



## UNIVERSITY OF CALICUT

### Abstract

General and Academic IV - Faculty of Science- Modified Scheme and Syllabus of M.Sc. Biotechnology CCSS PG programme, with effect from 2024 admission in accordance with the Regulations for CCSS in the University Teaching Departments, with multiple entry and exit options (2024) - Approved- Implemented- Orders Issued.

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### **G & A - IV - J**

U.O.No. 13615/2025/Admn

Dated, Calicut University.P.O, 27.09.2025

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- Read:-*1. U.O.No. 15360/2024/Admn dated 07.10.2024.  
2. U.O. No. 5258/2025/Admn dated 27.03.2025.  
3. Remarks from Chairperson, Board of Studies in Biotechnology (SB) dated 02.09.2025.  
4. Approval of the Dean, Faculty of Science dated 09.09.2025.  
5. Orders of the Vice-chancellor on 26.09.2025.

### ORDER

1. The scheme and syllabus of MSc Biotechnology (CCSS) programme in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024), was implemented in the University of Calicut with effect from 2024 Admission , vide paper read (1).
2. Vide the paper read (2), sanction was accorded to implement the resolutions outlined in the minutes of the meeting CCSS PG Academic Committee held on 10.03.2025, including the amendments made in the Regulations for CCSS in the University teaching departments with multiple entry and exit options (2024).
3. The Board of studies in Biotechnology (Single Board), vide paper read(3),incorporated the necessary amendments and recommended to approve the modified scheme and syllabus of MSc Biotechnology (CCSS) programme, with effect from 2024 Admission onwards, in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024) .
4. The Dean, Faculty of Science, vide paper read (4), approved the recommendation of the Board of Studies in Biotechnology (Single Board).
5. The Vice Chancellor has approved the above recommendation and accorded sanction to implement the modified scheme and syllabus of M.Sc Biotechnology (CCSS ) Programme offered by Department of Biotechnology, University of Calicut, with effect from 2024 admission, in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024), exercising the powers as per section 10(13) of Calicut

University Act 1975.

6. The modified Scheme and Syllabus of M.Sc Biotechnology (CCSS) programme in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024), is thus Implemented with effect from 2024 Admission.
7. U.O.No. 15360/2024/Admn dated 07.10.2024 stands modified to this extent.
8. Orders are issued accordingly. (Syllabus appended)

Ajayakumar T.K

Assistant Registrar

To

The Head, Department of Environmental Sciences

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Section Officer



**2 year PG Biotechnology / Semester 7-10 FYUGP**

**FYUGP Curriculum**

2024 Admission Onwards

**Dept of Biotechnology**  
University of Calicut  
Calicut University PO,  
Malappuram, Kerala  
673635

**DEPARTMENT OF BIOTECHNOLOGY  
UNIVERSITY OF CALICUT**

**M. Sc. BIOTECHNOLOGY PROGRAM (CCSS – OBE)**

**1. VISION AND MISSION**

**VISION**

To achieve excellence in education and research through a cutting-edge curriculum, innovative teaching methods, and leadership in high-impact research.

**MISSION**

- **Educational Excellence:** Deliver a cutting-edge curriculum that equips students with advanced knowledge in emerging areas of biotechnology, supported by innovative teaching methods and hands-on laboratory experiences.
- **Research Innovation:** Foster a culture of inquiry and innovation, encouraging faculty and students to undertake high-impact research projects addressing local and global biotechnology challenges.
- **Industry and Entrepreneurial Collaboration:** Build strong partnerships with biotechnology companies, research institutes, and government agencies to facilitate collaborative research, internships, and entrepreneurship through startup initiatives, incubation facilities, mentorship programs and job placements.
- **Sustainable and Inclusive Practices:** Focus on sustainable and eco-friendly biotechnological solutions that address climate change, food security, and environmental conservation. Ensure inclusive growth by engaging underrepresented communities and promoting diversity within the department.
- **Global Engagement:** Forge partnerships with leading international universities and research institutions for student and faculty exchanges, joint research projects, and global learning opportunities, preparing students to be globally competent professionals.
- **Community Impact and Public Awareness:** Engage with the local community through outreach programs that educate and raise awareness about the benefits and ethical considerations of biotechnology. Conduct workshops, seminars, and public lectures to disseminate knowledge and foster dialogue between scientists and the public.
- **Infrastructure and Resource Mobilization:** Develop and maintain world-class laboratories, research centers, and teaching facilities that provide a conducive environment for cutting-edge research and education. To support the department's growth and development initiatives, secure diverse funding sources, including government grants, private sector investments, and international grants.

### 3. MSc Biotechnology PROGRAMME STRUCTURE

The MSc Biotechnology programs offered by the department under the 'Calicut University Regulations for Choice-based Credit Semester System (CCSS), 2024'. Admissions shall be conducted through entrance examinations.

**3.1 Two-Year M. Sc. Biotechnology Degree (after 3-year B. Sc. Biotechnology):** The students who acquire a minimum of 88 credits as per the credit structure in the 4<sup>th</sup> and 5<sup>th</sup> year at 500 and 600 academic levels, will be awarded a two-year M. Sc. Biotechnology degree.

**3.2 One-Year M. Sc. Biotechnology Degree** (after 4-year B. Sc. Biotechnology Honours): Graduates with four-year B. Sc. Honours degree in Biotechnology will be eligible for this course. They have to acquire a minimum of 44 credits as per the credit structure in the 5<sup>th</sup> year of the 600 academic level and will be awarded a one-year M. Sc. Biotechnology degree.

### 4. PROGRAMME DURATION AND CREDIT STRUCTURE

**4.1. Academic Calendar:** An academic year includes 200 working days, divided into two semesters and with a summer break. Each semester consists of 90 academic days and 10 for co-curricular and orientation activities, spanning 18 weeks with 5 working days each.

**4.2. Instructional Hours:** A semester offers 450 instructional hours, with 15 days reserved for exams and related activities. The curriculum is designed for 15 weeks of transactions per semester.

**4.3. Program Duration and Semester Allocation:** The 2-year PG program includes four semesters over two years. Odd semesters (VII and IX) will be from June to October, while even semesters (VIII and X) will be from November to March.

### 5. STRUCTURE OF CURRICULAR CONTENTS

This curriculum is comprised of two broad components, namely: (i) Discipline Specific Pathway Components, and (ii) Discipline Specific Capstone Components.

**5.1. Discipline Specific Pathway Components (Major/Minor):**

**5.1.1. Major Component:** Main focus of study allowing students to delve into the particular subject of study.

**5.1.2. Minor Component:** Supplementary courses that can be related or unrelated to the primary area of study.

**5.2. Capstone Level Courses:** This aims for the students to showcase their comprehensive knowledge through advanced courses, internships, fieldwork, research projects etc.

**5.2.1. Internship:** All students shall undergo an Internship or Apprenticeship in a firm, industry, or organization, or training in labs with faculty and researchers of their institution or other research institutions during the summer vacation

**5.2.2. Research Project/Dissertation:** All students shall undertake a Research Project under a supervisor having 20 credits (600 level) during Semester X.

## **6. ATTENDANCE**

- 6.1.** Class participation is one of the most important ways by which students acquire knowledge and understand course materials.
- 6.2.** Absence from classes due to valid reasons may be treated as authorized absence and appropriate chances for make-up shall be provided to ensure timely completion of the course.
- 6.3.** The authorized absence includes absence due to participation in meetings or events organized by the department or the University, or in a regularly scheduled curricular or extracurricular activity prescribed by the college or the University, and absence due to unavoidable or other legitimate circumstances such as illness, injury, family emergency, care-related responsibilities, severe weather conditions, academic or career-related interviews, etc. Apart from this, all other eligible leaves such as maternity leave, and menstrual leave shall also be treated as authorized absences.
- 6.4.** Participation in such activities may be treated as presence *in lieu* of their absence on the production of participation/ attendance certificate (within two weeks) in curricular /extracurricular activities (maximum 9 days in a semester).
- 6.5.** The minimum requirement of attendance during a semester shall be 75% for male students for each course and an exemption of 3% is sanctioned to female students. Attendance shall be maintained by the course teacher. 10% condonation can be granted on the attendance requirements by the Chairman of the Academic Committee on genuine grounds, provided it is also recommended by the Department Council. A fee for this purpose may be collected as prescribed by the Academic Committee and approved by the Syndicate.
- 6.6.** Candidates who do not satisfy the required minimum attendance in a course shall be awarded zero grade points in that course. Such a student can write the examination for the entire courses of the semester in which a shortage of attendance occurs as supplementary examination only after the completion of the entire programme.
- 6.7.** If the attendance is less than 50%, the student is ineligible to continue the programme and has to seek readmission.
- 6.8.** A minimum requirement of attendance 50% can be sanctioned for genuine reasons to attend the final examinations by collecting appropriate fees as prescribed by the Academic Committee and approved by the Syndicate.

## **7. ASSESSMENT AND EVALUATION**

The assessment and evaluation of each course during every semester will have two modes: Continuous evaluation and End-semester evaluation.

- 7.1. Continuous Assessment:** 50% of weightage will be given to the continuous (internal) evaluation. Each semester has continuous evaluation, by the teacher who is conducting the course. The continuous assessment shall be based on a predetermined transparent system involving periodic written tests, viva-voce, seminars, and attendance in respect of theory courses and based on written tests, viva-voce, and lab skill/records in respect of practical courses as detailed below:

| Course     | Criteria                                                                                                                   | Marks | Total |
|------------|----------------------------------------------------------------------------------------------------------------------------|-------|-------|
| Theory     | Attendance*                                                                                                                | 5     | 30    |
|            | Assignment/Seminar/GD                                                                                                      | 5     |       |
|            | Written Test                                                                                                               | 25    |       |
| Practicals | Lab Skill /Quality of Records<br>Practical Test<br>Viva Voce/ Seminar Presentation/Advanced Research<br>Paper Presentation |       | 20    |

**\*(Attendance – G5% s above: 5marks, G0 to G5%: 4 marks, 85 to G0%: 3 marks, 80 to 85%: 2 marks, 75 to 80%: 1mark, below 75%: Nil)**

To ensure transparency in the evaluation process, original answer scripts of the test paper will be returned to the students after evaluation within a week of the conduct of the tests. Any dispute regarding the continuous assessment shall be taken up with the concerned teacher within 48 hours. The continuous assessment marks awarded to the students in each course in a semester shall be notified on the notice board at least one week before the commencement of the relevant end-semester examination.

The students (2024 admission) can register for quality assured MOOC Courses with 4 credits in various combinations (4 / 1+3/ 2+2 ) based on the availability in online programmes offered on the Study Webs of Active Learning for Young Aspiring Minds (SWAYAM) or other online educational platforms approved by the department council from time to time. If suitable MOOC Courses with grades and credit details are not available at online portals, the Department Council will offer offline courses as alternatives to MOOC.

Failure in MOOC courses and reattempts to secure sufficient MOOC credits to the Programme requirements are the sole responsibility of the students.

Students can enrol in MOOC courses with more than 4 credits ( MOOC courses with higher credits above 4) , but the Pareekshabhavan /University will only consider the 4 credits acquired for the semester.

**SGPA grade point and MOOC evaluation:** Credits and marks for the MOOC courses from the Swayam portal or the other department council approved organizations attended by students are considered directly as per UGC directions; no further re-evaluation of MOOC courses is needed.

Any disparity in the course title, content, credit, Grade attained by the candidates or any other matter related to MOOC courses will be settled by the Department council in concurrence with CCSS as per the requirement without compromising the quality standards.

- 7.2. End Semester Examination:** 50% weight shall be for the end semester examination. Each course (theory) will have an end-semester examination after the completion of the syllabus prescribed for that particular semester. The students can apply for a Save a Year (SAY) examination for the Final semester examination by applying within 7 days from the publication of results.

| Theory Examination                                   | Marks |
|------------------------------------------------------|-------|
| A written examination with double internal valuation | 50    |

- 7.3. Evaluation scheme for the Project/Dissertation:** The valuation shall be jointly done by the supervisor of the project in the department and an expert from the approved panel, based on a well-defined scheme of valuation. If internal experts are not available in the department, the Chairman has the power to nominate an expert from other departments in the university or any other reputed institution as a special case. The following break-up is suggested for the valuation. The concerned Department Council/ Board of Studies may decide on an alternative break-up, if required, specific to the discipline of study.

| Sl. No.      | Criterion                                                                    | Weightage (%) |
|--------------|------------------------------------------------------------------------------|---------------|
| 1            | Review of Literature and formulation of the Research Problem/ Objectives     | 20            |
| 2            | Methods and Description of the techniques used                               | 15            |
| 3            | Analysis and Discussion of results                                           | 30            |
| 4            | Presentation of the report, organization, linguistics style, references etc. | 15            |
| 5            | Viva-voce examination based on the Project work/Dissertation                 | 20            |
| <b>Total</b> |                                                                              | <b>100</b>    |

## 8. GRADING

- 8.1.** The indirect absolute grading system, in which marks are compounded to grades based on pre-determined class intervals and letter grades based on the UGC-recommended 10-point grading system shall be used.
- 8.2.** Students are graded in each course based on the percentage of marks earned (continuous assessment and end-of-semester examination marks combined) using the grading system shown below:

| Range of Marks (%) | GradePoint | LetterGrade |             |
|--------------------|------------|-------------|-------------|
| 90–100             | 9.0–10.0   | O           | Outstanding |

|           |          |     |                     |
|-----------|----------|-----|---------------------|
| 80–89.99  | 8.0–8.99 | A+  | Excellent           |
| 70–79.99  | 7.0–7.99 | A   | Very Good           |
| 60–69.99  | 6.0–6.99 | B+  | Good                |
| 50–59.99  | 5.0–5.99 | B   | Above Average       |
| 45–49.99  | 4.5–4.99 | C   | Average             |
| 40–44.99  | 4.0–4.49 | D   | Pass*               |
| 0 – 39.99 | 0        | F   | Failed/RA(Reappear) |
| –         | 0        | Abs | Absent              |

\* Pass only if the student scores a minimum 40% in the end-semester examination). There is no separate minimum for continuous evaluation.

Remarks: Pass minimum for each course is 40%; and that for aggregate (continuous assessment + End semester) is 40% and hence % marks range from 0 – 39.99 corresponds to the letter grade 'F'.

Conversion Formula: Percentage of Marks = Grade point X10

- 8.3.** Each student shall be assigned a grade point and a letter grade in each course based on the percentage of marks scored in the course (continuous assessment and end-semester examination marks taken together) as shown above. The minimum grade point required for passing a course is 4.0.
- 8.4.** The student is required to pass all the core courses and the stipulated minimum number of elective courses in order to complete the programme successfully.
- 8.5.** After the completion of a semester, the Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given under its definition. The minimum SGPA required for the successful completion of a semester is 5.0. However, a student with an SGPA less than 5.0 in a semester is permitted to proceed to the next semester.
- 8.6.** The Cumulative Grade Point Average (CGPA) of the student is calculated at the end of a program. For the CGPA computation, only the best-performed courses with maximum credit points (P) alone shall be taken subject to the restrictions on the credits of Core and Elective courses prescribed for a specific PG degree program. The CGPA of a student determines the academic level of the student in a program and is the criterion for ranking the students.
- 8.7.** An overall letter grade (Cumulative Grade) for the whole program shall be awarded to the student based on the value of CGPA using the same criterion for assigning a letter grade for a course on the basis of the grade point. The minimum CGPA required for the successful completion of a programme is 5.0, which corresponds to 50% marks.
- 8.8.** A student who secures zero grade points (F grade) in a course is permitted to register for repeating the course when the course is offered to the next batch in case of shortage of attendance.
- 8.G.** A student who does not complete the stipulated requirements of a course gets I Grade (Course Incompletion). However, such a student shall be permitted by

the Academic Committee, with the concurrence of the Department Council, to complete the course at a later time along with the respective semester.

- 8.10.** If a student receives a grade point of less than 6.0 in a course, she or he may register for a re-examination within 7 days of the announcement of results in order to improve performance and may appear for the re-examination in the following semester for an end semester examination. However, there will be no opportunity for continuous evaluation improvement. The student need not attend classes for a re-examination course. When registering for a re- examination course, the candidate will be awarded the higher of the marks obtained during regular registration or new registration. However, the continuous assessment marks will be carried forward to determine the new grade point in the re-examination course.
- 8.11.** Courses in all programs should be completed before the commencement of the final semester. The final semester shall contain the projects, dissertation, and viva voce only.

## **9. FAIRNESS OF THE EVALUATION**

The Department Council has the responsibility to ensure a fair evaluation of the students. Any complaints from the students about the conduct of courses and evaluation or any complaints from the teacher about the students shall be enquired by the Department Council. If the council fails to sort out such complaints, it shall be reported to the Academic Committee for further enquiry by a Committee duly constituted by the Academic Committee. If the complaint still exists or prevails, the two-tier Grievance Redressal Committee will sort it out.

## **10. STUDENT EVALUATION OF THE COURSES AND TEACHERS**

There shall be a questionnaire prepared by the Academic Committee to evaluate the specific courses and the concerned teachers confidentially by the students at the end of each semester. The required questionnaire shall be designed by the Academic Committee (Appendix-I). These confidential reports must be used to improve the quality of courses and academic standards and must not be linked to teacher career advancement.

