**Appendix-X**
**Resolution No. 8 [8-1(8-1-3)]**

# UNIVERSITY OF DELHI

## MASTER OF SCIENCE
### (Biochemistry)
(Proposed August 2021)

# PROGRAMME BROCHURE

Post-graduate CBCS (Biochemistry) Revised Syllabus as approved by the Standing committee held on 24th August 2018, Academic Council on 15th July 2019 and Executive Council on 21st July 2019 (E.C. (2) -20.07.2019)

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# I. About the Department

## I.1 Historical Background and Department Highlights

The Department of Biochemistry, a vibrant and premiere unit of the University, was established in 1983. Initially, the Master's course in Biochemistry was offered as a guest course at the Vallabhbhai Patel Chest Institute (VPCI), University of Delhi. In 1986, under the pioneering leadership of its founding father Prof. B.K. Bachhawat, the course moved full-fledged to South Campus and research activities took wing, heralding a new beginning and glorious future. The activities of the department revolve around the central theme of "Development of molecular strategies to combat various human diseases". One of the commendable contributions of the department has been the creation and sustenance of rigorous, dynamic and vibrant teaching and research programme that imparts conventional and new knowledge in an innovative manner, which ensures that fresh, young minds are trained and oriented to create newer knowledge in turn. In the department, teaching over the years has reached impeccable standards and research attained world-class quality. We boast of a world class faculty equipped with state-of-the art facilities that constantly churn out productivity – be it extremely well trained students who find placement in various spheres of the professional world; research publications that are well cited; patents or technology that have reached the market (diagnostic kits); or technologies that have shown great potential for the near future (vaccine, gene therapy, drug, drug delivery). Our faculties have carved out a niche for themselves on the scientific arena and have won several awards, accolades and honors. Our students are equally productive and attain success regularly in all possible ways.

## I.2 About the Programme

The two-year full time M.Sc. programme in Biochemistry endeavors to provide students with excellent training in Biochemistry emphasizing on solid background of basic concepts as well as rapid advancement in the field. In addition to theoretical knowledge, considerable emphasis is given on hands on experience in the forefront areas of Biochemistry and Biotechnology through practical training in masters' laboratory in the first year. To augment such training, an important feature of the programme pertains to the course on Practical Skills in Research that will allow students to get hands-on-experience in tools and methods used in Biochemistry and Biotechnology in specific labs allotted to students in third semester followed by dissertation carried out on a research topic under the supervision of a mentor. The emphasis is to expose students to various aspects pertaining to research including the habit of scientific reading, research methodology, analytical ability, organizational capability, independent thinking, experimental design and execution capability and scientific writing. Another outstanding feature that defines the programme and inculcates self-learning is the two courses on seminars (one in each year) that students are required to present in open forum for collective evaluation by the departmental faculty members. In the first year, students will be required to present seminars on important scientific topics and concepts after critical review of the scientific literature. In the second year, they are required to present update on the area of their dissertation research. This aspect of the programme helps students learn how to critically assess research papers, distill the best

of the information and present the same in a concise and clear manner. The enlightening exercise will give them experience of public speaking and instill confidence. Advanced students can take advantage of the two elective courses on human diseases (infectious diseases and life-style disorders) to align themselves with the central theme of the department and equip better for future research in aspects of human diseases and disorders, the need of the hour in the country. Students who join the programme from non-biochemistry background in life sciences can take advantage by opting for the courses on Intermediary Metabolism and Advanced Techniques in Biochemistry, which will help them align better with the course. The open elective course in Basics of Biochemistry will also provide students, especially from other programmes in the University, an overview of the biochemical principles and concepts in various aspects of the subject.

In addition, the department regularly organizes seminars by national and international researchers to expose the students to a repertoire of scientific areas and scientific methodology to complement the courses in the programme. Although summer training is not a compulsory part of the curriculum, students are encouraged to undergo summer training in the department or other institutions during summer vacation, especially through national fellowships like those provided by the three Indian academies of Sciences. The department has separately allocated funds for educational tours to support their visits to various institutions / universities / industries. Students are encouraged to attend national conferences to expose them to the scientific community to learn the latest developments in science. Students are also encouraged to present posters and co-author papers and reviews. The department also organizes symposiums and conferences inviting eminent scientists across the country. For a holistic development, several cultural and sports activities are also organized round the year.

## I.3 About Post Graduate Attributes

It is expected that at the end of the programme, each student is independent in their thought processes and can make an informed choice about their subsequent career. The program is expected to motivate students for higher education, especially research, while providing trained manpower for biotechnology industry as well. The students are expected to be able to apply biochemical principles to understand various complex processes in life sciences and provide biotechnological solutions to combat various human diseases. They are expected to be ethically sound and ready for the next phase of their development.

## I. 4 About the process of course development involving various stakeholders at different stages

For the design of curriculum, selection of courses and drafting of syllabus for each course, suggestions from stakeholders were obtained at each stage. The course structure was initially framed in a faculty meeting and suggestions were sought from stakeholders in an open meeting where both the parties were physically present. Based on the suggestions, the

course structure was re-framed and syllabus for each course was drafted. Subsequently, the draft was made available on the departmental website and suggestions from stakeholders and peers were invited. Comments and suggestions were obtained from stakeholders, peers and experts through e-mails, which were then discussed in faculty meeting and incorporated appropriately. The revised draft was shown to selected peers and stakeholders yet again. The re-revised draft was deliberated in a meeting of the Committee of Courses and the final draft was prepared.

# II. Introduction to CBCS (Choice Based Credit System)

## Choice Based Credit System:

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses will be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enables the potential employers in assessing the performance of the candidates.

## Definitions:

(i) 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre

(ii) 'Course' means a segment of a subject that is part of an Academic Programme

(iii) 'Programme Structure' means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission

(iv) 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course

(v) 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre

(vi) 'Open Elective' means an elective course which is available for students of all programmes, including students of same department. Students of other Department will opt for these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

(vii) 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course

(viii) 'SGPA' means Semester Grade Point Average calculated for individual semester.

(ix) 'CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(x) 'Grand CGPA' is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into percentage marks is given in the Transcript.

# III. M.Sc. Programme Details:

## Programme Objectives (POs):

The proposed programme shall be governed by the Department of Biochemistry, Faculty of Interdisciplinary and Applied Sciences, University of Delhi South Campus, New Delhi-110021.

A two-year program will lead to the award of a M.Sc. degree in Biochemistry. Students will be offered advanced level theory and practical courses in subjects like proteins, cell biology, immunology and immunotechniques, enzymes and their biotechnological applications, molecular biology, recombinant DNA technology and applications in biotechnology, developmental biology, proteomics and metabolomics and advanced techniques in genomics. The emphasis is on training students for research. This includes work by second-year students in research laboratories to carry out projects under the supervision of faculty members in addition to two practical courses in the first year. Before students initiate dissertation research projects, they will also be trained adequately in the various basic tools, techniques and instrumentation in specific research laboratories. Students are also required to present critical reviews on various current and significant topics in seminars for evaluation in the first year. In the second year, they present seminars on assigned research topics. In the process they develop oratory and writing skills. In keeping with the objectives of the department, elective courses have also been included to impart knowledge in infectious diseases and life style disorders, in intermediary metabolism and advanced techniques in biochemistry. The department also offers a basic course in biochemistry for interested students across the University with background in life sciences.

The department strives to achieve the following programme objectives:

- The foremost objective of the programme is to empower students with clear understanding of the basic concepts of biochemistry and provide them knowledge of the recent advances so that they can independently assess the vast scope in the field.

- The programme aims to train students to enable them to apply biochemical principles, theoretically and experimentally, to understand various complex life processes, while providing biotechnological solutions to combat various human diseases.
- It is expected that at the time of completion of the programme each student is confident and independent in their thought processes and can make an informed choice about their subsequent career.
- The program is expected to motivate students for higher education, especially research and provide trained manpower for biotechnology industry.
- They are expected to be ethically sound and ready for the next phase of their development, skilled in the art of self-reading, oration and scientific writing.

## Programme Specific Outcomes (PSOs):

A post-graduate student upon completion of the programme is expected to gain the following attributes:

- In-depth knowledge of Biochemistry with inter-disciplinary perspective of other branches of life sciences.
- Competence for research and innovation in Biochemistry as a skilled experimentalist.
- Analytical and problem solving skills with regard to biochemical principles of life processes and technologies for combating human diseases.
- Critical thinking about the concepts in Biochemistry and ability to critically review scientific literature for development of new theories and testable hypothesis.
- Capacity for decision making with regard to scientific progress, personal development and career choice.
- Ability to work independently, while still promoting teamwork and collaboration skills.
- Oratory (public speaking), scientific conversation and writing skills.
- Leadership and organizational skills.
- Demonstration of integrity, honesty, ethical behavior and sense of responsibility.
- Appreciation of diversity in scientific community and responsibility towards society and nation.
- Environmental awareness vis-à-vis bio-waste generation, disposal and management and safety and security issues.

## Programme Structure:

The Master's programme is a two-year course divided into four semesters. A student is required to complete 96 credits for the completion of course and the award of degree.

| | | ***Semester*** | ***Semester*** |
|---|---|---|---|
| **Part – I** | First Year | Semester I | Semester II |
| **Part – II** | Second Year | Semester III | Semester IV |

### Course Credit Scheme

| **Semester** | **Core Courses** | | | **Elective Course** | | | **Open Elective Course** | | | **Total Credits** |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. of papers | Credits (L+T/P) | **Total Credits** | No. of papers | Credits (L+T/P) | **Total Credits** | No. of papers | Credits (L+T/P) | **Total Credits** | |
| I | 3 (2L+1P) | 8L+8P | **16** | 2 | 8L | **8** | 0 | 0 | **0** | **24** |
| II | 5 (4L+1P) | 16L+8P | **24** | 0 | 0 | **0** | 0 | 0 | **0** | **24** |
| III | 5 (4L+1P) | 16L+8P | **24** | 0 | 0 | **0** | 0 | 0 | **0** | **24** |
| IV | 2 (1L+1D) | 4L+16D | **20** | 0 | 0 | **0** | 1 | 4L | **4** | **24** |
| **Total Credits for the Course** | **15** | **(44L + 24P + 16D)** | **84** | **2** | **8L** | **8** | **1** | **4L** | **4** | **96** |

* For each Core and Elective Course there will be 4 lecture hours of teaching per week.
* Open Electives to the maximum total of 8 credits.
* Duration of examination of each paper shall be 3 hours.
* Each paper will be of 100 marks out of which 70 marks shall be allocated for semester examination and 30 marks for internal assessment.
* L= Theory; P = Practical; D = Dissertation

## Semester wise Details of M.Sc. Biochemistry Course

| **Semester I** | | | | |
|---|---|---|---|---|
| **Number of core courses (3)** | **Credits in each core course** | | | |
| Course | Theory | Practical | Tutorial | Credits |
| Core course 1 (BCCC101)<br>Proteins – Structure, Folding and Engineering | 4 | | | 4 |
| Core course 2 (BCCC102)<br>Seminar on Current Topics | 4 | | | 4 |
| Core course 3 (BCCC103)<br>Practicals | | 8 | | 8 |
| Total credits in core course | 16 | | | |
| | | | | |
| **Number of elective courses (2)*** | Credits in each Elective course | | | |
| Credits in each elective course (4) | Theory | Practical | Tutorial | Credits |
| Elective course 1 | 4 | | | 4 |
| Elective course 2 | 4 | | | 4 |
| Total credits in elective courses | 8 | | | |
| | | | | |
| **Number of Open Electives (0)** | Credits in each open elective | | | |
| | Theory | | | Credits |
| Open Elective | X | | | x |
| Total credits in open elective | X | | | |
| | | | | |
| Total credits in Semester I- **24** | | | | |

*** List of Elective Course**

1. Infectious Diseases: Molecular basis, Control and Prevention (BCEC101)
2. Intermediary Metabolism and Clinical Correlation (BCEC102)
3. Life Style Disorders : Cancer and Cardiovascular Diseases (BCEC103)
4. Advanced Techniques in Biochemistry (BCEC104)

(**Note** – Elective course 1 is a choice between BCEC101 and BCEC102. Elective course 2 is a choice between BCEC103 and BCEC104)

## Semester wise Details of M.Sc. Biochemistry Course

| **Semester II** | | | | |
|---|---|---|---|---|
| **Number of core courses (5)** | **Credits in each core course** | | | |
| Course | Theory | Practical | Tutorial | Credits |
| Core course 1 (BCCC201) Cell Biology | 4 | | | 4 |
| Core course 2 (BCCC202) Immunology and Immunotechniques | 4 | | | 4 |
| Core course 3 (BCCC203) Enzymes and their Biotechnological Applications | 4 | | | 4 |
| Core course 4 (BCCC204) Molecular Biology | 4 | | | 4 |
| Core course 5 (BCCC205) Practicals | | 8 | | 8 |
| Total credits in core course | 24 | | | |
| | | | | |
| **Number of elective courses (0)** | Credits in each Elective course | | | |
| Credits in each elective course | Theory | Practical | Tutorial | Credits |
| Elective course | X | | | |
| Elective course | X | | | |
| Total credits in elective courses | 0 | | | |
| | | | | |
| **Number of Open Electives (0)** | Credits in each open elective | | | |
| | Theory | | | Credits |
| Open Elective | X | | | |
| Total credits in open elective | 0 | | | |
| | | | | |
| Total credits in Semester II - **24** | | | | |

## Semester wise Details of M.Sc. Biochemistry Course

| **Semester III** | | | | |
|---|---|---|---|---|
| **Number of core courses (5)** | **Credits in each core course** | | | |
| Course | Theory | Practical | Tutorial | Credits |
| Core course 1 (BCCC301) Recombinant DNA Technology and Applications in Biotechnology | 4 | | | 4 |
| Core course 2 (BCCC302) Developmental Biology | 4 | | | 4 |
| Core course 3 (BCCC303) Proteomics and Metabolomics | 4 | | | 4 |
| Core course 4 (BCCC304) Presentation: Concepts in Research | 4 | | | 4 |
| Core course 5 (BCCC305) Practical Skills in Research | | 8 | | 8 |
| Total credits in core course | 24 | | | |
| | | | | |
| **Number of elective courses (0)** | Credits in each Elective course | | | |
| Credits in each elective course | Theory | Practical | Tutorial | Credits |
| Elective course | X | | | |
| Elective course | X | | | |
| Total credits in elective courses | 0 | | | |
| | | | | |
| **Number of Open Electives (0)** | Credits in each open elective | | | |
| | Theory | | | Credits |
| Open Elective | X | | | |
| Total credits in open elective | 0 | | | |
| | | | | |
| Total credits in Semester III - **24** | | | | |

**Semester wise Details of M.Sc. Biochemistry Course**

| **Semester IV** | | | | |
|---|---|---|---|---|
| **Number of core courses (2)** | **Credits in each core course** | | | |
| Course | Theory | Practical | Tutorial | Credits |
| Core course 1 (BCCC401) Advanced Techniques in Genomics for Biotechnology | 4 | | | 4 |
| Core course 2 (BCCC402) Dissertation by Research | | 16 | | 16 |
| Total credits in core course | 20 | | | |
| | | | | |
| **Number of elective courses (0)** | Credits in each Elective course | | | |
| Credits in each elective course | Theory | Practical | Tutorial | Credits |
| Elective course | X | | | |
| Elective course | X | | | |
| Total credits in elective courses | 0 | | | |
| | | | | |
| **Number of Open Electives (1)** | Credits in each open elective | | | |
| | Theory | | | Credits |
| Open Elective 1 (BCOE401) Basics of Biochemistry | 4 | | | 4 |
| Total credits in open elective | 4 | | | |
| | | | | |
| Total credits in Semester IV - **24** | | | | |

## Selection of Elective Courses:

Students will have the freedom to select two out of the four discipline-specific **Elective Courses**, which will be taught in sets of two. The first set will include "Infectious Diseases: Molecular Basis, Control and Prevention" and "Intermediary Metabolism and Clinical Correlation". Thus, students can select one course from this set. The second set will include "Life Style Disorders: Cancer and Cardiovascular Diseases" and "Advanced Techniques in Biochemistry". Students can select one course from this set as well. However, they will be counseled and advised by teachers to opt for the elective course that best suits their capability, future interests, prior training and degree. Students, who are admitted with Bachelor's degree in Biochemistry, will have solid understanding of metabolism and could opt for the course on Infectious Diseases for advanced learning and a future research scope. Students with research aptitude and future interests in research career either in academia or

industry could opt for the course on Advanced Techniques, so on and so forth. A minimum of 7 students would have to select a course for it to be offered in the department.

The **Open Elective** course will be open to all students in the University with a prior degree in a relevant area of life sciences and preference will be given to students from programmes other than Biochemistry. Students may be counseled before they select this course. A maximum of 25 students will be selected for this course based on counseling on a first-come-first-serve basis.

## Teaching:

The faculty of the Department is primarily responsible for organizing lecture work for all the courses. Each faculty in the department takes immense pride in teaching and almost equally shares teaching responsibilities for the theory papers, with each teacher teaching 2-3 courses (4 credits) independently. The instructions related to practical courses are provided jointly by the faculty members, with each faculty taking responsibility of few units according to a prior arrangement that allows students to best exploit the expertise of the faculties. Mentoring students for the seminar topics in the first semester is the joint responsibility of all the faculty members of the department and their seminars at the end of the semester is evaluated jointly by all the faculties as well. The Presentations on Concepts in Research and the Practical Skills in Research in the third semester will be mentored by the respective faculty in whose laboratory the student concerned is assigned to at the end of the second semester. The end-semester seminars by the students in these two courses will be jointly evaluated by all the faculties, while internal assessment marks will be adjudged by the respective mentor. The dissertation research will be supervised by the respective faculty to whose lab a particular student is assigned. The plan of work, execution of research objectives, compilation and interpretation of data, compilation of dissertation thesis, issues related to ethics and plagiarism, etc. will be solely under the supervision of the concerned faculty. The presentation of the research findings at the end of the fourth semester will be jointly evaluated by all the faculties of the department. The open elective course will also be taught jointly by the teachers of the department. Faculty from some other Departments, Institutes and Constituent Colleges may be invited for Guest Lectures, Special Seminars and Workshops or Tutorials.

There shall be 90 instructional days excluding examination in a semester.

## Eligibility for Admissions:

**Admission** to M.Sc. Biochemistry and Biotechnology programme is either through **Entrance Examination** (only written) or **Merit Based Selection**, with 50% seats reserved for each of the two categories.

For **Entrance Examination**, the **Eligibility Criteria** is: B.Sc. (General) or B.Sc. (Honours) or an equivalent undergraduate degree in any branch of life sciences with 60% or above marks in qualifying exam.

For **Merit Based Selection**, the **Eligibility Criteria** is: B.Sc. (Hons) in Biochemistry from the University of Delhi (after 10+2+3) with 60% or above marks in qualifying exam.

The **entrance test** will consist of 100 questions. The question paper shall consist of Multiple Choice Question (MCQ). Duration of the test will be 2 hours. Each question will carry 4 (Four) marks and each question will have only one correct answer as an option. There will be NEGATIVE MARKING for wrong answer. Each correct answer shall be awarded 4 marks, while one mark will be deducted for each wrong answer.

The **syllabus for entrance test** covers courses from general biochemistry including essential molecules of life; proteins and enzymes; metabolism of carbohydrates, lipids, amino acids and nucleotides; cell biology, membrane biology and bioenergetics; human physiology and hormones; gene organization, replication, DNA repair, transcription and gene expression; concepts in genetics; genetic engineering and immunology. For details, please visit the departmental website at http://biochem.du.ac.in/web.

A total of 12 seats are sanctioned to the department, of which 6 are in General Category, 3 in OBC category, 2 in SC and 1 in ST category.

## Assessment of Students' Performance:

1. English shall be the medium of instruction and examination.
2. Examinations shall be conducted at the end of each Semester to assess students' performance as per the Academic Calendar notified by the University of Delhi.
3. End semester examinations will be given a weightage of 70% of the total marks in a course, while 30% will be based on internal assessment. Internal assessment will evaluate students' performance over the entire semester.
4. Assessment of students' performance, based on Learning Outcomes for each course, shall consist of:

    **4.1.** Each theory paper in all semesters will carry 100 marks. Of the specified maximum marks, 30% marks shall be reserved for internal assessment based on classroom participation, seminar, tests, viva-voce and attendance. The weightage to be given to each of these components is detailed in the appropriate section below. Any student who fails to participate in the components of internal assessment will be debarred from appearing in the end-semester examination in the specific course and no internal assessment marks will be awarded. His/her internal assessment marks will be awarded as and when he/she attends regular classes in the courses in the next applicable semester. No special classes will be conducted for him/her during other semesters. The duration of written examination for each paper for end semester examination (70% marks) shall be three hours, except for the paper on open elective, which shall be for one and half hours.

**4.2.** Examinations for practicals for semesters I and II will comprise of 200 marks of which 30% marks will be reserved for internal assessment based on components described below (along with their weightage). Practical examination for each semester (I and II) would be for 8 hours duration in total and the components would include : 100 marks for practical test assigned on the day of the exam at the end of the semester; 40 marks for viva-voce.

