# BANASTHALI VIDYAPITH

## Bachelor of Science (Biotechnology)


### Curriculum Structure

First Semester Examination, December, 2019
Second Semester Examination, April/May, 2020
Third Semester Examination, December, 2020
Fourth Semester Examination, April/May, 2021
Fifth Semester Examination, December, 2021
Sixth Semester Examination, April/May, 2022

**BANASTHALI VIDYAPITH**
**P.O. BANASTHALI VIDYAPITH**
**(Rajasthan)-304022**

July, 2019

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**No. F. 9-6/81-U.3**

**Government of India**
**Ministry of Education and Culture**
**(Department of Education)**

New Delhi, the 25th October, 1983

# N O T I F I C A T I O N

In exercise of the powers conferred by Section 3 of the University Grants Commission Act, 1956 (3 of 1956) the Central Government, on the advice of the Commission, hereby declare that Banasthali Vidyapith, P. O. Banasthali Vidyapith, (Rajasthan) shall be deemed to be a University for the purpose of the aforesaid Act.

Sd/-
**(M. R. Kolhatkar)**
Joint Secretary of the Government of India

# N O T I C E

Changes in Bye-laws/Syllabi and Books may from time to time be made by amendment or remaking, and a Candidate shall, except in so far as the Vidyapith determines otherwise, comply with any change that applies to years she has not completed at the time of change.

## Programme Educational Objectives

The B.Sc. Biotechnology programme aims at holistic development of the students through the innovative and unique Five fold Educational ideology of Banasthali Vidyapith. This programme broadly includes core subjects of biotechnology, botany, zoology and chemistry. The courses in the programme aim to provide a basic and advanced understanding of the different disciplines of each core subject by means of a lecture series and laboratory work. The program has identified necessary competencies in the respective areas for which all essential theoretical, practical and field based skills will be provided.

The main objectives of the B. Sc. Biotechnology programme are to:

- provide an introduction to the basic concepts of biotechnology and its recent advances
- gain in-depth knowledge of different areas of biotechnology such as biochemistry, immunology, bioinformatics, molecular biology, cell biology, environmental biology, cell and tissue culture techniques, genetic engineering etc.
- develop logical thinking, analytical and independent learning skills
- create awareness amongst students towards the importance of multidisciplinary approach for problem solving skills in biotechnology
- provide broad exposure to various societal, ethical and commercial issues in the various aspects of biotechnology
- raise sensitivity to professional ethical codes of conduct, social values and respect for all
- train the students for an academic and professional fields of biotechnology
- develop an ability to work in collaboration with expertise of different subjects in industries and research
- imbibe and inculcate the basic foundation of biotechnology among students so that they can excel in esteemed academic institutes, various public and private sector organizations with professional competence, technical knowledge and analytical skills

## Programme Outcomes

**PO1: Biotechnology knowledge:** This course provides necessary theoretical and practical experience in all divisions of biotechnology to pursue a professional career in this field.

**PO2: Planning ability:** Demonstrate effective planning abilities including time management, resource management and organizational skills. Develop and implement plans and organize work to meet deadlines.

**PO3: Problem analysis:** Utilize subject and practical knowledge to think analytically, design experiments, handle scientific instruments, drawing logical inferences from the scientific experiments while solving problems for the betterment of society.

**PO4: Modern tool usage:** Utilize gained knowledge to apply appropriate methods, resources and related computational tools with an understanding of their limitations.

**PO5: Leadership skills:** Develop students with sound concepts in biotechnology who can excel as leaders both in academics and industries. Develop enterpreunership skills to explore the market potential of products and processes, creating business plans and raising money from venture capitalists.

**PO6: Professional identity:** Understand, analyse and communicate the value of their professional roles in society (e.g. biotechnologist, researchers, educators, managers, employers, employees).

**PO7: Hands-on training:** Laboratory experiments will provide hands-on training on experimenting with biomolecules and thereby develop a research aptitude for various allied fields of biotechnology.

**PO8: Bioethics:** Imbibe ethical, moral and social values in personal and social life leading to highly cultured and civilized personality.

**PO9: Communication**: Develop various communication skills such as reading, listening, speaking, writing and make effective presentations, which will help them in expressing their ideas and views clearly and effectively.

**PO10: Environment and sustainability:** Utilize the acquired knowledge to maintain the environmental friendly philosophy with sustainability of various environmental resources. Also to create awareness amongst others to keep the environment safe and clean.

**PO11: Life-long learning:** Develop trained human resources in biotechnology to promote quality education and to initiate lifelong learning process for productive career.