## **10. PROGRAMME SPECIFIC OUTCOMES (PSOs)**

On successful completion of the Two-year M. Sc. Biotechnology program (CCSS) of the University of Calicut, the students will be able to:

| <b>Sl. No.</b> | <b>Statements</b>                                                                                                                                                                                                               |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PSO1</b>    | <b>Advanced Knowledge and Skills in Biotechnology:</b> Master advanced biotechnology concepts, techniques, and applications in areas such as molecular biology, genetic engineering, bioinformatics, and bioprocess technology. |

|             |                                                                                                                                                                                                                                                         |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PSO2</b> | <b>Research Proficiency and Innovation:</b> Adept at designing, conducting, and analyzing independent research projects, critically evaluating scientific literature, and presenting their findings effectively.                                        |
| <b>PSO3</b> | <b>Industry Readiness and Professional Competence:</b> Acquire skills for professional careers in biotechnology through practical experience gained from internships, industry collaborations, and hands-on laboratory training.                        |
| <b>PSO4</b> | <b>Ethical and Sustainable Biotechnological Practices:</b> Understand the ethical, legal, and social implications of biotechnology and commit to sustainable practices addressing global challenges like environmental conservation and public health.  |
| <b>PSO5</b> | <b>Global and Entrepreneurial Perspectives:</b> Develop global outlook and entrepreneurial mindset, enabling them to innovate, start biotech ventures, and contribute to the international biotechnology community through collaboration and leadership |

| Sem | Level   | Course code | Disciple Specific Course                                                                  | Theory Credit | Pr. Credit | Total Credit | External Marks | Internal Marks | Total Marks |
|-----|---------|-------------|-------------------------------------------------------------------------------------------|---------------|------------|--------------|----------------|----------------|-------------|
| 7   | 500-599 | BIT07C501   | Biochemistry and Analytical techniques                                                    | 3             | 1          | 4            | 50             | 50             | 100         |
|     |         | BIT07C502   | Microbial Technology                                                                      | 3             | 1          | 4            |                |                |             |
|     |         | BIT07C503   | Cell and Developmental Biology                                                            | 3             | 1          | 4            |                |                |             |
|     |         |             | <b>Disciple Specific Electives (Any TWO)</b>                                              |               |            |              |                |                |             |
|     |         | BIT07E501   | Environmental Biotechnology                                                               | 4             |            | 4            |                |                |             |
|     |         | BIT07E502   | Enzyme Technology                                                                         | 4             |            | 4            |                |                |             |
|     |         | BIT07E503   | Cancer Genetics                                                                           | 4             |            | 4            |                |                |             |
|     |         | BIT07E504   | Molecular Neurobiology                                                                    | 4             |            | 4            |                |                |             |
|     |         | BIT07M501   | MOOC I from the list of courses approved by the Department Council or Cellular metabolism | 4             |            | 4            |                |                |             |
| Sem | Level   | Course code | Disciple Specific Course                                                                  | Theory Credit | Pr. Credit | Total Credit | External Marks | Internal Marks | Total Marks |
| 8   | 500-599 | BIT08C501   | Immunology and Immunotechniques                                                           | 3             | 1          | 4            | 50             | 50             | 100         |
|     |         | BIT08C502   | Genetics and Molecular Biology                                                            | 3             | 1          | 4            |                |                |             |
|     |         | BIT08C503   | IPR                                                                                       | 4             |            | 4            |                |                |             |
|     |         |             | <b>Disciple Specific Electives (Any ONE)</b>                                              |               |            |              |                |                |             |
|     |         | BIT08E501   | Molecular Oncology                                                                        | 4             |            | 4            |                |                |             |
|     |         | BIT08E502   | Stem Cells and Regenerative Medicine                                                      | 4             |            | 4            |                |                |             |
|     |         | BIT08E503   | Molecular Virology                                                                        | 4             |            | 4            |                |                |             |
|     |         | BIT08E504   | Food and Dairy Biotechnology                                                              | 4             |            | 4            |                |                |             |
|     |         | BIT08M501   | MOOC II from the list of courses approved by the Department Council                       | 4             |            | 4            |                |                |             |
| Sem | Level   | Course code | Disciple Specific Course                                                                  | Theory Credit | Pr. Credit | Total Credit | External Marks | Internal Marks | Total Marks |
| 9   | 600-699 | BIT09C601   | Omics and Bioinformatics                                                                  | 3             | 1          | 4            | 50             | 50             | 100         |
|     |         | BIT09C602   | Bioprocess Technology                                                                     | 3             | 1          | 4            |                |                |             |
|     |         | BIT09C603   | Genetic Engineering and Its Applications                                                  | 3             | 1          | 4            |                |                |             |
|     |         |             | <b>Disciple Specific Electives (Any TWO)</b>                                              |               |            |              |                |                |             |
|     |         | BIT09E601   | Molecular Therapeutics                                                                    | 4             |            | 4            |                |                |             |
|     |         | BIT09E602   | Research Methodology and Scientific Communication skills                                  | 4             |            | 4            |                |                |             |

|            |              | BIT09E603          | Fermentation Technology                                              | 4                    |                   | 4                   |                       |                       |                    |
|------------|--------------|--------------------|----------------------------------------------------------------------|----------------------|-------------------|---------------------|-----------------------|-----------------------|--------------------|
|            |              | BIT09E604          | Cancer Diagnostics and Therapeutics                                  | 4                    |                   | 4                   |                       |                       |                    |
|            |              | BIT09E605          | Plant and Animal Biotechnology                                       | 4                    |                   | 4                   |                       |                       |                    |
| <b>Sem</b> | <b>Level</b> | <b>Course code</b> | <b>Disciple Specific Course</b>                                      | <b>Theory Credit</b> | <b>Pr. Credit</b> | <b>Total Credit</b> | <b>External Marks</b> | <b>Internal Marks</b> | <b>Total Marks</b> |
| 10         | 600-699      | BIT10P601          | Project                                                              | Nil                  | Nil               | 20                  |                       |                       | 100                |
|            |              | BIT10C601          | <b>OR</b><br>Bio entrepreneurship                                    | 4                    |                   | 4                   | 50                    | 50                    |                    |
|            |              | BIT10C602          | Bioethics                                                            | 4                    |                   | 4                   |                       |                       | 100                |
|            |              | BIT10C603          | Marine Biotechnology                                                 | 4                    |                   | 4                   |                       |                       |                    |
|            |              | BIT10C604          | Nanobiotechnology                                                    | 3                    | 1                 | 4                   |                       |                       |                    |
|            |              | BIT10C605          | Good Laboratory and Biomanufacturing Practices                       | 3                    | 1                 | 4                   |                       |                       |                    |
|            |              | BIT10M601          | MOOC III from the list of courses approved by the Department Council | 4                    |                   | 4                   |                       |                       |                    |

## **2 year PG/ Semester 7-10 Biotechnology**

## SEMESTER 7/First Year PG Biotechnology- Semester 1

| Semester 7 FYUGP/First year PG Biotechnology Semester 1 |             |                                                                                                  |         |           |           |             |
|---------------------------------------------------------|-------------|--------------------------------------------------------------------------------------------------|---------|-----------|-----------|-------------|
| Course Level                                            | Course Code | Discipline Specific Courses                                                                      | Credits | Int Marks | Ext Marks | Total Marks |
| 500-599                                                 | BIT07C501   | Biochemistry and Analytical techniques                                                           | 4       | 50        | 50        | 100         |
|                                                         | BIT07C502   | Microbial Technology                                                                             | 4       | 50        | 50        | 100         |
|                                                         | BIT07C503   | Cell and Developmental Biology                                                                   | 4       | 50        | 50        | 100         |
|                                                         |             | <b>Discipline Specific Electives<br/>Any TWO</b>                                                 |         |           |           |             |
|                                                         | BIT07E501   | Environmental Biotechnology                                                                      | 4       | 50        | 50        | 100         |
|                                                         | BIT07E502   | Enzyme Technology                                                                                | 4       | 50        | 50        | 100         |
|                                                         | BIT07E503   | Cancer Genetics                                                                                  | 4       | 50        | 50        | 100         |
|                                                         | BIT07E504   | Molecular Neurobiology                                                                           | 4       | 50        | 50        | 100         |
|                                                         | BIT07M501   | MOOC I from the list of courses approved by the Department Council <b>or</b> Cellular metabolism | 4       | 50        | 50        | 100         |

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |  |                                          |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|--|------------------------------------------|
| BIT07C501               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Biochemistry and Analytical Techniques     |  |                                          |
| Semester 7              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Discipline Specific Courses                |  | Level: 500-599                           |
| 4 Credit                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Hours per week:5<br>Theory-3, Practicals-2 |  | Marks: 100<br>Internal- 50, External- 50 |
| Course Outcomes<br>(CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |  |                                          |
| CO1                     | Students shall gain knowledge about protein structural organization, Ramachandran plot for understanding protein structure, structure function relationship in model proteins, protein folding and pathways of protein degradation and principles of protein purification.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                            |  | R, U, An, Ap                             |
| CO2                     | Students shall acquire knowledge about the general principles of enzyme catalysis, activity quantification, enzyme characterization and regulation, relevance in metabolic regulation and catalytic strategies.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |  | R, U, An, Ap                             |
| CO3                     | Learners shall gain knowledge about the properties, structure, biological functions and structure function relationship of carbohydrates, nucleic acids and lipids.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                            |  | R, U, An, Ap                             |
| CO4                     | Students shall learn about the physical principles and applications of different microscopic and spectroscopic techniques to investigate various aspects of biomolecular structure, function, and interactions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |  | R, U, An, Ap                             |
| CO5                     | Students shall learn about the physical principles and applications of different chromatographic and electrophoretic techniques for isolation, purification as well as biochemical and functional analysis of biomolecules. They shall also gain knowledge about the principles and applications of centrifugation and filtration techniques for biomolecular isolation, purification and structural and functional characterization.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                            |  | R, U, An, Ap                             |
| Course Content          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |  |                                          |
| I                       | Protein structure/function and Enzyme catalysis: amino acids – structure and functional group properties, peptides and covalent structure of proteins, Ramachandran plot, the evolution of protein structure, structure-function relationships with reference to a model proteins like hemoglobin; Protein folding, chaperons, diseases associated with protein folding.<br>general principles of catalysis; quantification of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition, and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens. |                                            |  | 12<br>Hours                              |

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| II                | <p><b>Carbohydrates, Nucleic Acids and Lipids:</b> Structure and function Sugars – mono and disaccharides, homo and heteropolysaccharides with specific reference to glycogen, amylose and cellulose, Glycoconjugates-Structure and function, proteoglycans; glycoproteins and glycolipids, lipopolysaccharides lipids - structure, and properties of important members of storage and membrane lipids; Lipids as signaling molecules; Lipoproteins; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; the difference in RNA and DNA structure, Types of RNA and DNA and importance in the evolution of DNA as the genetic material; Chemical properties of nucleic acids.</p>                                                                                                                                                                                                                                                                    | 11 Hours |
| III               | <p><b>Spectroscopy and Microscopy:</b></p> <p>Isolation and purification of biomolecules. Electromagnetic spectrum and its interaction with biomolecule. Absorption, emission, and scattering of electromagnetic waves. Fluorescence and phosphorescence, general properties of fluorophores, FRET, FLIP and FRAP, FACS: Basics and uses. Colorimetry and Spectrophotometry: basic principle and instrumentation, Beer- Lambert's Law and its deviations. Visible/UV/fluorescent spectroscopy; Theory and application of Circular Dichroism, NMR, ESR and Mass Spectroscopy.</p> <p>Light Microscopy: Basic principles, Darkfield; Phase Contrast; Differential Interference Contrast; Fluorescence microscopy and Optical arrangement, light source; filters sets: excitation filter, optical layout for image capture; Confocal microscopy, Electron Microscopy: TEM and SEM, Preparation of specimens for Microscopy including EM. Electron tunneling and Atomic Force Microscopy, X-ray diffraction of biomolecules-DNA and Protein.</p> | 11 Hours |
| IV                | <p><b>Chromatography Techniques:</b> basic principle, Paper; Thin layer and HPTLC Chromatographic methods; Chromatographic methods for macromolecular separation — Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; pseudo-affinity and metal affinity chromatography. HPLC and FPLC.</p> <p>Electrophoretic techniques, theory and application of Polyacrylamide and Agarose gel electrophoresis, native and SDS PAGE, Capillary electrophoresis; Iso-electric focusing, 2D Electrophoresis, Gradient electrophoresis; Pulsed field gel electrophoresis. Electrophoresis mobility shift. Centrifugation- Basic principles (RCF, Sedimentation coefficient); Types of centrifuges - Micro centrifuge, High speed C Ultracentrifuges; preparative centrifugation; differential C density gradient centrifugation and their Applications; Analytical centrifugation; Brief introduction of membrane based techniques: Dialysis and reverse osmosis.</p>                                                   | 11 Hours |
| V                 | <p><b>Practicals</b></p> <ul style="list-style-type: none"> <li>• Preparation of solutions and adjustment of pH using acids, bases</li> <li>• Colorimetry and spectrometry – Beer's Lamberts law</li> <li>• Estimation of biomolecules</li> <li>• Purification of proteins – preparation, precipitation and chromatography</li> <li>• Electrophoresis – Native, Non reducing and reducing PAGE</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 30 Hours |
| <b>References</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |          |

- Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.
- Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.
- Voet, D., C Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley C Sons.
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- Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.
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- Keith Wilson and John Walker, Principles and techniques of practical Biochemistry, 5th Edition, Cambridge University Press, 2000.
- D. Holme C H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.
- R. Scopes, Protein purification-Principles C Practices, 3rd Edition, Springer Verlag, 1994.

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| BIT07C502               |                                                                                                                                                                                                                                                                                                                                                                                                                             | Microbial Technology                         |  |                                          |  |
| Semester 7              |                                                                                                                                                                                                                                                                                                                                                                                                                             | Discipline Specific Courses                  |  | Level: 500-599                           |  |
| 4 Credit                |                                                                                                                                                                                                                                                                                                                                                                                                                             | Hours per week: 5<br>Theory- 3, Practical- 2 |  | Marks: 100<br>Internal- 50, External- 50 |  |
| Course Outcomes<br>(CO) |                                                                                                                                                                                                                                                                                                                                                                                                                             |                                              |  |                                          |  |
| CO1                     | Understand the different strategies for the detection and isolation of industrially important microorganisms and it's yield improvement by improving the strain.                                                                                                                                                                                                                                                            |                                              |  | U                                        |  |
| CO2                     | Familiarise with principles of bioprocess, media and inoculum preparation and understand the importance of various bioprocess parameters in production and the importance of process control.                                                                                                                                                                                                                               |                                              |  | An                                       |  |
| CO3                     | Illustrate different types of concentration and purification methods, especially in the context of selected biotech products.                                                                                                                                                                                                                                                                                               |                                              |  | An                                       |  |
| CO4                     | Familiarize with the advantages of using recombinant strains to produce value-added products and also to understand the limitations of using it in a commercial process.                                                                                                                                                                                                                                                    |                                              |  | An                                       |  |
| Course Content          |                                                                                                                                                                                                                                                                                                                                                                                                                             |                                              |  |                                          |  |
| I                       | Isolation and screening of industrially important microorganisms from soil. Primary and secondary of microbial metabolites- strategies. Specific screening strategies for detection and isolation of antibiotic, organic acids, enzymes and vitamin producing microorganisms. Strain maintenance. Microbial strain improvement methods- physical, chemical and biological. selection of mutants and use of rDNA technology. |                                              |  | 12 Hours                                 |  |
| II                      | Basic principles as applicable to bioprocess. Cropreservation, media preparation and formulation, inoculum build-up, sterilisation of media and air, seed inoculum and it's importance in reduction of batch time, aeration and agitation, process optimisation and process control.                                                                                                                                        |                                              |  | 12 Hours                                 |  |
| III                     | Down stream processing: Concentration and purification of bioproducts with respect to selected microbial products: Penicillin, Ethanol and proteases.                                                                                                                                                                                                                                                                       |                                              |  | 10 Hours                                 |  |
| IV                      | Recombinant protein production in microbes: Range of Microbial rDNA products and Issues pertaining to its large scale production. Industrial microbes as cloning hosts( Bacteria and yeast)and it's limitations.                                                                                                                                                                                                            |                                              |  | 11 Hours                                 |  |

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| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Practicals</b> <ul style="list-style-type: none"> <li>Isolation of protease producing microbes using casein agar media.</li> <li>Isolation, purification and aseptic transfer of pigment producing soil microorganism</li> <li>Strain maintenance - agar slants, soil stocks, deep freezing-revival of cultures after one month</li> <li>Aerobic and anaerobic cultures - <i>Saccharomyces cerevisiae</i></li> <li>Effect of pH and temperature on microbial growth</li> <li>Wet and dry weight measurements of microbial biomass.</li> <li>Static filtration- concept of filter cake and filter aid</li> <li>Air filtration - maintenance of sterility</li> <li>Precipitation of proteins/ enzymes by ethanol and acetone.</li> </ul> | 30 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |
| <ul style="list-style-type: none"> <li>Reed, G: Prescott C Dunns Industrial Microbiology. CBS Publishers C Distributors. 2004</li> <li>Patel, A.H. Industrial Microbiology. Laxmi Publications. 2022</li> <li>Pankaj Kumar Arora. Microbial Technology for Health and Environment. Springer. 2020</li> <li>Arora, R., Microbial Biotechnology: Energy and Environment, CABI Publishing.</li> <li>Ahmad, I., Ahmad, F. and Pichtel, J. Microbes and Microbial Technology: Agriculture and Environmental Applications.</li> <li>Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.</li> <li>Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2<sup>nd</sup> edition. Panima Publishing Co. New Delhi.</li> <li>Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.</li> <li>Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |

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|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|--|-----------------------------------------|
| BIT07C503            |                                                                                                                                                                                                      | Cell and Developmental Biology              |  |                                         |
| Semester 7           |                                                                                                                                                                                                      | Discipline Specific Courses                 |  | Level: 500-599                          |
| 4 Credit             |                                                                                                                                                                                                      | Hours per week: 5<br>Theory-3, Practicals-2 |  | Marks: 100<br>Internal- 50, External-50 |
| Course Outcomes (CO) |                                                                                                                                                                                                      |                                             |  |                                         |
| CO1                  | Understand the structure, composition and biological functions of cell membranes. Evaluate the various membrane protein in transporting the solutes across the membrane. Analyze the cellular matrix |                                             |  | U, An                                   |
| CO2                  | Describe how and where proteins are sorted, packed and transported. Determine the molecular assembly of the cytoskeleton. Evaluate the role of cytoskeleton in maintaining cell shape, movement.     |                                             |  | U, An                                   |
| CO3                  | Explain the principle, analyze and classify signaling molecules, ligands, receptors involved in cell communications. Differentiate apoptosis and necrosis. Identify the regulators in cell cycle     |                                             |  | An                                      |
| CO4                  | Analyze the developmental stages, pattern formation, homeotic gene effects, Cell lineages and developmental control genes in <i>Drosophila</i> & <i>C elegans</i> .                                  |                                             |  | An                                      |

| Course Content |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |
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| I              | <b>Cell membrane and functions</b><br>Membrane structure and Composition- lipid bilayer, Membrane proteins, Membrane carbohydrates, glycocalyx. Principles of membrane transport - Pumps, carriers and channels. Cell junctions and cell adhesion. Extracellular matrix in animals and cell wall in plants                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 11 Hours |
| II             | <b>Protein Trafficking and Cytoskeleton</b><br>Endo-membrane systems - Endoplasmic Reticulum, Golgi complex, lysosomes, peroxisomes. Protein trafficking and sorting, - nuclear transport, import of proteins into mitochondria and chloroplast. Vesicular trafficking-exocytosis and endocytosis.<br>Cytoskeleton – microtubules, actin and intermediate filaments, associated proteins (MAPs and actin-binding proteins); cell shape and motility; Molecular motors.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 12 Hours |
| III            | <b>Cell Signaling, Cell Cycle and Apoptosis</b><br>Cell Signaling- signaling molecules C their receptors, functions of cell surface receptors: G Proteins – coupled receptors, tyrosine kinase, enzyme-linked receptors, pathways of Intracellular signal transduction: C-AMP pathway, Cyclic GMP, PI3- Kinase Phospholipids C Calcium homeostasis, RAS/ RAF C MAP kinase, JAK /STAT C TGF – $\beta$ /Smad pathways, NF- $\kappa$ B signaling, Wnt pathway, signaling based on pro- cleavage pathway (Hedgehog, Notch C SHP-2- ER signaling). Cell cycle and its regulation; Apoptosis – intrinsic and extrinsic pathways                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 12 Hours |
| IV             | <b>Developmental Biology</b><br>Cellular Movements and Pattern Formation. Differentiation of germ layers; Cellular polarity; cell memory, cell determination. Hierarchy of gene action – maternal, segmentation and homeotic gene effects in <i>Drosophila</i> ; Cell lineages and developmental control genes in <i>C.elegans</i> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 10 Hours |
| V              | <b>Cell Biology</b> <ul style="list-style-type: none"> <li>Study of mitotic stages – Onion root tip squash preparation</li> <li>Preparation and analysis of salivary gland chromosomes of <i>Drosophila</i></li> <li>Staining of buccal epithelial smear to demonstrate Barr body</li> <li>Chromosome aberration in onion root tips-demonstration by root tip squashes.</li> <li>Cell isolation and trypan blue cell exclusion test for viability</li> <li>Staining of blood film to study blood cells</li> <li>Mammalian cell culture facility, in-vitro cell culture, trypsination, cell counting and reseeding (Demo).</li> </ul> <b>Developmental Biology</b> <ul style="list-style-type: none"> <li>Lifecycle of <i>Drosophila</i> : Egg, Embryo, Larvae, Pupae and Adult Phenotypes</li> <li>Fecundity assay</li> <li>Live observation of embryonic development of <i>Drosophila</i> : To collect, prepare and examine developing live embryos of <i>Drosophila</i> (Demo)</li> <li>Study of genetic basis of segmentation in <i>Drosophila melanogaster</i> using embryonic cuticle patterns (Demo)</li> <li>Study of models with neat, labelled sketches and notes: <i>Drosophila</i>– blastula CS, gastrula CS.</li> </ul> | 30 Hours |

| References                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
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| <ul style="list-style-type: none"><li>• Alberts et al: Molecular Biology of the cell. 6th Edition. Garland Science, New York / UK</li><li>• Lodish et al; Molecular cell Biology, Latest edition, W.H. Freeman C Company, 2000.</li><li>• Cell and Molecular Biology – Concepts and Experiments by Gerald Karp. John Wiley and Sons Inc. Latest edition</li><li>• Waston et al. Molecular Biology of the gene, Latest Edition, Pearson Prentice Hall, USA.</li><li>• B.M. Turner - Chromatin C Gene regulation, Latest Edition, Wiley-Blackwell.</li></ul> |

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| BIT07E501            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Environmental Biotechnology:  |                                          |
| Semester 7           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Discipline Specific Elective  | Level: 500-599                           |
| 4 Credit             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Hours per week: 4<br>Theory-4 | Marks: 100<br>Internal- 50, External- 50 |
| Course Outcomes (CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                               |                                          |
| CO1                  | Understand different aspects of industrial and environmental pollution and it's implications.                                                                                                                                                                                                                                                                                                                                                                                              |                               | U                                        |
| CO2                  | Familiarize with different technology options for waste water using conventional and biotech methods.                                                                                                                                                                                                                                                                                                                                                                                      |                               | An                                       |
| CO3                  | Outline various applications of environmental Biotechnology in industries- paper and Pulp, leather,food and dairy industry.                                                                                                                                                                                                                                                                                                                                                                |                               | An                                       |
| CO4                  | Explain the concept of bioremediation by various techniques including biosorption and the scope of its application in various fields.                                                                                                                                                                                                                                                                                                                                                      |                               | An                                       |
| Course Content       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                               |                                          |
| I                    | Introduction to environmental Biotechnology.Different types of pollution - soil, water and air pollution. Xenobiotics and its sources. Biological magnification. Indicators of pollution,Biosensors and biochips                                                                                                                                                                                                                                                                           |                               | 10 Hours                                 |
| II                   | Technology options for the treatment of waste water: Physical, chemical and biological treatment. Aerobic processes: activated sludge,CASP, Trickling filter,RBCs and Oxidation ditches.<br>Anaerobic digestion process: Production of methane and methanogenic pathway.Anaerobic filters, anaerobic sludge membrane bioreactor, UASBR. Micro and membrane filtration process. Solid waste management.                                                                                     |                               | 12 Hours                                 |
| III                  | Applications of environmental Biotechnology in paper and pulp, leather,food and dairy industry and bioleaching                                                                                                                                                                                                                                                                                                                                                                             |                               | 12 Hours                                 |
| IV                   | Bioremediation and The role of microbes in remediation of polluted sites-in situ and ex situation Bioremediation.Biosorption using bacteria and fungi. Bioremediation of Xenobiotics - pesticides and heavy metals.Remediation of oil spills/ superbugs and biofilms.                                                                                                                                                                                                                      |                               | 11 Hours                                 |
| V                    | Microbial growth on agar medium as an indicator of air pollution.<br>Physical treatment of waste water: Flocculation-using alum<br>Use of sand filter<br>Chemical treatment of waste water:<br>Precipitation using ferric chloride<br>Settling of particles using pH adjustment<br>Aerobic waste water treatment: CASP technology<br>Trickling filter<br>Anaerobic digestion: Production of biogas from food wastes<br>Paper industry: Delignification of rice straw using lignase enzyme. |                               | 15 Hours                                 |

| References                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
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| <ul style="list-style-type: none"> <li>• Anderson L and Tilman D A. (1997) Fuels from waste, Academic Press.</li> <li>• Christon, J. Harst (1997) Manual of Environmental Microbiology, ASM Press, Washington DC.</li> <li>• Ericksson Ed., (1997) Biotechnology in the pulp and paper industry, Springer –Verleg.</li> <li>• Evans G G and Judy Furlong., (2011) Environmental Biotechnology: Theory and Application (2nd Ed.).Wiley publications.</li> <li>• Industrial pollution management by jogand.</li> </ul> |  |

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| BIT07E502            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Enzyme Technology              |                                          |          |
| Semester 7           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Discipline Specific Elective   | Level: 500-599                           |          |
| 4 Credit             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Hours per week: 4<br>Theory- 4 | Marks: 100<br>Internal- 50, External- 50 |          |
| Course Outcomes (CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                |                                          |          |
| CO1                  | Learn the basics of Enzymology, Role in catalysing the biological reaction by reducing activation energy                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                |                                          | U        |
| CO2                  | Understand the Enzyme kinetics, inhibition, mathematical equations and different graphical representation                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                |                                          | U        |
| CO3                  | Understand Enzyme regulation and multienzyme complexes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                |                                          | An       |
| CO4                  | Application of Enzyme Medical, industrial and research applications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                |                                          | An       |
| CO5                  | Practical experience in enzyme activity measurements                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                |                                          | An       |
| Course Content       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                |                                          |          |
| I                    | Basic principle of enzyme reaction energetics<br>Historical aspects enzymes as biocatalyst. Similarity and difference between chemical catalysts and enzymes Utility of enzyme in medical industrial, food and research applications. Concept of activation energy and the role of enzyme in decreasing activation energy. Lock and key and induced fit hypothesis. Catalytic site and the general properties. Enzyme activity measurements, different units, specific activity. Factors influencing enzyme activity. end point and Kinetic analysis of enzyme activity               |                                |                                          | 12 Hours |
| II                   | Enzyme classification and kinetics<br>Classification and nomenclature- classical C EC recommendation. Coenzymes ,Active site. Fast Kinetics Enzyme kinetics- single substrate, M.M equation, determination of Vmax C Km, Turnover number Kcat, Efficiency of enzyme LB plot, Eadie-Hofstee Plot and Hanes plot. Sequential and ping pong mechanism. Mechanism of enzyme action catalytic strategies with examples- general acid base catalysis. Covalent catalysis, Metal ion catalysis, Catalysis by approximation C orientation. Catalysis by preferential transition state binding |                                |                                          | 12 Hours |
| III                  | Enzyme Inhibition and regulation<br>Enzyme inhibition- Mechanism and rate studies. Reversible and irreversible inhibition. Reversible enzyme inhibition- competitive, non competitive and                                                                                                                                                                                                                                                                                                                                                                                             |                                |                                          | 12 Hours |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | uncompetitive inhibition. LB plot for inhibitors Enzyme regulation- Allosteric regulation, zymogen activation, covalent modification. Cooperatively- MWC and sequential mode of allosteric enzyme. Hill coefficient. Multi-enzyme complex, pyruvate dehydrogenase, fatty acid synthetase, glutamine synthetase |          |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Medical applications of Enzymes</b><br>Enzyme application: quantification using enzymes; Glucose estimation In Clinical laboratory Diagnostic application, Enzyme profile: Heart, Kidney, Cancer Therapeutic application. Use of enzyme in synthetic antibiotic                                             | 12 Hours |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Industrial application<br>enzymes in Biotransformation, steroid biotransformation, Use of Immobilised enzymes, Enzyme biosensors<br>Enzymes in research: Enzymes used in recombinant DNA technology                                                                                                            | 12 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                |          |
| <ul style="list-style-type: none"> <li>• Biochemistry. Jeremy M. Berg John and Tymoczko Lubert Stryer. W H Freeman C Co. NY.</li> <li>• Biochemistry. Jeffery Zubay. Wm C Brown Pub.</li> <li>• Biochemistry. Mathews C K and KE van Holde. Benjamin Cumming Pub. Co.</li> <li>• Biochemistry with Clinical Correlation. Thomas M Devlin. Wiley- Liss Publication</li> <li>• Enzymes. M. Dixon, et al, Longmans, London</li> <li>• Lehninger's Principle of Biochemistry. Nelson L D and M M Cox. Macmillan Worth Publication Inc.</li> <li>• Biochemistry. Donald Voet, Judith G Voet, Charlottew Pratt. John Wiley and Sons.</li> <li>• Textbook of Medical Physiology. Guyton C Hall</li> <li>• Fundamentals of Enzymology. Nicholas C. Price CLews Stevens, Ox.Uni. Press.</li> <li>• Enzymes: Biochemistry, Biotechnology, Clinical chemistry. T Palmer. East West Press</li> </ul> |                                                                                                                                                                                                                                                                                                                |          |

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| BIT07E503                   | <b>Cancer Genetics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                 |                 |
| <b>Semester 7</b>           | <b>Discipline Specific Elective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Level: 500-599</b>                           |                 |
| <b>4 Credit</b>             | <b>Hours per week: 4</b><br>Theory-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Marks: 100</b><br>Internal- 50, External- 50 |                 |
| <b>Course Outcomes (CO)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 |                 |
| <b>CO1</b>                  | Students will gain knowledge about the concept of cancer as a genetic disease, and the mechanism of cancer progression.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | R, U,                                           |                 |
| <b>CO2</b>                  | Learners will develop an understanding about the oncogenes and tumor suppressor genes and their functions. They also will develop an understanding about the various mechanisms of activation /inactivation of these genes during cancer progression.                                                                                                                                                                                                                                                                                                                                                                                                                  | R, U, An                                        |                 |
| <b>CO3</b>                  | Students will learn about the various cellular processes that are deregulated during the progression of cancer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | R, U, An                                        |                 |
| <b>CO4</b>                  | Students will learn about how the knowledge about cancer genetics could be translated into gene-based diagnostics and therapeutics and prevention strategies.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | R, U, An, Ap                                    |                 |
| <b>Course Content</b>       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 |                 |
| <b>I</b>                    | <b>Introduction to human cancers:</b> An overview of the cancer problem; epidemiology of cancer, Causes of cancer; Cancer and environment -physical, ionizing and non-ionizing radiation, chemical agents and radio nuclides, biological carcinogens; viruses in cancer; sporadic and hereditary cancer.                                                                                                                                                                                                                                                                                                                                                               |                                                 | <b>10 Hours</b> |
| <b>II</b>                   | <b>Cancer diagnosis and therapy :</b> General characteristics and hallmarks of cancers and cancer cells, cancer diagnosis; tumor markers-tumor specific and tumor associated markers, cancer prevention –primary and secondary prevention strategies, cancer therapy.                                                                                                                                                                                                                                                                                                                                                                                                  |                                                 | <b>12 Hours</b> |
| <b>III</b>                  | <b>Cancer genetics:</b> Genetic changes in cancer cells; Inherited cancer predisposition; Oncogenes, retroviral oncogenes -function of oncogenes; Activation of oncogenes- RAS family, complex genomic arrangements and gene amplification –the MYC gene family, chromosomal translocation-BCR-ABL gene; Tumour suppressor Genes, Retinoblastoma and Knudson’s two-hit hypothesis, Inactivation of TS genes- The “second hit” and Loss of heterozygosity, PRb and cell cycle, P53 functions and its inactivation,APC in hereditary and sporadic cancer, classification of tumor suppressor genes and its role in hereditary cancers, Mechanisms of cancer epigenetics. |                                                 | <b>11 Hours</b> |
| <b>IV</b>                   | <b>Cell transformation and Carcinogenesis:</b> mechanism of carcinogenesis, cancer genes associated with cell proliferation and survival, defects in DNA repair and genetic instability; cell protection mechanisms in cancer.; Cell cycle check point and cancer; telomerase activity, Inhibition of apoptosis, invasion and metastasis, heterogeneity and clonal evolution, Colon cancer as a model for carcinogenesis.                                                                                                                                                                                                                                              |                                                 | <b>12 Hours</b> |
| <b>V</b>                    | <b>Cancer Genetics in the clinic:</b> Uses of genetic information-Elements of cancer risk, Detection of germline cancer genes in carriers, mutated genes as cancer biomarkers, gene based assays for early diagnosis of cancer, targeting mutated                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 | <b>15 Hours</b> |

|                                                                                                                                                                                                                                                                                                                                                                                                                       |                                   |  |
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|                                                                                                                                                                                                                                                                                                                                                                                                                       | gene products for cancer therapy. |  |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                     |                                   |  |
| <ul style="list-style-type: none"> <li>Genetics of Cancer: Genes Associated with Cancer invasion, Metastasis and Cell Proliferation;</li> <li>GV Sherbet and M S Laksmi; Academic Loress</li> <li>The Biology of Cancer; Robert A Weinberg; Garland Science.</li> <li>Alberts et al., Molecular Biology of the Cell, Carland 2008.</li> <li>Molecular Genetics of Cancer, 2nd Revised Edition, Bios, 2001.</li> </ul> |                                   |  |