**4.3.** The "Seminar" paper in Semester I will carry 100 marks and the components for assessment shall be: Content – 20 marks; Understanding of subject matter – 25 marks; Presentation – 25 marks; Handling questions and answers – 20 marks; Term paper – 10 marks. The examination shall be held at the end of the semester over two days and each student will present for 1 hour each and will have to be present on both the days. The seminar topics for presentation will be provided jointly by the faculties at the beginning of semester I.

**4.4.** The paper on "Presentation: Concepts in Research" in Semester III will carry 100 marks of which 30 marks will be reserved for internal assessment based on components described below. The components for assessment out of the rest 70 marks at the end of the semester shall be: Content – 10 marks; Understanding of subject matter – 20 marks; Presentation – 20 marks; Handling questions and answers – 10 marks; Term paper – 10 marks. The topic for presentation shall be assigned at the beginning of semester III by the faculty to whose lab a student is assigned for dissertation research. The topic of presentation will be related to the area of research that the student is assigned. The examination shall be held at the end of the semester over two days and each student will present for 1 hour each and will have to be present on both the days.

**4.5.** The paper on "Practical Skills in Research" in Semester III will carry 200 marks of which 60 marks will be reserved for internal assessment based on components described below. The components for assessment out of the rest 140 marks at the end of the semester shall be: Plan of work – 20 marks; Presentation – 40 marks; Understanding of techniques in research area – 50 marks; Question handling (viva-voce) – 30 marks. Students will prepare a plan of work including aims and objectives and optimize / standardize research techniques specific to the research project that they are assigned for dissertation. At the end of the semester, students will need to present their plan of research work and the details of the techniques learnt in an open seminar. The duration of presentation would be 30 minutes for each student.

**4.6.** Dissertation work would comprise of research work carried out by each student during the semesters III and IV in the supervision of a particular faculty member. Each student will be assigned to a particular faculty member (mentor) at the beginning of semester III to plan and execute a research project. The

student would carry out the review of literature on the topic of research and formulate the plan of work in consultation and supervision of the mentor. The student would then learn and standardize / optimize all techniques required to conduct the research experiments for the remaining part of semester III. The work plan and techniques learnt will be evaluated as part of the paper on Practical Skills in Research as mentioned in point 4.5. Extensive research work will be performed in the duration of semester IV in the supervision of the mentor. Towards the end of semester IV, the student will compile the research work including review of literature, aims and objectives, methodology and results and discussion in the form of a dissertation in the supervision of the mentor. At the end of semester IV, students would make presentations in the presence of all faculty members and would be collectively assessed by the faculty members. Marks will be assigned to each student collectively by the faculty based on the components outlined below and internal assessment throughout the year by the mentor. The duration of presentation would be 30 minutes for each student.

Total marks for dissertation shall be 400 and evaluation will be as follows:

| | | |
|---|---|---|
| Internal assessment* | = | 120 marks |
| Content and organization of thesis | = | 140 marks |
| Presentation and Viva-voce | = | 140 marks |
| Total | = | **400** marks |

(* - The components of internal assessment are outlined in the appropriate section below)

5. Examinations for courses shall be conducted only in the respective odd and even Semesters as per the Scheme of Examination. Regular as well as Ex-Students shall be permitted to appear/reappear/improve in courses of odd semesters only at the end of odd semesters and for even semester with the even.

## Scheme of Examination as per Ordinance IX (8):

Passing and Promotion Rules for the M.Sc. Course under the choice Based Credit System (CBCS) Scheme is as under.

8 (1) Pass Grade and Promotion Criteria

(a) The result of all the post-graduate courses under the CBCS shall be prepared on the basis of a 10 point grading system with Letter Grades as per the formula prescribed by the University Grants Commission with minor changes in the computation of the grade cut offs as per the Table 'A' given below. The minimum 'Numerical Grade' required to pass any course is '4' (Letter Grade 'D') in the total of End Semester Examination & Internal Assessment of the course for both theory & practical.

| Letter grade | Numerical Grade | Formula | Computation of grade cut off |
|---|---|---|---|
| O (Outstanding) | 10 | $m \geq x+2.5\sigma$ | The value $x+2.5\sigma$ to be taken into account for grade computation will be Actual $x+2.5\sigma$ or 90% whichever is lower. |
| A+ (Excellent) | 9 | $x+2.0\sigma \leq m < x+2.5\sigma$ | The value $x+2.0\sigma$ to be taken into account for grade computation will be Actual $x+2.0\sigma$ or 80% whichever is lower. |
| A (Very Good) | 8 | $x+1.5\sigma \leq m < x+2.0\sigma$ | The value $x+1.5\sigma$ to be taken into account for grade computation will be Actual $x+1.5\sigma$ or 70% whichever is lower. |
| B+ (Good) | 7 | $x+\sigma \leq m < x+1.5\sigma$ | The value $x+1.0\sigma$ to be taken into account for grade computation will be Actual $x+1.0\sigma$ or 60% whichever is lower. |
| B (Above average) | 6 | $x \leq m < x+\sigma$ | The value x to be taken into account for grade computation will be Actual x or 50% whichever is lower. |
| C (Average) | 5 | $x-0.5\sigma \leq m < x$ | The value $x-0.5\sigma$ of to be taken into account for grade computation will be Actual $x-0.5\sigma$ or 40% whichever is lower. |
| D (Pass) | 4 | $x-\sigma \leq m < x-0.5\sigma$ | The value $x-1.0\sigma$ of to be taken into account for grade computation will be Actual $x-\sigma$ or 30% whichever is lower. |
| F (Fail) | 0 | $x-\sigma > m$ | |

A student obtaining Letter Grade F (Numerical Grade 0) shall be considered failed and will be required to re-appear in the examinations

**(b)** No student will be detained in I or III Semester on the basis of his/her performance in I or III Semester examination; i.e. the student will be promoted automatically form I to II semester and III to IV Semester.

**(c)** A student shall be eligible for promotion from 1st Year to 2nd Year/III semester of the course provided he/she has passed 50% paper of I and II Semesters taken together. However, he/she will have to clear the remaining paper/s while studying in the 2nd year (III and IV semesters) of the programme.

**(d)** Students who do not fulfill the promotion criteria (c) above shall be declared fail in the 1st Year. However, they shall have option to retain the **Grades** in the papers in which they have secure minimum 'Numerical Grade **4**' (Letter Grade '**D**') i.e. Pass Grades as per the formula prescribed at **Table 'A'.**

**(e)** A student who has to reappear in a course prescribed for Semester I/III may do so only in the odd Semester examinations to be held in November/December. A student

who has to reappear in a course prescribed for Semester II/IV may do so only in the even Semester examinations to be held in April/May.

**(f)** The results in Grades shall be prepared on the basis of the actual performance of the student in the percentage scale and not on the basis of the formula prescribed at Table 'A' for computation of Grades (since the number of students is less than 30).

**(g)** Examination for Practical, wherever applicable shall be based on continuous evaluation.

**(h)** Duration of end semester theory examination of Core, Elective and Ability Enhancement compulsory courses (AECC) shall be three hours and for 100 marks each (70% End semester performance and 30% Internal Assessment). The Internal Assessment shall be based on combination of tutorials, classroom participation, project work, seminar, term papers, tests, assignments and attendance. The weightage given to each of these components shall be decided and announced by the respective Departments in the beginning of semester.

**(i)** There shall be no supplementary examinations.

**8 (2) Reappearance in passed papers:**

(a) A student may reappear in any theory Course prescribed for a semester, on foregoing in writing her/his previous performance in the paper/s concerned. This can be done once only in the immediate subsequent semester examination only (for example, a student reappearing in a Course prescribed for Semester I examination, may do so along with the immediate next semester III examinations only).

(b) A candidate who has cleared the papers of part II (III & IV Semesters) may reappear in any course of III or IV Semester only once, at the immediate subsequent examination on foregoing in writing her/his previous performance in the paper/s concerned, within the prescribed span period. (Note: The candidate of this category will not be eligible to join any higher course of study)

(c) In the case of reappearance in a paper, the result will be prepared on the basis of candidate's current performance in the examination.

(d) In the case of candidate, who opts to re-appear in any paper/s under the aforesaid provisions on surrendering her/his earlier performance but fails to re-appear in the paper/s concerned, the **Grades** Previously secured by the candidate in the paper/s in which she/he has failed to re-appear shall be taken into account while determining her/his result of the examination held currently.

(e) Reappearance in Practical examinations, dissertation, project and field work shall not be allowed.

(f) A student who reappears in a Course shall carry forward the internal assessment marks, originally awarded.

**8 (3) Eligibility for award of Degree and Division Criteria:**

(a) A student who passes all the papers (minimum 'Numerical Grade **4**') prescribed for Semester I to Semester IV examinations would be eligible for the award of degree. Such a student shall be categorized on the basis of the combined result of Semester I

to Semester IV examinations as follows: (Based on the Conversion Formula from CGPA to final Percentage)

| | |
|---|---|
| 60% or more | First Division |
| 50% or more but less than 60 % | Second Division |
| Less than 50% & declared passed | Third Division |

(b) The formula for calculating the final percentage of marks from Cumulative Grade Point Average (CGPA) for final year students under CBCS will be as follows:

**Final Percentage of marks = CGPA based on overall four semesters x 9.5**

**8 (4) Issue of Transcripts:**

Based on the grades earned, a Grade Certificate shall be issued to all the registered students by the University after every semester and a consolidated transcript indicating the performance in all seminars. The Grade Certificate will display the course details (code, title of the paper, number of credits, grade secured) along the SGPA of each semester and CGPA earned based on overall six semesters.

The percentage shall not be displayed on the Grade Certificate/Transcript. Only the formula approved for the conversion of CGPA into percentage will be displayed on the Grade Certificate/Transcript

## Attendance Requirement:

No student shall be considered to have pursued a regular course of study and be eligible to take examination unless he/she has attended 75% of the total number of lectures, tutorials, seminars, practicals and dissertation research conducted in each semester, during his/her course of study. Under special circumstances, the Head of the Department may allow students with at least 65% attendance to take the examination upon written request with appropriate justification and documentary evidences. Attendance will be marked if the student is present physically during roll call in the beginning of the class and attends the entire class. If the student comes 15 minutes after the start of class or leaves 15 minutes before the class is over, the student maybe marked absent and this decision will be at the discretion of the concerned teacher.

## Span Period:

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of **four** years from the date of admission to the Part-I/Semester-I of the M.Sc. Programme.

## Guidelines for the Award of Internal Assessment Marks for M.Sc. Programme (Semester Wise)

Internal assessment will comprise 30% of the maximum marks in a specified paper. Internal assessment will have several components like attendance marks, marks for mid-term written test / assignment / seminar, marks for discipline and interaction in class, etc. as outlined below semester wise. Marks for mid-term written test / assignment / seminar and attendance will be discussed with the students and copies for written test / assignment will be returned to students appropriately marked.

Attendance will be marked separately for each theory and practical papers as well as for Dissertation. Attendance marks will be included as part of 30% internal assessment in each paper and marked in three tiers. A student who attends 91-100% of the classes will be awarded 5 marks (out of 30 in internal assessment), students who attend 81-90% of the classes will be awarded 4 marks, students who attend 75-80% of the classes will be awarded 2 marks. No attendance marks will be awarded if a student attends less than 75% of the classes. The marks for each component of attendance will be doubled when the internal assessment marks is out of 60 (as in the practicals paper).

Internal assessment components for theory papers (4 credits, 100 marks) in Semester I/II/III/IV: Attendance - 5 marks; Class interaction/discipline – 5 marks; Written test/ Assignment/ Seminar/ Viva-voce (with documented evidence) – 20 marks; Total = 30 marks.

Internal assessment components for Practical papers (8 credits, 200 marks) in Semester I/II: Attendance – 10 marks; Class interaction/ discipline – 10 marks; Notebook record keeping – 20 marks; Experimental ability/Seminars – 20 marks; Total = 60 marks.

Internal assessment components for the paper on Presentation: Concepts in Research (4 credits, 100 marks) in Semester III : Attendance in lab – 5 marks; Interactions / Discipline in Lab – 5 marks; Ability to retrieve literature – 10 marks; Preparation of seminar/ term paper – 10 marks; Total = 30 marks

Internal assessment components for Practical Skills in Research (8 credits, 200 marks) in Semester III : Attendance in lab – 10 marks; Lab interactions / Discipline –10 marks; Notebook record keeping – 20 marks; Experimental ability – 20 marks; Total = 60 marks.

Internal assessment components for Dissertation (16 credits, 400 marks) in Semester IV: Regularity/ attendance – 10 marks; Intellectual ability and creativity – 20 marks; Independence/motivation – 20 marks; Execution of experiments/Consistency/Reproducibility – 40 marks; Record keeping – 20 marks; Lab discipline – 10 marks; Total = 120 marks.

**NOTE:**

The promotion/passing/attendance/other rules are subject to change from time to time by the University, and the rules prevailing at that time will be applicable.

# IV: Course Wise Content Details for M.Sc. Programme:

**The contents of the courses are arranged subsequently as per the table below:**

***Part I: Semester I***

| Paper Code | Paper title | Type of Course | Credit | Page No. |
|---|---|---|---|---|
| BCCC101 | Proteins – Structure, Folding and Engineering | Core | 4 | 23 |
| BCEC101<br>OR<br>BCEC102 | Infectious Diseases: Molecular basis, Control and Prevention<br>OR<br>Intermediary Metabolism and Clinical Correlation | Elective | 4 | 28<br><br>32 |
| BCEC103<br>OR<br>BCEC104 | Life Style Disorders: Cancer and Cardiovascular Diseases<br>OR<br>Advanced Techniques in Biochemistry | Elective | 4 | 36<br><br>39 |
| BCCC102 | Seminar on current topics | Core | 4 | 43 |
| BCCC103 | Practicals | Core | 8 | 46 |
| **Total Credits** | | | **24** | |

***Part I : Semester II***

| Paper Code | Paper title | Type of Course | Credit | Page No. |
|---|---|---|---|---|
| BCOE201 | Basics of Biochemistry | Open Elective | 4 | 50 |
| BCCC202 | Immunology and Immunotechniques | Core | 4 | 54 |
| BCCC203 | Enzymes and their Biotechnological Applications | Core | 4 | 57 |
| BCCC204 | Molecular Biology | Core | 4 | 61 |
| BCCC205 | Practicals | Core | 8 | 65 |
| **Total Credits** | | | **24** | |

***Part II : Semester III***

| Paper Code | Paper title | Type of Course | Credit | Page No. |
|---|---|---|---|---|
| BCCC301 | Recombinant DNA Technology and Applications in Biotechnology | Core | 4 | 70 |
| BCCC302 | Developmental Biology | Core | 4 | 74 |
| BCCC303 | Cell Biology | Core | 4 | 78 |
| BCCC304 | Presentation : Concepts in Research | Core | 4 | 83 |
| BCCC305 | Practical Skills in Research | Core | 8 | 86 |
| **Total Credits** | | | **24** | |

***Part II : Semester IV***

| Paper Code | Paper title | Type of Course | Credit | Page No. |
|---|---|---|---|---|
| BCCC401 | Advanced Techniques in Genomics for Biotechnology | Core | 4 | 89 |
| BCCC402 | Dissertation by Research | Core | 16 | 93 |
| BCCC403 | Proteomics and Metabolomics | Core | 4 | 96 |
| **Total Credits** | | | **24** | |

(Key: BC – Biochemistry; CC – Core Course; EC – Elective Course; OE – Open Elective)

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester I

### BCCC101: Proteins – Structure, Folding and Engineering

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to offer detailed knowledge about proteins, the dynamic biomolecules that sustain life through myriad of diverse functions, providing basic concepts of structures of proteins, their mechanism of folding and methods to engineer them for various applications.

**Course Learning Outcomes:**

- Students will acquire insight into levels of protein structures – their basic constituents, forces that stabilize protein structures, their various modules and arrangements.
- Students will learn how proteins fold during and following translation and the consequences of improper folding.
- Students will acquire insight into protein structure-function relationship learning the significance of protein structures in their ability to perform various functions.
- Students will learn about the types, methods and strategies of protein engineering and examples of successful protein engineering in various applications.

**Contents:**

**Unit I:** Introduction: Importance and Significance of proteins; Functional diversity, Ubiquity, Classes and Dynamism; Structure-function relationship; Key Features. Amino acids as constituents: Ways of representation, Classification, Stereochemistry, Chemical and structural features, Acid/Base properties and their applications. Physico-chemical interactions in biological systems: Covalent & non-covalent interactions, Importance of weak interactions in protein structures.

**Unit II:** Levels of protein structure: *Primary structure*: Flexibility and conformational restrictions, Characteristics of peptide bond, Ramachandran plot. *Secondary structure*: H-bonding scheme, Diversity in alpha-helices, Helix capping, Beta-stand and sheet, Turns and loops, Importance of loops. *Supersecondary structure*: Domains and motifs. *Tertiary structure*: General properties and characteristics, Structure prediction (modeling). *Quaternary structure*: Concept of subunits and promoters and their association, Importance of quaternary structure; Various examples, Myoglobin and Hemoglobin structures and their relation to cooperativity and allostery.

**Unit III:** Fibrous and Globular proteins, Structural Features of Membrane proteins

**Unit IV:** Protein Folding and its biotechnological applications: The "protein folding problem" and problems in protein folding; Anfinsen's classical experiment; Folding curves and transitions; Models of protein folding; Assisted protein folding (Chaperones); Misfolding

and diseases; Mechanism of sickle-cell disease; Intrinsically disordered proteins; Industrial and medical applications.

**Unit V:** Protein Engineering: Basic principles; Types and Methods; Strategies in protein engineering (Directed evolution, Comparative design, Rational design); Applications and case studies.

**Unit VI:** Solvent Engineering: Physical basis for protein denaturation/ stability; Preferential binding and preferential hydration models; Various stabilizers and their applications.

**Unit VII:** Sequencing and amino acid composition of peptides and proteins – Conventional and Modern methods and their applications in protein identification, validation, characterization, disease biology, diagnosis and drug discovery. Artificial peptide synthesis and their applications.

**Suggested Readings:**

1. C. Branden, T. Tooze. 1999. Introduction to Protein Structure (2nd Ed.), Garland Science, Taylor and Francis Group, New York, USA. ISBN: 978-0-8153-2305-1.
2. T.E. Creighton. 2002. Proteins: Structures and Molecular Properties (3rd Ed.), W.H. Freeman and Company, New York, USA. ISBN 978-0716770305.
3. R. H. Pain. 2000. Mechanisms of Protein Folding, Oxford University Press, Oxford, England. ISBN 978-0716770305.
4. S. Lutz, U. T. Bornscheuer. 2008. Protein Engineering Handbook, Wiley-VCH, Weinheim, Germany. ISBN: 978-3-527-31850-6.
5. V. N. Uversky, A.L. Fink. 2006. Protein Misfolding, Aggregation and Conformational Diseases: Part A: Protein Aggregation and Conformational Diseases (Protein Reviews), Springer, New York, USA. ISBN: 978-1-4419-3851-0.

**Teaching Plan*:**

**Week 1:** Introductory classes: General introduction to the course; Providing an understanding of course objectives and outcome: General introduction to proteins.
**Week 2:** Amino acids as constituents of proteins; numerical problems.
**Week 3:** Physico-chemical interactions in biology; non-covalent interactions in proteins.
**Week 4:** Levels of protein structures: primary structure
**Week 5:** Levels of protein structures: secondary structure
**Week 6:** Levels of protein structures: supersecondary structure
**Week 7 :** Levels of protein structures: quaternary and tertiary structure
**Week 8:** Fibrous and globular proteins; Membrane proteins
**Week 9:** Revision of the above units; mid-term test
**Week 10:** Basic concepts and landmark experiments in protein folding; development of theories of protein folding; intrinsically disordered proteins
**Week 11:** Protein misfolding and diseases; industrial and medical applications.
**Week 12:** Protein engineering: basic principles, methods and strategies; applications.
**Week 13:** Solvent engineering of proteins: basic principles, models and applications.
**Week 14:** Sequencing and amino acid composition of proteins and their applications.