# Curriculum Structure
## Bachelor of Science (Biotechnology)

### Semester - I

| Course | Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| | | General English / सामान्य हिन्दी | 2 | 0 | 0 | 2 |
| | | Core Foundation Course – I | 2 | 0 | 0 | 2 |
| **Botany** | | | | | | |
| BOT | 101 | Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms | 6 | 0 | 0 | 6 |
| BOT | 101L | Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab | 0 | 0 | 4 | 2 |
| **Biotechnology** | | | | | | |
| BT | 102 | Cell and Molecular Biology- I | 6 | 0 | 0 | 6 |
| BT | 102L | Cell and Molecular Biology - I Lab | 0 | 0 | 4 | 2 |
| **Chemistry** | | | | | | |
| CHEM | 102 | Inorganic Chemistry –I | 6 | 0 | 0 | 6 |
| CHEM | 102 L | Inorganic Chemistry –I Lab | 0 | 0 | 4 | 2 |
| | | **Semester Total:** | **22** | **0** | **12** | **28** |

### Semester - II

| Course | Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| | | सामान्य हिन्दी/General English | 2 | 0 | 0 | 2 |
| | | Core Foundation Course – II | 2 | 0 | 0 | 2 |
| **Biotechnology** | | | | | | |
| BT | 103 | Biostatistics, Bioinformatics and Instrumentation | 6 | 0 | 0 | 6 |
| BT | 103L | Biostatistics, Bioinformatics and Instrumentation Lab | 0 | 0 | 4 | 2 |
| **Zoology** | | | | | | |
| ZOO | 101 | Non-Chordates and Proto-Chordates | 6 | 0 | 0 | 6 |
| ZOO | 103L | Non-Chordates and Proto-Chordates Lab | 0 | 0 | 4 | 2 |
| **Chemistry** | | | | | | |
| CHEM | 103 | Organic Chemistry – I | 6 | 0 | 0 | 6 |
| CHEM | 103 L | Organic Chemistry – I Lab | 0 | 0 | 4 | 2 |
| | | **Semester Total:** | **22** | **0** | **12** | **28** |

## Semester - III

| Course | Code | Course Name | L | T | P | C * |
|---|---|---|---|---|---|---|
| | | Core Foundation Course –III | 2 | 0 | 0 | 2 |
| | | Elective Foundation Course-I | 2 | 0 | 0 | 2 |
| **Botany** | | | | | | |
| BOT | 201 | Angiosperms Taxonomy and Economic Botany | 6 | 0 | 0 | 6 |
| BOT | 201L | Angiosperms Taxonomy and Economic Botany Lab | 0 | 0 | 4 | 2 |
| **Biotechnology** | | | | | | |
| BT | 202 | Biochemistry, Biophysics and Enzymology | 6 | 0 | 0 | 6 |
| BT | 209L | Biochemistry, Biophysics and Enzymology Lab | 0 | 0 | 4 | 2 |
| **Chemistry** | | | | | | |
| CHEM | 202 | Physical Chemistry – I | 6 | 0 | 0 | 6 |
| CHEM | 202 L | Physical Chemistry – I Lab | 0 | 0 | 4 | 2 |
| | | **Semester Total:** | **22** | **0** | **12** | **28** |

## Semester - IV

| Course | Code | Course Name | L | T | P | C * |
|---|---|---|---|---|---|---|
| | | Core Foundation Course – IV | 2 | 0 | 0 | 2 |
| | | Elective Foundation Course – II | 2 | 0 | 0 | 2 |
| **Biotechnology** | | | | | | |
| BT | 207 | Genetics, Microbiology and Immunology | 6 | 0 | 0 | 6 |
| BT | 210L | Genetics, Microbiology and Immunology Lab | 0 | 0 | 4 | 2 |
| **Zoology** | | | | | | |
| ZOO | 202 | Comparative Anatomy and Embryology of Chordates | 6 | 0 | 0 | 6 |
| ZOO | 202L | Comparative Anatomy and Embryology of Chordates Lab | 0 | 0 | 4 | 2 |
| **Chemistry** | | | | | | |
| CHEM | 201 | Inorganic Chemistry – II | 6 | 0 | 0 | 6 |
| CHEM | 201 L | Inorganic Chemistry – II Lab | 0 | 0 | 4 | 2 |
| | | **Semester Total:** | **22** | **0** | **12** | **28** |

## Semester - V

| Course Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|
| | Vocational Course – I | 2 | 0 | 0 | 2 |
| | Core Foundation Course - V/ | 2 | 0 | 0 | 2 |
| | Elective Foundation Course-III | | | | |
| **Botany** | | | | | |
| | Botany Elective-I | 6 | 0 | 0 | 6 |
| | Botany Elective-I Lab | 0 | 0 | 4 | 2 |
| **Biotechnology** | | | | | |
| | Biotechnology Elective-I | 6 | 0 | 0 | 6 |
| | Biotechnology Elective-I Lab | 0 | 0 | 4 | 2 |
| **Chemistry** | | | | | |
| | Discipline Elective – I | 6 | 0 | 0 | 6 |
| | Discipline Elective – I Lab | 0 | 0 | 4 | 2 |
| | **Semester Total:** | **22** | **0** | **12** | **28** |