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|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|--|
| BIT07E504                   | <b>Molecular Neurobiology:</b><br><b>PSO:</b><br>The course will provide in-depth molecular and cellular neurobiology knowledge emphasizing human neurobiology. The introduction focuses on neurodevelopment, neuroanatomy, type of nervous system cells, and mechanisms of neural communication. During the later phases of this course, students will learn more about integrated functions of the nervous system like sensory processing and the programming of motor functions. In addition, students will also get a basic understanding of how new memories are formed, stored, and retrieved in the brain. The course also focuses on the neuroscience of brain diseases and describes the current neuroscience research methods. |                                                 |  |
| <b>Semester 7</b>           | <b>Discipline Specific Elective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Level: 500-599</b>                           |  |
| <b>4 Credit</b>             | <b>Hours per week: 5</b><br>Theory-3, Practical-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Marks: 100</b><br>Internal- 50, External- 50 |  |
| <b>Course Outcomes (CO)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                 |  |
| <b>CO1</b>                  | Demonstrate a solid understanding of basic neuroanatomy and nervous system function at molecular, cellular and systems levels. Describe the structure and function of nervous system cell types                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | U                                               |  |
| <b>CO2</b>                  | Describe how neurons are connected and how they communicate and control our behavior. Describe the functions of the nervous system - regulation of sensation, integration and response, with special emphasis on cognitive functions like learning and memory.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | An                                              |  |
| <b>CO3</b>                  | Describe neurological disorders such as Parkinson’s Disease, Alzheimer’s disease, Amyotrophic lateral sclerosis (ALS), Huntington’s disease, Schizophrenia, psychiatric disorders, Traumatic Brain Injury and Stroke<br><br>Explain current neurobiological techniques, such as brain histology, optogenetics, electrophysiology, CLARITY, behavioral analyses and transgenics.                                                                                                                                                                                                                                                                                                                                                          | An                                              |  |
| <b>CO4</b>                  | Analyze a given theoretical problem/case, identify gaps in knowledge and retrieve knowledge independently to be able to present a scientifically sound solution.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Ap                                              |  |
| <b>Course Content</b>       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                 |  |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Organization of the nervous system: CNS, PNS, Neuroanatomy, Meninges, Cerebrospinal fluid, Blood-Brain Barrier, Neuron structure, classification and function, Glial cells: Structure and function of glial cells, Glial – Neuronal interaction, Neurotrophic factors, Neurogenesis-Birth and migration of neurons, Neural stem cells, Brain aging.                                                                                                                                                                                         | 10 Hours |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Neurotransmission- Propagation of nerve impulses and molecular mechanisms: Biological and electrical properties of neurons, Membrane Potential, Action Potential, Molecular mechanisms of generation of action potential, Propagation of Action Potentials, Synaptic Transmission, Neurotransmitters- chemistry, synthesis, storage, release and uptake, Neurotransmitters Receptors- Ionotropic, Metabotropic; Postsynaptic Mechanisms, Synaptic Integration, Long-Term Potentiation and Depression, Synaptic Plasticity, Hebb's Postulate | 12 Hours |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Neural Control Systems: Sensory The Visual System, Audition, Vestibular Sensation and Chemical Senses, Movement and Motor Control.<br>Neuroendocrinology- Overview of hypothalamic and pituitary hormones, endocrine secretions and feedback control; Pineal gland circadian rhythm<br>Neuroimmunology-Role of astrocytes and microglial cells in inflammation, NeuroAIDS                                                                                                                                                                   | 11 Hours |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Complex Brain Functions and Brain Disorders: Sleep; Brain Waves and Sleep Stages, Reward and Addiction, Learning and Memory; Cognitive development, Short-term, long-term and Working Memory<br>Neurodegenerative disorders- Parkinson's, Alzheimer's, and Huntington's Diseases, Amyotrophic Lateral Sclerosis, Epilepsy, Anxiety C PTSD                                                                                                                                                                                                   | 12 Hours |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Open ended Unit/Demo</b><br>• <b>Techniques in Neuroscience</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 30 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |
| <ul style="list-style-type: none"> <li>Principles of Neural Science (5 th Edition) by Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell, McGraw Hill Education; 2012</li> <li>Neuroscience (6th Edition) by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony Samuel La Mantia, Richard D. Mooney, Michael L. Platt, Leonard E. White; 2017</li> <li>Basic Neurochemistry. Molecular, Cellular and Medical aspects (8 th Edition) by George J. Siegel, Bernard W. Agra off, R. Wayne Albers, Stephen K. FisherC Michael D. Uhler.; 2011</li> <li>From Neuron to Brain (5th Edition) by John G. Nicholls, A. Robert Martin, David A. Brown, Mathew E. Diamond, David A. Weisblat, Paul A. Fuchs; 2012</li> <li>Neurobiology (3rd Edition) by Gordon M. Shepherd, 1994</li> <li>Molecular Neurobiology, A Practical Approach-1. Chad and H. Wheal; 1991</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |

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|-------------------|--------------------------------------|-------------------------------------------------|
| <b>BIT07M501</b>  | <b>Cellular metabolism</b>           |                                                 |
| <b>Semester 7</b> | <b>MOOC I</b>                        | <b>Level: 500-599</b>                           |
| <b>4 Credit</b>   | <b>Hours per week: 4</b><br>Theory-4 | <b>Marks: 100</b><br>Internal- 50, External- 50 |

| <b>Course Outcomes<br/>(CO)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----------|
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | The students shall gain fundamental knowledge on various biochemical pathways that regulate carbohydrate metabolism and shall understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.                                                                                                                                                                                                                     | U  |          |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | The students shall gain fundamental knowledge on various biochemical pathways regulating the nucleotide metabolism and shall understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.                                                                                                                                                                                                                      | An |          |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | The students shall gain fundamental knowledge on various biochemical pathways regulating lipid metabolism and protein turn over and shall understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.                                                                                                                                                                                                         | An |          |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | The students shall gain fundamental knowledge about various classes of vitamins, their sources, chemical nature and deficiency diseases in the context of their metabolic functions of vitamins.                                                                                                                                                                                                                                                                   | Ap |          |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |          |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Carbohydrate metabolism Part 1: glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; disorders of carbohydrate metabolism. |    | 12 Hours |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Carbohydrate metabolism Part 2: Glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway                                                                                                                                       |    | 12 Hours |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Nucleotide metabolism -<br>Purine and pyrimidine biosynthesis-de novo pathway and salvage pathway; purine and pyrimidine breakdown; Metabolic disorders in the context of nucleotide metabolism; HAT medium                                                                                                                                                                                                                                                        |    | 12 Hours |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Lipid and amino acid metabolism: Fatty acid synthesis and breakdown [Beta oxidation]; cholesterol synthesis and regulation by mevalonate pathway; disorders of lipid metabolism; Protein turnover and amino acid metabolism, Inborn errors in metabolism; phenyl ketonuria and alkaptonuria; urea cycle                                                                                                                                                            |    | 12 Hours |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Vitamins and co-factors in metabolism: Introduction to vitamins, daily requirements and storage of vitamin, classification of vitamins, chemical nature and metabolic functions of vitamins, vitamin deficiency diseases.                                                                                                                                                                                                                                          |    | 12 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |          |
| <ul style="list-style-type: none"> <li>• Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.</li> <li>• Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.</li> <li>• Voet, D., C Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley C Sons.</li> <li>• Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261.</li> <li>• Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.</li> <li>• Freifelder D.; Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd edition, W.H. Freeman C Company, San Fransisco, 1982.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |    |          |

- Keith Wilson and John Walker, Principles and techniques of practical Biochemistry, 5th Edition, Cambridge University Press, 2000.
- D. Holme C H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.
- R. Scopes, Protein purification-Principles C Practices, 3rd Edition, Springer Verlag, 1994.

## Semester 8/First Year PG Biotechnology Semester 2

| Semester 8 FYUGP/First year PG Biotechnology Semester 2 |             |                                                                           |         |           |           |             |
|---------------------------------------------------------|-------------|---------------------------------------------------------------------------|---------|-----------|-----------|-------------|
| Course Level                                            | Course Code | Discipline Specific Courses                                               | Credits | Int Marks | Ext Marks | Total Marks |
| 500-599                                                 | BIT08C501   | Immunology and Immunotechniques                                           | 4       | 50        | 50        | 100         |
|                                                         | BIT08C502   | Genetics and Molecular Biology                                            | 4       | 50        | 50        | 100         |
|                                                         | BIT08C503   | IPR                                                                       | 4       | 50        | 50        | 100         |
|                                                         |             | <b>Discipline Specific Electives<br/>Any ONE</b>                          |         |           |           |             |
|                                                         | BIT08E501   | Molecular Oncology                                                        | 4       | 50        | 50        | 100         |
|                                                         | BIT08E502   | Stem Cells and Regenerative                                               | 4       | 50        | 50        | 100         |
|                                                         | BIT08E503   | Molecular Virology                                                        | 4       | 50        | 50        | 100         |
|                                                         | BIT08E504   | Food and Dairy Biotechnology                                              | 4       | 50        | 50        | 100         |
|                                                         | BIT08M501   | MOOC II- MOOC from the list of courses approved by the Department Council | 4       |           |           |             |

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|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--|
| BIT08C501            | Immunology and Immunotechniques                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |  |
| Semester 8           | Discipline Specific Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Level: 500-599                           |  |
| 4 Credit             | Hours per week: 5<br>Theory-3, Practical-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Marks: 100<br>Internal- 50, External- 50 |  |
| Course Outcomes (CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |  |
| CO1                  | Learn how immune system works for the body defence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | U                                        |  |
| CO2                  | Evaluate usefulness of immunology in health and disease context.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | An                                       |  |
| CO3                  | Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic responses.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | An                                       |  |
| CO4                  | Identify proper designing of research experiments in immunology of their own interests                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Ap                                       |  |
| Course Content       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |  |
| I                    | <b>Organs and cells involved in immune response Introduction, history, development and scope.</b><br>Immunity, classification of immunity. Innate (non- specific), acquired. (specific) and passive immunity. Clonal nature of immune response. Immune system, organs and tissues of the immune system. Primary (central) - thymus, bone marrow, bursa of Fabricius; secondary (peripheral) - spleen, lymph nodes, mucosa associated lymphoid tissue (MALT). Organization and structure of lymphoid organs. Lymphocytes – T cells and B cells – formation, development and maturation; plasma cells and null cells – natural killer cells, killer cells, lymphokine - activated killer cells; phagocytes / macrophages; antigen presenting cells – macrophages, B-lymphocytes, dendrite cells, langerhans cells; follicular dendrite cells, neutrophils, eosinophils, basophils, mast cells. Complement system its activation and regulation pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP) | 10 Hours                                 |  |
| II                   | <b>Antigen and antibody reactions</b><br>Antigens (immunogens) (Ag): definition, complete antigens, haptens, antigenic determinants or epitopes; antibodies (Immunoglobulins)- definition, general structure of Ig, Ig determinants, physico- chemical properties of Ig, classes of Ig- G, M, A, D, E; mention abnormal Igs; antigen – antibody reactions- mechanism, precipitation reactions, agglutination reactions, complement fixation, neutralization, opsonisation. Complement system: definition, general features, major histocompatibility complex (MHC). Immune response-definition, types of immune responses- humoral immune response (antigen mediated immunity - AMI) and cellular immune response (cell mediated immunity - CMI), immunological memory, immunological tolerance and immune suppression.                                                                                                                                                                                                            | 12 Hours                                 |  |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Immunology of diseases and vaccines</b><br>Hyper sensitivity / allergy: definitions, classification- types I, II and III; Immuno deficiency diseases (ID)- definition, primary IDs, disorders of immune mechanism (humoral, cellular and combined IDs), disorders of complements, disorders of phagocytosis, secondary IDs, Acquired Immune Deficiency Syndrome (AIDS); Tumour immunology, tumour markers tumour immunotherapy approaches. Auto immunity- definition, mechanism, auto immune diseases; transplantation immunity-definition, classification of transplants, graft versus host reactions; graft rejection, mechanism of graft rejection, factors affecting graft survival; Immunisation and vaccination- definitions, vaccines; types of immunization- active immunization- killed and live attenuated vaccines, microbial extracts, vaccine conjugates, toxoids, recombined vaccines, DNA/RNA vaccines, subunit vaccines; passive immunization- pooled normal human Igs, specific Igs (hyper antisera); combined immunization. | 15<br>Hours |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Polyclonal and monoclonal antibodies.</b><br>Hybridoma techniques- T cell cloning and their applications. ELISA, RIA, Western blotting, Fluorescent techniques, Fluorescent activated cell sorting (FACS). Complement fixation test: microcytotoxicity. Antibody engineering. Humanization of antibodies Phage display                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8<br>Hours  |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Open ended Unit/Demo</b> <ul style="list-style-type: none"> <li>• Agglutination reaction</li> <li>• Precipitation reaction</li> <li>• Lymphocyte separation</li> <li>• Blood cell counting</li> <li>• ELISA</li> <li>• Western Blotting</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 30<br>Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |
| <ul style="list-style-type: none"> <li>• Judy Owen, Jenni Punt, Sharon Stranford Kuby Immunology. W.H. Freeman.</li> <li>• David Male, Jonathan Brostoff, David Roth, Ivan Roitt Immunology,</li> <li>• William E. Paul Fundamental Immunology, . LWW.</li> <li>• Kenneth M. Murphy Janeway's Immunobiology, . Garland Science.</li> <li>• Kindt, T. J., Goldsby, R. A., Osborne, B. A., Kuby, . Kuby Immunology. New York: W.H. Freeman.</li> <li>• Brostoff, J., Seaddin, J. K., Male, D., Croitt, I. M. . <i>Clinical Immunology</i>. London: Gower Medical Pub.</li> <li>• Murphy, K., Travers, P., Walport, M., Janeway, C.. <i>Janeway's Immunobiology</i>. New York: Garland Science.</li> <li>• Paul, W.E.. <i>Fundamental Immunology</i>. New York: Raven Press.</li> <li>• Goding, J. W.. <i>Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology</i>. London: Academic Press.</li> <li>• Parham, P.. <i>The Immune System</i>. New York: Garland Science.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |             |

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|------------------------|---------------------------------------------------|----------------------------------------------------|
| BIT08C502              | <b>Genetics and Molecular Biology</b>             |                                                    |
| <b>Semester 8</b>      | <b>Discipline Specific Courses</b>                | <b>Level: 500-599</b>                              |
| <b>4 Credit</b>        | <b>Hours per week: 5</b><br>Theory-3, Practical-2 | <b>Marks: 100</b><br>Internal- 50,<br>External- 50 |
| <b>Course Outcomes</b> |                                                   |                                                    |

| (CO)           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |             |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------|
| <b>CO1</b>     | Students shall gain information on ways of mapping genes in bacteria and in bacteriophages, which take advantage of the processes of conjugation, transformation, and transduction and also acquire knowledge about the Fine structure analysis of bacteriophage genes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | R,<br>U,<br>An,<br>Ap |             |
| <b>CO2</b>     | Students shall learn factors controlling heredity, how genes are transmitted from generation to generation, how gene expression is influenced by internal and external environment, and how genes interact, enabling students to Analyze the pattern of trait transmission in a human pedigree or in crosses of experimental organisms. Students shall also learn about linkage analysis and use the data to map eukaryotic genes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | R,<br>U,<br>An,<br>Ap |             |
| <b>CO3</b>     | Explain the process of DNA replication, including its stages, enzymes, and comparison between prokaryotic and eukaryotic replication. Analyze DNA damage, mutations, and repair mechanisms, including various repair pathways. Apply the recombination process for creating Knock in /Out systems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | An,<br>Ap             |             |
| <b>CO4</b>     | Explore transcription and RNA processing in prokaryotes and eukaryotes, along with the regulation of gene expression and translation processes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | An                    |             |
| Course Content |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |             |
| <b>I</b>       | <b>Microbial genetics</b><br>Concept of a gene in pre-DNA era; mapping of genes in bacterial chromosomes by classical genetic crosses- conjugation, Transduction, and Transformation; Transduction mapping of Bacteriophage genes, complementation tests, and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 10<br>Hours |
| <b>II</b>      | <b>Mendelism and extensions and deviations</b><br>Mendelism, Incomplete dominance, Co-dominance, lethal alleles, epistasis, Multiple alleles, gene expression and the environment, Phenocopy, Pleiotropy, Sex-influenced and Sex-limited traits, Chromosome theory of heredity, Chromosomes and sex determination Humans and Flies, Sex-linked inheritance and Hemophilia, Variability in gene expression: Penetrance and Expressivity, extrachromosomal Inheritance, Maternal genetic effect, Quantitative traits and inheritance, linkage analysis, screening of mutations based on phenotypes and mapping the same, Morgan units, chi-square tests, two-point test cross and three-point test cross for gene mapping in flies, pedigree analysis in mapping human genes, Essentials of population genetics, genetic structure of populations-genotype and allele frequencies, Hardy-Weinberg Law. |                       | 11<br>Hours |
| <b>III</b>     | <b>DNA Replication, Repair and Recombination</b><br>DNA Replication: Replicons, mapping origins of replication, salient features of replication: initiation, elongation and termination in prokaryotes and eukaryotes. DNA repair: Photoreactivation, Nucleotide excision repair, Mismatch correction, SOS repair. Recombination: Homologous and non-homologous, Site-specific recombination, Chi sequences in prokaryotes, FLP/FRT and Cre/Lox recombination.                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 12<br>Hours |
| <b>IV</b>      | <b>Prokaryotic and Eukaryotic Transcription and Translation</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 12          |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>Prokaryotic Transcription- Transcription unit, Promoters; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Transcriptional Regulation-Positive and negative; Operon concept - lac, trp, ara, his, gal; Transcriptional control in lambda phage. Eukaryotic transcription and regulation. Post Transcriptional Modifications: hnRNA, mRNA processing: 5'-Cap formation; 3'-end processing and polyadenylation; RNA Splicing; processing of tRNA and rRNA; RNA editing; Catalytic RNA.</p> <p>Translation machinery- Ribosomes; Composition and assembly. Universal genetic code; Degeneracy of codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co-and post-translational modifications; Genetic code in mitochondria.</p>                                                                                             | Hours    |
| <b>v</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <p><b>Demo/Practical</b></p> <ul style="list-style-type: none"> <li>• <b>Genetics</b></li> <li>• Mendelian genetics: Mutants; Study of different mutant phenotypes: eye mutants, body color, wings shape etc.</li> <li>• Simple problems based on Monohybrid cross, Dihybrid cross, Test cross, Incomplete dominance, Multiple alleles, Sex linked inheritance</li> <li>• Study of genetic disorders : Down's syndrome, turner's syndrome, Klinefelter's syndrome etc.</li> <li>• Autosomal and Sex-linkage analysis using Pedigree data</li> </ul> <p><b>Molecular Biology</b></p> <ul style="list-style-type: none"> <li>• Genomic DNA isolation of Eukaryotic system</li> <li>• Genomic DNA isolation of Prokaryotic system</li> <li>• Isolation of total RNA and cDNA Preparation (Demo)</li> <li>• PCR Techniques (Demo)</li> <li>• Protein extraction and SDS-PAGE</li> <li>• Western blotting (<b>Demo</b>)</li> </ul> | 30 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |
| <ul style="list-style-type: none"> <li>• Hartl, D. L., C Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett.</li> <li>• Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman.</li> <li>• Tamarin, R. H., C Leavitt, R. W. (1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown.</li> <li>• Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press</li> <li>• Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007</li> <li>• J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Seitz C A.M. Weiner; Molecular Biology of the Gene, 6<sup>th</sup> Edition, Benjamin Cummings Publishing Company Inc, 2007.</li> <li>• Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.</li> <li>• David E Bruns, Edward R Ashwood, C Carl A Burtis; Fundamentals of Molecular Diagnostics, Saunders/Elsevier 2007</li> <li>• Lela Buckingham and Maribeth Flaws; Molecular Diagnostics: Fundamentals, Methods, C Clinical Applications; F. A. Davis Company 2008</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |

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| BIT08C503 | IPR |
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| Semester 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Discipline Specific Courses                                                                                                                                                                                                                                                 | Level: 500-599                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| 4 Credit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Hours per week: 4<br>Theory-4                                                                                                                                                                                                                                               | Marks: 100<br>Internal- 50, External- 50 |
| <b>Course Outcomes (CO)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                             |                                          |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Understand the concept of innovation and intellectual property and it's importance in global economy especially in biotechnology industry.                                                                                                                                  | U                                        |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Explain the criteria for securing patents, and problems faced due to existing prior art and implications of infringing the field / granted patent.                                                                                                                          | An                                       |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Depict the role of global bodies in IP protection and role of IP in research and development.                                                                                                                                                                               | An                                       |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | List the steps involved in filling PCT application, and analyze issues related to commercialisation, and role of IDA and NBA in granting biotech patents.                                                                                                                   | Ap                                       |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                             |                                          |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Definition of science, Engineering and technology. Difference between discovery and invention. Introduction to intellectual property and types of IP. IP and it's importance in improving global economy and it's relevance especially in biotechnology industry.           | 10<br>Hours                              |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Criteria for securing patents- novelty, non - obviousness and industrial application. Concept of prior art. Infringement and it's implications.                                                                                                                             | 12<br>Hours                              |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | International framework for protection of intellectual property -GATT, WTO, WIPO and Trips. Wipo administered treatise. Basic principles of trading as per WTO. The importance of IP in industrial Research and development                                                 | 11<br>Hours                              |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | PCT and steps in filing the PCT application. Precautions before filing patent application, the role of IDA and NBA in biotech patenting procedure                                                                                                                           | 12<br>Hours                              |
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Basic and applied research, Traditional knowledge and its relevance in Indian context, Examples of biotech inventions, Commercialisation of technology – Licensing – exclusive and non-exclusive licence, upfront fee/ premium, royalty, Patent data bases, Budapest treaty | 15<br>Hours                              |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                             |                                          |
| <ul style="list-style-type: none"> <li>Ganguli.P(2001), intellectual property rights: Unleashing the knowledge economy, New Delhi,Tata McGraw hill pub.</li> <li>B L Wardehra 2000 Law Relating to Patents Trade marks Copyright design C Geographical Indications Universl law Publishing Pvt Ltd.</li> <li>NS Gopalakrishnan, T.G. Agitha 2009 Principles of Intellectual property. Eastern Book Company.</li> <li>Complete reference to intellectual property rights laws (2007) snow white publications.</li> <li>What everyone should know about patents: subbaram.</li> </ul> |                                                                                                                                                                                                                                                                             |                                          |

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| BIT08E501  | <b>Molecular Oncology</b>    |                |
| Semester 8 | Discipline Specific Elective | Level: 500-599 |

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| <b>4 Credit</b>        | <b>Hours per week: 4</b><br>Theory-4 | <b>Marks: 100</b><br>Internal- 50, External- 50 |
| <b>Course Outcomes</b> |                                      |                                                 |

| <b>(CO)</b> |                                                                                                                                                                                                                    |                    |  |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--|
| <b>CO1</b>  | Students will be equipped with knowledge regarding cancer as a global health problem, the epidemiology, causes, general properties, prevention and therapeutic strategies of cancer.                               | R,U                |  |
| <b>CO2</b>  | Learners will develop a thorough understanding about the etiology and molecular biology of different cancers, equipping them for molecular cancer research.                                                        | R,U,<br>An         |  |
| <b>CO3</b>  | Students will be equipped with knowledge on cancer immunity, mechanisms of immune evasion by cancers and the use of this information in designing the development of cancer prevention and therapeutic strategies. | R, U,<br>An        |  |
| <b>CO4</b>  | Students will learn about different methods and models in cancer research to pursue basic, translational and clinical research                                                                                     | R, U,<br>An,<br>Ap |  |

| <b>Course Content</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| <b>I</b>              | <b>An overview of the cancer problem</b><br>Cancer incidence and prevalence, the genetic basis of cancer, exogenous and indigenous factors causing cancer, hallmarks of cancer, cancer diagnosis, prevention and therapy.                                                                                                                                                                                                                 | 10<br>Hours |
| <b>II</b>             | <b>Molecular pathology in cancers</b><br>Molecular mechanism of apoptosis and replicative senescence and its deregulation in cancers, Cell signalling pathways relevant to cancer viz. Mitogen activated protein kinase signalling, Protein kinase B signalling, p53 network, Wnt- beta catenin signalling and Nuclear factor kappa B pathway                                                                                             | 12<br>Hours |
| <b>III</b>            | <b>Molecular biology of human cancers</b><br>Etiology and molecular mechanism of carcinoma-Colon, cervical and liver cancer, leukemia-Chronic myelogenous leukemia, promyelocytic leukemia; lymphoma-Burkitt lymphoma.                                                                                                                                                                                                                    | 11<br>Hours |
| <b>IV</b>             | <b>Cancer immunology</b><br>Cancer immune surveillance, innate and adaptive antitumor immunity, interplay of innate and adaptive antitumor immunity, Immune evasion by cancer cells, Inflammation and cancer risk, , Cancer vaccines, cancer Immunotherapy.                                                                                                                                                                               | 12<br>Hours |
| <b>V</b>              | <b>Cancer Research</b><br>Basic research, translational research, clinical research, research in the area of prevention and epidemiology, causes and molecular biology of cancer, diagnosis and treatment. methods and models in cancer research -In vitro -2D/3D cultures and in vivo models – syngenic and allogenic mice models xenograft models- ectopic, orthotopic, PDTX, metastasis model and genetically engineered mouse models. | 15<br>Hours |

| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                            |  |
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| <ul style="list-style-type: none"> <li>Genetics of Cancer: Genes Associated with Cancer Invasion, Metastasis and Cell Proliferation; GV Sherbet and M S Laksmi; Academic Loress</li> <li>The Biology of Cancer; Robert A Weinberg; Garland Science.</li> <li>Alberts et al., Molecular Biology of the Cell, Carland 2008.</li> <li>Molecular Genetics of Cancer, 2nd Revised Edition, Bios, 2001.</li> </ul> |  |

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| BIT08E502 | <b>Stem cells and Regenerative Medicine</b> |
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| <b>Semester 8</b> | <b>Discipline Specific Elective</b>  | <b>Level: 500-599</b>                           |
| <b>4 Credit</b>   | <b>Hours per week: 4</b><br>Theory-4 | <b>Marks: 100</b><br>Internal- 50, External- 50 |

| <b>Course Outcomes (CO)</b> |  |  |  |
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| <b>CO1</b> | Understand the classification and sources of stem cells, including embryonic, adult, and induced pluripotent stem cells.                                                                                                                                                                         | U  |  |
| <b>CO2</b> | Analyze stem cell properties, proliferation, and differentiation, focusing on blastocyst cells, organogenesis, and stem cell preservation. Explore adult stem cells, regeneration factors, and molecular signaling pathways (Notch, Wnt, Hedgehog) controlling proliferation and differentiation | An |  |
| <b>CO3</b> | Apply the knowledge of stem cell culture and differentiation for tissue engineering for therapy                                                                                                                                                                                                  | Ap |  |
| <b>CO4</b> | Understand the regulatory and ethical issues of stem cell research. Apply the knowledge for preparing stem cell based clinical and preclinical research.                                                                                                                                         | Ap |  |

| <b>Course Content</b> |  |  |  |
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| <b>I</b>   | <b>Introduction to Stem Cells</b><br>Definition, properties, proliferation, Types of stem cells, human embryogenesis--gametogenesis, fertilization and embryo development Ectoderm, mesoderm and endoderm development and process of organogenesis and regulation                                                                                                                                                                                       | 12<br>Hours |
| <b>II</b>  | <b>Isolation, Characterization, Differentiation and Cryopreservation</b><br>Isolation of human Embryonic stem cells, generation of human induced pluripotent stem cells. Methodologies for pluripotent stem cell culture, characterization of pluripotency. Molecular signaling regulating stem cell proliferation and differentiation- Notch Signaling, Wnt signaling, Hedgehog signaling, FGF, LIF- smad, Protein Kinase. Stem cell cryopreservation  | 13<br>Hours |
| <b>III</b> | <b>Biomaterials in Tissue engineering</b><br>Properties of Materials, Classes of materials used in medicine: Metals, Polymers, Hydrogels, Bioresorbable and Biodegradable Materials, Ceramics, Natural materials, Composites, Thin films, grafts, Coatings, Medical fibers and Biological functional materials.<br>Testing biomaterials: In Vitro and In Vivo assessment of tissue compatibility. Testing of blood- material interactions. Animal model | 11<br>Hours |
| <b>IV</b>  | <b>Application of Stem Cells</b><br>Overview of embryonic and adult stem cells for therapy and applications in 3D Bioprinting-Neurodegenerative diseases; Parkinson's, Alzheimer's, Spinal Cord Injuries and other Brain Syndromes; Tissue systems Failures; Diabetes; Cardiomyopathy; Kidney failure; Liver failure; Cancer; Hemophilia.                                                                                                               | 12<br>Hours |

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| <b>V</b>          | <b>Ethical Issues associated with stem cell-based regenerative medicine field</b><br>Regulatory and Ethical Considerations of stem cell and Gene Therapy, Regulatory body and Institutional research guidelines and approvals, PI responsibilities, Pre clinical regulatory consideration and Patient Advocacy | 12<br>Hours |
| <b>References</b> |                                                                                                                                                                                                                                                                                                                |             |

- Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press
- Stem cell biology and gene therapy, Booth C., Cell Biology International, Academic Press
- Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Alexander Battler, Jonathan Leo, Springer
- Stem Cell Biology and Gene Therapy. Quesenberry PJ, Stein GS, eds. (£65.00.) Wiley, 1998.
- Progress in gene therapy, Volume 2, Pioneering stem cell/gene therapy trials, Roger Bertolotti, Keiya Ozawa and H. Kirk Hammond, VSP international science publishers
- Stem Cells Handbook: Stewart Sell, Humana Press; Totowa NJ, USA; Oct. 2003,
- Human Embryonic Stem Cells: The Practical Handbook by Stephen Sullivan and Chad A Cowan.

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| BIT08E503            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Molecular Virology            |                                          |          |
| Semester 8           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Discipline Specific Elective  | Level: 500-599                           |          |
| 4 Credit             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Hours per week: 4<br>Theory-4 | Marks: 100<br>Internal- 50, External- 50 |          |
| Course Outcomes (CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                               |                                          |          |
| CO1                  | Learn about the structure, multiplication, classification of viruses                                                                                                                                                                                                                                                                                                                                                                                              |                               |                                          | U        |
| CO2                  | Molecular mechanism of utilization of host machinery, replication and multiplications of different viruses                                                                                                                                                                                                                                                                                                                                                        |                               |                                          | An       |
| CO3                  | Learn about some of viral disease infecting plant and animal and their control measures                                                                                                                                                                                                                                                                                                                                                                           |                               |                                          | An       |
| CO4                  | Application of viruses in various biotechnological process                                                                                                                                                                                                                                                                                                                                                                                                        |                               |                                          | Ap       |
| Course Content       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                               |                                          |          |
| I                    | General properties of viruses- Structure and Morphology, Cultivation. Methods used for viral quantification and enumeration. Electron-microscopic studies Viral classification DNA and RNA viruses, Laboratory requirements for cultivation. Lawn culture, Embryonated egg inoculation, Animal inoculation, Permissive and non-permissive hosts and cells. Tissue - Types of cell lines used for the study. Viral Tropism, Factors responsible for viral tropism. |                               |                                          | 10 Hours |
| II                   | Virus classification, international agency for virus classification<br>Replication of DNA viruses and RNA viruses, effects of viruses on the host cells – cyto-pathic effect. Virus Host interaction- Acute infection, chronic/persistent infection latent infection and slowly progressive virus infection Viral inclusion bodies - methods of staining and demonstration. Of virus growth in cell culture                                                       |                               |                                          | 12 Hours |
| III                  | Bacteriophages Lambda phage, T phages, Filamentous phages M 13 phages. Lytic and lysogenic cycles of Lambda phage. M13 replication Types of plant viruses,                                                                                                                                                                                                                                                                                                        |                               |                                          | 11 Hours |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Economic losses due to important viruses; DNA viruses, RNA viruses, satellite viruses, satellite RNA, satellite DNA, viroids, virusoids; Disease symptoms, local and systemic movement of viruses, plasmodesmata and virus movement. Genomic Organization of DNA viruses; Caulimovirus – eg. Cauliflower mosaic virus, Replication of CaMV, Badnavirus – Rice tungro virus (RTBV); Nanovirus – Banana bunchy top virus. Potato virus Y (PVY), Citrus tristeza virus; Bromoviridae, Alfalfa mosaic virus, Rice dwarf virus |                                                 |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Animal viruses Poxviruses, Papilloma Viruses, Human Herpes Viruses, Adenoviruses, Picornaviruses, Rotaviruses, Paramyxoviruses and Rhabdoviruses, Reoviruses, Retroviruses Flaviviruses, Coronaviruses Human Swine fever virus Cancer causing RNA and DNA Viruses. Viral arthritis. Control of animal viral diseases, Antiviral agents, Combination therapy, Nucleic acid based therapies. Antigenic shift and antigenic drift. Emerging viral diseases. Immune aversion mechanism of viruses,                            | 12 Hours                                        |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Virus detection and diagnosis; Infectivity assays- Sap transmission, insect vector transmission, agroinfection (using Agrobacterium); Ultracentrifugation, electron microscopy, serological methods, immunoelectrophoresis, direct double-antibody sandwich method, Dot ELISA, Immunosorbent electron microscopy (ISEM), Decoration technique, Polymerase chain reaction; DNA and oligonucleotide microarray; Gene silencing, PTGS & TGS, viral suppressors of gene silencing.                                            | 15 Hours                                        |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                 |
| <ul style="list-style-type: none"> <li>Ed. C.L. Mandahar, Molecular biology of Plant viruses, Kluwer academic publishers, Dordrecht, Roger Hull (Ed), Mathews Plant Virology, 4th Edition, Academic Press, San Diego,</li> <li>D.G.A. Walkey (Ed), Applied Plant Virology, 2nd Edition, Chapman C Hall, London,.</li> <li>Text Book of Microbiology: Ananthanarayanan C Jayaram Panikker</li> <li>Medical Virology: Fenner and White</li> <li>Principles and Practice of Infectious diseases – Madell, Bennett, Dolin Vol- 1 C 2</li> <li>Medical Microbiology : David Greenwood, Slack, Peutherer</li> <li>Essentials of Diagnostic Virology: G. Storch</li> <li>Notes on Medical Virology By Morag.C. Timbury</li> <li>Diagnostic methods in Clinical Virology : N.R. Grist</li> <li>Fundamentals of Molecular Virology By Nicholas H. Acheso</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                 |
| <b>BIT08E504</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Food and Dairy Biotechnology</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                 |
| <b>Semester 8</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Discipline Specific Elective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Level: 500-599</b>                           |
| <b>4 Credit</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Hours per week: 4</b><br>Theory-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Marks: 100</b><br>Internal- 50, External- 50 |
| <b>Course Outcomes (CO)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                 |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Describe development and contributions of food and dairy Biotechnology to the global economy. Compare traditional and modern techniques and stress the role of microbes in industry.                                                                                                                                                                                                                                                                                                                                      | U                                               |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Explain various processing techniques used in food and dairy industry.                                                                                                                                                                                                                                                                                                                                                                                                                                                    | An                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Point out the various processing and production technology involved in                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                 |

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| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | milk/dairy industry.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | An          |  |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Understand the quality controls employed in milk and dairy industry as well as various analytical techniques used to assure quality.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Ap          |  |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |             |  |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Review of food and dairy industry. Chronological development and it's contribution to national and global economy. Traditional and modern processing techniques applicable to food and dairy industry. The role of microbes in preservation and spoilage of food and dairy products. Biochemical composition of milk and dairy products .                                                                                                                                                                                                                                                                                         | 10<br>Hours |  |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Processing techniques used in food and dairy industry: Pasteurisation LTH, HTSH, UHT processes, sterilisation and related equipment. Cryopreservation and equipments. Dehydration and drying methods-spray, freeze and sun drying.<br>Food processing techniques: Irradiation, pulsed electric field processing and recently emerging technologies.                                                                                                                                                                                                                                                                               | 12<br>Hours |  |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Milk processing and standardization: Quality check and control of raw milk. Standardization and homogenization.<br>Cheese production technology: Different types of cheeses and it's manufacturing. Butter and ghee production and quality control. Production of ice cream: raw materials, formulation aspects, production and freezing techniques. Utilisation of wastes from dairy industry as substrate for fermentation industry: Casein ,whey and lactose.                                                                                                                                                                  | 11<br>Hours |  |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Quality control and assurance of food safety.<br>Microbes associated with raw milk: Significance of specific groups of microorganisms in milk i.e. psychrotrophic, mesophilic, thermophilic and thermophilic . Hazard analysis and critical control points( HACCP) and Current Good manufacturing practices (cGMP).<br>Preservatives and additives used in food products, packaging, labelling, regulations and consumer rights /awareness.<br>Analytical techniques in food and dairy industry: Physical, chemical and microbiological quality related parameters in milk and dairy products: Fat, protein and lactose content . | 12<br>Hours |  |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Preparation of curd and observation of lactobacillus.<br>Butter and ghee production<br>Cheese/ paneer and whey production<br>Comparison of LTH and HTSH for disinfection of milk. Wine production<br>Preservatives used for increasing shelf life of food products - citric acid<br>Display and technical discussion related to processed food products - Spray dried milk, cheese, Sun dried fish, Dry yeast granules, Milk in tetrapack sterilized by UHT process.                                                                                                                                                              | 15<br>Hours |  |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |             |  |
| <ul style="list-style-type: none"> <li>Smith.J(2019). "Introduction to Food and Dairy Industry." Publisher.</li> <li>Johnson, A. et al. (2020). "Global Regulations in the Food and Dairy Sector." Journal of Food Science, 45(2), 123-145.</li> <li>Fellows, P. (2017). "Food Processing Technology: Principles and Practice." Publisher.</li> <li>Steinkraus,k.H.(2008),"Handbook of Indigenous fermented foods.CRC press.</li> <li>Stanbury, P.F., Allan Whitaker and S.J. Hall. 1997. Principles of Fermentation Technology.Aditya books private Ltd., New Delhi.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |             |  |

- Pederson, C.S. 1971. Microbiology of food fermentations, AVI Publishing company. westport, Connecticut Biotechnology: Food Fermentation by V.K, Joshi and Ashok Pandey.