**Week 15:** Artificial peptide synthesis and their applications. Course revision, tests, solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness of students)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will learn about the significance of proteins in life; their classification; Key features of proteins that help them acquire diverse function; Properties of each of the proteinogenic amino acid along with their functional significance in protein structures; Characteristics of various physico-chemical interactions and importance of non-covalent interactions in providing proteins their shape and stability. | Outlining history of development of knowledge about proteins through power point presentations and landmark publications; Use of stereochemical models; Question and answer sessions in the class; Amino acid characteristics will be explained using chalk and board; Two and three-dimensional pictures of the interactions in protein structures. | Names of proteins will be provided and students will be asked to classify them in various functional classes; Students will be assigned the task of identifying examples of proteins that directly relate to each key feature of protein structures. Structures of amino acids will be shown in ball and stick representation and students will need to identify them along with their stereochemical identity; numerical problems relating to their pKa and pI and how such knowledge is used in industry. A host of characteristics and features will be provided to students and they will need to match them with the type of non-covalent interactions. |
| II. | Students will learn about the characteristics of peptide bond and how torsional angles are measured; Ramachandran plot and its use in validating protein structures. They will learn about the | Chalk and Board for teaching the basic concepts; Power point presentations for 3D structure demonstration; Teaching module on protein structure-function (with myoglobin/ haemoglobin as prototype), created for E-Pathshala (UGC, MHRD) will also be used. | Sequence of small sized proteins will be given and students will be asked to identify the protein and model their three-dimensional structure and predict their secondary structures. They will be assigned the task of retrieving PDB coordinates of any given |

| | | | |
|---|---|---|---|
| | characteristics of interactions and nature of H-bonding that lead to secondary structures; Features of domains and motifs; General features of tertiary structures and arrangement of side chains; Concepts of subunits and their organization and consequences to protein structure and function | | protein and use the structure to plot Ramachandran maps. The domains in a given protein can be predicted and visualized along with the subunits and their interface. |
| III. | Students will learn about structural features and differences between fibrous and globular proteins with examples; Structural aspects of membrane proteins and their relation to function. | Power point presentations; Chalk and board; Student interaction in class; Case studies with examples of each protein structural class. | Students will be shown images of proteins and they have to identify globular and fibrous proteins and relate their structures to potential functions. Sequences of potential membrane proteins will be given and students will predict membrane topology. |
| IV | Students will learn as to how proteins fold and what challenges they face during folding; They will learn about Chaperones that help in protein folding; Diseases caused due to protein misfolding; The concept of intrinsically disordered proteins and how they contradict classical structure-function relationship; Case studies of various applications. | Concepts will be taught using chalk and board and notes; Power point presentations for images for clarity of concepts; Research papers will be provided for applications; Numerical problems will be solved. | Students will be provided experimental data whereby folding was probed using various enzymatic and biophysical tools against various denaturants and they will need to generate folding transition curves, calculate transition mid-point and free energy of reaction and compare stabilities of proteins; They will generate tables depicting names of proteins and the diseases caused by misfolding; They will predict intrinsically disordered proteins in genomes of organisms. |
| V. | Students will learn the rationale, basic principles, types, methods and | Basic concepts will be explained; Students will divide into groups and take up one strategy for protein engineering | Case studies will be assigned to students that report successful protein engineering programme |

| | | | |
|---|---|---|---|
| | strategies of protein engineering with specific examples | and discuss along with teacher. Papers that report biotechnological applications will be retrieved. | leading to translational value in agriculture, industry or biotechnology. |
| VI. | Students will learn why some proteins are more stable than others and the role of solvent in stability and unfolding; Models of solvent-protein interactions; Applications of solvent formulation in protein stability | Basic concepts explained on board and with power point presentations. Various solvents used in the lab, in industry and elsewhere will be classified and their importance in protein stability, shelf life and other medical formulations will be discussed. | Case studies for various solvent stabilizers of proteins and their applications. Students will classify solvents into the preferential hydration and preferential binding models. They will search for formulations used in medicine and industry. |
| VII. | Students will learn how to sequence proteins and how to determine their amino acid compositions; Applications of such techniques; Students will learn how artificial peptides are synthesized and what are their applications | Classical papers on sequencing will be discussed. Applications will be taught. Analytical problems will be specified. | Protein sequences will be given to students and they will be asked to generate in silico fragments and assign their masses and align against know PMF databases; Case studies of applications They will retrieve publications related to artificial enzymes and summarize their various applications and present 5 minutes seminars. |

## MASTER OF SCIENCE, BIOCHEMISTRY
## Semester I

### BCEC101: Infectious Diseases: Molecular Basis, Spread, Control and Prevention

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to offer detailed knowledge about the mechanisms of disease, cause, transmission, detection, treatment and prevention.

**Course Learning Outcomes:**

- Students will gain overall knowledge about the mechanisms of disease cause, transmission, detection, treatment and prevention.
- Students will develop the ability to relate to any existing or emerging infection as well as will learn about drug resistance and its mechanisms. The students will have the know-how to research and develop new tools for their management.

**Contents:**

**Unit I:** Overview of infectious diseases, infectious agents - Bacteria, Viruses, protozoa and fungi, pathogenicity and virulence; Facultative / obligate intracellular pathogens.

**Unit II:** Bacterial disease, epidemiology, signs and symptoms, causative agent, history, infection and pathogenicity, Diagnostics, Therapeutics and vaccines. Drug resistance, mechanisms, Multidrug efflux pumps, extended spectrum β-lactamases (ESBL) and implications on public health, molecular mechanisms for Tuberculosis, Typhoid, Cholera

**Unit III:** Viral diseases, epidemiology, signs and symptoms, causative agent, history, infection and pathogenesis, Detection, Drugs and inhibitors, Vaccines, molecular mechanisms for AIDS, hepatitis, influenza, dengue, polio, herpes.

**Unit IV:** Parasitic diseases epidemiology, signs and symptoms, causative agents, history, Vectors, life cycle, Host parasite interactions, Diagnostics, Drugs and Inhibitors, Resistance, Vaccine development, molecular mechanisms for Malaria.

**Unit V:** Emerging and re-emerging infectious diseases and pathogens including X-MDR *M. tuberculosis*, MRSA, SARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever, and Chlamydiae, opportunistic fungal pathogens.

**Suggested readings**

1. Klein's Microbiology (2008) 7th Ed., Prescott, Harley, Willey, J.M., Sherwood, L.M., Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.

2. Principles and practices of Infectious diseases, 7th edition, Mandell, Douglas and Bennett. S, Volume, 2. Churchill Livingstone Elsevier. ISBN: 978-0-443-06839-3
3. Sherris Medical Microbiology: An Introduction to Infectious Diseases. (2010). Kenneth J. Ryan, C. George Ray, Publisher: McGraw-Hill. ISBN-13: 978-0071604024 ISBN-10: 0071604022
4. Medical Microbiology. (2012). Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller, Elsevier Health Sciences. ISBN: 978-0-323-08692-9.
5. Bacterial Pathogenesis: A molecular approach by Salyers AA and Whitt DD eds. American Society for Microbiology Press, Washington, DC USA. 2002

**Teaching Plan*:**

**Week 1:** Introductory classes: Overview of infectious diseases, infectious agents - Bacteria, Viruses, protozoa and fungi, pathogenicity and virulence; Facultative / obligate intracellular pathogens.

**Week 2:** Bacterial disease, epidemiology, signs and symptoms, causative agent, history, infection and pathogenicity, Diagnostics, Therapeutics and vaccines.

**Week 3:** Drug resistance, mechanisms, Multidrug efflux pumps, extended spectrum β-lactamases (ESBL) and implications on public health.

**Week 4:** Molecular mechanisms for Tuberculosis

**Week 5:** Molecular mechanisms for Typhoid, Cholera

**Week 6:** Viral diseases, epidemiology, signs and symptoms, causative agent, history, infection and pathogenesis, Detection.

**Week 7:** Molecular mechanisms for AIDS, hepatitis. Detection, Drugs and inhibitors, Vaccines,

**Week 8:** Molecular mechanisms for influenza, dengue, polio, herpes. Detection, Drugs and inhibitors, Vaccines.

**Week 9:** Course revision, tests, solving problems, mid-term assessment, power-point presentation by students on various assigned topics

**Week 10:** Parasitic diseases epidemiology, signs and symptoms, causative agents, history, Vectors.

**Week 11:** Molecular mechanisms for Malaria, life cycle, Host parasite interactions

**Week 12:** Diagnostics, Drugs and Inhibitors, Resistance, Vaccine development,

**Week 13:** Emerging and re-emerging infectious diseases and pathogens including X-MDR *M. tuberculosis*, MRSA.

**Week 14:** SARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever, and Chlamydiae, opportunistic fungal pathogens

**Week 15:** Revision and end term assessment. Discussion of assessment performance, discussion of problems and solutions, final dispersal.

(*The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

## Facilitating the achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will gain overall knowledge about the mechanisms of disease cause, transmission, detection, treatment and prevention. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics. |
| II. | Students will learn about various bacterial diseases, their molecular mechanisms and intervention strategies. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics. |
| III | Students will learn about various viral diseases, their molecular mechanisms and intervention strategies. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics. |
| IV. | Students will learn about | Students will be | Internal assessment tests (mid- |

| | | | |
|---|---|---|---|
| | various parasitic diseases, their molecular mechanisms and intervention strategies. | asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics. |
| V. | Students will develop the ability to relate to any existing or emerging infection as well as will learn about drug resistance and its mechanisms. The students will have the know-how to research and develop new tools for their management. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester I

### BCEC102 : Intermediary Metabolism and Clinical Correlation

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

### Course Objectives:

The objective is to offer detailed and comprehensive knowledge about the synthesis and catabolism of biomolecules such as carbohydrates, lipids, amino acids and nucleotides. The regulation of the metabolic processes as well as the disease correlation of the metabolic disorders will also be taught.

### Course Learning Outcomes:

- Students will learn about various kinds of biomolecules and their physiological role.
- Students will gain insight into the detailed synthesis and breakdown of the various biomolecules
- Students will gain knowledge about various metabolic disorders and will help them to know the importance of various biomolecules in terms of disease correlation.
- Students will learn about the integration of various metabolic pathways and their cross-talk.

### Content

**Unit I**: Carbohydrate metabolism. Overview of metabolism and metabolic reactions, catabolism, anabolism, ATP as energy currency of the cell, reducing power of the cell. Anaerobic production of ATP, Glycolysis, Fermentation, Regulation, Utilization of sugars other than glucose. Gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway, glucuronic acid pathway. Aerobic production of ATP, TCA cycle, regulation. Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases. Signaling pathways, Hormonal regulation of carbohydrate metabolism, molecular aspects of diseases caused by dysregulation of metabolic pathways

**Unit II:** Lipid Metabolism. Absorption, transport and storage of lipids and TAGs, Lipid metabolism and regulation, Biosynthesis and degradation of TAGs and phospholipids, fatty acid oxidation, ketone bodies metabolism, ketoacidosis, cholesterol metabolism, Molecular mechanism of steroid and lipoprotein metabolism, diseases caused by abnormal metabolic pathways.

**Unit III:** Amino Acids and Nucleotide Metabolism. Role of essential and non-essential amino acids in growth and development. Protein calorie malnutrition - Kwashiorkar and Marasmus, catabolism of amino acids. Glucogenic and ketogenic amino acids. Disorders of amino acids metabolism, biosynthesis of urea, its regulation and urea cycle disorders, overview of amino acid synthesis, Biosynthesis of non-essential amino acids and its regulation, precursor functions of amino acids and its importance, De novo synthesis and

breakdown of purine and pyrimidine nucleotides, regulation and salvage pathways, Digestion of nucleic acids, Inhibitors of nucleotide metabolism, Disorders of nucleotide metabolism

**Unit IV:** Role of vitamins in metabolic processes and various diseases resulting from the deficiencies of vitamins.

**Unit V:** Integration of metabolic pathways, tissue specific metabolism (brain, muscle, and liver).

**Suggested readings**

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4 / BRV ISBN: 978-0-470-60152-5.
3. Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
4. Harper's Biochemistry (2012) 29th ed., Murray, R.K., Granner, D.K., Mayes and P.A., Rodwell, V.W., Lange Medical Books/McGraw Hill. ISBN:978-0-07-176-576-3.

**Teaching Plan*:**

**Week 1:** Overview of metabolism and metabolic reactions, catabolism, anabolism, ATP as energy currency of the cell, reducing power of the cell.
**Week 2:** Anaerobic production of ATP, Glycolysis, Fermentation, Regulation, Utilization of sugars other than glucose
**Week 3:** Gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway, glucuronic acid pathway
**Week 4:** Aerobic production of ATP, TCA cycle, regulation. Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases.
**Week 5:** Signaling pathways, Hormonal regulation of carbohydrate metabolism, molecular aspects of diseases caused by dysregulation of metabolic pathways
**Week 6:** Absorption, transport and storage of lipids and TAGs, Lipid metabolism and regulation
**Week 7:** Biosynthesis and degradation of TAGs and phospholipids, fatty acid oxidation, ketone bodies metabolism, ketoacidosis
**Week 8:** Cholesterol metabolism, Molecular mechanism of steroid and lipoprotein metabolism, diseases caused by abnormal metabolic pathways.
**Week 9:** Role of essential and non-essential amino acids in growth and development
**Week 10:** Protein calorie malnutrition - Kwashiorkar and Marasmus, catabolism of amino acids. Glucogenic and ketogenic amino acids
**Week 11:** Disorders of amino acids metabolism, biosynthesis of urea, its regulation and urea cycle disorders, overview of amino acid synthesis.
**Week 12:** Biosynthesis of non-essential amino acids and its regulation, precursor functions of amino acids and its importance.
**Week 13:** *De novo* synthesis and breakdown of purine and pyrimidine nucleotides, regulation and salvage pathways.

**Week 14:** Digestion of nucleic acids, Inhibitors of nucleotide metabolism, Disorders of nucleotide metabolism
**Week 15:** Role of vitamins in metabolic processes and various diseases resulting from the deficiencies of vitamins. Integration of metabolic pathways, tissue specific metabolism (brain, muscle, and liver). Course revision, Final-term internal assessment test, solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will learn about various kinds of biomolecules and their physiological role. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Internal assessment tests (mid-term and end-term) will be conducted. |
| II. | Students will gain insight into the detailed synthesis and breakdown of the various biomolecules | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation | Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics. |

| | | | |
|---|---|---|---|
| | | mode. | |
| III. | Students will gain knowledge about various metabolic disorders and will help them to know the importance of various biomolecules in terms of disease correlation. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Internal assessment tests (mid-term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics. |
| IV. | Students will learn about the integration of various metabolic pathways and their cross-talk | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Internal assessment test (end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester I

### BCEC103: Lifestyle Disorders: Cancer and Cardiovascular Diseases

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to provide knowledge about common life style disorders with detailed insight into two major killers: Cancer and Cardiovascular diseases.

**Course Learning Outcomes:**

- Students will learn about the various life style associated disorders.
- Students will gain detailed insight into Cancer and Cardiovascular diseases with regards to the molecular mechanisms, causes, symptoms, stages, diagnosis and treatments.
- Students will learn about alternative medicines; current research status, various ethical, social and regulatory issues.

**Contents:**

**Unit I:** Introduction: Life style associated disorders like obesity, diabetes, chronic obstructive pulmonary diseases (COPD), cancer and cardiovascular diseases (CVDs); Causes, symptoms, complications, diagnosis, intervention and management of disease; Two major killers: Cancer and Cardiovascular diseases

**Unit II:** Cancer: History of cancer; Characteristics of normal and transformed cells; Hallmarks of cancer; Causes and symptoms; Pathophysiology; Stages of cancer; Molecular basis of neoplastic growth and metastasis, Key oncogenic pathways; Proto-oncogenesis and Tumor suppressor genes; Cancer causing mutations; Tumor viruses, Overview of important techniques related to cancer research.

**Unit III:** Cardiovascular diseases: Definition; The origin of cardiovascular diseases (electrical, structural and circulatory) and types of CVDs; Defining the broad spectrum of ailments; Understanding the underlying factors; Stages of CVDs; Molecular basis of CVDs like hypertension, coronary heart (artery) disease, cerebrovascular disease, cardiomyopathy, cardiac hypertrophy, atherosclerosis, myocardial infarction.

**Unit IV**: Diagnosis and Treatment strategies : Biochemical analysis of cancer and screening methods; Current treatment modalities and their disadvantages, major side effects; Molecular approaches to cancer treatment; Factors affecting prognosis of cancer; Challenges of treatment and disease control strategies. Diagnosis and biomarkers for CVDs; Treatment strategies and management of the condition; Drugs and their discovery; Model systems and animals for CVDs.

**Unit V:** Recent Advances: Introduction to alternative medicines; Case studies; Research status and scope; Ethical, social and regulatory issues.

**Suggested Readings:**

1. Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Introduction to Human Physiology (2012) 8th edition; Lauralee Sherwood. Brooks/Cole, Cengage Learning. ISBN-13: 978-1133104544 ISBN-10: 1133104541
3. The Cell: A Molecular Approach (2009) 5th ed., Cooper, G.M. and Hausman, R.E., ASM Press & Sunderland (Washington DC), Sinauer Associates, MA, ISBN:978-0-87893-300-6.
4. The World of the cell, 7th edition (2009). Lewis J. Kleinsmith, Jeff Hardin, Gr Wayne M.Becker. ISBN-13: 978-0805393934 ISBN-10: 0805393935.
5. Life style disorders, National health portal of India (https://www.nhp.gov.in/lifestyle-disorder_mtl)

**Teaching Plan*:**

**Week 1:** Introductory classes: General introduction to the course; Providing an understanding of course objectives and outcome: General introduction to Life style associated disorders
**Week 2:** Specific Life style associated disorders like obesity, diabetes, chronic obstructive pulmonary diseases (COPD) will be discussed along with their causes, symptoms, diagnosis, intervention and management of disease
**Week 3:** History of cancer; Characteristics of normal and transformed cells; Hallmarks of cancer; Causes and symptoms of cancers.
**Week 4:** Pathophysiology; Stages of cancer; Molecular basis of neoplastic growth and metastasis, Key oncogenic pathways;
**Week 5:** Proto-oncogenesis and Tumor suppressor genes; Cancer causing mutations; Tumor viruses.
**Week 6:** Biochemical analysis of cancer and screening methods; Current treatment modalities and their disadvantages, major side effects.
**Week7:** Molecular approaches to cancer treatment; Factors affecting prognosis of cancer; Challenges of treatment and disease control strategies.
**Week 8:** Overview of important techniques related to cancer research.alternative medicines; Case studies; Research status and scope; Ethical, social and regulatory issues.
**Week 9:** Course revision, tests, solving problems; mid-term test.
**Week 10:** Cardiovascular diseases: Definition; The origin of cardiovascular diseases (electrical, structural and circulatory) and types of CVDs. Defining the broad spectrum of ailments; Understanding the underlying factors; Stages of CVDs;
**Week 11:** Molecular basis of CVDs like hypertension, coronary heart (artery) disease.
**Week 12:** Cerebrovascular disease, cardiomyopathy, cardiac hypertrophy,
**Week 13:** Atherosclerosis and myocardial infarction; Diagnosis and biomarkers;
**Week 14:** Treatment strategies and management of the condition.
**Week 15:** Drugs and their discovery; Model systems and animals for CVDs. Course revision, tests, solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

## Facilitating the achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will learn the key features of life style associated disorders, their general causes, symptoms, diagnosis, intervention and management of disease. | Power point presentations, discussion of research articles and reviews | Students will be given assignments for example, students will be asked to match symptoms with the correct disease; oral questions will be asked. |
| II | Students will learn why some cells lose control and become cancerous and the roles of oncogenes and tumor suppressors. | Power point presentations; discussion of research articles and reviews | Oral questions will be asked, students will be given analytical problems relating to cancer research to solve. Students will be asked to read original research papers and discuss the plan of experimental approach and findings. |
| III | Students will learn about different types of CVDs; Factors responsible for the disease; Stages and molecular basis of the disease. | Power point presentations; discussion of research articles and reviews | Assignments consisting of analytical problems related to CVDs will be given to students. Students will be reading research papers for short presentation. |
| IV | Knowledge will be imparted regarding diagnostic approaches, treatment modalities and challenges of treatment. | Power point presentations; discussion of research articles and reviews. | Students will be asked questions regarding different biomarkers and diagnostic methods for cancer and CVDs used in clinics. |
| V | Students will learn about the current research status for cancer and CVDs. They will get to know about the alternative medicines available. They will also learn about the ethical and regulatory issues pertaining to use of drugs, their discovery and commercialization. | Latest research papers will be discussed; News and Views section of journals will be discussed; Traditional Indian medicine and literature will be discussed. | Students will be asked to present findings of original research papers, oral discussions and written test will be carried out at the end of the semester. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester I

### BCEC104: Advanced Techniques in Biochemistry

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The course intends to enlighten students about the basic principles underlying biochemical, biophysical and computational techniques that are frequently employed in research programmes, their methodologies and applications in solving biochemical problems.

**Course Learning Outcomes:**

- Upon successful completion of the course, students will be able to explain and correlate principles and methodologies of various techniques in biochemistry, molecular biology, cell biology, computational biology and biophysical chemistry.
- Students will obtain insight into how each of the techniques taught in this course can be applied to solve problems in biochemistry and based on the understanding they will be able to design and execute experiments during their dissertation and further research endeavour.
- Students will have better understanding of research publications where one or more of the techniques taught in this course are applied.

**Contents:**

**Unit I:** Biochemical: Limited proteolysis; Transverse urea gradient gel electrophoresis; Radioisotope and their use in biology, autoradiography, radioactive labeling of biological macromolecules; Equilibrium dialysis, principles and applications; Protein–protein interaction studies through pull down and immunoprecipitation assays.

