ-line gene segments, somatic gene recombination, N and P nucleotide addition and somatic hypermutation; Mechanism of antigen-antibody interaction; principle and applications of precipitation, agglutination reactions, ELISA, RIA, Western Blotting, and immunofluorescence techniques; Hybridoma technique- principle and methodology for production of monoclonal antibodies; Biomedical applications of murine and humanized monoclonal antibodies

UNIT- IV – Cell Mediated Immunity- 8h

Functions of T cell subsets-Th1, Th2, Treg, CTLs, and NK cells; Mechanism of activation of T cells; Tolerance mechanisms-central and peripheral tolerance-clonal deletion, clonal anergy; Role of cytokines in immune regulation; T cell-B cell interaction-immunoglobulin class switching; Mechanism of target cell killing by CTLs and NK cells-death signaling-induction of apoptosis-intrinsic and extrinsic pathways

UNIT- IV – Immunopathology- 10h

Types and causes of hypersensitivity reactions, autoimmune diseases and immune deficiency diseases; Transplantation immunity-types of grafts and the mechanism of graft rejection; Applications of physical, chemical and biological immunosuppressive agents. Vaccines: conventional vaccines-attenuated, killed and subunit vaccines; Modern vaccines- recombinant vaccines, DNA vaccines and Edible vaccines

Text Books:

1. Punt, J., Stranford, S., Jones, P., Owen, J. (2018) Kuby's Immunology, W. H. Freeman, New York.
2. Murphy, K. and Weaver, C. (2016) Janeway' s Immunobiology, Garland Science, New York.

Suggested Reading:

1. Delves, P.J., Martin, S.J., Burton, D.R., Roitt, I.M. (2017) Roitt's Essential

Immunology, Wiley-Blackwell Publishers, New Jersey

COURSE OUTCOME: *Students will learn the basics of immune-surveillance mechanisms by both humoral and cell mediated immunity at molecular and cellular level. Students will also acquire knowledge on immunological techniques, immuno prophylaxis and immunotherapy.*

BCMB 538 - PROTEOMICS

3 Credits

COURSE OBJECTIVES: *The course focuses on the detailed study of proteins which represent the major proportion of functional molecules of the cell. The course will familiarize students on the application of technologies for the analysis and quantification of proteins.*

Pre-requisite: Master's Level Course in Genetic Engineering.

UNIT- I – Introduction to Proteomics 8h

Human genome - Genomes to Proteomes - HUPO –Human Proteome Project, Branches of proteomics - Protein extraction Methods: Subcellular fractionation, Density gradients, Ultrafiltration, - Protein fractionation - Affinity purification –Removal of interfering compounds, salts, DNA, lipids, Protein solubilization methods, chaotropes, detergents, etc - Sample handling and storage - Stable Isotope Labeling with Amino acids in Culture (SILAC)

UNIT- II – Structural Proteomics 6h

Protein structure-function relationship – Disulfide bonds, Post translational modifications, Glycosylation, Phosphorylation, other modifications, Applications - methods for detection of protein-protein interactions - Yeast 1 and 2 hybrid systems – Phage display – Surface Plasmon Resonance (SPR) - Fluorescence Resonance Energy Transfer (FRET).

UNIT- III – Proteomic Techniques for Analysis 10h

1D and 2-D gel electrophoresis – Mass Spectrometry – Principles - MALDITOF - RP chromatography /Tandem mass spectrometry – Protein sequence analysis -Peptide mass finger printing- N-terminal determination methods- Protein modification – Protein microarrays – Tissue microarray – Infra red Protein array with Quantitative Readout (IPAQ) -- Algorithms for proteomics – OMSSA - SEQUEST - MASCOT.

UNIT- IV – Protein expression 8h

Expression Systems –, *E. coli*, Yeast, *Pitchia pastoris*, Bacculovirus - introduction, detection and purification of expressed transgenes - antibody capture – antibody generation and Engineering – Protein/peptide chemical synthesis –- Protein-polynucleotide interactions Reconstitution of proteins in lipid vesicles, - Liposomes-Peptide and protein drugs.

UNIT- V – Proteomic approach for Clinical studies 8h

Protein Biomarker Discovery and Validation - low abundance and hydrophobic proteins. High through put techniques to identify protein molecules in sample Body fluid profiles, blood disease profiles, diabetes profiles stroke and myocardial infarction, Alzheimer, Proteomics in Biotechnology.

Text Books

1. Twyman, R.M. (2014) Principles of Proteomics, Taylor & Francis group, New York, USA.
2. Comai..L. Katz. .J., Mallick, P. (2017) Proteomics: Methods and Protocols. Humana Press Inc., New York.

Suggested Reading

1. Cathy H. Wu.C.H, Cecilia N. Arighi.C.N. and Karen E. Ross. K.E. (2017) Protein Bioinformatics, Humana Press Inc., New York.
2. O'Connor C.D. and Homes. B. D. (2007) Proteomics, Scion Publishing Ltd., Banbury.

COURSE OUTCOME: *The course will impart the knowledge of Structural Proteomics, advances in high throughput technologies, protein engineering approaches for protein structure-function research.*

BCMB 560 - GENETIC ENGINEERING LAB

1 Credit

1. Culture of *E. coli* cells & plasmid isolation
2. Preparation of competent cells
3. Calcium chloride mediated transformation
4. Ligation of DNA
5. Polymerase chain reaction
6. Restriction fragment length polymorphism
7. Random amplified polymorphic DNA
8. Sub-cloning of GFP protein

Reference:

Sambrook, J. and Russell, D.W. (2012) Molecular Cloning: A Laboratory Manual –a set of 3 volumes, CSHL Press, New York.