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| BIT08M501 | <b>MOOC II-</b> MOOC from the list of courses approved by the Department Council |
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## Semester 9 /Second Year PG Biotechnology- Semester 3

| Semester 9 FYUGP/First year PG Biotechnology Semester 3 |             |                                                          |         |           |           |             |
|---------------------------------------------------------|-------------|----------------------------------------------------------|---------|-----------|-----------|-------------|
| Course Level                                            | Course Code | Discipline Specific Courses                              | Credits | Int Marks | Ext Marks | Total Marks |
| 600-699                                                 | BIT09C601   | Omics and Bioinformatics                                 | 4       | 50        | 50        | 100         |
|                                                         | BIT09C602   | Bioprocess Technology                                    | 4       | 50        | 50        | 100         |
|                                                         | BIT09C603   | Genetic Engineering and Its Applications                 | 4       | 50        | 50        | 100         |
|                                                         |             | <b>Discipline Specific Electives<br/>Any TWO</b>         |         |           |           |             |
|                                                         | BIT09E601   | Molecular Therapeutics                                   | 4       | 50        | 50        | 100         |
|                                                         | BIT09E602   | Research Methodology and Scientific Communication skills | 4       | 50        | 50        | 100         |
|                                                         | BIT09E603   | Fermentation Technology                                  | 4       | 50        | 50        | 100         |
|                                                         | BIT09E604   | Cancer Diagnostics and Therapeutics                      | 4       | 50        | 50        | 100         |
|                                                         | BIT09E605   | Plant and Animal Biotechnology                           | 4       | 50        | 50        | 100         |

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|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------|--|
| BIT09C601            | Omics and Bioinformatics                                                                                                                                                                                                                                                                          |  |                                          |  |
| Semester 9           | Discipline Specific Courses                                                                                                                                                                                                                                                                       |  | Level: 600-699                           |  |
| 4 Credit             | Hours per week: 5<br>Theory-3 Practical - 2                                                                                                                                                                                                                                                       |  | Marks: 100<br>Internal- 50, External- 50 |  |
| Course Outcomes (CO) |                                                                                                                                                                                                                                                                                                   |  |                                          |  |
| CO1                  | Students will acquire knowledge about genetic mapping, physical mapping, different methods of whole genome mapping, various sequencing technologies, Next-generation sequencing technology platforms and strategies for whole genome sequencing.                                                  |  | R, U, An                                 |  |
| CO2                  | Students will be equipped with knowledge and skills on the concepts, methodologies and applications of Comparative Genomics. Students will also gain knowledge about transcriptomics and various methods to analyse gene expression profiling for various applications in Biotechnology research. |  | R, U, An                                 |  |

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| <b>CO3</b>            | Students will acquire knowledge about the concept of Proteomics, strategies, methods and tools in proteomics for various applications in Biotechnology research.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | R, U, An, Ap |          |
| <b>CO4</b>            | Students will learn about various databases including nucleic acid, protein, structural databases, database and gain skills related to data base mining, use of various computational tools that facilitate Biotechnology research.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | R, U, An, Ap |          |
| <b>Course Content</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |              |          |
| <b>I</b>              | <b>Whole genome mapping and sequencing</b><br>Methods and techniques used for mapping, Physical mapping, radiation hybrid maps, HAPPY maps; DNA sequencing-principles; Sangers / Maxam Gilbert method, pyro-sequencing, Next –generation sequencing technologies; translation to large scale projects; Human Genome Project; Strategies for whole genome sequencing, whole genome shot gun sequencing, Hierarchical shot gun sequencing, Recognition of coding and non-coding sequences and gene annotation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |              | 10 Hours |
| <b>II</b>             | <b>Comparative Genomics and Functional Genomics</b><br>Comparing genomes by sequence alignment; SNPs; Methods for SNP analysis, Genome-wide association studies, International Hap Map Project, Transcriptome analysis -Direct sequence sampling, SAGE, Microarrays- Spotted microarrays and oligonucleotide chips, RNA –Seq, introduction to metagenomics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |              | 12 Hours |
| <b>III</b>            | <b>Proteomics: proteomics technologies</b><br>protein expression profiling, 2D-PAGE, multiplex proteomics, DIGE analysis, Multi-dimensional liquid chromatography-mass spectrometry analysis, High throughput protein annotation and correlative database searching, Peptide mass fingerprinting, computational methods for protein annotation and proteome analysis; MALDI-TOF MS in quantitative proteomics and analysis of protein modifications, phosphoproteomics-IMAC and MS analysis; Proteome databases. Analysis of protein interactions, protein chips, Reverse phase Protein Array, analytical and functional protein chips, PCR directed protein-in situ arrays, PISA, NAPPa, DAPA; functional proteomics; Applications of proteomics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |              | 11 Hours |
| <b>IV</b>             | <b>Bioscience and computers</b><br>bioinformatics, Scientific disciplines linked to bioinformatics, Support systems for bioinformatics, Introduction to databases and database management, Sequence database and genomic database, Introduction to public databases, like NCBI, EMBL, DDBJ, Data formats in databases, sequence search C retrieval, gene annotation, Bioinformatic tools; BLAST, primer design, restriction mapping, etc., List of freely available bioinformatics websites and tools; DNA/RNA sequence search C retrieval, Hyperlinks in NCBI - all resources, PubMed, PubChem, latest scientific blogs, BLAST and its importance, BLAST algorithm (Heuristic method and BLOSUM62), Types of BLAST, Primer design and restriction mapping, Submission of DNA/RNA sequence to public databases in detail, DNA secondary structure analysis, Applications of nucleotide sequencing in various disciplines in bioscience; Submission of protein sequences, DNA/Protein sequence alignment and analysis; CLUSTAL W and CLUSTAL X, Phylogenetic analysis and molecular phylogeny; cladogram, Pairwise and multiple sequence analysis, Applications of protein sequence alignment in various disciplines in bioscience. |              | 12 Hours |

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| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Practicals</b> <ul style="list-style-type: none"> <li>• Introduction on protein secondary structure, analysis and Ramachandran Plot, Structure retrieval from protein (primary C secondary) databases, 3D visualization, analysis and interpretation (webserver/stand-alone software)Methods of protein modeling in detail; homology, threading/fold recognition, ab initio, Structural comparison of proteins and other macromolecules, Superimposition of modelled or existing macromolecular structure analysis and interpretation, Applications of molecular modelling in various disciplines in bioscience</li> <li>• From lab to computer; modelling of wet lab experimentally derived macromolecules via molecular simulation and vice-versa, 2D and 3D modelling, Cheminformatics and immunoinformatics, Protein docking and types; small molecule, peptide-protein and macromolecule docking, Web servers and stand-alone versions for molecular docking</li> <li>• Methods of protein docking; binding site prediction, ligand preparation, protein preparation, dock score or G-score, Functional genomics to structural genomics and vice-versa, Binding energy and dissociation cont. (<math>\Delta G/K_d</math>) prediction and analysis of docked protein complexes, comparison and interpretation</li> <li>• Protein-protein interactions; interfacial contacts (ICs) and non-interacting residues (NIS), Superimposition of docked protein complexes, analysis and interpretation, In silico drug design or computer-aided drug design (CADD) and other applications, Molecular dynamics and pharmacogenomics.</li> </ul> | 30<br>Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |
| <ul style="list-style-type: none"> <li>• Primrose, S. B., Twyman, R. M., Primrose, S. B., C Primrose, S. B. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.</li> <li>• Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press.</li> <li>• Campbell, A. M., C Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |

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|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|--|------------------------------------------|
| BIT09C602            |                                                                                                                                                                     | Bioprocess Technology                      |  |                                          |
| Semester 9           |                                                                                                                                                                     | Discipline Specific Courses                |  | Level: 600-699                           |
| 4 Credit             |                                                                                                                                                                     | Hours per week: 5<br>Theory-3, Practical-2 |  | Marks: 100<br>Internal- 50, External- 50 |
| Course Outcomes (CO) |                                                                                                                                                                     |                                            |  |                                          |
| CO1                  | Clarify the different screening strategies for detection and isolation of industrially important microorganisms and it's yield improvement by improving the strain. |                                            |  | U                                        |
| CO2                  | Familiarise with principles of bioprocess, media and inoculum preparation and understand the importance of various bioprocess parameters in production.             |                                            |  | An                                       |
| CO3                  | Describe different types of bioreactors - it's advantages and disadvantages.                                                                                        |                                            |  | An                                       |

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| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Explain different types of purification methods especially in the context of selected biotech products.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Ap          |  |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |  |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Introduction to bioprocess technology. Microbial growth, the relevance of pure cultures in bioprocess development. process development and scale up. Types of microbial cultures and growth kinetics - batch, fed batch and continuous.                                                                                                                                                                                                                                                                                                                                                                                                   | 10<br>Hours |  |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Upstream processing: Fermentation media and inoculum preparation: Raw materials for industrial fermentations. Media preparation, formulation, sterilisation of media and inoculum build up. concept of seed fermentor and its importance in reduction of batch time. Inoculum preparation for bacteria and fungi.                                                                                                                                                                                                                                                                                                                         | 12<br>Hours |  |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Bioreactor and modes of fermentations: Design of CSTR, its different parts and functions. Air lift, Tower fermentors, immobilized bioreactor, and photobioreactor. Submerged and solid state fermentations advantages and applications.                                                                                                                                                                                                                                                                                                                                                                                                   | 11<br>Hours |  |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Down stream processing: biomass separation methods - flocculation, floatation, filtration and centrifugation.<br>Product oriented operations: Precipitation, two phase extraction, adsorption, gel exclusion, ion exchange and affinity chromatography. Drying of biological products - contact and adiabatic drying. Lyophilization and spray drying.                                                                                                                                                                                                                                                                                    | 12<br>Hours |  |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Practicals</b><br>Isolation of protease producing microbes using casein agar media.<br>Isolation, purification and aseptic transfer of pigment producing soil microorganism<br>Strain maintenance - agar slants, soil stocks, deep freezing-revival of cultures after one month<br>Aerobic and anaerobic cultures - <i>Saccharomyces cerevisiae</i><br>Effect of pH and temperature on microbial growth<br>Wet and dry weight measurements of microbial biomass.<br>Static filtration- concept of filter cake and filter aid<br>Air filtration - maintenance of sterility<br>Precipitation of proteins/ enzymes by ethanol and acetone | 30<br>Hours |  |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |  |
| <ul style="list-style-type: none"> <li>• Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.</li> <li>• Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2<sup>nd</sup> edition. Panima Publishing Co. New Delhi.</li> <li>• Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.</li> <li>• Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2<sup>nd</sup> edition, Elsevier Science Ltd.</li> <li>• Colin Ratledge and Bjorn Kristiansen, Basic Biotechnology (3rd Edn.). 2022.</li> <li>• Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Eaglewood.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |  |

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| BIT09C603            | Genetic Engineering and Its Applications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |  |
| Semester 9           | Discipline Specific Courses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Level: 600-699                           |  |
| 4 Credit             | Hours per week: 5<br>Theory-3, Practical-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Marks: 100<br>Internal- 50, External- 50 |  |
| Course Outcomes (CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |  |
| CO1                  | Learn about the importance of Genetic engineering in Biotechnology. programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | U                                        |  |
| CO2                  | Understand the basic tools, techniques required for performing recombinant DNA technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | An                                       |  |
| CO3                  | Practical experience in doing recombinant DNA technology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | An                                       |  |
| CO4                  | Applications of genetic engineering in biological research and biotechnology industries                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Ap                                       |  |
| Course Content       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |  |
| I                    | <b>Introduction and tools for genetic engineering</b><br>Basic principles of genetic engineering, Scope and impact of genetic engineering in modern society; General requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing Recombinant Screening and selection Labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, subtractive hybridization ,fluorescence in situ hybridization. Cloning vectors: Plasmid-based, Bacteriophage-based (Lambda - Insertion and Replacement vectors M13 / mp vectors), Phagemids (pUC18/19 and Bluescript vectors), Cosmids, Artificial chromosomes (YACs, BACs, PACs, HACs). Principles for maximizing gene expression - Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies Mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors. | 10 Hours                                 |  |
| II                   | <b>Introduction of foreign DNA into host, Genomic/cDNA libraries, transcript mapping, protein-DNA interaction</b><br>Insertion of foreign DNA into host cells - transformation, electroporation, transfection construction of libraries; genomic libraries - walking /hopping /jumping libraries. Isolation of total RNA /mRNA ; reverse transcriptase and cDNA synthesis, cDNA libraries - full length / vector-primed. S1 mapping, Primer extension, RNase protection and Reporter assays. Construction of microarrays – types -genomic arrays, cDNA arrays and oligo arrays and applications. Study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 12 Hours                                 |  |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Different types of PCR techniques</b><br>Basic principles of PCR: requirements for a standard reaction ; primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.                                                                                                                                  | 11<br>Hours                                     |
| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>DNA sequencing, Mutagenesis, protein engineering, gene-silencing and genome-editing</b><br>DNA sequencing techniques, Sangers / Maxam Gilbert method, Automated DNA sequencing, pyro-sequencing, Next –generation sequencing technologies.<br>Site-directed mutagenesis and protein engineering. Gene silencing techniques - introduction to siRNA/vectors and siRNA technology; Micro RNA. Principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops. Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice and disease models.<br>Genetic manipulation in different model systems ( e.g. Drosophila,C. elegans)<br>Genome editing by CRISPR-CAS technology ; Chinese and American clinical trials. | 12<br>Hours                                     |
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Practicals</b> <ul style="list-style-type: none"><li>Isolation of plasmid and Genomic DNA</li><li>DNA ligation reaction</li><li>Preparation of competent cell and chemical transformation</li><li>Screening recombinant / Xgal screening</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 30<br>Hours                                     |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |
| <ul style="list-style-type: none"><li>Old, R. W., Primrose, S. B., C Twyman, R. M. (Latest edition). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.Molecular Cloning : A laboratory manual- Sambrook and Russell. Vol I,II, and III CSHL.</li><li>Green, M. R., C Sambrook, J. Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.</li><li>Brown, T. A. Genomes (3rd ed.). New York: Garland Science Pub.</li><li>DNA cloning: A practical approach- D.M Glover and B,D, Hames</li><li>Molecular biotechnology- Glick and Pasternak</li><li>Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.</li></ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |
| BIT09E601                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Molecular Therapeutics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                 |
| <b>Semester 9</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Discipline Specific Elective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Level: 600-699</b>                           |
| <b>4 Credit</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Hours per week: 4</b><br>Theory-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Marks: 100</b><br>Internal- 50, External- 50 |
| <b>Course Outcomes (CO)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                 |

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| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                     | Understand the Drug delivery systems including gene delivery                                                                                                                                                                                                                      | U        |  |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                     | Analyze Therapeutic approaches using stem cells and its pros and cons                                                                                                                                                                                                             | An       |  |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                     | Evaluate the Recombinant therapeutic products and importance                                                                                                                                                                                                                      | An       |  |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                     | Analyze the Immunotherapeutic approaches against cancers                                                                                                                                                                                                                          | Ap       |  |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                   |          |  |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                       | Gene therapy; Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Retro and adeno virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery.                                                             | 12 Hours |  |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                      | Cellular therapy; Stem cells: definition, properties and potency of stem cells; Sources: embryonic and adult stem cells; Concept of tissue engineering; Role of scaffolds; Role of growth factors; Role of adult and embryonic stem cells; Clinical applications; Ethical issues. | 12 Hours |  |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                     | Recombinant therapy; Clinical applications of recombinant technology, Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors.                                     | 12 Hours |  |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                      | Immunotherapy; Monoclonal antibodies and their role in cancer; Role of recombinant interferons; Immunostimulants; Immunosuppressors in organ transplants; Role of Cytokine therapy in cancers; Vaccines: types, recombinant vaccines and clinical applications.                   | 12 Hours |  |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                       | Gene silencing technology; Antisense therapy; siRNA; Tissue and organ transplantation; Transgenics and their uses; Cloning; Ethical issues.                                                                                                                                       | 12 Hours |  |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                   |          |  |
| <ul style="list-style-type: none"> <li>Bernhard Palsson and Sangeeta N Bhatia, Tissue Engineering, 2nd Edition, Prentice Hall,</li> <li>Pamela Greenwell, Michelle McCulley, Molecular Therapeutics: 21st century medicine, 1st Edition, Springer,</li> <li>Molecular Therapeutics: 21st Century Medicine by <a href="#">Pamela Greenwell</a> (Author), <a href="#">Michelle McCulley</a> (Author) WILEY publishers</li> </ul> |                                                                                                                                                                                                                                                                                   |          |  |