**Unit II**: Molecular biology: DNA and RNA isolation; Northern Blot; Southern Blot; Western Blot; *In situ* hybridization; *In vitro* transcription assay; *In vitro* translation assay; Electrophoretic Mobility Shift Assay; DNA foot printing assay; RNAse protection assay; Chromatin immunoprecipitation; Reporter assays.

**Unit III:** Cell biology: Introduction to mammalian cell culture techniques; Immortalization of cells; Overexpression and Silencing of genes; Generation of transient and stable lines; Cell synchronization techniques; Cell cycle analysis using FACS; Preparation of mouse embryonic fibroblasts; Cytotoxicity and apoptosis tests; Cell viability assays; Cell staining techniques; Assays for cell proliferation, migration invasion of cells and anchorage independent growth of cells. Posttranslational modification - Kinase assay and Ubiquitination assays; Techniques for assessment of Protein and mRNA turnover; Subcellular fractionation and identification of various fractions.

**Unit IV:** Computational: Databases; Genome mining; Virtual cloning; Sequence analysis – alignment, phylogeny, protein primary structure analysis; Protein classification and Structure Prediction, Modeling; Protein structure visualization, superimposition and analysis; Docking and small molecule libraries; Drug design and discovery.

**Unit V:** Biophysical: Hydrodynamic methods: Centrifugation, Sedimentation; Spectroscopic methods: Absorbance, Fluorescence, Chemiluminescence, Phosphoresence, Circular dichroism, IR, ESR, FRET, Biomolecular fluorescence complementation assay, FRAP (Fluorescence recovery after photobleaching); Calorimetric methods: Differential Scanning Calorimetry (DSC) and Isothermal titration Calorimetry (ITC); Structural methods : NMR; X-ray crystallography; Imaging techniques : Fluorography, PET, MRI; Microscopy: Fluorescence microscopy, Confocal microscopy, Electron microscopy, CE Microscopy; Specialized techniques : Patch clamp.

**Suggested Readings:**


1. D. Sheehan. 2009. Physical Biochemistry: Principles and Applications (2nd Ed.), John Wiley and Sons Ltd, Chichester, England. ISBN: 978-0-470-85603-1.
2. J. Cavanagh, W.J. Fairbrother, A.G. Palmer III, M. Rance, N. J. Skelton. 2007. Protein NMR Spectroscopy: Principles and Practice, Academic Press, San Diego, USA. ISBN: 978-0-12-164491-8.
3. D. W. Mount. 2004. Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory, Plainview, New York, USA. ISBN: 978-0-879-69712-9.
4. M. Zvelebil, J.O. Baum. 2007. Understanding Bioinformatics (1st Ed.), Garland Science, Taylor and Francis Group, New York, USA. ISBN: 978-0815340249.
5. Gale Rhodes. 2006. Crystallography Made Crystal Clear (3rd Ed.), Academic Press, Burlington, USA. ISBN: 978-0-125870733.
6. K. Wilson and J. Walker. (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th Edition), Cambridge University Press.
7. G.M. Cooper. 2000. The Cell: Molecular Approach, ASM Press, Washington, D.C. USA.
8. J.R. Harris, J. M. Graham, D. Rickwood. (2006) Cell Biology Protocols. , J Wiley and Sons Inc.
9. M.R. Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press


**Teaching Plan*:**

**Week 1:** General introduction to the course; Limited proteolysis; Transverse urea gradient gel electrophoresis; Radioisotope and their use in biology; Equilibrium dialysis, principles and applications

**Week 2:** Protein–protein interaction studies: Pull down assays, Immunoprecipitation.

**Week 3:** DNA and RNA isolation; Northern Blot; Southern Blot; Western Blot; *In situ* hybridization

**Week 4:** *In vitro* transcription assay; *In vitro* translation assay; Electrophoretic Mobility Shift Assay;

**Week 5:** DNA foot printing assay; RNAse protection assay; Chromatin immunoprecipitation; Reporter assays.

**Week 6:** Revision of the above units; mid-term test

**Week 7:** Introduction to mammalian cell culture techniques; Immortalization of cells; Overexpression and Silencing of genes; Generation of transient and stable lines; Cell synchronization techniques; Cell cycle analysis using FACS

**Week 8:** Preparation of mouse embryonic fibroblasts; Cytotoxicity assay; Cell viability assays; Cell staining techniques; Cell proliferation assay;

**Week 9:** Migration assay; Invasion assay; Soft agar assay; Apoptosis assays; Kinase assay; Ubiquitination assay; Protein and mRNA turnover assays; Subcellular fractionation and identification of various fractions.

**Week 10:** Databases; Genome mining; Virtual cloning; Sequence analysis – alignment, phylogeny, protein primary structure analysis; Protein classification and Structure Prediction

**Week 11:** Modeling; Protein structure visualization, superimposition and analysis; Docking and small molecule libraries; Drug design and discovery.

**Week 12:** Centrifugation, Sedimentation; Absorbance, Fluorescence, Chemiluminescence, Phosphoresence, Circular dichroism; IR, ESR, FRET, Biomolecular fluorescence complementation assay, FRAP (Fluorescence recovery after photobleaching)

**Week 13:** Differential Scanning Calorimetry (DSC) and Isothermal titration Calorimetry (ITC); NMR;

**Week 14:** X-ray crystallography; Fluorography, PET, MRI;

**Week 15:** Fluorescence microscopy, Confocal microscopy, Electron microscopy, CE Microscopy; Patch clamp. Course revision, tests, solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness of students)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will learn various biochemical techniques including urea gradient gel electrophoresis; use of radioisotopes in biology, Equilibrium dialysis, Protein interaction through pull down and IP | Chalk and board and power point presentations, regular question-answer activities. consultation of text books and reviews | Assessment through interactive discussion in the class, periodic question-answer sessions during teaching; Students will identify a publication each where the techniques have been applied. |
| II. | Students will learn molecular biology techniques like Northern Blot; Southern Blot; Western Blot; EMSA, DNA foot printing; ChIP etc. | Chalk and board and power point presentations, regular question-answer activities, consultation of relevant research articles. | Oral questions will be asked, students will be given to solve analytical problems relating to class teachings. Students will be asked to read research papers and discuss the experimental approach and findings. |

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| III. | Various cell biology techniques like cell culture, overexpression and silencing, cell cycle analysis, turnover studies, localization, cellular movements etc. will be learnt and students will be able to apply this knowledge to carry out research. | Chalk and board and Power point presentations, regular question-answer activities, consultation of relevant research articles and reviews. | Students will solve research problem based assignments, Students should be able to suggest appropriate techniques to be used to address research problems. Students will also be asked to present results of relevant research papers. |
| IV | Students will learn about in silico databases; Genome mining; Virtual cloning; Sequence analysis – alignment, phylogeny, protein primary structure analysis; Structure Prediction, Docking studies, Drug design techniques. | Chalk and board and Power point presentations, consultation of relevant research articles and reviews. | Oral questions, quiz and puzzles will be used for day to day evaluation during class. Students will be assigned sequences to identify genes in genome databases; Students will be assigned genes to design cloning strategy. Unknown sequences will be assigned as tasks and students will identify proteins and predict characteristics and structures. |
| V | Students will learn biophysical techniques including centrifugation, absorbance, fluorescence, chemiluminescence, CD, IR, ESR, FRET, FRAP, Differential Scanning ITC; NMR; X-ray crystallography; Fluorography, PET, MRI; Microscopic techniques | Chalk and board and Power point presentations, student interaction and discussion of case studies. | Students will be evaluated through class discussion, assignments and tests.<br><br>Students will be given a research problem and asked to address the question using combination of techniques; Experimental designs. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester I

### BCCC102: Seminar on Current Topics

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The course intends to inculcate self-learning by allowing students the opportunity to explore an important and current scientific topic on their own and present collated information that reflects their understanding of the topic.

**Course Learning Outcomes:**

- Upon successful completion of the course, students will learn how to survey scientific literature, screen relevant information, apply their knowledge of biochemistry to understanding of research findings and analyse the results reported in literature.
- Students will learn how to prepare power point presentations, how to deliver seminars, how to present and discuss scientific findings and how to compile information to prepare a write-up as a scientific document.
- Students will learn how to compile and cite bibliography in scientific text.
- Students will learn aspects of plagiarism and be aware of softwares to avoid plagiarism.

**Contents:**

**Unit I:** Students, in this paper, would present open seminars on important and current scientific topics assigned to them by faculties, which would be collectively evaluated by the departmental faculty. The students would survey the available literature on the topics assigned to them, shortlist the relevant material, understand the concepts, techniques and methodologies employed in the research articles, analyze the results obtained and collate the information into a comprehensive presentation.

**Unit II**: The students would compile a detailed write-up on the topic assigned and submit as a term paper. As part of the term paper, they would be compiling the relevant bibliography and cite them in the term paper.

**Unit III:** Students would be educated on the aspects of plagiarism and use of the appropriate softwares to avoid the same.

**Suggested Readings:**

1. Research papers on the topic suggested by faculties to students.
2. The standard textbooks of Biochemistry

**Teaching Plan*:**

**Week 1-2:** Students will be assigned topics by faculties of the department. A presentation on the "Art of Presentation" (created by department faculties) will be utilized to train students in the various norms of scientific oration, literature search, bibliography collation, the style of referencing, etc.
**Week 3-8:** Students will search databases to retrieve literature related to the topic.
**Week 9:** Students will discuss with faculties about their preliminary understanding of the topics and any other difficulties faced in their literature screening.
**Week 10-14:** Further search of literature by students and collation of information into a power point presentation.
**Week 15:** Discussion with faculties on the power point presentations prepared. Preparation of the write-up on the collated information by students.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness of students)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will know how to search for research papers using combination of key words; They will learn how to download references and save them in appropriate softwares like EndNote; Students will learn to differentiate review articles from research articles; Students will learn how to make power point files and how to make presentations in public | A power point presentation on the art of presentation will be utilized initially to train students; Interactions with students will be conducted to answer their queries. Previous presentations by students will be shown. | Topic on current and important research area will be assigned individually to students and they will be asked to retrieve literature and show them to teachers for verification. They will be shown review and research articles and asked to identify them. They will be motivated to make short presentations as journal club seminars for practice of oration. |
| II | Students will learn how to prepare a write-up to summarize their understanding of a research topic; They will have advanced learning or MS Word, MS Excel and other softwares. They will learn how to cite references in text and how to organize them in a bibliographic section either manually or | Teachers will describe how to prepare write-up and what are the points to keep in mind while doing so. Student queries will be entertained by teachers. They will be shown previous term papers for better | Students will need to write term paper on the topic assigned. If needed, they will be asked to write short essays on simpler topics for practice of writing. Department also often organizes essay writing competition to allow students the opportunity to improve writing. |

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| | using softwares like EndNote | understanding | |
| III | Students will learn about the softwares of plagiarism and how to use them. | Students will be informed about the issues related to plagiarism. They will be asked to visit Library where commercial plagiarism softwares are available. | They will be asked to run their write-up through plagiarism softwares and show the outcome to teachers. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester I

### BCCC103: Practicals

**Marks: 200 (8 Credits)** **Duration: 240 Hrs (15 weeks)**

**Course Objectives:**

The objective of this practical course is to provide hands-on-experience in preparing basic reagents for biochemistry experiments, protein quantitation and characterization, electrophoresis, bacterial cell culture and immunotechniques.

**Course Learning Outcomes:**

- Students will learn about various good lab practices, working in labs and use of instruments.
- Students will get hands on training for bacterial cell culture, transfection with bacteriophage and its analysis
- Students will learn various immunotechniques and protein characterization tools, both *in silico* and *in vitro*, which can be applied for research purposes.
- The course will provide better understanding of controls in experiments and the art of design, execution and analysis of experiments. Students will learn the art of record keeping and presentation of data.

**Contents:**

**Unit I:** Buffers: theory and practice. Preparation and storage of buffers and protein stock solutions: Concept of pH, buffers and pKa; Preparation of buffers in the laboratory over a pH range (2 to 11); Use of pH meters. Handling of buffers and storage concerns.

**Unit II**: Protein quantitation and characterization: Protein handling, storage and concentration; Protein estimation by reagent, dye and non-invasive methods; Concept of extinction coefficient. Spectroscopic characterization of proteins and measurements of their stabilities.

**Unit III:** *In silico* protein sequence and structure analysis**.** Mining and retrieval of sequences and structures from PDB; Prediction of physical and intrinsic parameters; Sequence alignment; Structure prediction and Homology modeling.

**Unit IV:** Electrophoresis and Immunoblotting. Analysis of proteins. Native PAGE and SDS-PAGE for multimeric and disulfide bonded proteins, Visualization of protein bands by Coomassie staining and Silver staining, concept of sensitivity of detection. Determination of molecular weight of a protein using standards, semi-log graph interpretation, Western blot analysis of the proteins using antibodies.

**Unit V:** ELISA- a qualitative and quantitative method for estimation of analytes, Indirect ELISA and estimation of antibody titres, sandwich ELISA for quantitation of antigen levels in samples. Applications of ELISA.

**Unit VI**: Agglutination- Heamagglutination assay and determination of ABO blood group, Latex bead agglutination, applications of agglutination

**Unit VII:** Bacteria and Bacteriophages (Lambda and Filamentous): Growing bacterial culture, preparation and sterilization of growth medium, Streaking, inoculation, growth curve, Growing small-scale Lambda phage and filamentous phage culture, isolating single plaque of filamentous phage by titration of serial dilutions, isolating single plaque of Lambda phage by titration of serial dilutions

**Suggested Readings:**

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. (2012) Biochemistry (7th Edition), WH Freeman and Company, USA.
3. M.R. Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press

**Teaching Plan*:**

**Week 1:** Buffers: theory and practice. Preparation and storage of buffers and protein stock solutions: Concept of pH, buffers and pKa; Preparation of buffers in the laboratory over a pH range (2 to 11); Use of pH meters. Handling of buffers and storage concerns.
**Week 2:** Protein quantitation and characterization: Protein handling, storage and concentration; Protein estimation by reagent, dye and non-invasive methods;
**Week 3:** Concept of extinction coefficient. Spectroscopic characterization of proteins and measurements of their stabilities.
**Week 4:** *In silico* protein sequence and structure analysis. Mining and retrieval of sequences and structures from PDB; Prediction of physical and intrinsic parameters;
**Week 5:** Sequence alignment; Structure prediction and Homology modeling,
**Week 6:** Analysis of proteins. Preparation of buffers and reagents, SDS-PAGE for multimeric and disulfide bonded proteins, Visualization of protein bands by Coomassie staining
**Week 7 :** Preparation of buffers and reagents, SDS-PAGE and Visualization of protein bands by Silver staining, concept of sensitivity of detection, Determination of molecular weight of a protein using standards, semi-log graph interpretation.
**Week 8:** Preparation of buffers and reagents, Native PAGE.
**Week 9:** Western blot analysis of the proteins using antibodies, staining/ visualization using DAB and ECL.
**Week 10:** Indirect ELISA and estimation of antibody titres, sandwich ELISA for quantitation

of antigen levels in samples. Applications of ELISA.

**Week 11:** Heamagglutination assay and determination of ABO blood group, Latex bead agglutination, applications of agglutination.

**Week 12:** Growing bacterial culture, preparation and sterilization of growth medium, Streaking, inoculation, growth curve.

**Week 13:** Growing small-scale Lambda phage and filamentous phage culture, calculating phage titre.

**Week 14:** Isolating single plaque of filamentous phage by titration of serial dilutions.

**Week 15:** Isolating single plaque of Lambda phage by titration of serial dilutions. Compilation of data, writing and submission of practical notebooks.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will learn about the good practices that are to be followed in lab; the safety concerns; arrangement of reagents and lab materials; how to keep records; how to prepare buffers and measure pH; how to store reagents and buffers; Concept of pKa and stock solution. | Teaching and learning activity will mainly include extensive discussions; chalk and board teaching; Discussion about principle and logic behind each methods and experiment. | Students will be asked to organize the laboratory as per good practice; They will be asked to identify the best salts and their conjugate acids and bases to be used to make buffers in the pH range 2-11; They will be asked to use Henderson-Hasselbach equation to calculate amounts of reagents needed to make buffers. They will make buffers and measure pH. |
| II | Students will learn how to estimate protein using both invasive and non-invasive techniques; handling of proteins and their storage to keep them in soluble and functional state; how to concentrate dilute proteins; how to determine extinction coefficient of proteins and their applications; how to use spectroscopy to characterize proteins and measure their stabilities and in solution structural content and folding state. | Extensive discussions; chalk and board teaching; Discussion about principle and logic behind each methods and experiment. Protocols and hand outs. | Unknown protein solutions will be assigned for estimation of protein concentration; Students will be asked to make stock solution of proteins and verify their concentration; They will be asked to find out extinction coefficient of given proteins; They will be assigned proteins to measure their spectroscopic properties and calculate transition mid-points, folding curves and thermodynamic parameters. |

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| III | Students will learn how to use computer based programmes to analyze amino acid sequences of proteins; how to mine and retrieve sequences from databases and structures from PDB; how to predict of physical and intrinsic parameters of proteins; how to align sequences; how to predict structures. | Students will be trained on computers; they will be informed about the various online tools available; Tutorials will be provided along with case studies. | Students will be assigned a protein each and they will have to retrieve amino acid sequence and undertake assignment in project mode. They will predict the properties of the protein, its secondary structure and tertiary structure based on homology modeling. They will visualize the protein structure, active site, etc. |
| IV | Students will learn polyacrylamide gel electrophoresis for detection of proteins, their visualization by different staining methods, the difference between denaturing and native gel electrophoresis. | Discussion about principle and logic behind each methods and experiment. Protocols and handouts. | Students will be given known/ unknown protein samples to determine their molecular weight using gel electrophoresis. |
| V | Students will learn the techniques of western blot and different formats of ELISA. They will be made aware of the use of these techniques in research and diagnostics. | Discussion about principle and logic behind each methods and experiment. Protocols and handouts. | Students will be given unknown samples for estimation. They will be given case studies on diagnostics. |
| VI | Students will learn about method for blood group testing and applications of the method in diagnostics. | Discussion about principle of methods and experiment. Protocols and handouts. | Students will perform blood group testing. |
| VII | Students will learn bacterial handling and culture, sterilization and decontamination methods, handling of bacteriophages. | Discussion about principle of methods and experiment. Protocols and handouts. Applications of the methods | Students will be given unknown samples for estimation of phage titre. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester II

### BCOE201: Basics of Biochemistry

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

### Course Objectives:

The objective is to offer basic concepts of biochemistry to students with diverse background in life sciences including but not limited to the structure and function of various biomolecules and their metabolism.

### Course Learning Outcomes:

- Students will learn about various kinds of biomolecules and their physiological role.
- Students will gain insight into the synthesis and breakdown of the various biomolecules
- Students will gain knowledge about various metabolic disorders and will help them to know the importance of various biomolecules in terms of disease correlation.

### Content

**Unit I:** Carbohydrates and Lipids: Monosaccharides, disaccharides, Polysaccharides, storage polysaccharides, Building blocks of lipids - fatty acids, glycerol, triacyl glycerol (TAG), Digestion, mobilization and transport of cholesterol and triacylglycerols.

**Unit II:** Carbohydrate metabolism: Glycolysis, pentose phosphate pathway, citric acid cycle, Synthesis of glucose from non-carbohydrate sources, glycogen metabolism, glycogen storage diseases.

**Unit III :** Fatty acid metabolism**:** β oxidation of fatty acids, regulation of fatty acid oxidation, Fatty acid synthesis and regulation.

**Unit IV:** Amino acid metabolism**:** Role of essential and non-essential amino acids in growth and development, Catabolism of amino acids, Overview of amino acid synthesis, Protein calorie malnutrition - Kwashiorkar and Marasmus, Disorders of amino acids metabolism.

**Unit V:** Nucleotide metabolism**:** *De novo* synthesis and breakdown of purine and pyrimidine nucleotides, regulation and salvage pathways. Disorders of nucleotide metabolism.

**Unit VI:** Proteins and Enzymes: Concepts of acids, bases, pH, pKa and buffers, Water & its role in life; Introduction to Protein structures and Protein folding; Structure-function relationship in proteins with Hemoglobin as an example; Enzyme as bio-catalysts: general introduction; Enzyme Kinetics, Inhibition and Regulation; Applications of Proteins and Enzymes.

**Unit VII:** Vitamins and Hormones**:** Different types of vitamins, their diverse biochemical functions and deficiency related diseases. Overview of hormones. Hormone mediated signaling. Mechanism of action of steroid hormones, epinephrine, glucagons and insulin. Role of vitamins and hormones in metabolism; Hormonal disorders; Therapeutic uses of vitamins and hormones.

**Suggested readings**

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
2. Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
3. Harper's Biochemistry (2012) 29th ed., Murray, R.K., Granner, D.K., Mayes and P.A., Rodwell, V.W., Lange Medical Books/McGraw Hill. ISBN:978-0-07-176-576-3.