BCMB 561 - IMMUNOLOGY LAB

1 Credit

1. Agglutination reactions- Active agglutination- Widal Test, Blood group analysis
2. Passive agglutination reactions -Latex agglutination Test
3. Precipitation reactions on gel-double immuno diffusion
4. Single radial immunodiffusion (SRID)
5. Immunoelectrophoresis (IEP)
6. ELISA technique
7. SDS-PAGE analysis
8. Immunoblotting technique

Reference:

Gordon, J.R. (2004) A Practical Guide to cellular and Molecular Research Methods in Immunology, Saskatchewan.

BCMB 441 - GENERAL MICROBIOLOGY

3 Credits

Course Objectives: *To develop a lucid understanding of the microbial diversity, structural features of prokaryotes, culture conditions for bacteria and major microbial diseases*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I- Introduction to Microbiology **6h**

History and scope of Microbiology. Germ theory of disease, Koch's postulates. Microscopy – principle and applications bright field, dark field, fluorescence, phase contrast and electron microscopes. Principle and uses of simple, differential, negative and spore staining techniques

UNIT- II -Microbial diversity: **8h**

Carl Woese's three domain system of classification. Major groups of bacteria- Archaebacteria, Eubacteria- identification of bacteria based on phenetic, physiologic/metabolic characteristics and molecular phylogeny. General characteristics of major groups of Fungi, viruses and protozoa

UNIT- III – Structural features of prokaryotic cells **8h**

Structure of Gram positive and Gram negative bacterial cell walls, periplasm, flagella, pili, capsule, cell membrane, nucleoid, plasmids, inclusion bodies and endospores; Life cycle of DNA and RNA viruses, bacteriophages - Lysogeny and Lytic cycle; Importance of virus like agents

UNIT- IV – Culture techniques **8h**

Sterilization methods-physical and chemical methods-disinfectants, antiseptic agents; Culture media - composition and uses of solid, liquid, simple, complex, differential and selective media; continuous and synchronous culture; bacterial growth kinetics; Effect of pH, temperature and radiation on growth

UNIT- V – Microbial diseases and antimicrobial agents **10h**

Respiratory diseases-diphtheria, tuberculosis, pneumonia and Influenza; Skin diseases-measles, chickenpox, human papilloma virus, and dermatophyte (tinea) infections; Diseases affecting GIT-Oral thrush, typhoid, cholera, pathogenic E. coli infections, amoebiasis, and hepatitis; Genitourinary infections –syphilis, candidiasis, HIV; Protozoan and helminthic diseases- malaria, trypanosomiasis and leishmaniasis, filariasis; Mode of action of antimicrobial agents - antibacterial, antiviral, antifungal, antihelminthic and antiprotozoan drugs; Mechanism of development of antibiotic resistance in microbes.

Text Books:

1. Willey, J.M., Sherwood, L., Prescott, L.M., Woolverton, C. (2015) Prescott, Harley and Klein's Microbiology, McGraw Hill Higher Education, New York.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2012). Microbiology: An Introduction. Benjamin Cummings, San Francisco.

Suggested Reading:

1. Black, J.G., (2012) Microbiology: Principles and explorations, John Wiley and Sons, New York.

COURSE OUTCOME: *The course will impart knowledge on microbial diversity, structural features of different prokaryotes, growth characteristics of bacteria, major microbial diseases and their control.*

BCMB 442 – HUMAN PHYSIOLOGY

3 Credits

COURSE OBJECTIVES: *This course aims to introduce the students to the Physiological concepts of homeostasis and control mechanisms and to study the functions of body systems- with emphasis on clinical relevance.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I – Introduction and the Digestive System **8h**

Internal environment and homeostasis- coordinated body functions. Digestion- digestive processes at various regions of digestive system, regulation of -gastric secretion and motility- intestinal secretion and motility - role of gastrointestinal hormones.

UNIT- II – Cardiophysiology **8h**

Functional anatomy of heart - genesis and spread of cardiac impulses - cardiac cycle- heart sound- cardiac output- cardiovascular regulatory mechanisms - basic E.C.G. (Lead-II).

UNIT- III – Respiratory physiology **8h**

Functional anatomy of respiratory tract - lung respiratory muscles. Mechanism of respiration - lung volumes and capacities - gas exchange in the lungs - regulation of respiration.

UNIT- IV – Renal physiology **8h**

Structure of nephron - glomerular filtration - tubular reabsorption and secretion. Formation of urine- regulation of water and mineral excretion - counter current multiplier and exchanger - renal role in acid base balance.

UNIT- V – Nerve and Muscle Physiology **8h**

Nerve physiology - structure of neuron and synapses – excitability - action potential - conduction of never impulse-synaptic transmission - neurotransmitter systems.

Muscle physiology- skeletal and smooth muscle - electrical properties and ionic properties - types of muscle contraction.

Text Books

1. Hall, J.E. and Guyton, C. (2015) Textbook of Medical Physiology. Saunders, Elsevier Inc., Philadelphia.
2. Pal, G.K. (2007) Textbook of Medical Physiology. Ahuja Publishing House, Delhi.

Suggested Reading

1. Barrett, K.E., Barman, S.M., Brooks, H.L., Boitano, S. (2012) Ganong's Review of Medical Physiology. McGraw-Hill Medical, New York.