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|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|----|
| BIT09E602               | Research Methodology and Scientific Communication Skills                                                                                                                                                       |                                          |    |
| Semester 9              | Discipline Specific Elective                                                                                                                                                                                   | Level: 600-699                           |    |
| 4 Credit                | Hours per week: 4<br>Theory-4                                                                                                                                                                                  | Marks: 100<br>Internal- 50, External- 50 |    |
| Course Outcomes<br>(CO) |                                                                                                                                                                                                                |                                          |    |
| CO1                     | Develop foundational skills in research preparation, including selecting a mentor, defining objectives, and maintaining a lab notebook.                                                                        |                                          | U  |
| CO2                     | Acquire proficiency in literature collection using various sources, digital libraries, and search engines, and develop the ability to critically evaluate and select suitable methods based on research plans. |                                          | An |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |
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| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Enhance presentation skills, including formal presentation techniques, using presentation tools, defending research findings, and creating and presenting scientific posters.                                                                                                                                                                                                                                                                                                                                        | An |          |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Attain technical writing skills for scientific communication, including understanding different report types, scientific writing principles, and the process of publishing articles, with a focus on elements like abstract, introduction, materials C methods, results, discussion, and references.                                                                                                                                                                                                                 | Ap |          |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Preparation for research: Choosing a mentor, lab and research question; maintaining a lab notebook. Topic selection – Planning research – defining objectives – Preparation of work plans. Identification of suitable methodology – Preparation of project proposal – summer school- Training in research institutes.                                                                                                                                                                                                |    | 10 Hours |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Collection of literature –News articles – Books – Journals. Digital library and search of articles - Google Scholar – PubMed-Inflibnet – Medline –Open access Journals – virtual sources-. Short communications – review articles. Collection of protocols and selection of suitable methods according to work plan. Observational and experimental research. Data analysis – construction of tables – headings –footer – Tabulation – Presentation of results – Use of statistical software to analyze the results. |    | 12 Hours |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Presentation skills - formal presentation skills; preparing and presenting using presentation tools; AI tools, defending interrogation; scientific poster preparation and presentation; participating in group discussions. Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; effective email strategy using the right tone and conciseness                                                                                           |    | 11 Hours |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Publishing of Articles: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials C methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers – peer review process.                                                                                       |    | 12 Hours |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Thesis structure – components- writing introduction- review of literature – materials and methods – Presentation of results - discussion of results based on literature – arriving at conclusions - preparation of summery/abstract – arrangement of bibliography and how to quote reference in thesis – appendix.                                                                                                                                                                                                   |    | 15 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |
| <ul style="list-style-type: none"> <li>Anderson, Dinston C Polle 1970 : Thesis and assignment , writing Wiley Eastern Limited</li> <li>Booth W C 2016 The Craft of Research Univerity of Chicago Press</li> <li>Rajendrakumar C. 2008 Research Methodology . New Age International Publishers</li> <li>Kothari C R 2004 Research Methodology . New Age International Publishers</li> <li>Gurumani N 2006 Research Methodology for Biological Sciences. MJP Publishers</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |

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| BIT09E603               | Fermentation Technology       |                                             |
| Semester 9              | Discipline Specific Elective  | Level: 600-699                              |
| 4 Credit                | Hours per week: 4<br>Theory-4 | Marks: 100<br>Internal- 50, External-<br>50 |
| Course Outcomes<br>(CO) |                               |                                             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |
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| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Understand the scope and development as well as screening and strain improvement strategies.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | U  |          |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Describe media making, sterilisation, and the importance of different bioprocess parameters in achieving high yields.                                                                                                                                                                                                                                                                                                                                                                                                                                                | An |          |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Specify different types of bioreactors and techniques of downstream processing                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | An |          |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Illustrate the Microbial production of various Biotech products like antibiotics, citric acid, vitamin etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Ap |          |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Introduction to Fermentation technology<br>History, Scope and Development of Fermentation technology; Isolation and screening of industrially important microorganisms – primary and secondary screening; Maintenance of Strains; Strain improvement: Mutant selection and Recombinant DNA technology.                                                                                                                                                                                                                                                               |    | 10 Hours |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Fermentation media<br>Natural and Synthetic media; Basic components of an media (Carbon sources; Nitrogen sources; Vitamins; Minerals; Anti-foaming agents); Role of buffers in media; Process of aeration, and agitation and process control.                                                                                                                                                                                                                                                                                                                       |    | 12 Hours |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Fermentor design<br>Basic designs of Fermentor; Type of fermentors: C S T R, Air lift, Bubble columns, Deep jet, Packed tower and fluidized bed. Scale up of fermentation and product development;<br>Down-stream processing and Product recovery; Regulation and safety.                                                                                                                                                                                                                                                                                            |    | 11 Hours |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Production of Microbial Products<br>Production of alcohol; Organic acid – Citric acid; Antibiotic – Penicillin, Amino acid – Glutamic acid; Vitamin – B12; Single Cell Protein (SCP).                                                                                                                                                                                                                                                                                                                                                                                |    | 12 Hours |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Primary and secondary of antibiotic producing microbes - giant colony inhibition spectrum<br>Strain improvement by physical mutagenesis.<br>Synthetic media and crude media<br>Growth of bacteria in different carbon sources- mono,di and polysaccharides. Effect of buffers on yield of product<br>Solid state fermentation - mushroom cultivation<br>Pretreatment of agroindustrial wastes by physical and chemical methods.<br>Production of ethanol - detection and estimation<br>Penicillin production by submerged fermentation process using fungal pellets. |    | 15 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |
| <ul style="list-style-type: none"> <li>• Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.</li> <li>• Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2<sup>nd</sup> edition. Panima Publishing Co. New Delhi.</li> <li>• Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.</li> <li>• Peter F Stanbury, Allan Whitaker, Stephen J Hall. Principles of Fermentation Technology. (2016).</li> <li>• Butterworth-Heinemann Press. UK. H. J. Peppler, D. Perlman. Microbial Technology: Fermentation Technology. (2014). Academic Press.</li> <li>• T. El-Mansi, C. Bryce, Arnold L. Demain, A.R. Allman. Fermentation Microbiology and Biotechnology. Second Edition. (2006). CRC Press, USA.</li> <li>• Hongzhang Chen. Modern Solid State Fermentation: Theory and Practice. (2013). Springer Press, Germany.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |          |

- John E. Smith. Biotechnology. (2009). Cambridge University Press.UK. Celeste M. Todaro, Henry C. Vogel.
- Fermentation and Biochemical Engineering Handbook. (2014). William Andrew Press. Norwich, NY.
- G. Lancini, R. Lorenzetti. Biotechnology of Antibiotics and other Bioactive Microbial Metabolites. (2014). Springer publications, Germany.

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| BIT09E604            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Cancer Diagnostics and Therapeutics |  |                                          |
| Semester 9           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Discipline Specific Elective        |  | Level: 600-699                           |
| 4 Credit             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Hours per week: 4<br>Theory-4       |  | Marks: 100<br>Internal- 50, External- 50 |
| Course Outcomes (CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                     |  |                                          |
| CO1                  | Students will be equipped with knowledge regarding cancer as a global health problem, general properties, types, genetic basis and mechanism of cancer progression and therapeutic resistance.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                     |  | R,U, An                                  |
| CO2                  | Students will develop knowledge on the most advanced molecular diagnostic approaches used in the clinic for early detection, prognosis, and disease surveillance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                     |  | U, An, Ap                                |
| CO3                  | Students will gain knowledge on the molecular mechanism underlying the conventional as well as novel approaches in cancer therapeutics equipping them to contribute towards research and development of novel therapeutics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                     |  | R,U, An                                  |
| CO4                  | Students will develop a thorough knowledge about cancer immunity and ways by which the knowledge is used towards development of various diagnostics, prevention strategies and therapeutics.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                     |  | R, U, An, Ap                             |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                     |  |                                          |
| I                    | Introduction to human cancers:<br>An overview of the cancer problem; General characteristics and hallmarks of cancers and cancer cells, Types of cancer, Genetic basis of cancer, cancer genes, multistep nature of cancer progression,tumor heterogeneity, clonal expansion and therapeutic resistance, Hereditary and sporadic cancer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                     |  | 10 Hours                                 |
| II                   | Cancer Diagnostics:<br>Significance of diagnostics in the prevention, early detection, prognosis of cancer; Applications of molecular detection techniques for Characterisation , classification, prognosis, therapeutic response and remission of the disease in the clinic; Important criteria in the use of molecular diagnostic assays in the clinic ;DNA, RNA and proteins as molecular markers, immunohistochemistry to detect specific protein markers, RNA-in-situ-hybridization to detect specific mRNAs, or fluorescence-in-situ hybridization to detect chromosomal aberrations.; Chemiluminescent immunoassay for serum protein biomarkers, NGS analysis of tumor DNA and cell free DNA , Microarray analysis of gene mutations, PCR-based assays for specific gene alterations or chromosomal translocations, Gene expression profiling / transcriptomics. Molecular diagnostics of haematological cancer, Molecular detection of carcinoma's, Pharmacogenetics and Pharmacogenomics. |                                     |  | 12 Hours                                 |

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| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Cancer therapeutics:</b><br>Radiation therapy, thermal, cryo and photoablation therapy, chemotherapy-neoadjuvant, adjuvant therapy, combination chemotherapy, Molecular mechanisms of cancer chemotherapy, cell cycle specific and cell cycle non-specific agents-DNA damaging agents; antimetabolites; antimitotic agents; antitumor antibiotics; apoptotic pathways.                     | <b>11<br/>Hours</b> |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Targeted drug therapy:</b><br>Targeting cell ectopic proteins, overexpressed proteins, altered proteins, deregulated cancer pathways and signal transducers, small molecule inhibitors and monoclonal therapy, hormone analogues and gene therapy.                                                                                                                                         | <b>12<br/>Hours</b> |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Cancer Immunotherapy :</b><br>Essentials of cancer immunobiology; CAR-T cell therapy, check point inhibitors-CTLA-4 (cytotoxic T lymphocyte associated protein 4), PD-1 (programmed cell death protein 1), PD-L1 (programmed cell death ligand 1), Monoclonal antibody therapy, cytokinin and interferon therapy, BCG vaccine and cytolytic virus based immunotherapy for localized tumor. | <b>15<br/>Hours</b> |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                               |                     |
| <ul style="list-style-type: none"> <li>• Genetics of Cancer: Genes Associated with Cancer invasion, Metastasis and Cell Proliferation;</li> <li>• GV Sherbet and M S Laksmi; Academic Loress</li> <li>• The Biology of Cancer; Robert A Weinberg; Garland Science.</li> <li>• Alberts et al., Molecular Biology of the Cell, Carland 2008.</li> <li>• Molecular Genetics of Cancer, 2nd Revised Edition, Bios, 2001.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                               |                     |

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|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|--|------------------------------------------|
| BIT09E605            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Plant and Animal Biotechnology |  |                                          |
| Semester 9           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Discipline Specific Courses    |  | Level: 600-699                           |
| 4 Credit             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Hours per week: 4<br>Theory-4  |  | Marks: 100<br>Internal- 50, External- 50 |
| Course Outcomes (CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                |  |                                          |
| CO1                  | To understand structural and functional organization of plant genomes, principles and applications of plant tissue culture, micropropagation                                                                                                                                                                                                                                                                                                                                             |                                |  | U, R                                     |
| CO2                  | To understand the principles and methodologies involved in the development of transgenic constructs or genetic transformation for plants and the application of plant tissue culture techniques.                                                                                                                                                                                                                                                                                         |                                |  | U, R, Ap                                 |
| CO3                  | Familiarize structural organization of plant genes and to explain the molecular mechanisms governing gene expression in plants. Also, it helps to describe the molecular mechanisms and components of genome editing and to understand the gene silencing approaches.                                                                                                                                                                                                                    |                                |  | U, R, Ap                                 |
| CO4                  | Outline advanced concepts, methodologies, recent innovations and tools in plant biotechnology. And, to apply molecular techniques for crop improvement, and its regulatory, and biosafety aspects.                                                                                                                                                                                                                                                                                       |                                |  | U, R, Ap                                 |
| CO5                  | To Identify and design the techniques for culturing animal cells, animal cloning, transgenic animals and their application in research and industry.                                                                                                                                                                                                                                                                                                                                     |                                |  | U, Ap                                    |
| CO6                  | Understand the principles and methodologies of molecular diagnostic techniques for the diagnosis of several diseases. And to apply knowledge of molecular tools for developing and characterizing novel animal vaccines targeting infectious diseases.                                                                                                                                                                                                                                   |                                |  | U, R, Ap                                 |
| CO7                  | Understand principles and applications of advanced molecular and cellular techniques and to assess ethical, regulatory, and biosafety concerns associated with the use of cutting-edge biotechnological methods in animals.                                                                                                                                                                                                                                                              |                                |  | U, Ap                                    |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                |  |                                          |
| I                    | Plant genome organization and Tissue culture techniques: Organization of nuclear, mitochondrial and chloroplast genome, introduction to plant tissue culture, Setting up of tissue culture laboratory, media formulation, Tissue culture and clonal propagation, synthetic or artificial seeds, Totipotency: growth and differentiation in tissue culture, Micropropagation: organogenesis and somatic embryogenesis. Somatic hybridization: Protoplast isolation and fusion             |                                |  | 10 Hours                                 |
| II                   | Development of transgenic constructs for plants and Tissue culture techniques: Ti plasmid: structure and function, Agrobacterium-mediated gene transfer, Selectable marker and Reporter genes in transgenic plants: applications, alternatives and biosafety. Methods of development of transgenic plants: Plant Viruses vector, Direct gene transfer methods: Electroporation, Microinjection, Gun Method, Chemical Gene Transfer Methods: Polyethylene glycol (PEG)-mediated transfer. |                                |  | 10 Hours                                 |
| III                  | Structure and Expression of Genes: Gene Structure and expression in Plants, Manipulating Gene Expression in Plants: CRISPR/Cas9, TALENs, ZFNs, RNAi, antisense RNA, CRISPR interference (CRISPRi)                                                                                                                                                                                                                                                                                        |                                |  | 10 Hours                                 |

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| IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Modern Approaches in Plant Biotechnology:</b> Development of crops with improved traits, such as drought resistance, virus resistance, herbicide tolerance and enhanced nutritional value. Synthetic Biology C Metabolomics: Engineering plants to produce valuable bioactive compounds, Nano-Green Biotechnology: Enhancing nutrient delivery and pest resistance. Microbiome Engineering. Pros and cons of GMO crops. | 10 Hours |
| V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Animal Cell Culture Technology:</b> Different cell culture techniques, Cell line culture, stem cells, cryopreservation. Cellular responses under <i>in vitro</i> conditions and growth pattern, Generation of clonal populations. Application of animal cell culture: drug testing, pharmaceutical proteins (monoclonal antibodies, insulin, and hormones).                                                             | 13 Hours |
| VI                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Nucleic acid-based diagnostics:</b> RFLP, RAPD : Its application, molecular diagnostics of pathogen in animals. Development of pathogen specific DNA probes, Southern and Northern hybridization. Development of animal vaccines : Peptide vaccines, Fusion protein vaccine, Peptide vaccine.                                                                                                                           | 12 Hours |
| VII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Cutting-Edge Techniques in Animal Biotechnology:</b> Animal cloning: Basic concepts and its application. Assisted reproductive techniques. Transgenic Animals for producing therapeutic proteins and human antibodies. 3D bioprinting and its applications. Sustainable Animal Biotechnology: Biodegradable vaccines, Precision livestock farming. Ethical issues in Animal Biotechnology.                              | 10 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                            |          |
| <ul style="list-style-type: none"> <li>• H.S. Chawla, Introduction to Plant Biotechnology; Science Publishers, 2004.</li> <li>• Hammond J et al., Plant Biotechnology- New Products and Applications. Springer, 1999.</li> <li>• C.N. Stewart Jr, Plant biotechnology and genetics: Principles, techniques, and applications. John Wiley &amp; Sons. 2016.</li> <li>• S. Umesha, Plant Biotechnology, 2nd Edn., CRC Press, 2019.</li> <li>• Amanda Capes-Davis, R., Ian Freshney. Freshney's culture of Animal cells: A manual of Basic technique and specialized applications. 8th edition, Wiley-Blackwell, 2021.</li> <li>• Ralf Portner, Animal Cell Biotechnology, Methods and Protocols, 4th edition, Humana Press, Springer US, 2019.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                            |          |

## Semester 10/Second Year PG Biotechnology- Semester 4

| Semester 10 FYUGP/Second year PG Biotechnology Semester 4 |              |             |                                                                            |         |           |           |             |
|-----------------------------------------------------------|--------------|-------------|----------------------------------------------------------------------------|---------|-----------|-----------|-------------|
|                                                           | Course Level | Course Code |                                                                            | Credits | Int Marks | Ext Marks | Total Marks |
|                                                           | 600-699      | BIT10P601   | Project                                                                    | 20      | NA        | NA        | 100         |
|                                                           |              |             | OR                                                                         |         |           |           |             |
|                                                           |              |             | <b>Discipline Specific Courses</b>                                         |         |           |           |             |
|                                                           |              | BIT10C601   | Bio entrepreneurship                                                       | 4       | 50        | 50        | 100         |
|                                                           |              | BIT10C602   | Bioethics                                                                  | 4       | 50        | 50        | 100         |
|                                                           |              | BIT10C603   | Marine Biotechnology                                                       | 4       | 50        | 50        | 100         |
|                                                           |              | BIT10C604   | Nanobiotechnology                                                          | 4       | 50        | 50        | 100         |
|                                                           |              | BIT10C605   | Good Laboratory and Biomanufacturing Practices                             | 4       | 50        | 50        | 100         |
|                                                           |              | BIT10M601   | MOOC III- MOOC from the list of courses approved by the Department Council | 4       |           |           |             |

|                         |                                                                                                                                                             |                                  |  |                                             |    |  |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|--|---------------------------------------------|----|--|
| BIT10C601               |                                                                                                                                                             | Bio entrepreneurship             |  |                                             |    |  |
| Semester 10             |                                                                                                                                                             | Discipline Specific Courses      |  | Level: 600-699                              |    |  |
| 4 Credit                |                                                                                                                                                             | Hours per week:<br>4<br>Theory-4 |  | Marks: 100<br>Internal- 50, External-<br>50 |    |  |
| Course Outcomes<br>(CO) |                                                                                                                                                             |                                  |  |                                             |    |  |
| CO1                     | Students should be able to gain entrepreneurial skills                                                                                                      |                                  |  |                                             | U  |  |
| CO2                     | Students will be able to identify the Biotech based companies, products and services.                                                                       |                                  |  |                                             | An |  |
| CO3                     | Students will know the legal and financial conditions for starting a business venture                                                                       |                                  |  |                                             | An |  |
| CO4                     | Students will be able to identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies |                                  |  |                                             | Ap |  |
| Course Content          |                                                                                                                                                             |                                  |  |                                             |    |  |