**Teaching Plan*:**

**Week 1:** Introductory classes: General introduction to the course; Carbohydrate and lipids; Monosaccharides, disaccharides, Polysaccharides, storage polysaccharides
**Week 2:** Building blocks of lipids - fatty acids, glycerol,triacyl glycerol (TAG), Digestion, mobilization and transport of cholesterol and triacylglycerols.
**Week 3:** Carbohydrate metabolism: Glycolysis, pentose phosphate pathway, citric acid cycle,
**Week 4:** Synthesis of glucose from non-carbohydrate sources, glycogen metabolism, glycogen storage diseases.
**Week 5:** Fattyacidmetabolism: β oxidation of fatty acids, regulation of fatty acid oxidation
**Week 6:** Fatty acid synthesisand regulation
**Week 7:** Amino acid Metabolism: Role of essential and non-essential amino acids in growth and development, Catabolism of amino acids
**Week 8:** Overview of amino acid synthesis, Protein calorie malnutrition - Kwashiorkar and Marasmus, Disorders of amino acids metabolism.
**Week 9:** Mid-term Internal Assessment test.
**Week 10:** Nucleotide Metabolism: *De novo* synthesis and breakdown of purine and pyrimidine nucleotides
**Week 11:** Regulation and salvage pathways. Disorders of nucleotide metabolism.
**Week 12:** Proteins and Enzymes: Concepts of acids, bases, pH, pKa and buffers, Water & its role in life; Introduction to Protein structures and Protein folding.
**Week 13:** Structure-function relationship in proteins with Hemoglobin as an example; Enzyme as bio-catalysts: general introduction; Enzyme Kinetics, Inhibition and Regulation; Applications of Proteins and Enzymes.
**Week 14:** Vitamins and Hormones: Different types of vitamins, their diverse biochemical functions and deficiency related diseases. Overview of hormones. Hormone mediated signaling.
**Week 15:** Mechanism of action of steroid hormones, epinephrine, glucagons and insulin. Role of vitamins and hormones in metabolism; Hormonal disorders; Therapeutic uses of vitamins and hormones. Course revision, End-term internal assessment test, solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

## Facilitating the achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will learn about dietary and storage form of carbohydrates. They will gain insight into the synthesis and breakdown of carbohydrates and about various metabolic disorders. | Power point presentations, discussions. | Quiz, internal assessment tests will be conducted. |
| II. | Students will learn about dietary and storage form of lipds. They will gain insight into the synthesis and breakdown of fatty acids and about various metabolic disorders. | Power point presentations, discussions. | Quiz, internal assessment tests will be conducted. |
| III. | Students will learn about the essential and non-essential amino acids. They will gain insight into the synthesis and breakdown of the amino acids and about various metabolic disorders. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Mid-term internal assessment tests will be conducted. |
| IV | Students will learn about the essential and non-essential amino acids. They will gain insight into the synthesis and breakdown of the amino acids and about various metabolic disorders. | Teaching will be conducted both through black board mode and power point presentation mode. Previous day's class revised before start of teaching. | Mid-term internal assessment tests will be conducted. |

| | | | |
|---|---|---|---|
| V | Students will gain knowledge about the synthesis and breakdown of purines and pyrimidines and their associated metabolic disorders. | Previous day's class revised before start of teaching. Teaching will be conducted both through black board mode and power point presentation mode. | Internal assessment tests (mid-term and end-term) will be conducted. |
| VI | Students will develop basic concepts related to buffers and pKa; Significance of water in biochemistry of life ; Students will learn about protein structures and folding, about structure-function relationship in proteins; Students will learn about enzyme function, enzyme kinetics, inhibition and regulation; Students will learn about the applications of proteins and enzymes in biotechnology. | Basic models will be used to explain stereochemistry and protein structures; Chalk and board teaching; Power point presentations and videos for augmenting basic concepts; Interactive discussion and problem soloving | Analytical problems related to pH, pKa, buffers; Identification of amino acids from ball and stick, space-filling models; Protein structure visualization; Analytical problems related to enzyme kinetics; assignments; internal assessment. |
| VII | Students will learn about the biochemical functions of various vitamins and hormones and their deficiency related diseases. Knowledge will be imparted about the therapeutic uses of vitamins and hormones as well. | Both chalk and board and powerpoint presentations will be used for teaching. There will be interactive learning through class discussions. | Assignments will be given related to class teaching, oral question answer sessions will help in evaluation of student's understanding. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester II

### BCCC202: Immunology and Immunotechniques

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective of the course is to provide an insight into the components of the immune system, their development, their functions and their mechanisms of action as well as the diseases associated with defects or malfunctioning of the immune system.

**Course Learning Outcomes:**

- Students will be able to understand the mechanisms used by the human body to fight foreign agents and disease-causing pathogens.
- Students will be able to devise strategies to combat infection or diseases produced by altered self.
- Students will develop ability to use this knowledge in the processes of immunization, antibody engineering, vaccine development, transplantation and cancer therapy.
- Students will develop ability to use various techniques of immunology in research work.

**Contents:**

**Unit I:** Introduction: Historical development of the branch "Immunology", Overview of the immune system, Molecules, cells and organs involved in immunity. Hematopoiesis, Innate immunity, adaptive immunity, Antigens, Immunogens, Haptens, Epitopes. Antigen-Antibody interactions, Discovery of immunoglobulins.

**Unit II**: Adaptive Immune response: Humoral Immunity, Structure and function of various classes of immunoglobulins, Immunogenetics, Generation of antibody diversity, class switching among constant-region genes, B-cell activation and differentiation, B-cell receptor and the immunoglobulin superfamily, Generation of B cells, Responses, Immunological memory, Cell mediated immunity, MHC restriction and mechanism of antigen presentation, T-cell receptors, maturation, activation and differentiation, Generation of different types of T cells, Responses, Immunological memory.

**Unit III:** Immune effector mechanisms: Properties of cytokines, receptors, The complement systems, mechanism of complement activation, pathology related to complement proteins Allergy, Cell biology of hypersensitivity reactions, Tolerance, Mechanisms of induction of autoimmunity, treatment of autoimmune diseases.

**Unit IV:** Immune system in health and disease: Immunodeficiencies, AIDS, Transplantation immunology, Tumor antigens and cancer immunotherapy, Infections, Concepts of vaccines, whole-organism vaccines, recombinant vaccines, DNA vaccine, synthetic peptide and multivalent sub unit vaccines.

**Unit V:** Immunotechniques: Applications of antibodies in diagnostics and routine laboratory assay systems. Agglutination reaction, principles of western blots, radioimmunoassay, ELISA, immunohistochemistry, Development of monoclonal antibodies, Flow cytometry, immunocytes identification and purification.

**Suggested Readings:**

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. (2012) Biochemistry (7th Edition), WH Freeman and Company, USA.
3. D. Male, J. Brostoff, D. Roth, I. Roitt, (2012) Immunology (8th Edition), Saunders, Elsevier, USA.
4. K. Murphy (2011) Janeway's Immunobiology (8th Edition), Garland Science, USA.
5. A. Abbas, A. Lichtman, S. Pillai, (2014) Cellular and Molecular Immunology (8th Edition), Saunders, Elsevier, USA.

**Teaching Plan*:**

**Week 1:** Historical development of the branch "Immunology". Overview of the immune system. Cells and organs involved in immunity. Hematopoiesis.
**Week 2:** Antigens, Immunogens, Haptens, Epitopes. Antigen-Antibody interactions. Discovery of immunoglobulins.
**Week 3:** Structure and function of various classes of immunoglobulins, Generation of antibody diversity, class switching among constant-region genes.
**Week 4:** B-cell activation and differentiation, B-cell receptor and the immunoglobulin superfamily, Generation of B cells, Responses, Immunological memory
**Week 5:** MHC restriction and mechanism of antigen presentation,
**Week 6:** T-cell receptors, maturation, activation and differentiation, Generation of different types of T cells, Responses, Immunological memory
**Week7 :** Revision of concepts, Mid-term assessment, quiz on topics covered
**Week 8:** Properties of cytokines, receptors
**Week 9:** The complement systems
**Week 10:** Cell biology of hypersensitivity reactions, Allergy
**Week 11:** Tolerance and autoimmunity, treatment of autoimmune diseases.
**Week 12:** Immunodeficiencies, AIDS, Transplantation immunology.
**Week 13:** Tumor antigens and cancer immunotherapy.
**Week 14:** Concepts of vaccines and different types of vaccines.
**Week 15:** Agglutination reaction, principles of western blots, radioimmunoassay, ELISA, immunohistochemistry. Development of monoclonal antibodies, Flow cytometry, Various immunocytes, their identification/purification.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

## Facilitating the achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will be able to understand the mechanisms used by the human body to fight foreign agents and disease-causing pathogens. | Through power point presentations, reading and discussion of landmark publications and group activities | Oral and written Review, quiz |
| II. | Students will be able to devise strategies to combat infection or diseases produced by altered self | Through mock case studies and activities | written Review, online quiz |
| III. | Students will develop ability to use this knowledge in the processes of immunization, antibody engineering, vaccine development, transplantation and cancer therapy | Through mock case studies and activities | Online quiz |
| IV. | Students will develop ability to use various techniques of immunology in research work | Through power point presentations, reading and discussion of applications of techniques | Oral presentations, online quiz |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester II

### BCCC203: Enzymes and their Biotechnological Applications

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to offer detailed knowledge about enzymes, which catalyze the entire repertoire of biochemical reactions in life processes, providing basic concepts of their mechanism of action, kinetics, regulation, inhibition, purification and diverse applications.

**Course Learning Outcomes:**

- Students will acquire insight into enzyme assays, kinetics, structure, regulation, mechanism of action and reaction intermediates and inhibition.
- Students will learn the various theories for enzyme action and regulation and experimental evidences thereof.
- Students will learn about the various applications of enzymology in research, medicine, biotechnology, agriculture.

**Contents:**

**Unit I:** Enzymology: Introduction, General characteristics of enzymes, Activation energy, Coupled reactions, Active site and its importance, Thermodynamics and Equilibrium; Enzyme activity; Specific activity and Units; Ribozymes; Abzymes; Classification and nomenclature of enzymes. Enzyme assays: Types, Continuous and discontinuous assays; Optimization of enzyme assays. Factors influencing catalytic efficiency and the mechanisms employed. Zymography. Mechanism of catalysis of various key enzymes at the molecular level.

**Unit II:** Enzyme kinetics: Significance; Rapid Equilibrium and Steady State approach, Henry-Michaelis-Menten's and Haldane equations, Significance of $K_m$, Catalytic efficiency and turnover number; Kinetic perfection. Order of kinetics. Methods of plotting enzyme kinetics data: Lineweaver-Burk, Hanes-Woolf, Woolf-Augustinsson-Hofstee, Eadie-Scatchard; Direct linear plot; Advantages and disadvantages; Integrated form of the Henry-Michaelis-Menten equation; Effect of pH and temperature. Formation of E. S covalent intermediates, transient kinetics, flow techniques (continuous, stopped, quenched), Temp-Jump relaxation experiments.

**Unit III:** Enzyme Inhibition, Models and types of inhibition; Kinetics and diagnostic plots

**Unit IV:** Multisubstrate enzymes; Multisite and Allosteric enzymes; Models and examples.

**Unit V:** Regulation and control of enzyme activity: Isozymes, Zymogens, reversible covalent modification, irreversible covalent modification, Half-site reactivity; Bifunctional enzymes.

**Unit VI**: Enzyme purification & Chromatography: Gel filtration, ion-exchange, hydrophobic interaction chromatography, affinity chromatography, reversed-phase chromatography; FPLC, HPLC and their applications.

**Unit VII:** Applied Enzymology: Application of enzymes in industry, diagnostics and medicine, agriculture, research; Immobilized enzymes. Case studies. Synthetic or artificial enzymes and Enzyme engineering; Case studies.

**Suggested Readings:**

1. I.H. Segel. 2010. Biochemical Calculations (2nd Ed), John Wiley and Sons, California, USA. ISBN: 978-0-471-77421-1.
2. P. F. Cook, W.W. Cleland. 2007. Enzyme Kinetics and Mechanism, Garland Science Publishing, London, England and New York, USA. ISBN: 978-0815341406.
3. T. Palmer, P. Bonner. 2007. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry (2nd Ed.), Woodhead Publishing House, Chichester, England. ISBN: 978-0-857099921.
4. R. Burgess, M. P. Deutcher. 2009. Guide to Protein Purification, Academic Press, San Diego, USA. ISBN: 978-0-12-374978-9.
5. D. Purich. 2010. Enzyme Kinetics: Catalysis and Control (1st Ed.), Academic Press, San Diego, USA. ISBN: 978-0-123809247.
6. N.C. Price, L. Stevens. 2000. Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins, Oxford University Press, USA. ISBN: 978-0-198-502296.

**Teaching Plan*:**

**Week 1:** Introductory classes: General introduction to the course; General characteristics of enzymes; Enzyme activity and units of measurements.

**Week 2:** Classification and nomenclature of enzymes

**Week 3:** Enzyme assays; Factors influencing catalytic efficiency and theories of enzyme action

**Week 4:** Enzyme kinetics – the basic concepts; Kinetic parameters; Order of kinetics

**Week 5:** Methods of plotting enzyme kinetics data; practical considerations; Effect of pH and temperature.

**Week 6:** Transient kinetics and methods to investigate transient kinetics

**Week 7:** Revision of the above units; mid-term test

**Week 8:** Enzyme inhibition, Models and types of inhibition;

**Week 9:** Enzyme inhibition, Kinetics and diagnostic plots

**Week 10:** Multisubstrate enzymes; Multisite and Allosteric enzymes; Models and examples

**Week 11:** Mechanism of catalysis of various key enzymes at the molecular level.

**Week 12:** Regulation and control of enzyme activity.

**Week 13:** Enzyme purification and chromatography

**Week 14:** Synthetic or artificial enzymes and Enzyme engineering; Case studies

**Week 15:** Applied Enzymology: Application of enzymes in industry, diagnostics and medicine, agriculture, research; Immobilized enzymes. Case studies. Course revision, tests, solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness of students)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will learn about general properties of enzymes like activation energy, active site, etc.; definition of enzyme activity and its various units; classes of enzymes and international nomenclature; they will learn how to perform and optimize enzyme assays; the types of enzyme assays; General mechanisms that enzymes employ to attain kinetic perfection and mechanism of catalysis at molecular level. | Outlining history of development of knowledge about enzymes through power point presentations and reading of landmark publications; Question and answer sessions in the class | Assignments to calculate units of enzyme activity; Classification of assigned enzymes and their nomenclature. A specific enzyme will be assigned to each student and they will need to develop protocol for enzyme assay. Case studies for model enzymes. |
| II | Importance of investigating enzyme kinetics; the important kinetic parameters like $K_m$, $V_{max}$, $K_{cat}$, etc.; derivation of Michaelis-Menten equation; Order of kinetics; Students will learn how to plot experimental data into various forms to calculate the various kinetic parameters and advantages and disadvantages of each such method. Students will learn how to measure fast kinetics | The basic concepts will be explained using chalk and board; Original paper by Michaelis-Menten will be discussed. Power point presentations for better representations. Student interaction in class | Students will be asked to derive MM equation without help. Numerical problems to estimate kinetic parameters. Students will be asked to rearrange MM equation to derive the various equations which underlie each linear plot. Experimental data will be provided to plot data and derive parameters using graph papers. Students will read papers on fast kinetics and discuss about the principles in class in groups of 3. |
| III | Students will learn about the various types of enzyme inhibitors; their mode of action and influence on enzyme kinetic parameters. They will learn to plot experimental data. | Concepts will be taught using chalk and board and notes; Power point presentations for images for clarity of concepts; Research papers will be provided for applications; | Numerical problems on various types of inhibitors. Identification of types of inhibition from kinetic schemes and diagnostics plots |

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| | | Numerical problems will be solved. | |
| IV | Students will learn how enzymes behave in presence of multiple substrates and how the kinetics is influence; Students will be introduced to multisite and allosteric enzymes and their mechanism of action | Chalk and Board for teaching the basic concepts; Power point presentations for better representations. | Students will be asked to compare the MM kinetics and kinetics of allosteric enzymes and write down the differences and advantages of each. They will be asked to write kinetic schemes on board. |
| V | Students will learn about the various ways that cells regulate enzyme activity *in vivo* | Chalk and Board for teaching including power point. Case studies will be discussed. | Students will be asked to find examples of each kind of regulation from literature and discuss in class in groups. |
| VI | Students will learn how to purify enzymes and the various kinds of chromatography employed for purification | Power points and videos to show purification steps. Hand outs. Class discussion. | Various problems will be assigned to determine strategies of protein purification, both analytical and numerical. |
| VII | Students will learn about the diverse applications of enzymes in research, medicine, industry and agriculture | Power point presentations, Hand outs, Research papers. | Students will find an application in each category from the literature and discuss the same in class. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester II

### BCCC204: Molecular Biology

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to offer detailed knowledge about the concept of genome, mechanisms of DNA replication, gene expression and translation in prokaryotes and eukaryotes so that students can apply this knowledge in enhancing their analytical and research problem solving skills.

**Course Learning Outcomes:**

- Students will acquire basic concepts of genome, its organization and maintenance in various life forms.
- Students will learn how DNA is replicated and repaired and hence the consequences of improper processes.
- Students will gain knowledge about the mechanisms of transcription, post-transcriptional processes and regulatory mechanisms governing overexpression and underexpression of genes. The knowledge gained will be utilized to design experiments.
- Students will understand the concept of Open Reading Frame and will be able to apply it in design of primers for gene amplification and cloning for heterologous expression.

**Contents:**

**Unit I:** The structure of DNA and RNA; Organization of Microbial Genomes, Organization of Eukaryotic Genomes.

**Unit II:** DNA Replication and Repair: Semiconservative nature of replication, origin of replication, isolation and mapping of replication origins. Regulation of replication initiation, modes of replication, action of reverse transcriptase, telomerase and their significance. Discovery and properties of DNA polymerases. Mode of action of inhibitors and their therapeutic applications. Different types of DNA damages, recognition of DNA damage, types of DNA repair systems including photoreactivation, excision repair, base flipping, mismatch repair, recombination repair, transcription coupled repair and SOS repair. Diseases associated with DNA repair problems.

**Unit III:** Biosynthesis of RNA (Transcription) in prokaryotes: General features of transcription, Discovery and assay of RNA polymerase, Bacterial RNA polymerase, Isolation and characterization of promoters, consensus sequences, up and down mutations. Conserved regions of sigma factors and their role in DNA binding. Elongation, Termination, intrinsic and rho dependent termination, mechanism of action of rho. Anti-termination and gene regulation, Inhibitors of transcription and applications as anti-microbial drugs.

**Unit IV:** Eukaryotic Transcription: Characteristics of promoters and enhancer elements. Activators and repressors of transcription, different DNA binding domains. Discovery and properties of eukaryotic RNA polymerases and their mode of action, inhibitors, basal transcription apparatus, initiation, elongation and termination of transcription. Post-transcriptional processing: Concept of introns and exons, spliceosome machinery, alternative splicing, polyadenylation and capping, processing of rRNA and tRNA. Catalytic roles of RNA; RNA editing.

**Unit V:** Protein synthesis in prokaryotes and eukaryotes: Concept of Genetic code Relationship between genes and proteins, concept of tRNA, triplet nature of genetic code, concept of mRNA, elucidation of genetic code, universality of genetic code, Wobble hypothesis and exceptions, degeneracy of genetic code, general features translation, activation of amino acids. Initiation: initiator tRNAs, RBS, initiation complex, initiation factors. Elongation: Elongation factors, peptide bond formation, translocation. Termination: release factors, ribosome release factors, polycistronic/ monocistronic synthesis, differences between prokaryotes and eukaryotes, coupling of transcription and translation. Role of antibiotics in understanding protein synthesis, Mode of action of various antibiotics in the inhibition of protein synthesis.

**Unit VI:** Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, induction of SOS response. Regulation of gene expression: Role of chromatin remodeling and gene silencing.

**Suggested readings**

1. D.L. Nelson, M.M. Cox. (2013). Lehninger Principles of Biochemistry (6th Edition),W.H. Freeman and Company, New York, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. (2012) Biochemistry (7th Edition), W.H. Freeman and Company; New York, USA.
3. B. Lewin, J. Krebs, S.T. Kilpatrick, E.S. Goldstein (2011). Genes X, (10th Volume) Jones and Bartlett Publishers, Sudbury, Massachusetts, USA.
4. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7th edition). Benjamin Cummings, San Francisco, USA.
7. R.F. Weaver (2007). Molecular Biology. (4th edition). McGraw Hill. New York. USA.
8. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter (2015). Molecular Biology of the Cell (6th Edition), Garland Science, New York, USA.
9. H. Lodish, B. Harvey, Arnold, S. Zipursky, S. Lawrence, P. Matsudaira, D. Baltimore, J. Darnell, E. James. (2008). Molecular Cell Biology. (6th Edition) W.H. Freeman and Company, New York, USA.
10. G. M. Cooper and R.E. Hausman. (2013). The Cell: A Molecular Approach (6th Edition), Sinauer Associates, Inc. Massachusetts, USA.
11. R.H. Garrett**, C.M.** Grisham**.** 2010**.** Biochemistry, Saunders College Publishers, Texas, USA.