COURSE OUTCOME

The course will impart understanding of the structure function association of the physiological systems.

BCMB 443 - PLANT BIOCHEMISTRY AND BIOTECHNOLOGY

3 Credits

COURSE OBJECTIVES: *To learn basic metabolic processes plants in addition to theoretical knowledge of various applications like tissue culture, transgenic crops and micro propagation.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I - Introduction to Plant cells **9 h**

Photosynthesis: Chloroplast- structure and function, photosynthetic pigments and light harvesting complexes, photo inhibition of photosynthesis, photosynthetic carbon reduction (PCR) cycle, C4 syndrome and Crassulacean acid metabolism. Oxidative respiration. Alternate electron pathways and Respiration rate.

UNIT- II- Nitrogen metabolism & Plant hormones **9 h**

Physical and biological nitrogen fixation - ammonification, nitrification, denitrification. Biochemistry and genetics of nitrogen fixation and ammonium assimilation.

Biosynthesis, physiological effects and mechanism of action of auxins, gibberellic acids, cytokinins, abscisic acid, ethylene, brassinosteroids and polyamines.

Photomorphogenesis – phytochrome, cryptochrome and photoperiodism.

UNIT- III - Plant Stress physiology & Secondary metabolites **7 h**

Plant stress, plant responses to abiotic and biotic stresses, water deficit and drought resistance, flooding, temperature stress, salt stress, ion toxicity, pollution stress and potential biotic stress (insects and diseases).

Functions of secondary metabolites – flavonoids, alkaloids, terpenoids, anthocyanins, tannins, steroids and lignin. Applications of secondary metabolites - drug development, biopesticides and biofertilizers.

UNIT- IV- Introduction to plant tissue culture **8 h**

Media composition and preparation. Culture types - callus culture, cell suspension culture, protoplast culture. Somatic embryogenesis, organogenesis, embryo culture and embryo rescue. Micropropagation. Protoplast isolation, protoplast culture and fusion, selection of hybrid cells, cybrids, somaclonal variation. Germplasm storage and cryo- preservation.

UNIT- V- Application of Plant Biotechnology **7 h**

Application of transgenesis in crop improvement – insect resistance, disease resistance, virus resistance, herbicide resistance and resistance to abiotic stress. Transgenics - Bt cotton, Bt brinjal and rice.

Text Book:

1. Taiz, L., Zeiger, E., Moller, I.M., Murphy, A. (2015) Plant Physiology and Development, Sinclair Associates.
2. Nelson, D.L. and Cox, M.M. (2017) Lehninger Principles of Biochemistry, Macmillan Higher Education, Basingstoke.

Suggested Reading:

1. Slater, A., Scott, N.W., Fowler, M.R. (2008) Plant Biotechnology. The Genetic Manipulation of Plants, Oxford University Press.
2. Heldt, H.W. and Piechulla, B. (2016) Plant Biochemistry. Academic Press, Cambridge.
3. Lea, P.J. and Leagood, R.C. (1999) Plant Biochemistry and Molecular Biology, John Wiley and Sons Ltd., New Jersey.

COURSE OUTCOME: *Basic knowledge of plant physiology and various metabolic processes and applications for crop improvement and micro propagation.*

BCMB 541 - CANCER BIOLOGY

3 Credits

COURSE OBJECTIVES:

To understand cancer and the complex mechanisms that underlie its development and progression and thus to identify ways to treat the disease.

Pre-requisite: Master's level course in Cell Biology and Molecular Biology.

UNIT-I- Introduction to Cancer **7 h**

Growth characteristics of cancers cells. Morphological and ultra structural properties of cancer cells. Types of growth -hyperplasia, dysplasia, anaplasia and neoplasia. Nomenclature of neoplasms. Differences between benign and malignant tumors. Hall marks of cancer. Epidemiology of cancer.

UNIT-II- Cancer cell biology and biochemistry **8 h**

Aberrant metabolism during cancer development. Warburg effect. Paraneoplastic syndromes. Tumor markers. Cellular proto-oncogenes-oncogenes activation. Growth factors- EGF, TNF-α and TGF-β and growth factor receptors–Signal transduction in cancer –transcription factors- NFAT, NF-kB, SMAD and STAT in cancer. RAS signaling in cancer.

UNIT-III- Carcinogenesis & Free radicals **8 h**

Chemical carcinogenesis- stages in chemical carcinogenesis - Initiation, promotion and progression. Ames test. Radiation and Viral carcinogenesis - DNA and RNA viruses in human cancer. Free radicals, antioxidants in cancer. Cancer endocrinology.

UNIT-IV - Cancer cell regulation **9 h**

Cell Cycle Regulation-Tumor suppressor genes p53, p21, Rb, BRCA1 and BRCA2. Telomeres and Immortality; cell- cell interactions, cell adhesion-invasion and metastasis - VEGF signaling, angiogenesis. Hypoxia; Epigenetics-Role of DNA methylation in gene silencing- epigenetic silencing; Apoptosis in cancer-cell death by apoptosis–role of caspases; Death signaling pathways-mitochondrial and death receptor pathways. Autophagy in cancer.

UNIT-V - Diagnosis and Cancer treatment **8 h**

Different types of diagnostic approach to detect cancer. Strategies of cancer treatment– chemotherapy - gene therapy; Immunotherapy- Immune checkpoint therapy and CAR T-Cell therapy; Radiotherapy and Cancer vaccines. Resistance against anticancer drugs. Nutrition and cancer management. Phytomedicine in cancer. Cancer drug discovery: genomics and proteomics approach. Cancer stem cells.