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| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Basics of bio-entrepreneurship</b><br>Introduction to bio-entrepreneurship, Scope of bio-entrepreneurship, Types of bio-industries Ownership, Development of entrepreneurship, Stages in entrepreneurial process, Role of entrepreneurs in economic development, entrepreneurship in India, Entrepreneurship – its barriers.                                                                                           | 10<br>Hours |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Innovation and entrepreneurship in bio business</b><br>Strategy and operations of bio-sector firms, Factors shaping opportunities for innovation and entrepreneurship in bio-sectors and the business implications of those opportunities, Entrepreneurship development programs of public and private agencies – MSME, DBT, BIRAC and Make India, Strategic dimensions of patenting and commercialization strategies. | 12<br>Hours |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Bio-markets</b><br>Negotiating the road from lab to the market - Strategies and processes of negotiation with financiers, Government and regulatory agencies, pricing strategy, Challenges in marketing in bio-business (market condition and segment, developing distribution channels, the nature, analysis and management of customer needs).                                                                       | 11<br>Hours |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Bio-management</b><br>Basic contracts and agreements for joint ventures and development, Business plan preparation including strategy and legal requirements, Business feasibility study, financial management, collaborations and partnerships                                                                                                                                                                        | 12<br>Hours |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Biotech enterprises</b><br>Desirables in start-up, Setting up Small, Medium C Large scale industry, Quality control in Biotech industries, Location of an enterprise, steps for starting a small industry, incentive and subsidies, exploring export possibilities                                                                                                                                                     | 15<br>Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                           |             |
| <ul style="list-style-type: none"> <li>Principles of Management P. C.Tripathi, P.N. Reddy Tata McGraw Hill Fifth Edition, 2012</li> <li>Entrepreneurship Development S.S.Khanka S.Chand C Co 2006</li> <li>Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Shimasaki, C. D. (2014). Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.</li> <li>Innovation, Commercialization, and Start-Ups in Life Sciences. Jordan, J. F. (2014), London: CRC Press.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                           |             |

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|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|--|---------------------------------------------|
| BIT10C602               |                                                                                                                                      | Bioethics                        |  |                                             |
| Semester 10             |                                                                                                                                      | Discipline Specific Courses      |  | Level: 600-699                              |
| 4 Credit                |                                                                                                                                      | Hours per week:<br>4<br>Theory-4 |  | Marks: 100<br>Internal- 50, External-<br>50 |
| Course Outcomes<br>(CO) |                                                                                                                                      |                                  |  |                                             |
| CO1                     | Understand the foundational principles of bioethics such as autonomy, beneficence, non-maleficence and justice                       |                                  |  | U                                           |
| CO2                     | Analyse ethical issues in healthcare, including end of life care, reproductive rights, genetic engineering and organ transplantation |                                  |  | An                                          |

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| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Evaluate the ethical implications of emerging medical technologies such as gene editing, artificial intelligence and reproductive technologies                                                                                                                                                                                         | An |          |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Understand the role of law policy and professional guidelines in shaping ethical practices and resolving ethical conflicts                                                                                                                                                                                                             | U  |          |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                        |    |          |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Introduction to bioethics. Definition and historical development of bioethics. Ethical theories and principles of bioethics. Human rights, privacy, justice, equity etc. Applications of ethical issues in human experimentation. Bioethics in laboratory, experiments on animals.                                                     |    | 10 Hours |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Principles of research ethics, case studies in research ethics. Importance of informed consent. The role of autonomy in health care decision making. The role of institutional review boards. Ethical consideration in assisted reproductive technologies. Ethical issues of prenatal diagnosis and genetic manipulation.              |    | 12 Hours |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Ethical implications of genetic testing, Reproductive cloning and therapeutic cloning and experiments with human cells. Genetic enhancement and gene editing. Privacy and confidentiality in genetic research. Ethical aspects of interfering in natural process. Hidden dangers in altering the genetic makeup.                       |    | 11 Hours |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Future directions in bioethics. Anticipating bioethical challenges of future. Professional responsibilities in bioethics. Carrier paths in bioethics and related fields.                                                                                                                                                               |    | 12 Hours |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Ethical principles in human subjects research. Historical cases and contemporary issues. Genetics and Biotechnology. Research ethics. Institutional review boards. Balancing individual rights and public good. Vaccination and epidemic responses. The intersection of environmental issues and bioethics. Sustainability and health. |    | 15 Hours |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                        |    |          |
| <ul style="list-style-type: none"> <li>• T M Murray, M J Mehlman 2000 Encyclopedia of ethical, legal and policy issues in Biotechnology, John Wiley C Sons</li> <li>• Ben Mephram, Bioethics: An introduction for the Biosciences 2 nd Edn Oxford university press 2008</li> <li>• Sathish M K. Bioethics and Biosafety. International publishing house ltd New Delhi 2011</li> <li>• Sree Krishna V. Bioethics and Biosafety in Biotechnology. New age international. 2007</li> <li>• Guidelines for safety assessment of food derived from genetically engineered plants.</li> </ul> |                                                                                                                                                                                                                                                                                                                                        |    |          |

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| BIT10C603            |                                                                                                                                                                              | Marine Biotechnology             |  |                                          |
| Semester 10          |                                                                                                                                                                              | Discipline Specific Courses      |  | Level: 600-699                           |
| 4 Credit             |                                                                                                                                                                              | Hours per week:<br>4<br>Theory-4 |  | Marks: 100<br>Internal- 50, External- 50 |
| Course Outcomes (CO) |                                                                                                                                                                              |                                  |  |                                          |
| CO1                  | Familiarize with definition and different aspects of marine biotechnology and it's applications.Userstand ethe importance of microalgae and it's biotechnological potential. |                                  |  | U                                        |

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| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Explain different types of corals and it's relevance in marine biotechnology- value added products from corals.                                                                                                                                                                                                                                                                  | An |          |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Outline different aspects of bioprocess engineering related to phototropic marine organisms,it's cultivation using photobioreactors and bioprospecting- biominerals.                                                                                                                                                                                                             | An |          |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Able to understand the importance of marine enzymes,it's production and purification as well as give a detailed account of various marine drugs including antimicrobial peptides produced by marine bacteria.                                                                                                                                                                    | Ap |          |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                  |    |          |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Marine Biotechnology - defenition, marine sources and research, Applications of marine biotechnology.Marine micro algae.Genetic enginnering for microalgae, photo bioreactors for marine micro algae.Marine algae and it's biotechnological potential.Description of marine algae with biotechnological potential.                                                               |    | 10 Hours |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Introduction to corals: potential pharmaceuticals from soft and hard corals.Marine sponges-sponge associated microorganisms, Biotechnological potential of marine sponges- pharmacological potential.                                                                                                                                                                            |    | 12 Hours |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Bioprocess Engineering of phototropic marine organisms - growth characteristics of phototropic suspension cultures,photobioreactor design and operation.Bioprospecting: Marine microbial habitats and their biotechnologically relevant microorganisms.<br>Marine biominerals:Biomineralized structures; Biocomposites; Biopolymers - polysaccharides, chitin, marine collagens. |    | 11 Hours |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Marine enzymes : Cultivation techniques of marine bacteria.Examples of marine enzymes.Down stream processing of marine enzymes.Marine derived metabolites: Approved marine drugs as pharmaceuticals.Antimicrobial peptides from microorganisms.Marine antimicrobial peptides.isolation of antimicrobial peptides.Marine derived fungal metabolites.                              |    | 12 Hours |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Marine biomaterials in therapeutics and diagnostic: biomaterials; classification of biomaterials. Marine biodiversity, biomaterials from marine environment, Statusof marine natural products as therapeutic agents, marine resources for medical diagnostic services.                                                                                                           |    | 10 Hours |
| <b>VI</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Microalgal Biotechnology: Sustainable biofuels from marine algae, Biodiesel production by Microalgal lipid transesterifucation, Bioethanol from microalgae, Microalgal biohydrogen production by sunlight and sea water                                                                                                                                                          |    | 5 Hours  |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                  |    |          |
| <ul style="list-style-type: none"> <li>• Hand book of marine Biotechnology,edited by Kim,springer - Verlag 2015.</li> <li>• Essentials of marine biotechnology,2019, by Se-Kwon Kim.</li> <li>• Iqbal Choudhary, M., and Thomsen, Attahur srahman2,005. Bioassay Techniques for Drug Development (Taylor and Francis).</li> <li>• Sethala, R., and Fernandes, P.B. Eds. 2001. Handbook of Drug Screening (Marcel Dekker Inc).</li> <li>• Zhang, L., and Demain, A.L. Eds. 2005. Natural Products Drug Discovery and Therapeutic Methods.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                  |    |          |

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| <b>BIT10C604</b> | <b>Nanobiotechnology</b> |
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| <b>Semester 10</b>                                                                                                                                                                                                                                                                                                                                                                           | <b>Discipline Specific Courses</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Level: 600-699</b>                              |
| <b>4 Credit</b>                                                                                                                                                                                                                                                                                                                                                                              | <b>Hours per week:</b><br><b>5</b><br>Theory-3,<br>Practical-2                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Marks: 100</b><br>Internal- 50, External-<br>50 |
| <b>Course Outcomes (CO)</b>                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                    |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                   | Basic properties of nanoparticles and structures                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | U                                                  |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                   | Learn the synthesis of nanoparticle                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | An                                                 |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                   | Characterization of nanoparticle with different techniques                                                                                                                                                                                                                                                                                                                                                                                                                                                       | An                                                 |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                   | Application of nanoparticles in diagnosis, therapy                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Ap                                                 |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                    |
| <b>I</b>                                                                                                                                                                                                                                                                                                                                                                                     | General properties of nanoparticles, Nanomaterial in biotechnology - biomedical applications with advanced research in the delivery of biomolecules, the delivery of drugs, the diagnosis of cancer, tissue engineering, the detection of biomarkers and imaging. These materials have numerous applications in fabricating biotechnology, an advanced area of research. Nanobiotechnological applications in Environment and food - detection and mitigation. Antimicrobial activity and biosensor applications | 10<br>Hours                                        |
| <b>II</b>                                                                                                                                                                                                                                                                                                                                                                                    | Bio nanostructures- Silica, carbon, Gold. Silver, Copper, Zinc nano particles of nanostructures, such as nanoparticles, nanocrystals, nano spores, nanorods, nanowires, nanoribbons, nanotubes, nano scaffolds, dendrimers, quantum dots, nanospheres, and nano capsules. Artificial cells Nanomaterials – Core/shell structures, Carbon-based Nanomaterials,                                                                                                                                                    | 12<br>Hours                                        |
| <b>III</b>                                                                                                                                                                                                                                                                                                                                                                                   | Protein based nanostructures Self assembly properties rotary molecular motors, Microarray, Magnetosomes, Bacteriorhodopsin. DNA based nanostructures. DNA-protein nanostructures Nanopore for sequencing nucleic acids Nanoparticle as cell transforming agents                                                                                                                                                                                                                                                  | 11<br>Hours                                        |
| <b>IV</b>                                                                                                                                                                                                                                                                                                                                                                                    | Synthesis Methods of Nanomaterials: Top down : Milling; Bottom-up approaches – Synthesis of zero dimensional metal, metal oxides, semiconductor nanoparticles by different routes – Synthesis using microbial, plant and animal cell extract. Characterization by XRD, SEM, TEM, AFM FTIR.                                                                                                                                                                                                                       | 12<br>Hours                                        |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                     | <b>Practicals</b> <ul style="list-style-type: none"> <li>Preparation of nanoparticles</li> <li>Characterization of Nano particle</li> </ul>                                                                                                                                                                                                                                                                                                                                                                      | 30<br>Hours                                        |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                    |
| <ul style="list-style-type: none"> <li>Nanobiotechnology: Concepts, Applications and Perspectives, Christof M.Niemeyer (Editor), Chad A. Mirkin (Editor), Wiley VCH.</li> <li>Nanobiotechnology - II more concepts and applications. Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH.</li> <li>Nanotechnology in Biology and Medicine: Methods, Devices, and Applications</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                    |

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| <b>BIT10C605</b> | <b>Good Laboratory and Biomanufacturing Practices</b> |
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| Semester 10             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Discipline Specific Courses                      |  | Level: 600-699                              |             |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|--|---------------------------------------------|-------------|
| 4 Credit                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Hours per week:<br>5<br>Theory-3,<br>Practical-2 |  | Marks: 100<br>Internal- 50, External-<br>50 |             |
| Course Outcomes<br>(CO) |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |  |                                             |             |
| CO1                     | Explain GLP- Definition, scope and its role in biomanufacturing industries. Good manufacturing practices, Quality control and quality assurance and GLP to be followed in the biotechnology industry.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |  | U                                           |             |
| CO2                     | Understand the rules to be followed when handling reagents, cleaning of glass ware, making records, preparation of standard solutions, calibration of various analytical equipment etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |  | An                                          |             |
| CO3                     | Familiarize with concept of biomanufacturing and explain the different steps involved in manufacturing of biomolecules , process evaluation, manufacturing of raw material and products.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |  | An                                          |             |
| CO4                     | Describe different aspects of biomanufacturing downstream processing, analytical methods, quality control and assurance, validation and product release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |  | Ap                                          |             |
| Course Content          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |  |                                             |             |
| I                       | Introduction to GLP, History, Scope, Definitions, Fundamental points of GLP (Resources, Characterization, Rules, Results). Standard Operating Procedures, Quality assurance unit, protocol for conduct of non- clinical testing, control on animal house, scope of quality certifications – responsibilities of QA C QC departments, Analysis of raw materials, finished products, packaging materials, in process quality control (IPQC).<br>General Laboratory Practices: Common calculations in Biotechnology laboratories. Understanding the details on the label of reagent bottles. Preparation of solutions. Molarity and normality of common acids and bases. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures and their handling. |                                                  |  |                                             | 10<br>Hours |
| II                      | Good Laboratory Practices:The rules to be followed in handling reagents, recommended practice for cleaning of glassware and its importance, Mandatory requirement for unambiguous records and procedure to be followed to maintain proper records. The importance of preventive maintenance and type of entries in an instrument logbook. Preparation of Standard Solutions and Buffers. Calibration of laboratory Instruments: pH meter, colorimeter, spectrophotometer, water bath, Distillation assembly, Burettes etc.                                                                                                                                                                                                                                                                                                                                    |                                                  |  |                                             | 12<br>Hours |
| III                     | Introduction to biopharmaceuticals:<br>Biotechnology and biopharmaceuticals, Historical perspective of pharmaceutical biotechnology, process of transforming new molecular entities into drugs.Role of manufacturing process, process evaluation, drug substance manufacturing, drug product manufacturing,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                  |  |                                             | 11<br>Hours |
| IV                      | Biopharmaceutical manufacturing and quality assurance:<br>Batch and continuous processes, cell banking, expression systems, and sterile technology, raw material and processing aids, purification of product, formulation and filling, labelling and packaging, product analytics, quality criteria of analytical methods, process analytics, validation of analytical methods. Quality assurance and quality control: Fundamentals of quality assurance,                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |  |                                             | 12<br>Hours |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | benefits, structure of quality management system documentation, audits, quality assurance in manufacturing, equipment specification ,bioprocess validation, product release, product recall.                                                                                                                                                                                                                                                                                                                                                                                                  |                     |
| <b>V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Practicals</b> <ul style="list-style-type: none"> <li>• Cleaning of glass wares</li> <li>• Instrumentation log book preparation - types of entries in log book.</li> <li>• Preparation of standard solutions</li> <li>• Preparation of buffers</li> <li>• Calibration of pH meter</li> <li>• Calibration of colorimeter</li> <li>• Calibration of spectrophotometer</li> <li>• Familiarisation with water bath, distillation unit and burettes .</li> <li>• Industry visit - quality control and quality assurance division</li> <li>• Biopharmaceuticals - product showcasing.</li> </ul> | <b>30<br/>Hours</b> |
| <b>References</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                     |
| <ul style="list-style-type: none"> <li>• Principles of Good laboratory practices by Pradeep Deshmukh.Published by Aadhyan books,2020.</li> <li>• How to Practice GLP, 3rd Edition, P.P. Sharma Guidelines for good laboratory practices-Indian council of medical research, New Delhi.</li> <li>• Handbook Good Laboratory Practices-World health organization (WHO) Biomanufacturing,chander prakash,surpreet singh,Rupinder singh,eds,first edition,2019, springer.</li> <li>• Biopharmaceutical manufacturing, principles, process and practices,Garry gilleskein,Charles Rutter,Becky MC cuen,oublusherDe Gruyter,2021.</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                     |

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| <b>BIT10M601</b> | <b>MOOC III-</b> MOOC from the list of courses approved by the Department Council |
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