**Teaching Plan*:**

**Week 1:** Introductory classes: General introduction to the course; Providing an understanding of course objectives and outcome: General introduction to the structure of DNA and RNA; Organization of Microbial Genomes, Organization of Eukaryotic Genomes.

**Week 2:** Basic concepts of DNA replication: Semiconservative nature of replication, origin of replication, isolation and mapping of replication origins.
**Week 3:** Discovery and properties of DNA polymerases. Mode of action of inhibitors and their therapeutic applications.
**Week 4:** Regulation of replication initiation, modes of replication, action of reverse transcriptase, telomerase and their significance.
**Week 5:** Different types of DNA damages and various repair mechanisms. Diseases associated with DNA repair problems.
**Week 6:** Introduction to eukaryotic transcription: promoters, enhancer, activators and repressors of transcription, transcription factors and their DNA binding domains.
**Week 7:** Discovery and properties of eukaryotic RNA polymerases and their mode of action, inhibitors. Basal transcription apparatus.
**Week 8:** Eukaryotic transcription initiation, elongation and termination processes. Post-transcriptional processing.
**Week 9:** Catalytic roles of RNA; RNA editing. Role of chromatin remodeling and gene silencing. Course revision, tests, solving problems, mid-term test.
**Week 10:** Biosynthesis of RNA (Transcription) in prokaryotes: General features of transcription, Discovery and assay of RNA polymerase, Bacterial RNA polymerase,
**Week 11:** Isolation and characterization of promoters, consensus sequences, up and down mutations
**Week 12:** Conserved regions of sigma factors and their role in DNA binding. Elongation, Termination, intrinsic and rho dependent termination, mechanism of action of rho. Anti-termination and gene regulation, Inhibitors of transcription and applications as anti-microbial drugs.
**Week 13:** Concept of Genetic code Relationship between genes and proteins, concept of tRNA, triplet nature of genetic code, concept of mRNA, elucidation of genetic code, universality of genetic code, Wobble hypothesis and exceptions, degeneracy of genetic code.
**Week 14:** General features translation, activation of amino acids. Initiation: initiator tRNAs, RBS, initiation complex, initiation factors.
**Week 15:** Elongation: Elongation factors, peptide bond formation, translocation. Termination: release factors, ribosome release factors, polycistronic/ monocistronic synthesis, differences between prokaryotes and eukaryotes, coupling of transcription and translation. Role of antibiotics in understanding protein synthesis, Mode of action of various antibiotics in the inhibition of protein synthesis. Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, induction of SOS response.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

## Facilitating the achievement of Course Learning Outcomes

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will understand how a long DNA molecule gets packaged in a small cell yet is available for its | Power point presentations; Teaching using chalk and board; | Discussions on seminal research articles will be carried out. Review- oral and written |

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| | function. | Oral discussion sessions in the class | |
| II | Students will learn about importance of replication and its inhibitors, important discoveries etc. Students will also learn about various strategies of DNA repair and diseases associated with DNA repair problems. | Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class | Various analytical problems will be assigned to students related to replication and repair. Discussions on original research articles will be carried out. |
| III | Students will gain knowledge about requirements of Transcription, concept of romoters, use of inhibitors in human health. | Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class | Quiz, written review, case studies |
| IV | Students will gain knowledge about requirements of Eukaryotic Transcription, application of inhibitors. They should be able to apply this knowledge for carrying out expression studies in research labs. Students will also learn about various post-transcriptional processings, concepts of splicing, catalytic roles of RNA and its applications | Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class | Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability. Class tests will be conducted for internal assessment. |
| V | Students will learn about concept of Open Reading Frame, how translation occurs and how can proteins be cloned and expressed. Use of inhibitors to understand cellular processes will also be highlighted. | Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class | Quiz, written review, case studies |
| VI | Students will learn about regulation of gene expression and silencing strategies | Power point presentations; Teaching using chalk and board; Oral discussion sessions in the | Regular question- answer session in class, class tests, solving of research experiment based questions. |

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## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester II

### BCCC205: Practicals

**Marks: 200 (8 Credits)** **Duration: 240 Hrs (15 weeks)**

**Course Objectives:**

The objective is to impart hands-on-training in animal cell culture, cloning, gene expression in *E. coli* and mammalian cells, protein purification, enzyme kinetics and *in silico* docking and virtual screening to enhance understanding of experimental design, execution and analysis.

**Course Learning Outcomes:**

- Students will learn about various good lab practices, working in tissue culture labs and bacterial handling and usage of various bioinformatic tools.
- Students will get hands on training for animal cell culture, transfection of foreign genes and their expression analysis
- Students will learn the tricks of gene cloning and its applications
- Students will learn protein purification techniques, enzyme assays which can be applied for research purposes.

**Contents:**

**Unit I:** Animal Tissue Culture. Introduction to animal tissue culture and various requirements. Growing mammalian cells, trypsinization, plating, cryofreezing and general maintenance of cells. Cell counting using Hemocytometer. Cell viability assay with Trypan blue; Investigation of the effect of various harsh conditions on cell viability.

**Unit II:** Preparation of Transfection Quality Plasmid DNA: Isolation of plasmids (midi-prep) using commercial columns, analysis of different forms of plasmid and estimation of DNA and total yield.

**Unit III:** Transfection and in-cell Visualization of the Ectopically Expressed Protein. Preparation of DNA Transfection Reagents. Introduction of foreign DNA (plasmids expressing GFP and DSRED) into mammalian cells. Visualization of the GFP and DSRED-tagged protein expression in live cells using fluorescent microscope; Calculation of transfection efficiency. Assessment of localization (nuclear or cytoplasm) and co-localization of the proteins.

**Unit IV:** Overexpression analysis. Harvestation of the transfected cells. Preparation of cell lysate and Western Blot analysis (using ECL) of the over expressed proteins.

**Unit V:** Live demonstration of Zebrafish embryogenesis: Microscopic visualization of early cleavages, sphere stage, shield stage, gastrulation, epiboly and somite formation.

**Unit VI:** Competent cell preparation and Transformation. Laboratory preparation of Competent cells (DH 5α).Transformation of circularized plasmid and calculation of transformation efficiency.

**Unit VII:** Cloning of gene. Amplification of gene by PCR, cloning of gene into expression vector to produce recombinant protein (Isolation of Vector, Restriction digestion, extraction of DNA from gel, Ligation, Transformation). Screening of positive clones by colony PCR and restriction digestion analysis.

**Unit VIII**: Expression, localization and purification of recombinant protein. Various methods to optimize expression, techniques to improve the solubility of the recombinant protein, packing of chromatographic columns, Ion exchange chromatography, gel filtration chromatography.

**Unit IX:** Measurement of kinetic parameters and inhibition studies. Determination of $K_m$, $V_{max}$, determination of optimal pH, determination of effect of temperature on the stability and activity of the enzyme. Determination of $K_i$ and mode of inhibition.

**Unit X:** Bioinformatics tools. Pathway predictions, network clustering for protein-protein interactions, docking and virtual screening. A short background to algorithms behind the used computer programs, general concepts of basic scripting.

**Suggested Readings:**

1. D.L. Nelson, M.M. Cox. (2013). Lehninger Principles of Biochemistry ($6^{th}$ Edition),W.H. Freeman and Company, New York, USA.
2. M.R. Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press.
3. Fred M. Ausubel *et al.* editors (2017) Current Protocols in Molecular Biology. John Wiley and Sons, Inc.
4. John E. Coligan *et al.* editors (2017) Current Protocols in Protein Science. John Wiley and Sons, Inc.
5. S.B. Primrose and R.M. Twyman. (2006) Principles of Genome Analysis and Genomics. (7th edition) Blackwell Publishing.
6. T.A. Brown. (2016) Gene Cloning and DNA Analysis. ($7^{th}$ Edition). Wiley-Blackwell publishing (Oxford, UK).
7. L. Wolpert, R. Beddington, T. Jessell. 2010. Principles of Development ($4^{th}$ Edition), Oxford University Press, New York, USA.

**Teaching Plan*:**

**Week 1:** Introduction to good laboratory practices; various sterilization techniques; animal tissue culture and maintenance of cells under *in vitro* conditions; visit to research and tissue culture lab. Introduction to the theory of plasmid isolation, animal tissue culture, protein over expression and detection. Preparation of reagents for plasmid isolation.
**Week 2:** Isolation of plasmids expressing GFP-proteins using commercial columns, analysis of different forms of plasmid and estimation of DNA and total yield.
**Week 3:** Isolation of plasmids expressing DSRED-proteins. Learn about tissue culture techniques, demonstration of sterile practices, growing and observing mammalian cells.
**Week 4:** Practical learning of cell trypsinization, plating, cryofreezing and general

maintenance of cells. Cell counting using Hemocytometer. Cell viability assay with Trypan blue; Investigation of the effect of various harsh conditions on cell viability.
**Week 5:** Preparation of DNA Transfection Reagents. Introduction of foreign DNA (plasmids expressing GFP and DSRED) into mammalian cells. Visualization of the GFP and DSRED-tagged protein expression in live cells using fluorescent microscope; Calculation of transfection efficiency. Assessment of localization (nuclear or cytoplasm) and co-localization of the proteins.
**Week 6:** Harvestation of the transfected cells. Preparation of cell lysate and Western Blot analysis (using ECL) of the over expressed proteins.
**Week 7:** Microscopic visualization of early cleavages, sphere stage, shield stage, gastrulation, epiboly and somite formation. Revision and presentation of the concepts learned in the above practicals; discussion of the results; mid-term test, tests, solving problems and checking lab records.
**Week 8**: Laboratory preparation of Competent cells (DH 5α). Transformation of circularized plasmid and calculation of transformation efficiency.
**Week 9:** Amplification of gene by PCR, beginning of the cloning of gene into expression vector to produce recombinant protein (Isolation of Vector, Restriction digestion).
**Week 10:** Completion of the cloning experiment (extraction of DNA from gel, Ligation, Transformation).Screening of positive clones by colony PCR and restriction digestion analysis. Learning various bioinformatics tools : Pathway predictions, network clustering for protein-protein interactions, docking and virtual screening.
**Week 11:** Checking expression and localization of the overexpressed protein.
**Week 12:** Optimization of growth conditions and induction conditions for optimum expression of the recombinant protein
**Week 13:** Packing of columns and large-scale purification of the recombinant protein.
**Week 14:** Determination of $K_m$, $V_{max}$ and determination of optimal pH,
**Week 15:** Determination of effect of temperature on the stability and activity of the enzyme.
Bioinformatics exercise: A short background to algorithms behind the used computer programs, general concepts of basic scripting. Determination of $K_i$ and mode of inhibition.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will learn about various good lab practices, working in tissue culture labs, cell counting, trypsinization, plating, and general maintenance of cells. Acquired skills can be applied for research purposes. | Chalk and Board teaching, discussion of lab practices, basic concepts of cell culturing | Students will be asked oral questions related to cell culture techniques and general GLPs. |
| II | Students will learn to | Discussion about | Group discussion, debates, |

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| | isolate plasmid DNA from bacteria, run agarose gel, identify different DNA forms, calculate DNA yield | the basics of plasmid isolation method using chalk and board | solving analytical questions, quiz etc. |
| III | Students will get hands on training for animal cell culture, of foreign genes and their expression analysis. They will learn the tricks of foreign DNA transfection into mammalian cells, they will also learn the use of fluorescent microscope to visualise transfected cells expressing GFP and DSRED-tagged proteins. | Basics of transfection will be taught using chalk and board, live demonstration of DNA precipitate preparation will be given, various methods of introducing DNA into cells will be discussed using powerpoint presentation and consultation of scientific articles | Oral questions will be asked, students will be encouraged to read research articles related to the practicals and discuss the findings |
| IV | Students will learn about various requirements for overexpressing foreign gene in mammalian cells, cell harvestation, lysis and expression analysis through western blotting | Various steps of the practical will be discussed using chalk and board method and consultation of relevant articles | Solving of practical based analytical questions, discussion of situations in research, quiz, students will be asked to prepare short presentations on the practicals performed and discuss their findings. |
| V | Students will gain knowledge about various developmental stages of Zebra fish – starting from initial cleavages to gastrulation, somite formation and organ development. | Powerpoint slides will be used to introduce the concept of embryonic development of zebra fish | Students will be shown pictures for identifying the developmental stages of zebra fish. They will also be asked questions on timeline of developmental stages as well. |
| VI | Students will learn how to work with bacterial cultures, prepare high efficiency competent cells and perform transformations | Students will be provided individual hands-on –training along with theory classes for understanding the concepts. | Students will be asked oral questions, they will be asked to solve a few problems related to calculation of transformation efficiencies. |
| VII | Students will get hands on training and in depth details for the cloning of foreign genes in various | Students will be given individual hands-on – training for the | Students will be given assignment tasks related to gene cloning and PCR |

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| | plasmids. Students will learn the tricks of gene cloning and its applications | experimental work along with theory classes for understanding the concepts. They will be taught various ways to clone a foreign gene, its various applications and troubleshooting | amplification, to design primers *in silico* and to devise new cloning. |
| VIII | Students will learn to carry out the expression and localization analysis for recombinant proteins. Students will also learn protein purification techniques. | Hands-on – training to pack purification columns. Various optimization techniques will be taught for achieving better expression and solubility of proteins. | Students will be given assignment tasks related to purification strategies. A small quiz will be conducted for assessment of their understanding of protein expression, localization and purification |
| IX | Students will learn enzyme assays which can be applied for research purposes. | Individual hands-on –training along with theory classes for understanding the concepts. Enzyme assays will be carried out under different conditions. | Discussions on the concepts of the enzymatic assays will be carried out, they will be asked oral questions and a small quiz will be conducted for the assessment of their concepts of enzyme inhibition. |
| X | Students will learn a few bioinformatics tools and concepts of basic scripting | Computer training to be able to employ the bioinformatics tools for research applications and scripting will be taught through power-point presentation | For the assessment of their bioinformatics knowledge, the students will be given tests and assignments tasks to design simple scripts |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester III

### BCCC301: Recombinant DNA Technology and Applications in Biotechnology

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to offer detailed knowledge about the fundamentals of recombinant DNA technology, in terms of reagents, techniques and strategies along with their applications.

**Course Learning Outcomes:**

Students will acquire insight into:

- Basic reagents used in recombinant DNA technology (RDT).
- Biology of plasmids, and phages and their uses in designing different cloning systems.
- Synthetic DNA, DNA amplification and DNA Sequencing.
- Different types of DNA libraries and their application to isolate genes.
- Various operons and their application into designing expression vectors for prokaryotic expression and fundamentals of eukaryotic expression systems.

**Contents:**

**Unit I:** Restriction and Modification systems in *E. coli* and their use in RDT; Restriction and Modification enzymes and their use; Basic techniques for RDT including Agarose gel electrophoresis, PAGE, Pulse field electrophoresis; DNA safety guidelines and regulatory aspects.

**Unit II**: Basic Biology of plasmids including their replication, copy number, Incompatibility of Plasmids, development of Plasmid vectors including screening and selection strategies; Biology of filamentous phages, development of phage and phagemid vectors and their applications, Biology of Bacteriophage lambda, Promoters and control circuits, phage assembly and *in vitro* packaging and development of vectors for different types of Libraries; Vectors for cloning large fragments of DNA, (Cosmid, PAC, YAC and BAC) and strategies for cloning large DNA fragments.

**Unit III:** Oligonucleotide synthesis, purification, and its application in cloning, screening of libraries, and mutagenesis. Synthetic gene assembly; Polymerase chain reaction and its application in research including cloning of PCR amplified fragments, mutagenesis and construction of Libraries. Real time/quantitative PCR, Basic DNA sequencing methods, Maxam and Gilbert's chemical and Sanger's chain termination methods, and automated DNA sequencing; Base calling and sequencing accuracy; Introduction to next generation sequencing (NGS).

**Unit IV:** Strategies for constructing cDNA libraries and screening using Nucleic acid and antibody probes. Subtractive Libraries, Expression-based strategies for cloning of functional

genes, Differential mRNA display; Strategies for constructing Genomic libraries and screening using nucleic acid probes.

**Unit V:** Understanding of Operons Lac, Trp, Arabinose, Tetracycline and their applications in the development of expression vectors. Use of Tags to aid protein solubility and Purification; Vectors and strategies for expressing heterogeneous proteins in *E. coli*, Yeast, Baculovirus, and mammalian cells.

**Suggested Readings:**

1. M.R. Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press.
2. Fred M. Ausubel *et al.* editors (2017) Current Protocols in Molecular Biology. John Wiley and Sons, Inc.
3. John E. Coligan *et al.* editors (2017) Current Protocols in Protein Science. John Wiley and Sons, Inc.
4. S.B. Primrose and R.M. Twyman. (2006) Principles of Genome Analysis and Genomics. (7th edition) Blackwell Publishing.
5. T.A. Brown. (2016) Gene Cloning and DNA Analysis. ($7^{th}$ Edition). Wiley-Blackwell publishing (Oxford, UK).
6. Articles/Reviews from Methods in Enzymology, Methods in Molecular Biology, Nature Biotechnology, Nature Methods, Nature Protocols, Current Opinion series, Annual Review Series, DBT's Biosafety Guidelines, Current Protocol series and various Journals.

**Teaching Plan*:**

**Week 1:** DNA safety guidelines and regulatory aspects; Restriction and Modification systems in *E. coli* and their use in recombinant DNA technology**.**
**Week 2:** Restriction and Modification enzymes and their uses.
**Week 3:** Basic techniques for RDT including Agarose gel electrophoresis, PAGE, Pulse field electrophoresis**.**
**Week 4:** Basic Biology of plasmids including their replication, copy number, Incompatibility of Plasmids, development of Plasmid vectors including screening and selection strategies.
**Week 5:** Biology of filamentous phages, development of phage and phagemid vectors and their applications.
**Week 6:** Biology of Bacteriophage lambda, Promoters and control circuits, phage assembly and *in vitro* packaging and development of vectors for different types of Libraries.
**Week 7:** Vectors for cloning large fragments of DNA, (Cosmid, PAC, YAC and BAC) and strategies for cloning large DNA fragments.
**Week 8:** Oligonucleotide synthesis, purification, and its application in cloning, screening of libraries, and mutagenesis. Synthetic gene assembly.
**Week 9:** Polymerase chain reaction and its application in research including cloning of PCR amplified fragments, mutagenesis and construction of Libraries. Real time/quantitative PCR.
**Week 10:** Basic DNA sequencing methods, Maxam and Gilbert's chemical and Sanger's chain termination methods, and automated DNA sequencing; Base calling and sequencing accuracy; Introduction to next generation sequencing (NGS).
**Week 11:** Strategies for constructing cDNA libraries and screening using Nucleic acid and antibody probes. Subtractive Libraries, Expression-based strategies for cloning of functional genes.

**Week 12:** Differential mRNA display; Strategies for constructing Genomic libraries and screening using nucleic acid probes.
**Week 13:** Understanding of Operons Lac, Trp, Arabinose, Tetracycline and their applications in the development of expression vectors.
**Week 14:** Vectors and strategies for expressing heterogeneous proteins in *E. coli***;** Use of Tags to aid protein solubility and Purification.
**Week 15:** Vectors and strategies for expressing heterogeneous proteins in Yeast, Baculovirus, and mammalian cells. Discussion on all internal assignments and test papers and problem solving.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will learn about the significance of Restriction and Modification System, properties and uses of different restriction and modification enzymes and DNA and DNA separation methods. | Describe different systems, and their applications with case studies using Power Point presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will be given home assignment at the end of first unit. |
| II. | Students will learn about biology of different types of vectors system including plasmid, and bacteriophages and their applications. | Describe different systems, and their applications with case studies using Power Point presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will undergo internal test with syllabus covered in the two units and their answers will be discussed in the following class. |
| III. | Students will learn about synthetic DNA, DNA amplification and different DNA Sequencing techniques including introduction to next generation sequencing. | Describe different methods and their applications with case studies using PowerPoint presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will be given home assignment at the end of third unit. |
| IV. | Students will learn about different types of cDNA and genomic libraries and their uses in selecting | Describe different strategies and systems, and their applications with case studies using PowerPoint | The students will undergo internal test with syllabus covered in the third and the fourth units and their |

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| | desired genes by various methods. | presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | answers will be discussed in the following class. |
| V | Students will learn about different operons and their control and uses in designing expression vectors. Students will also learn about different types of expression systems. | Describe different strategies and systems, and their applications with case studies using Power Point presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will be given home assignment at the end of fifth unit. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester III

### BCCC302: Developmental Biology

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to impart knowledge about the significant processes of development, various model organisms and their applications in research, modern implications of developmental biology in understanding and treatment of various human diseases.

**Course Learning Outcomes:**

- Students will acquire knowledge about basic concepts of developmental processes, fertilization, germ layer formation and patterning of body plan.
- Students will gain detailed insight into the molecular events of embryogenesis, various model systems and their applications in understanding human development and associated defects.
- Students will learn about Stem cells, their roles in development and significance in development of regenerative medicines, current applications and advancement in stem cell research.