Text Book:

1. Weinberg, R.A. (2013) The Biology of Cancer, Garland Science, New York.
2. McKinnell, R.G., Parchment, R.E., Perantoni, A.O., Pierce, G.B., Damjanov, I (2006).The Biological Basis of Cancer, Cambridge University Press, Cambridge.

Recommended Reading:

1. Pelengaris, S. and Khan, M. (2013).The Molecular Biology of Cancer. Wiley-Blackwell Publication, New Jersey
2. Alison, M.R. (2003). The Cancer Hand Book. Nature Publishing Group.
3. Hanahan, D. and Weinberg R.A. (2011) Hallmarks of Cancer: The Next Generation. Cell.; 144(5):646-674. doi: 10.1016/j.cell.2011.02.013.

4. PDQ Cancer Information Summaries. Bethesda (MD): National Cancer Institute (US); 2002-NCBI Bookshelf ID: NBK82221.

COURSE OUTCOME:

On completion of this course, a student will get the basic biochemistry, development of cancer and regulation at cellular level. Strategies of anti-cancer drug therapy have also been introduced.

BCMB 542 - CLINICAL BIOCHEMISTRY

3 Credits

COURSE OBJECTIVES: *The course focuses on understanding the methodology and interpretation of biochemical testperformed on body fluids and tissues to support diagnosis, treatment and monitoring disease.*

Pre-requisite: Master Level Course in Metabolism.

UNIT- I - Clinical biochemistry and quality assurance 8h

Clinical biochemistry: concept, definition and scope; Biological samples: types, collection, processing, stability and storage; Phlebotomy tubes; Chemical composition of biological fluids: blood, urine and cerebrospinal fluid; Reference range; Quality assurance; Accuracy, precision and reliability; other factors in quality control Factors. Values in health and diseases.

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UNIT- II – Kidney and Liver function test 10h

Kidney function test: Assessment of renal function, creatinine clearance, renal calculi, uremia, Laboratory investigation of kidney disorders: acute and chronic renal failure.

Liver function tests: Clinical features and diagnosis of liver function tests. Bile pigments formation of bilirubin, urobilinogen, bile acids. Jaundice; pre-hepatic, hepatic and post hepatic, plasma changes, clinically important enzymes; alkaline phosphatase, AST, ALT and isoenzymes of creatinine kinase and LDH, prothrombin time.

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UNIT- III – Disorders of carbohydrate and lipid metabolism 6h

Diabetes mellitus, insulin receptors and c- peptide assay, proinsulin and insulin antibodies. Hemoglobin A1c; fructosamines, insulin tolerance test. Glycogen storage diseases, galactosemia, fructosuria, pentosuria. Obesity, Hypercholesterolemia, Metabolic syndrome

.

UNIT- IV – Prenatal Diagnosis 8h

Prenatal diagnosis of diseases, Amniocentesis and chorionic villus sampling (CVS). amniotic fluid and fetal blood examination. Acetylcholinesterase and other tests on amniotic fluid. Karyotyping, Chromosomal abnormalities by cytogenetics. Newborn screening: PKU, cystic fibrosis and sweat tests.

.

UNIT- V – Molecular diagnosis of genetic defects 8h

DNA probes; restriction fragment length polymorphism (RFLP); polymerase chain reaction (PCR); amplification of mRNA. Diagnosis of genetic diseases by molecular biology techniques (cystic fibrosis, Hemachromatosis, thalassemias, sickle cell diseases), Clinical diagnosis of AIDS.

Text Books

1. Carl, A., Burtis, C.A., Bruns, D.E. (2014) Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics, Saunders Philadelphia, USA.
2. Chatterjee, M.N. and Shinde.R. (2012) Text book of Medical. Biochemistry Jaypee Medical Publishers, New Delhi, India.

Suggested Reading

1. Walker, S.W., Beckett, G.J., Rae, P. Ashby, P. (2013) Lecture Notes: Clinical Biochemistry. Wiley-Blackwell, Hoboken, USA
2. Swaminathan, R. (2011) Handbook of Clinical Biochemistry. World Scientific Publishing Co Pte Ltd., Singapore.

COURSE OUTCOME: *The course will enable the students to clinically assess the laboratory indicators of diseases and the biochemical and molecular tools needed to accomplish preventive, diagnostic, and therapeutic intervention on hereditary and acquired disorders.*

BCMB 543 – STEM CELL AND REGENERATIVE BIOLOGY

3 Credits

COURSE OBJECTIVES: *The course will focus on the biology and mechanism involving stem cells, their applications in replacing, regenerating and engineering human cells for translational regenerative medicine and ethical issues associated with the same.*

Pre-requisite: Master's level course in Cell Biology.

UNIT- I – Introduction to Stem Cells **6h**

Definition and Criteria for Stem Cells; Pluripotent, Multipotent and Totipotent Stem cells; Primordial germ cells, Embryonic stem cells; Amniotic fluid derived stem cells; Cord blood stem cells.

UNIT- II – Stem Cell Biology and Mechanisms **10h**

Molecular Basis of Pluripotency, Mechanisms of Self Renewal, Role of LIF/JAK/STAT, Nodal/Activin/TFGβ, FGF/MAP kinase pathways, Chromatin signature of pluripotent cells, Cell cycle regulators in Stem cells; Stem cell niches, Change of phenotype and differentiation, Senescence of Dividing somatic cells, aging and stem cell renewal, Quiescent Stem Cells.

UNIT- III –Tissue and Organ Development **10h**

Differentiation in early development, Potency, Commitment, Polarity and the specification of asymmetric divisions, induction, competence determination and differentiation, morphogenetic gradients, cell fate and cell lineages, Epigenetic silencing and lineage commitment; Cellular differentiation of the nervous system, Progenitors in adult brain, Epithelial stem cells; Adult progenitor cells, Mesenchymal stem cells, Plasticity; De-differentiation, Cancer stem cells.

UNIT- IV – Stem Cell Technology **8h**

Characteristics and characterization of Human Pluripotent Cells; Fluorescence and Magnetic bead assisted cell sorting, Derivation, characterization and maintenance of Murine and Human Embryonic Stem Cells, Differentiation of embryonic stem cells; Derivation of induced pluripotent stem cells; Derivation and differentiation of Human Embryonic Germ Cells; Genomic Reprogramming, Fate Mapping of Stem Cells.

UNIT- V – Stem Cells in Regenerative Therapeutics **6h**

Neural stem cells in Neurodegenerative diseases; Hematopoietic stem cell transplantation; Epithelial stem cells and burns; Stem cells and heart disease; Pancreatic stem cells and diabetes; Liver stem cells and cell therapy for liver disease; Embryonic stem cells in tissue engineering, Examples of stem cells in Clinical Trials and translational therapeutics, stem cell banking, Ethical concerns in stem cell research.

Text Books:

1. Lanza, R. and Atala, A. (2013) Essentials of Stem Cell Biology, Academic Press, California.
2. Huang, N.F., L'Heureux, N., Song, L. (2018) Engineering Stem Cells for Tissue Regeneration. World Scientific Publishing Company

Suggested Reading:

1. Scott, C.T. (2006) Stem Cell Now, Pearson Education, New Jersey.
2. Marshak, D.R., Gardner, R.L., Gottlieb, D. Lanza, R., Atala, A (ED.) (2001) Stem Cell Biology. Cold Spring Harbor Press, New York.

COURSE OUTCOME: *The course will provide the basic understanding of stem cell biology and their applications in translational therapeutics.*

BCMB 544 CLINICAL RESEARCH AND REGULATIONS

3 Credits

***OBJECTIVES*:** *This is a job oriented course which will introduce the basic principles of modern drug design, discovery and regulations of drug development. The course will impart knowledge on clinical trials management, regulatory affairs and patent rights.*

Pre-requisite: Master's Level Course in Genetic Engineering.

UNIT- I **8h**

General Introduction to public health, drug design and drug discovery, Sources of drugs – Plants, Microbial and Animal origin, Recombinant therapeutic proteins – Use of transgenic models for therapeutic purpose, Drug delivery systems, Pre-clinical drug development strategies.

UNIT- II **6h**

Clinical Trials – Fundamentals of clinical operations, Study design and methodology in clinical trials, Inclusion and Exclusion criteria, Informed Consent process, Clinical Trials Phase- I, II, III, IV; Monitoring treatment outcome and Termination of a trial, Clinical data management, Quality control; Ethical, Legal and Regulatory aspects of clinical trials.

UNIT- III **6h**

Quality Assurance in Clinical studies- Brief Introduction to Pharmacodynamics, Pharmacokinetic (ADME) aspects, Pharmacoepidemiology. **Pharmacovigilance** – Introduction, Importance of safety monitoring, Identification and reporting of Adverse Drug Reaction (ADR), WHO adverse reaction terminologies and CTCAE guidelines, Risk assessment and management, Pharmacovigilance in India and Global perspective – CDSCO (India), US FDA, EMEA (Europe), Japan and Canada.

UNIT- IV **9h**

Regulatory Affairs - Regulatory aspects for drug product design, Drug and Cosmetics Act, Schedule-Y, Regulatory bodies in India and regulations in developed countries, Medical device registration; Preparation, review and submission of drug master files to regulatory bodies, Final approval procedures. **Patent and Intellectual property rights** – Importance and overview of IPR, The Indian Patents Act, Type of patents, Provisional applications and Patent infringement.

UNIT- V **7h**

Guidelines: Guides to Good Manufacturing Practice (GMP), Good Laboratory Practice (GLP), Good Clinical Practice (GCP), Central Drugs Standard Control Organization (CDSCO) guidelines, International Council for Harmonization of Technical Requirement for Pharmaceuticals for Human Use **(ICH) guidelines** – Quality, Safety, Efficacy and Multidisciplinary guidelines; WHO and FDA guidelines; NABL and NABH.

Text books:

1. Rick, N.G. (2015) Drugs: From Discovery to Approval, Wiley-Blackwell, Singapore.
2. Weinberg, S. (2009) Guidebook for Drug Regulatory Submissions, Wiley publishers, Hoboken, New Jersey.
3. Guarino, R.A. (2009) New Drug Approval Process: Global challenges and Solutions, Informa Healthcare, London.

Suggested Reading:

1. Preston, C.L. (2016) Stockley's drug Interactions, Pharmaceutical Press, London.
2. Kerns E.H. and Li Di. (2008) Drug-like Properties: Concepts, Structure Design and Methods:

from ADME to Toxicity Optimizatio, Elsevier Inc, Academic Press, California.
3. Carson P.A. and Dent N. (2007) Good Clinical, Laboratory and Manufacturing Practices Techniques for the QA Professional, The Royal Society of Chemistry, Cambridge.