**Contents:**

**Unit I:** History and basic concepts of developmental processes, mechanisms of specifying cell fate, role of development in evolutionary change.

**Unit II:** Early events of fertilization, implantation, generation of multicellular embryo, formation of germ layers, patterning of vertebrate body plan. Morphogenesis: Cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation and cell migration.

**Unit III:** Molecular events of embryogenesis: Nieuwkoop center, Spemann-Magold organizer theory and mesodermal induction. Role of cell-cell communication in development; Concepts of induction and competence; Epithelial-mesenchymal interactions and developmental signals from extracellular matrix. Brief discussion on role of various signaling pathways during development.

**Unit IV:** Model systems

A. *C. elegans*: Study of cell lineage, cell fate determination, regulation of blastomere identity, anterior-posterior axis formation and organogenesis (vulva formation).
B. *Drosophila*: Polarily determination of embryo by maternal genes, pattern formation, formation of body segments, homeotic genes and their significance.
C. *Zebrafish*: Developmental stages, somite formation, mechanisms of pigment patterning in fish skin.

D. *Mouse:* Vertebrate development, determining function of genes during development by generation of knockout and knock-in models.
E. *Arabidopsis*: Development and morphogenesis of plants, role of phytohormones, embryogenesis, flowering, shoot and root development.

**Unit V:** Role of stem cells in development: Definition, types and properties of stem cells, adult stem cells and embryonic stem cells, cancer stem cells, stem cell markers, applications of stem cells, advancement in research and associated ethical issues.

**Unit VI:** Medical implications of developmental biology: Developmental disorders, *in-vitro* fertilization, design of future medicines like gene therapy, therapeutic cloning and regeneration therapy.

**Suggested readings:**

1. S. F. Gilbert. 2008. Developmental Biology (9th Edition), Sinauer Associates, Inc., MA, USA.
2. D.L. Riddle, T. Blumenthal, B.J. Meyer, J.R. Priess. 1997. *C. elegans* II. Cold Spring Harbor Laboratory Press, New York, USA.
3. Worm Book: The Online Review of *C. elegans* Biology. 2005. The *C. elegans* Research Community, Pasadena, USA. (www.wormbook.org)
4. L. Wolpert, R. Beddington, T. Jessell. 2010. Principles of Development (4th Edition), Oxford University Press, New York, USA.
5. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira. 2003. Molecular Cell Biology, W.H. Freeman, New York, USA.
6. Nagy, M. Gertsenstein, K Vintersten, R. Behringer. 2003. Manipulating the mouse embryo: a laboratory manual, Cold spring Harbor Press, New York, USA.

**Teaching Plan*:**

**Week 1:** Introductory classes: General introduction about the history and basic concepts of developmental processes, mechanisms of specifying cell fate, role of development in evolutionary change.
**Week 2:** Early events of fertilization, implantation, generation of multicellular embryo, formation of germ layers.
**Week 3:** Patterning of vertebrate body plan. Morphogenesis: Cell adhesion, cleavages, mid-blastula transition and formation of blastula.
**Week 4:** Gastrulation, different cellular movements, neural tube formation and cell migration.
**Week 5:** Molecular events of embryogenesis: Nieuwkoop center, Spemann-Magold organizer theory and discussion of experimental evidences.
**Week 6:** Mesodermal induction: different signaling mechanisms. Role of cell-cell communication in development; Concepts of induction and competence.
**Week 7:** Epithelial-mesenchymal interactions and developmental signals from extracellular matrix. Role of various signaling pathways during development. Revision of the covered units, mid-term test.
**Week 8:** Introduction of model organisms and their applications.

*C. elegans*: Study of cell lineage, cell fate determination, regulation of blastomere identity, anterior-posterior axis formation and organogenesis (vulva formation).
**Week 9:** *Drosophila*: Polarily determination of embryo by maternal genes, pattern formation, formation of body segments, homeotic genes and their significance.
**Week 10:** *Zebrafish*: Developmental stages, somite formation, mechanisms of pigment patterning in fish skin.
**Week 11:** *Mouse:* Vertebrate development, determining function of genes during development by generation of knockout and knock-in models.
**Week 12:** *Arabidopsis*: Development and morphogenesis of plants, role of phytohormones, embryogenesis, flowering, shoot and root development.
**Week 13:** Role of stem cells in development: Definition, types and properties of stem cells, adult stem cells and embryonic stem cells, cancer stem cells.
**Week 14:** Stem cell markers, applications of stem cells, advancement in research and ethical issues.
**Week 15:** Medical implications of developmental biology: Developmental disorders, *in-vitro* fertilization. Design of future medicines like gene therapy, therapeutic cloning and regeneration therapy. Course revision, presentation of the concepts learned in the class, class test, discussion of the results; solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will learn about basic concepts of developmental processes, how cell fate is determined and link between development evolution. | Chalk and board and power point presentations, regular question-answer activities. Consultation of text books and reviews | Assessment through interactive discussion in the class, periodic question-answer sessions during teaching |
| II. | Role of various signaling pathways will be learnt, early events of fertilization, implantation, germ layer formation and patterning of vertebrate body plan. | Chalk and board and power point presentations, regular question-answer activities, consultation of relevant research articles and watching movies. | Oral questions will be asked, students will be given to solve analytical problems relating to class teachings. Students will be asked to read original research papers and discuss the experimental approach and findings. |
| III. | Students will learn the molecular events of embryogenesis: Nieuwkoop center, | Chalk and board and Power point presentations, regular question- | Writing assignments given to students, schematics of various molecular events will be shown with missing links, |

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| | Spemann organizer theory and mesodermal induction. | answer activities, consultation of relevant research articles and reviews. | students will fill in the names of the missing molecules. Students will be asked to present results of relevant research papers. |
| IV | Students will learn about utility of various model organisms to follow development processes and hence diseases. | Chalk and board and Power point presentations, regular question-answer activities, consultation of relevant research articles and reviews. | Pictures of various mutants will be shown for students to identify the developmental defects, oral questions, quiz and puzzles will be used for day to dayevaluation during class. |
| V | Properties and significance of stem cells and their role in development will be learnt, they different types and their research applications including current status in India. | Chalk and board and Power point presentations, regular interaction activities, discussion of case studies. | Students will be asked to segregate different type of stem of cells based on the markers, they will be asked design experiments to test stemness properties of cells in animal models. |
| VI | Students will learn about developmental disorders, IVF, therapeutic cloning and regenerative medicine. | Chalk and board and Power point presentations, student interaction discussion of case studies. | Students will be evaluated through class discussion, assignments and tests. |

**MASTER OF SCIENCE, BIOCHEMISTRY**

**Semester III**

## BCCC303: Cell Biology

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

### Course Objectives:

The objective is to offer detailed knowledge about cell biology, various cellular organelles and the signal transduction pathways associated with the cellular processes of the cells. The course also aims to provide into the insights of how classical cellular pathways by experimentally discovered.

### Course Learning Outcomes:

- Students will learn about cell theory, cell cycle mechanisms, various cellular organelles and their fractionation
- Students will acquire insight into the processes of transport across cell membranes, process of endocytosis and protein sorting/translocation to various organelles.
- Students will gain knowledge about the concepts of various cellular signal transduction pathways
- Students will acquire insight into the mechanisms of cellular responses under varying conditions
- Students will learn the association of the defects in the signaling processes to various diseases.

### Contents:

**Unit I**: The Cell Theory of Life, Sub-cellular organelles, Cytoskeleton and Extracellular matrix, Cell cycle: Historical background, Difference between Prokaryotic and Eukaryotic cells. Isolation and characterization of sub-cellular organelles. Structure and function of sub-cellular organelles. Role in control of cell shape, motility and in intracellular transport. Structure and movement of cilia and flagella. Microtubules, structure and dynamics. Assembly of various extracellular matrix and their role in integrating cells into tissues and cell-cell interactions. Restriction point of cell cycle and Quiescent cells. Control of cell cycle in yeast and mammalian cells. Role of various cycle-CDK complexes in the transition of various checkpoint of cell cycle. Role of ubiquitin-protein ligase –SCF and APC/C in the control of cell cycle. Cytokinesis.

**Unit II:** Transport across cell membranes: Understanding membrane transport phenomenon, Passive and active transport, Symport, uniport and antiport. Overview of membrane structure and function. Endocytosis and endosome-endosome fusion, Classification of endocytosis, phagocytosis and pinocytosis, clathrin-independent endocytosis, receptor-mediated endocytosis. Mechanism of formation of clathrin coated pits and vesicles, role of assembly particles in receptor-mediated endocytosis, vesicle fusion. An overview of exocytosis. Transport of cholesterol and iron in mammalian cells. Identification and mechanism of

action of various molecular factors (like Rab5, PI-3-Kinase) involved in endosome-endosome fusion

**Unit III:** Protein sorting and targeting: Historical background, Protein translocation across ER-membrane, SRP. Modification and quality control of protein in ER: Golgi vesicular traffic, Protein import in mitochondria, peroxisomes, chloroplasts. Signal for Import and Export of Macromolecules from Nucleus. Glycosylation in mammalian cells, origin, nature and types of Glycosylation. Role of Glycosylation in protein stability and folding with reference to ER exit.

**Unit IV:** Short Term and Long Term Cellular Signaling: General principles of signaling by cell surface receptors, endocrine, paracrine and autocrine signaling, types of cellular responses induced by signaling molecules, components of intracellular signal-transudation pathways. G-protein coupled receptor system, General mechanism of the activation of effectors molecules associated with GPCRs, GPCRs that activate or inhibit adenylatecyclase, activate phospholipase C, regulating ion channels. Signaling of growth factors (EGF and Insulin) via activation of receptor tyrosine kinases. Signaling of TGFβ by direct activating Smad proteins. Cytokine signaling via JAK/STAT pathway

**Unit V:** Cell Survival and Death Signal: Programmed cell death and role of Caspase protein in apoptosis. Various pro-apoptotic and anti-apoptotic regulators and pathways.

**Suggested readings**

1. H. Lodish, A. Berk, C.A. Kaiser, M. Kreiger, M. P. Scott, A. Bretscher, H. Ploegh, P. Matsudaria. 2008. Molecular Cell Biology, W.H. Freeman and Company, New York., USA.
2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P Walter. 2002. Molecular Biology of the Cell, Garland Publishing, Inc. New York. USA.
3. G.M. Cooper. 2000. The Cell: Molecular Approach, ASM Press, Washington, D.C. USA.
4. J.M. Graham and R. Rickwood. 1997. Subcellular Fractionation: A Practical Approach, IRL Press, Oxford University Press. U.K.
5. D.L. Nelson, M.M. Cox. 2008. Lehninger Principles of Biochemistry, W.H. Freeman and Company, New York, USA.
6. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York.
7. G. Zubey. 1993. Biochemistry, Wm. C. Brown Publishers, Oxford. U.K.
8. L. Harvey, B. Arnold, Z.S. Lawrence, M. Paul, D. Baltimore, J.E. Darnell. 1999. Molecular Cell Biology, W. H. Freeman & Co, New York, USA.
9. J.G. Siegel, B. W. Agranoff, A. R. Wayne, S.K. Fisher, M.D. Uhler. 1999. Basic Neurochemistry: Molecular, Cellular, and Medical Aspects, Lippincott,Williams& Wilkins, Philadelphia, USA.

**Teaching Plan*:**

**Week 1:** Introductory classes: General introduction to the course; The Cell Theory of Life and sub-cellular organelles
**Week 2:** Cytoskeleton and Extracellular matrix
**Week 3:** Cell cycle phases and regulation
**Week 4:** Transport across cell membranes; membrane structure and function
**Week 5:** Endocytosis, vesicle formation and fusion
**Week 6:** Overview of exocytosis and endosome-endosome fusion
**Week 7:** Protein sorting, glycosylation, translocation and quality control in ER
**Week 8:** Protein export from ER to various organelles
**Week 9:** Mid-term Internal Assessment test, power-point presentation by students as part of their assessment on various topics
**Week 10:** Introduction to cellular signalling and its general principles
**Week 11:** Short Term Signaling- part I
**Week 12:** Short Term Signaling- part II
**Week 13:** Long Term Signaling – part I
**Week 14:** Long Term Signaling – part II
**Week 15:** Cell Survival and Death Signal**.** Course revision, End-term internal assessment test, solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will learn about cell theory, cell cycle mechanisms, various cellular organelles and their fractionation | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Historical research articles/reviews for landmark discoveries will be discussed. Teaching will be conducted both through black | Mid-term internal assessment test will be conducted. Students will be asked to prepare and present research/review articles related on various topics assigned to them. |

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| | | board mode and power point presentation mode. | |
| II. | Students will acquire insight into the processes of transport across cell membranes, process of endocytosis and protein sorting/translocation to various organelles. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Historical research articles/reviews for landmark discoveries will be discussed. Teaching will be conducted both through black board mode and power point presentations mode | Mid-term internal assessment test will be conducted. Students will be asked to prepare and present research/review articles related on various topics assigned to them. |
| III. | Students will gain knowledge about the concepts of various cellular signal transduction pathways | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Historical research articles/reviews for landmark discoveries will be discussed. Teaching will be conducted both through black board mode and power point presentations mode | End-term internal assessment test will be conducted. |
| IV. | Students will acquire insight into the mechanisms of cellular responses under varying conditions | Students will be asked to orally revise the previous class before every new class helping | End-term internal assessment test will be conducted. |

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| | | them in better understanding and their doubts cleared, if any. Historical research articles/reviews for landmark discoveries will be discussed. Teaching will be conducted both through black board mode and power point presentations mode | |
| V. | Students will learn the association of the defects in the signaling processes to various diseases | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Historical research articles/reviews for landmark discoveries will be discussed. Teaching will be conducted both through black board mode and power point presentations mode | End-term internal assessment test will be conducted. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester III

### BCCC304: Presentation: Concepts in Research

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The course intends to help students in understanding the background of a specific research area and to enhance their ability to explore relevant literature and assimilate and collate the information into a comprehensive seminar on the status of research topic assigned to them.

**Course Learning Outcomes:**

- Students will learn how to survey scientific literature in an assigned topic, screen relevant information and apply their knowledge gained through theory and practical classes in understanding the original research articles.
- Students will learn to summarize the relevant information from the assembled literature and develop their overall understanding for the logic behind various experimental approaches and critical analysis of the results.
- Students will improve their power point presentation preparation skills, oration skills, learn how to present and discuss scientific findings in a logical manner and how to compile information to prepare a write-up as a scientific document.
- Students will learn how to compile and cite bibliography in scientific text.
- Students will learn aspects of plagiarism and be aware of softwares to identify plagiarism.

**Contents:**

**Unit I:** Students would present seminar on the current status of any area related to the research topic assigned to them by the faculty in whose lab the student was assigned for dissertation research. Their understanding in the form of presentation would be collectively evaluated by the departmental faculties. The students would survey the available literature on the topics assigned to them, shortlist the relevant material, understand the concepts, experimental approaches, analyze the results outlined and collate the information into a comprehensive presentation.

**Unit II**: The students would compile a detailed write-up on the topic of seminar and submit as a term paper. As part of the term paper, they would be compiling the relevant bibliography and learn how to appropriately cite them in the term paper.

**Unit III:** Students would be educated on the aspects of plagiarism and use of the appropriate softwares to avoid the same.

**Suggested Readings:**

1. Research papers on the topic suggested by faculties to students.
2. The standard textbooks of Biochemistry

**Teaching Plan*:**

**Week 1-2:** Students will be assigned topics by the dissertation mentor faculty. Students will be trained with skills of literature search, usage of correct key words, bibliography collation, the style of referencing, etc.
**Week 3-8:** Students will search databases to retrieve literature related to the assigned topic.
**Week 9:** Students will discuss with the concerned faculty about their preliminary understanding of the topics and any other difficulties faced in their literature screening.
**Week 10-14:** Further search of literature by students and collation of information into a power point presentation.
**Week 15:** Discussion with faculties on the power point presentations prepared, learning various norms of scientific presentation, oration practice etc. Preparation of the write-up on the collated information by students.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness of students)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will know how to search for research papers for the relevant research topic using combination of key words; They will learn how to download references and save them in appropriate softwares like EndNote; Students will learn how to make power point files and how to make research related presentations in public | Regular discussion on the research topics, checking the progress of their literature search, holding frequent question answer sessions, showing sample power point presentation to train students. | Topic relevant to the research area will be assigned individually to students and they will be asked to retrieve literature and show them to teachers for verification. They will be motivated to make short presentations as journal club seminars for practice of oration, learn how to identify research problems. |
| II | Students will learn the skills of scientific documentation, how to prepare a write-up to summarize their understanding of a research topic; They will have advanced learning or MS Word, MS Excel and other softwares. They will learn | Teachers will describe how to prepare write-up and discuss the key points to keep in mind while drafting the documents. Student queries will be entertained | Students will need to write term paper on the topic assigned. If needed, they will be asked to write short essays on simpler topics for practice of writing. |

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| | how to cite references in text and how to organize them in a bibliographic section either manually or using softwares like EndNote | by teachers. | |
| III | Students will learn about the softwares of plagiarism and how to use them. | Students will be informed about the issues related to plagiarism. They will be shown how to avoid plagiarism. They will be asked to visit Library where commercial plagiarism softwares are available. | They will be asked to run their write-up through plagiarism softwares and show the outcome to teachers. They will be asked to reorganize the write-ups to reduce the % plagiarism. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester III

### BCCC305: Practical Skills in Research

**Marks: 200 (8 Credits)** **Duration: 240 Hrs (15 weeks)**

**Course Objectives:**

The course aims to augment experimental skills of students through training in several research methods, tools, techniques and instrumentation associated with their dissertation research area in the mentorship of a specific faculty for personal attention and systematic learning.

**Course Learning Outcomes:**

- Students will be able to build up on their hands-on-learning in practical classes in the first year and gain practical experience in basic research tools, methods, instruments in a systematic manner in a defined research ambience along with Ph.D. students in the supervision of a specific faculty.
- Students will be able to understand the scope of research in their assigned dissertation research topic, successfully outlining the aims and objectives for subsequent dissertation work in the fourth semester.
- They will learn the principle behind various research tools and techniques and collate the materials and methods that will be subsequently used in their research dissertation.

**Contents:**

**Unit I:** Students will be allotted laboratories under the supervision of a specific faculty for research work in the beginning of Semester III. The faculty will assign research project to the student. Students will subsequently get hands on training in several research methods, tools, techniques and instrumentation associated with the research topic assigned to them using existing protocols and standard operating procedures available in the laboratory. They will perform these basic experiments several times to achieve perfection and prepare their hands for research projects.

**Unit II:** Students will optimize research protocols necessary for the research project assigned to them by making appropriate modifications, if any, in the existing protocols to suit their research aims and objectives. They will study the principle behind various research tools and techniques and collate the materials and methods that will be subsequently used in their research dissertation. They will also study, from existing literature, the various applications of the tools and techniques they learn. With the help of the mentor they will identify the scope of research and outline potential aims and objectives for subsequent research.

**Unit III:** They will collate and summarize the information and present the details of the practical skills they learnt in the form of a seminar at the end of the semester. They will also present their work plan to be pursued in the fourth semester.

**Unit IV**: The students would compile a detailed write-up on the tools and techniques they learnt along with their principle, precautions, advantages, disadvantages and various applications and submit as a term paper. They will also outline the work plan of dissertation research in their term paper. As part of the term paper, they would be compiling the relevant bibliography and cite them appropriately.

**Suggested Readings:**

1. Protocol Manuals, Review articles, and Research papers on the tools and techniques learnt in the laboratory.
2. The standard textbooks of Biochemistry

**Teaching Plan*:**

**Week 1-2:** Students will be assigned research topics by the specific mentor assigned for the supervision. They will discuss the research topics with their mentors and obtain the protocols and standard operating procedures for various basic research methods and tools used in the specific laboratory. They will also obtain protocol manuals and some basic review articles describing the methods and instruments.
**Week 3-8:** Students get hands on training in several research methods, tools, techniques and instrumentation associated with the research topic assigned to them using existing protocols and standard operating procedures available in the laboratory. Alongside they will learn the principles and other details of all the methods, tools and instruments.
**Week 9:** Students will discuss with faculties in details about their preliminary understanding of the tools and techniques and the relevant modifications needed in the protocols, if any, for further work.
**Week 10-14:** Continuation of learning the tools and methods and also identifying research scope, aims and objectives. Students, along with mentors, will formulate future research plan and methodology of work. Further search of literature by students and collation of information into a power point presentation will also be done.
**Week 15:** Discussion with faculties on the power point presentations prepared. Practice of oration also will be encouraged. Preparation of the write-up on the collated information by students for the term paper.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness of students)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will be initiated into a research area in a research lab. Students will learn several research methods, tools, techniques and instrumentation associated with the research topic. They will | Teaching and learning will be mainly through one-to-one interactions with mentor and Ph.D. students in the specified lab. | Research topic will be assigned to students and they will be asked to retrieve literature and show them to teachers for verification. They will present the methods they learnt in lab meetings and to mentors. |

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| | achieve perfection in handling research protocols and get their hands prepared for research projects. | | |
| II | Students will learn to optimize research protocols for their own research project. They will learn the basic principles behind various research tools and techniques. They will learn to collate and write materials and methods. They will also learn about the various applications of the tools and techniques | Teaching and learning will be mainly through one-to-one interactions with mentor and Ph.D students in the specified lab. Protocol manuals and research papers will be provided. | Students will be assigned to write necessary modifications in research protocols and show them to mentors. They will be asked to find research papers where such tools were used. |
| III | Students will learn to summarize information about their practical skills. They will learn to prepare seminar and improve their oration skills. | Teaching and learning will be through one-to-one interactions with mentor and Ph.D. students and through research publications. | Students will be assigned the task of preparing power point presentations to demonstrate their learning and oration capabilities |
| IV | The students would learn how to write about the tools and techniques they learnt along with their principle, precautions, advantages, disadvantages and various applications. They will learn to formulate research plan and cite references appropriately. | Teaching and learning will be through one-to-one interactions with mentor and Ph.D. students and through research publications. | Students will need to write term paper on the methods learnt. If needed, they will be asked to write short essays on simpler topics for practice of writing. Department also often organizes essay writing competition to allow students the opportunity to improve writing. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester IV

### BCCC401: Advanced Techniques in Genomics for Biotechnology

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to offer advanced knowledge about Genomic techniques employed in understanding cellular function and also in Industrial application for producing therapeutic molecules.