COURSE OUTCOME

The students will get orientation towards the protocols followed in pharmaceutical industry.

BCMB 545 - DEVELOPMENTAL BIOLOGY AND AGEING

3 Credits

COURSE OBJECTIVES: *The course offers a detailed understanding of the intricacies of developmental biology and how each step of development, patterning and ageing process takes place and how it is regulated at the molecular and cellular level.*

Course Pre-requisite: Master Level Course in Cell Biology and Molecular Biology.

UNIT - 1– Introduction to Developmental Biology 6h

History and basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation. Morphogenetic gradients, cell fate and cell lineages, stem cells, genomic equivalence and the cytoplasmic determinants, imprinting, mutants and transgenics in analysis of development.

UNIT - II– Early embryonic development 9h

Early mammalian development: Production and structure of human gametes. Molecular events during mammalian fertilization, acrosome reaction, zygote and prevention of polyspermy. Patterns and molecular mechanism of mammalian cleavage, formation of blastula, gastrulation, neural tube and differentiation of neurons. Formation of extra embryonic membranes, anterior-posterior, dorsal-ventral and left-right axis formation.

UNIT-III– Cell- cell communication and signaling in development 6h

Concepts of induction and competence, epithelial-mesenchymal interactions, role of FGF-RTK pathway, JAK-STAT, Hedgehog family, Wnt family, TGF-β superfamily, Notch pathway and developmental signals from extracellular matrix. Juxtacrine signaling and cell patterning.

UNIT -IV– Model organisms, organogenesis and Sex determination 9h

C. elegans: Study of cell lineage, mosaic development and organogenesis vulva formation. Axes and pattern formation in Drosophila and Amphibia. Organs derive from ectoderm, mesoderm and endoderm. Vertebrate eye lens induction and development of tetrapod limb. Sex determination in mammals and Drosophila. Overview of genetic errors of human development and human diseases.

UNIT - V– Postembryonic development and ageing 10h

Metamorphosis of frog, regeneration in Salamander limbs and mammalian liver. Ageing: Replicative and chronological ageing. Theories of ageing – Ageing of stem cells – programmed cell death. Telomeres and Telomerase. Genes, epigenetics, nutrients regulations of ageing process. Progeria – neurodegenerative – metabolic diseases. Anti-ageing approaches – stem cells and regeneration therapy.

Text Books:

1. Balinsky, B.I. (2012) An Introduction to Embryology, Cengage, Boston.
2. Gilbert, S.F. (2013) Developmental Biology, Sinauer Associates Inc., Massachusetts.

Suggested reading:

1. Wolpert, L., Tickle, C., Arias, A.M. (2015) Principles of Development, Oxford University Press, Oxford.
2. Slack, J.M.W. (2012) Essential Developmental Biology, Wiley Blackwell Publishers, New Jersey.
3. Kanungo, M.S. (2005) Genes and Aging, Cambridge University Press, Cambridge.

COURSE OUTCOME: *The course will enable to gain a clear understanding of the stages of development, patterning and ageing process in various model organisms.*

BCMB 546 – NEUROBIOLOGY

3 Credits

COURSE OBJECTIVES: *The course focuses on the basic concepts Neurobiology and observing the interdisciplinary nature of the Neurosciences will encourage participation from students majoring in Physics, Chemistry, Psychology and Computer Science alongside the students of the School of Life Sciences.*
Pre-requisite: Bachelor's level course in Basic Biology.

UNIT- I – Gross Neuroanatomy and Cellular Components of Nervous System 10h
Neurons to Cognition: Gross Neuroanatomy of the Brain and Spinal Cord – Central and Peripheral Nervous System – Special Senses - Vision, Hearing and Balance, Olfaction and Taste, Tactile response, Pain perception - Effector endings. Cellular Components of the Nervous system: Ultrastructure of Neurons and synapses, Ion channels, transporters and action potential, modulation and neuronal integration - astrocytes, oligodendrocyte, Schwann cells, and ependymal cells - Microglia. Cellular representation of perception and action, space cells and spatial perception, Association Cortices and Cognition.

UNIT- II – Developmental Neurobiology 7h
Induction and patterning of body axis and neural development –Homeotic induction, morphogenic gradients, role of sonic hedgehog, TGF β and Wnt signaling, generation and survival of neurons and glia – Role of Notch Signaling and JAK STAT pathway - Activity dependent maturation of synapses – plasticity of mature synapses and circuits. Regeneration and Repair: Regenerative repair in the CNS and PNS, Stem cells in regenerative therapy.

UNIT- III –Neurotransmitters 10h
Neurotransmitters, synthesis, storage, release, transmitter action, receptors, signal transduction and reuptake – Glutamate, excitotoxicity - GABA, glycine, general anesthetics, competitive and noncompetitive antagonists - acetylcholine, anticholinergics, nicotine, curare,
acetylcholinesterase inhibition, organophosphates – monoamine neurotransmitters - Dopamine, serotonin, norepinephrine, epinephrine, histamine - endocannabinoids, retrograde signaling, neurotransmission and its regulation. Neuropeptides: Classes of neuropeptides, neuropeptide receptors and mode of action – opioid receptors and their endogenous ligands.

UNIT- IV – Brain and Behavior: 7h
Approaches and methods in study of behavior; Proximate and ultimate causation; Development of behavior; Social communication; Habitat selection, Social dominance, Mating systems, Parental investment and Reproductive success; Aggressive behavior, Migration, orientation and navigation, Photo-periodism, Circadian Rhythm– Sleep and arousal. Neural basis of Complex Behaviors: Learning, memory, Emotions, Stress and Adaptation, Altruism and evolution.