**Course Learning Outcomes:**

Students will acquire insight into:

- Strategies employed for studying protein-protein interactions, high-throughput protein expression including antibody gene cloning and engineering.
- Mutagenesis by recombinant methods, co-expression of protein, determination of gene function, Microarray techniques.
- Different platforms employed in Next generation sequencing for whole genome and RNA sequencing.
- Large-scale expression and purification of proteins of therapeutic grade including regulatory aspects.
- Modifying genes at cellular level, micro/siRNA, transgenic animals, and plants.

**Contents:**

**Unit I:** Recombinant DNA strategies to study protein interactions. (Phage display, Ribosome Display, Cell Display, Protein fragment complementation). High-throughput genome-wide cloning and protein expression strategies and applications. Antibody gene cloning and engineering, humanization and Human antibodies.

**Unit II**: Mutagenesis: Chemical, random, site-directed and newer methods, and strategies for protein engineering such as DNA shuffling to produce better variants and to study their functions. Determining the Function of Individual genes (Gene deletion, over-expression and complementation, Genome-wide insertional mutagenesis); Regulated vectors for controlled expression of multiple genes (co-expression) to study gene function. Microarray techniques for DNA, Proteins and Antibodies. Global expression profiling.

**Unit III:** Fundamentals of Whole-Genome Sequencing, Next Generation Sequencing, Sequencing of Phage, Viral and Bacterial Genomes, Human Genome sequencing, RNA Seq, comparative genomics.

**Unit IV:** Strategies for large-scale expression of recombinant proteins in heterogonous hosts. Purification and downstream processing to produce Therapeutic grade recombinant proteins and monoclonal antibodies, and regulatory aspects.

**Unit V:** Engineering such as CRISPR/Cas; Micro/siRNA technology and applications in studying gene functions; Gene transfer and expression in plant, Gene transfer in mammals and applications.

**Suggested Readings:**


1. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2017) 5th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC).
2. Erica Golemis and Peter D. Adams (2005) Protein-Protein Interactions: A Molecular Cloning Manual. Cold Spring Harbor Laboratory Press,
3. M.R.Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press.
4. Fred M. Ausubel *et al.* editors (2017) Current Protocols in Molecular Biology. John Wiley and Sons, Inc.
5. John E. Coligan *et al.* editors (2017) Current Protocols in Protein Science. John Wiley and Sons, Inc.
6. John E. Coligan *et al.* editors (2017) Current Protocols in Immunology. John Wiley and Sons, Inc.
7. S.B. Primrose and R.M. Twyman. (2006) Principles of Genome Analysis and Genomics. (7th edition) Blackwell Publishing.
8. T.A. Brown. (2017) Genomes 4. (IV edition), Garland Science,
9. Carlos F Barbas III, Dennis R Burton and Gregg J Silverman., (2001), Phage Display: A Laboratory Manual, Cold Spring Harbor Laboratory Press.
10. Robert Aitken(Editor) (2009) Antibody Phage Display: Methods and Protocols (Methods in Molecular Biology).
11. Articles/Reviews from Methods in Enzymology, Methods in Molecular Biology, Nature Biotechnology, Nature Methods, Nature Protocols, Current Opinion series, Annual Review Series, DBT's Regulatory Guidelines, Current Protocol series and various Journals.


**Teaching Plan*:**

**Week 1:** Recombinant DNA strategies to study protein interactions. (Phage display, Ribosome Display, Cell Display, Protein fragment complementation).
**Week 2:** Antibody gene cloning and engineering, humanization and Human antibodies.
**Week 3:** High-throughput genome-wide cloning and protein expression strategies and applications.
**Week 4:** Mutagenesis: Chemical, random, site-directed and newer methods, and strategies for protein engineering such as DNA shuffling to produce better variants and to study their functions.
**Week 5:** Determining the Function of Individual genes (Gene deletion, over-expression and complementation, Genome-wide insertional mutagenesis**.**
**Week 6:** Regulated vectors for controlled expression of multiple genes (co-expression) to study gene function.
**Week 7:** Microarray techniques for DNA, Proteins and Antibodies. Global expression profiling.

**Week 8-9** Fundamentals of Whole-Genome Sequencing, Next Generation Sequencing, Sequencing of Phage, Viral and Bacterial Genomes, Human Genome sequencing, RNA Seq, comparative genomics.
**Week 10-12:** Strategies for large-scale expression of recombinant proteins in heterogonous hosts. Purification and downstream processing to produce Therapeutic grade recombinant proteins and monoclonal antibodies, and regulatory aspects.
**Week 13:** Cellular Engineering such as CRISPR/Cas**.**
**Week 14:** Micro/si RNA technology and applications in studying gene functions.
**Week 15:** Gene transfer and expression in plant, Gene transfer in mammal and applications. Discussion on all internal assignments and test papers and problem solving.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I | Students will learn about Strategies employed for studying protein-protein interactions, high-throughput protein expression including antibody gene cloning and engineering. | Describe different strategies and systems, and their applications with case studies using Power Point presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will be given home assignment at the end of first unit. |
| II. | Students will learn about Strategies employed Mutagenesis by recombinant methods, co-expression of protein, determination of gene function, Microarray techniques. | Describe different strategies and systems, and their applications with case studies using Power Point presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will undergo internal test with syllabus covered in the two units and their answers will be discussed in the following class. |
| III. | Students will learn about Different platforms employed in Next generation sequencing for whole genome and RNA sequencing. | Describe different platforms, and their applications with case studies using Power Point presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will be given home assignment at the end of third unit. |
| IV. | Students will learn about Strategies employed for Large-scale expression and purification of proteins of therapeutic grade including regulatory aspects. | Describe different strategies and systems, and their applications with case studies using Power Point presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will undergo internal test with syllabus covered in the third and the fourth units and their answers will be discussed in the following class. |

| | | | |
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| V | Students will learn about Strategies employed for Modifying genes at cellular level, microRNA, siRNA, transgenic animals, and plants. | Describe different strategies and systems, and their applications with case studies using PowerPoint presentations and discussions on important publications. The pdf of such publications will be sent to students in advance. | The students will be given home assignment at the end of fifth unit. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester IV

### BCCC402: Dissertation by Research

**Marks: 400 (16 Credits)** **Duration: 480 hrs (15 weeks)**

### Course Objectives:

The objective of the course is to build a strong research foundation for students, which will help them pursue research as a profession. The aim is to develop skills to formulate work plan, design and execute experiments and analyze data followed by a comprehensive presentation of the research findings.

### Course Learning Outcomes:

- Students will learn to survey scientific literature, identify scope for a research project, generate hypothesis and work plan for solving the research problem, design and execute experiments along with appropriate controls to address the problem, critically analyze the results generated, troubleshoot for failed experiments and decide the next course of action.
- Students will improve their oral presentation and scientific writing skills. They will learn how to compile the information in a thesis format including bibliography citation.
- Students will experience the entire gamut of a research project, which will instil confidence and self-belief in them for higher education.

### Contents:

**Unit I:** Students will carry out the research project assigned to them in semester III and present their research findings in a seminar at the end of semester IV. The practical skills acquired by the students as well as the concepts and theoretical knowledge gained in semester III in the assigned area will enable them to carry out the research project assigned to them. Students will learn to find lacunae or missing links in a research topic, identify interesting and important research problems, build connections and generate hypothesis for solving the assigned research problem. Students will learn to understand scientific discoveries through reading of original research articles, learn about the ways to approach a problem, understand the utilities of various research techniques to answer the research related queries. They will design and execute the experiments using appropriate controls.

**Unit II:** Students will learn to perform experiments independently in the supervision of a mentor. They will analyse the findings along with the mentor and try to understand the implications of the findings. In case of problems of failed experiment, they will troubleshoot the problems and re-design the experiment or find an alternative solution. Based on the results of a previous experiment, they will design the subsequent experiment. At the end of

the semester, students will conclude the findings and understand how much of the research problem has been addressed.
**Unit III**: Students will prepare a powerpoint file summarizing their research findings and including the research background, rationale of the project, aims and objectives and conclusions and future prospects. They will present the same at the end of the semester to be jointly evaluated by the faculties of the department.

**Unit IV:** Students will compile the research findings in a thesis format in terms of introduction, hypothesis, aims and objectives, results along with tables and figure legends, discussion of the implications of the findings based on existing literature and comment on the future directions and significance of the research work. They will learn how to present the information in a print format including citation of bibliography both in the scientific text and in the reference section. Students will use appropriate softwares to identify and reduce the plagiarism in their write-up.

**Suggested Readings:**

1. Research publications on the research topic.
2. The standard textbooks of Biochemistry

**Teaching Plan*:**

**Week 1-2:** Students will search literature related to the research topic and some relevant research reviews and original papers will also be provided by the dissertation mentor faculty. Students will be trained to find gaps in research based on literature, generate hypothesis and to ask questions and design research problems.
**Week 3-8:** Students will design experiments to address the research problems and perform the experiments in the lab. Standardizations and optimizations will be done.
**Week 9:** Students will discuss with the concerned faculty about their preliminary understanding of the results and any other difficulties faced in their experiments.
**Week 10-14:** Reproducible results will be analyzed, statistical significance will be evaluated, figures will be prepared, discussions and conclusions will be documented.
**Week 15:** Discussion with faculties on the power point presentations prepared, learning various norms of scientific presentation, oration practice etc. Preparation of the write-up on the dissertation by the student. Plagiarism check and bibliography insertions will be done.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness of students)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|

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|---|---|---|---|
| I | Students will know how to find missing links from reading of research papers for the relevant research topic; They will also learn to identify interesting research problems; generate hypothesis and design aims and objectives of the research project | Regular discussion on the research topics with mentor and other PhD students in the lab; frequent question answer sessions. | Topic relevant to the research area will be assigned individually to students and they will be asked to retrieve literature and show them to teachers for verification. They will design and execute the experiments keeping appropriate controls. They will discuss their plan of work and design of experiments with mentors. |
| II | Students will learn to perform experiments independently. They will learn to analyse the results along with the mentor. They will learn to troubleshoot the problems and re-design the experiment; Students will learn to conclude the findings. | One-to-one discussion with mentors and Ph.D scholars in the laboratory; Research papers and review articles will be provided for further reading. | Identification of errors in an experiment and explanation for failed experiments. Finding solutions to problems and alternatives to experiments. |
| II and IV | Students will learn the skills of scientific documentation, how to prepare seminar and write-up to summarize their understanding of a research topic; They will have advanced learning or MS Word, MS Excel and other softwares. They will learn how to cite references in text and how to organize them in a bibliographic section either manually or using softwares like EndNote | Teachers will describe how to prepare write-up and discuss the key points to keep in mind while drafting the documents. Student queries will be entertained by teachers. | Students will need to prepare seminars for presentation using power point files. Students will need to write term paper on the topic assigned. If needed, they will be asked to write short essays on simpler topics for practice of writing. |

## MASTER OF SCIENCE, BIOCHEMISTRY

### Semester IV

### BCCC403: Proteomics and Metabolomics

**Marks: 100 (4 Credits)** **Duration: 60 Hrs (15 weeks)**

**Course Objectives:**

The objective is to offer detailed knowledge about the concepts and applications proteomics and metabolomics. This course emphasizes on the advancement from protein chemistry to the field of proteomics. The methodology and the instrumentation involved in conducting experiments to proteomics and metabolomics are discussed in the course.

**Course Learning Outcomes:**

- Students will learn about the usefulness of the field of proteomics. They will learn various proteomics techniques, their detailed methodology and instrumentation involved. Importantly, this course makes them learn the benefits of using proteomics tools over other approaches.
- Students will acquire insight into various applications of proteomics tools in research (biomarker discovery and drug discovery).
- Students will gain knowledge about the concepts of metabolomics and the applications of these tools
- Students will gain a detailed knowledge of mass spectrometry along with its various components and its applicability in proteomics and metabolomics.

**Content**

**Unit I:** Introduction to proteome, proteomics technology, types and kinds of proteomics investigation, overview of systems biology, evolution from protein chemistry to proteomics, importance of proteomics.

**Unit II:** Abundance-based proteomics, Quantitation proteomics, Interaction Proteomics: Sample preparation and pre-fractionation steps, two-dimensional gel electrophoresis (2-DE), 2D-DIGE and their applications. Merits and demerits of gel based proteomics. MudPIT, Mass spectrometry (Ionizers, analyzers and detectors) technology, data analysis – computational/bioinformatics tools and its application in proteomics. ICAT, SILAC, iTRAQ, and their applications. Proteomic profiling for host-pathogen interaction, Understanding proteomics for post-translational modifications. Protein-Protein Interaction (PPI) and its application in proteomics. Yeast two-hybrid, bacterial two-hybrid system, immunoprecipitation, protein microarrays, Nucleic Acid Programmable Protein Array (NAPPA), Label-free nanotechnologies in proteomics, Surface Plasmon Resonance (SPR)

**Unit III:** Application of proteomics for drug discovery. Biomarkers and drug targets identification. Validation of drug targets and assessment of its toxicology**,** Bioinformatics and proteomics: computational models of proteomics networks.

**Unit IV:** Introduction to metabolomics world. High throughput screening systems and utility. Lessons from metabolites, metabolic fingerprinting, and metabolic profiling. Biotechnological potentials of metabolomics. Proteomics approaches in metabolomics. Analysis of differential protein expression, post-translational modifications and protein activity for metabolomics. HPLC and FPLC based approaches in metabolomics.

**Unit V:** Application for cellular metabolomics for metabolic pathway structure. Size of metabolome, metabolite identification, pathway identification and pathway integration. Computational approaches for metabolite identification and translation of results into biological knowledge. Metabolite profiling for infectious disease. Application of metabolite profiling in heart disease. Metabolic signature and metabolite profiling in heart disease.

**Unit VI:** Metabonomics in preclinical pharmaceutical discovery and development. Analytical considerations, and biological aspects and applications.

**Suggested readings**

1. T. Palzkill. 2002. Proteomics, Kluwer Academic Publishers, New York, USA.
2. E.D. Hoffmann, V. Stroobant. 2007. Mass Spectrometry: Principles and Applications, John Wiley & Sons Ltd. The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England.
3. D. Kambhampati. 2004. Protein Microarray Technology, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.
4. E. Fung. Methods in Molecular Biology, Volume 264: Protein Arrays, Humana Press Inc., Totowa, NJ.
5. S.G. Villas-Boas. 2007. Metabolome Analysis: An Introduction, Wiley-Blackwell, USA.
6. B. J. Nikolau. 2007. Concepts in Plant Metabolomics, Wurtele, Eve Syrkin, Springer, USA.
7. J. Lindon, J. Nicholson, E. Holmes. 2006. The Handbook of Metabonomics and Metabolomics, Elsevier B.V., Netherlands.

**Teaching Plan*:**

**Week 1:** Introductory classes: General introduction to the course; Introduction to proteome, proteomics technology, types and kinds of proteomics investigation, overview of systems biology, evolution from protein chemistry to proteomics, importance of proteomics.
**Week 2:** Abundance-based proteomics: Sample preparation and pre-fractionation steps, Gel-based proteomics - two-dimensional gel electrophoresis (2-DE), evolution of 2DE, two-dimensional fluorescence difference in-gel electrophoresis (DIGE), Staining techniques. Applications of 2D and DIGE techniques in biological systems, merits and demerits of gel based proteomics. Two-dimensional gel electrophoresis for biomarker discovery, MudPIT.
**Week 3:** Mass spectrometry (Ionizers – ESI, MALDI, SELDI; Analyzers – Quadrupole, QIT, Magnetic sorter)
**Week 4:** Mass spectrometry (Analyzers – TOF, TOF-Ref, FTMS; detectors) and its application in proteomics. Mass spectrometry data analysis - computational/bioinformatics tools.
**Week 5:** Quantitation proteomics – ICAT, SILAC, iTRAQ, applications of quantitation proteomics. Proteomic profiling for host-pathogen interaction, Understanding proteomics for

post-translational modifications.
**Week 6:** Interaction Proteomics: Protein-Protein Interaction (PPI) and its application in proteomics. Methods to study PPI. Yeast two-hybrid, bacterial two-hybrid system, immunoprecipitation, protein microarrays, Nucleic Acid Programmable Protein Array (NAPPA), Label-free nanotechnologies in proteomics, Surface Plasmon Resonance (SPR)
**Week 7:** Application of proteomics for drug discovery. Biomarkers and drug targets identification. Validation of drug targets and assessment of its toxicology
**Week 8:** Bioinformatics and proteomics: computational models of proteomics networks.
**Week 9:** Mid-term Internal Assessment test, power-point presentation by students as part of their assessment on various topics
**Week 10:** Introduction to metabolomics world. High throughput screening systems and utility. Lessons from metabolites, metabolic fingerprinting, and metabolic profiling. Biotechnological potentials of metabolomics.
**Week 11:** Proteomics approaches in metabolomics. Analysis of differential protein expression, post-translational modifications and protein activity for metabolomics.
**Week 12:** HPLC and FPLC based approaches in metabolomics. Criteria for the selection of chromatography methods and their importance in metabolomics.
**Week 13:** Application for cellular metabolomics for metabolic pathway structure. Size of metabolome, metabolite identification, pathway identification and pathway integration. Computational approaches for metabolite identification and translation of results into biological knowledge.
**Week 14:** Metabolite profiling for infectious disease. Application of metabolite profiling in heart disease. Metabolic signature and metabolite profiling in heart disease.
**Week 15:** Metabonomics in preclinical pharmaceutical discovery and development. Analytical considerations and biological aspects and applications. Course revision, End-term internal assessment test, solving problems.

(* The weekly design of teaching plan is indicative in nature and there may be deviations based on teaching requirements and batch to batch variations in basic understanding and responsiveness)

**Facilitating the achievement of Course Learning Outcomes**

| Unit No. | Course Learning Outcomes | Teaching and Learning Activity | Assessment Tasks |
|---|---|---|---|
| I. | Students will be introduced to the field of proteomics and they will learn about the usefulness of the field of proteomics. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted both through black board mode and power point presentation mode. | Mid-term internal assessment test will be conducted. |

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| II. | They will learn various proteomics techniques, their detailed methodology and instrumentation involved. Students will gain a detailed knowledge of mass spectrometry along with its various components and its applicability in proteomics and metabolomics. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Videos for explaining the mass spectrometry technology will be shown in the class for a better understanding of the concepts. Teaching will be conducted both through black board mode and power point presentations mode | Mid-term internal assessment test will be conducted. They will be given quiz to analyze the mass spectrometry problems and perform data analysis. |
| III. | Students will acquire insight into various applications of proteomics tools in research (biomarker discovery and drug discovery). | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Research articles using the proteomics tools for various research applications will be discussed. Teaching will be conducted both through black board mode and power point presentations mode | Mid-term internal assessment test will be conducted. Students will be asked to prepare and present research/review articles related on various topics assigned to them. |
| IV. | Students will be introduced to the field of metabolomics and its general utility. | Students will be asked to orally revise the previous class before every new class helping them in better understanding and | End-term internal assessment test will be conducted. |

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| | | their doubts cleared, if any. | |
| V | Students will gain knowledge about the concepts of metabolomics and the applications of these tools. | Research articles using the metabolomics tools for various research applications will be discussed. Teaching will be conducted both through black board mode and power point presentations mode | End-term internal assessment test will be conducted. |
| VI | Students will learn about the concepts of metabonomics and various applications of metabonomics in biomarker analysis and drug discovery | Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Research articles for the applications of metabonomics will be discussed. Teaching will be conducted both through black board mode and power point presentations mode | End-term internal assessment test will be conducted. |