UNIT- V – Neurodegenerative and Neurochemical Disorders 6h
Ageing Brain - Senile dementia - Dementia of Alzheimer's Type, Parkinson's disease, Amyotrophic lateral sclerosis – Brain Ischemia and Reperfusion –Seizures and Epilepsy – Autism - Diseases involving myelin, Multiple Sclerosis. Chemical imbalances of the Brain: Personality Disorders - Anxiety disorders - Disorders of Mood, depression, bipolar disorder - Pharmacology of neuroleptics, anxiolytics, antidepressants – Disorders of thought - Schizophrenia, Pharmacology of antipsychotics, Narcotics and Addiction.

Text Books
1. Purves, D., Augustine, G.J., Fitzpatrick, D., Hall, W.C., LaMantia, A.S., Mooney, R.D., Platt, M.L., White, L.E. (2017) Neuroscience, Oxford University Press, Oxford.

2. Brady, S.T., Siegel, G. J., Albers, R.W., Price, D.L. (2012) Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology. Academic Press, Cambridge.

Suggested Reading

1. Hall, J.E. and Guyton, C. (2015) Textbook of Medical Physiology. 13th edition by Saunders, Elsevier Inc., Philadelphia.
2. Barrett, K.E., Barman, S.M., Brooks, H.L., Boitano, S. (2012) Ganong's Review of Medical Physiology. McGraw-Hill Medical, New York.
3. Crossman, A.R. and Neary, D. (2014) Neuroanatomy. Churchill Livingstone, London.

COURSE OUTCOME: *The course will provide the basic understanding of anatomical organization of the central and peripheral nervous system and its development, how communication in neural circuits leads to sensory perceptions, movement, behavior, learning and memory. Mechanisms of neurodegenerative processes and cellular processes of regeneration and basic neuropharmacology.*

BCMB 547 - INDUSTRIAL CONVERGENCE IN LIFE SCIENCES

2 Credits

COURSE OBJECTIVES:

Skill development geared towards trained manpower for employment & entrepreneurship
Understand the present trends in life science industry
Familiarization to role of microbiome & awareness
Responsibility towards environment & climate change
Initiate curiosity in entrepreneurship.

Course Pre-requisite: Master's Level Course in Genetic Engineering.

UNIT – I **6h**

Introduction to biofoundries & biofactories – Introduction to synthetic biology. Production of artemisinin as case study. Building the new bio-economy. Introduction to Biofoundries & circuits. Role of automation and robotics in biofactories; use of plants for engineering biologics & small molecules. Biosurfactants as an example of microbial cell factory based production.

UNIT- II **5 h**

Contemporary techniques in industry – Gene shuffling for large scale pathway assembly and engineering; Choices for microbial hosts for industrial applications– bacteria, yeast, insect. Gene editing methods – CRISPR/ Cas; Gene sequencing – Pyro sequencing, Nanopore sequencing.

UNIT- III **5 h**

Microbiome Communities – Definition & role of microbiome on human health and wellbeing; Role of 16s rRNA based identification – metagenomics approaches for microbiome analysis; Human Microbiome project; Anti-microbial resistance and superbugs – methods to counter; specific case studies on its influence (positive & negative) on plants (soil microbiome), animals (poultry – minimize use of antibiotics) and aquaculture (viruses). Rapid responses to counter bio-terrorism.

UNIT – IV: **5h**

Conservation Biology & Climate Change - Impact of climate change, Community response and Government policies, Ecological footprint, Clean Development Mechanism (CDM); Earth summit, Kyoto protocol, Framework convention on Climate change (UNFCCC); Genetic methods for conservation biology; Assessment of carbon and water footprint on processes. Biodiversity act & agencies regulating it (National & State biodiversity authorities). Potential biological methods to counter plastic & e-wastes.

UNIT – V **5h**

Introduction to Entrepreneurship in life sciences – Need for entrepreneurship in life-sciences, Types of life-science companies in India (biopharma, bioagri, bioinformatics, bio services, biocatalysts, bioindustrial) and their growth; New startups & bio-medical device companies; Types of bio-incubators (Bioparks, Bioclusters, BioNests); Bio industry associations – BIO, ABLE,

AIBA; Funding avenues in India for entrepreneurship development – Government initiates (DBT - BIRAC), philanthropic (Gates, Wellcome, DNDi) & private funding; Types of companies and steps in company formation; Steps in compiling business plan. Introduction to regulatory agencies – DGCI, CIB, NBA, GEAC, FSSAI, CDSCO, ISO.

Text Books:

1. Clark, D. and Pazdernik, N. (2015) Biotechnology, Academic Cell Press, Cambridge.
2. De Martinis, D. et al., (2017) Engineering the plant factory for the production of biologics and small molecule medicines, Edited by Frontiers Research topics..
3. Sharma, D. and Saharan, B.S. (2018) Microbial Cell Factories, CRC Press, Boca Raton, Florida.
4. Braman, J.C. (2018) Synthetic biology – methods and protocols, Humana Press, New York.
5. Kauffman, C.M. (2015) Our Changing Climate: Introduction to Climate Science, American Meteorological Society.
4. Sodhi, N.S. and Ehrlich, P.R. (2010) Conservation Biology for All, Oxford University Press, Oxford.
5. Douglas, A.E. (2018) Fundamentals of Microbiome Science: How Microbes Shape Animal Biology, Princeton University Press, Princeton.
6. Ivaturi, V.K., Ganesh, M., Mittal, A., Subramanya, S., Sadagopan (2017) The Manual for Indian Start-ups: Tools to Start and Scale-up your new venture, Penguin Random House India.
7. The Staff of Entrepreneur Media (2015) Start Your Own Business: The Only Startup Book You'll Ever Need, Entrepreneur Press.

Suggested Reading:

1. Gene editing
   i. https://www.neb.com/tools-and-resources/feature-articles/crispr-cas9-and- targeted-genome-editing-a-new-era-in-molecular-biology
   ii. https://www.addgene.org/crispr/guide/
2. Pyro sequencing: http://www.archivesofpathology.org/doi/pdf/10.5858/arpa.2012-0463-RA
3. Nanopore sequencing: https://nanoporetech.com/resource-centre/introduction-nanopore-sequencing
4. BioFoundry: http://cnpg.comparenetworks.com/347117-A-Biofoundry-for-Next - Generation-Synthetic-Biology/
5. Industrialization of Biology: A Roadmap to accelerate the Advanced manufacturing of chemicals, National Academy of Sciences, 2015.
6. Biotech Industry survey: https://www.ibef.org/download/Biotechnology-March-2017.
7. CII report on biotech startups in India, 2017.
8. BIRAC annual report, 2017.

BCMB 548 - NANOBIOTECHNOLOGY

3 Credits

COURSE OBJECTIVES: *The aim of this course is to provide basic knowledge about applications of nanoscience in the field of Biotechnology and Medicine.*

Pre-requisite: Bachelor's level course in Life Sciences.

UNIT- I – Introduction **8 h**

Overview of Nanomaterials and nanoparticles in biological applications; Biomimetic nanostructures; Overview of DNA and protein based nanostructures; Inorganic nanoparticles; Applications of nanotechnology in bioseperations, enzymatic reactions and tissue/cell culture.

UNIT- II- Biological synthesis and characterization of nanomaterials **8 h**

Biosynthesis- microbial, plant mediated synthesis. biofunctionalization of nanosurfaces with peptides and proteins. Bacteriorhodopsin: structure and its potential applications in nanobiotechnology; S-layers: structure and its applications; Cell-nanomaterial interactions; Monitoring nano-bio interactions: Cell targeting and cell penetrating peptides Atomic Force Microscopy.

UNIT -III -Implications of Nanobiotechnology **5 h**

Nanotoxicity: Absorption and distribution of Nanoparticles *in vivo*; Toxicological effects of nanoparticles in various target organs *in vivo*.

UNIT- IV -Nanostructures for Analytics **7h**

Nanoparticles for electrobiochemical assays; Quantum dots in biology; Nanoparticle based bio-sensors; Protein nanoarrays; DNA nanoarrays; Lab-on-a-chip; Microfluidics: Definition and history, Advantages of microfluidic devices and their potential for nanobiotechnology.

UNIT- V -Nanoparticles for Diagnostic and Therapeutics **12 h**

Introduction to drug delivery; Drug delivery systems based on nanotechnology: PLGA, lipid based nanoparticles, nanocrystals; Nanocarriers for applications in medicine; siRNA delivery using nanoparticles; Targeted drug delivery using nanocarriers; Nanoparticle contrast agents for magnetic resonance imaging; Nanodiamonds for bioimaging and therapeutic applications; Nanotherapeutics.

Text Books:

1. Auclair, C., Boisseau, P., Houdy, P., Lahmani, M. (2009) Nanoscience: Nanobiotechnology and Nanobiology. Springer-Verlag Berlin Heidelberg.
2. Niemeyer, C.M. and Mirkin, C.A.(2004). Nanobiotechnology: Concepts, Applications and Perspectives. Wiley-VCH, Weinheim, Germany.

Suggested Reading:

1. Niemeyer, C.M. and Mirkin CA.(2007).Nanobiotechnology II: More Concepts and Applications. Wiley-VCH, Weinheim, Germany.

COURSE OUTCOME: *The course will enable to account for interaction of biomolecules with surfaces of different chemical and physical species, account for production and the applications of various types of nanostructured materials.*

BCMB 580 - PRE- PROJECT & PRESENTATION

1 Credit

COURSE OBJECTIVES:

To enable the students to identify a research problem, perform review of literature, plan a study to address the same and frame a research proposal and defend the same.

Course Pre-requisite: Master Level Course on Biostatistics and Scientific Writing.

Course Plan –

This course will have the following components –

1. Identifying a Research Problem.
2. Performing Review of Literature.
3. Planning a study to address the research question.
4. Presentation and defense of the Research Proposal.

COURSE OUTCOME:

The students will learn to -

- *Identify research gaps through study of scientific literature and device ways to address the same.*
- *Review Literature in their respective field of Research.*
- *Gain the experience of presenting a research proposal before an evaluating committee.*

BCMB 581 - DISSERTATION

4 Credits

COURSE OBJECTIVES:
To enable the students to have hands-on research experience and write a comprehensive report, present, and defend the same.

Course Pre-requisite: BCMB 548: Pre-Project and Presentation

Course Plan -

This course will have the following components –

1. Executing the proposed Research Plan.
2. Designing and planning experiments.
3. Performing experiments or *in silico* studies based on the criteria.
4. Writing a Comprehensive Research Report.
5. Presentation and defense of the Dissertation.

COURSE OUTCOME:
The students will learn to execute a research proposal, prepare a project report and present, and defend the same.