## Semester - VI

| Course Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|
| | Vocational Course – II | 2 | 0 | 0 | 2 |
| | Elective Foundation Course-III/ | 2 | 0 | 0 | 2 |
| | Core Foundation Course - V | | | | |
| **Zoology** | | | | | |
| | Zoology Elective-II | 6 | 0 | 0 | 6 |
| | Zoology Elective-II Lab | 0 | 0 | 4 | 2 |
| **Biotechnology** | | | | | |
| | Biotechnology Elective-II | 6 | 0 | 0 | 6 |
| | Biotechnology Elective-II Lab | 0 | 0 | 4 | 2 |
| **Chemistry** | | | | | |
| | Discipline Elective – II | 6 | 0 | 0 | 6 |
| | Discipline Elective – II Lab | 0 | 0 | 4 | 2 |
| | **Semester Total:** | **22** | **0** | **12** | **28** |

**Botany: Discipline Elective Courses- I**

| Course | Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| BOT | 302 | Introduction to Genetics and Genetic Engineering | 6 | 0 | 0 | 6 |
| BOT | 302L | Introduction to Genetics and Genetic Engineering Lab | 0 | 0 | 4 | 2 |
| BOT | 303 | Plant Physiology and Ecology | 6 | 0 | 0 | 6 |
| BOT | 303L | Plant Physiology and Ecology Lab | 0 | 0 | 4 | 2 |
| BOT | 304 | Ethnobotany | 6 | 0 | 0 | 6 |
| BOT | 304L | Ethnobotany Lab | 0 | 0 | 4 | 2 |
| BOT | 305 | Horticulture | 6 | 0 | 0 | 6 |
| BOT | 305L | Horticulture Lab | 0 | 0 | 4 | 2 |

**Zoology: Discipline Elective Courses- II**

| Course | Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| ZOO | 301 | Animal Physiology | 6 | 0 | 0 | 6 |
| ZOO | 301L | Animal Physiology Lab | 0 | 0 | 4 | 2 |
| ZOO | 305 | Environmental Biology and Biostatistics | 6 | 0 | 0 | 6 |
| ZOO | 305L | Environmental Biology and Biostatistics Lab | 0 | 0 | 4 | 2 |
| ZOO | 304 | Developmental Biology | 6 | 0 | 0 | 6 |
| ZOO | 304L | Developmental Biology Lab | 0 | 0 | 4 | 2 |
| ZOO | 303 | Applied Zoology | 6 | 0 | 0 | 6 |
| ZOO | 303L | Applied Zoology Lab | 0 | 0 | 4 | 2 |

**Biotechnology: Discipline Elective Courses-I & II**

| Course | Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| BT | 307 | Genetic Engineering, rDNA Technology and Cell & Tissue Culture Technology | 6 | 0 | 0 | 6 |
| BT | 307L | Genetic Engineering, rDNA Technology and Cell & Tissue Culture Technology Lab | 0 | 0 | 4 | 2 |
| BT | 301 | Advances in Biotechnology | 6 | 0 | 0 | 6 |
| BT | 301L | Advances in Biotechnology Lab | 0 | 0 | 4 | 2 |
| BT | 313 | Animal and Plant Biotechnology | 6 | 0 | 0 | 6 |
| BT | 313L | Animal and Plant Biotechnology Lab | 0 | 0 | 4 | 2 |
| BT | 315 | Environmental Biotechnology | 6 | 0 | 0 | 6 |
| BT | 315L | Environmental Biotechnology Lab | 0 | 0 | 4 | 2 |

**Chemistry: Discipline Elective Courses-I & II**

| Course | Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| CHEM | 302 | Organic Chemistry - II | 6 | 0 | 0 | 6 |
| CHEM | 302L | Organic Chemistry - II Lab | 0 | 0 | 4 | 2 |
| CHEM | 305 | Molecular Modeling and Drug Design | 6 | 0 | 0 | 6 |
| CHEM | 305L | Molecular Modeling and Drug Design Lab | 0 | 0 | 4 | 2 |
| CHEM | 303 | Physical Chemistry - II | 6 | 0 | 0 | 6 |
| CHEM | 303L | Physical Chemistry - II Lab | 0 | 0 | 4 | 2 |
| CHEM | 304 | Analytical Methods in Chemistry | 6 | 0 | 0 | 6 |
| CHEM | 304L | Analytical Methods in Chemistry Lab | 0 | 0 | 4 | 2 |

**List of Core Foundation Courses**

| Course | Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| BVF | 002 | Environment Studies | 2 | 0 | 0 | 2 |
| BVF | 013 | Indian Cultural Heritage | 2 | 0 | 0 | 2 |
| BVF | 017 | Selected Writings of Great Authors - I | 2 | 0 | 0 | 2 |
| BVF | 020 | Women in Indian Society | 2 | 0 | 0 | 2 |
| BVF | 015 | Parenthood and Family Relation | 2 | 0 | 0 | 2 |

**List of Elective Foundation Courses**

| Course | Code | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| BVF | 010 | Design Thinking | 2 | 0 | 0 | 2 |
| BVF | 012 | Human Body and Health | 2 | 0 | 0 | 2 |
| BVF | 016 | Science of Happiness | 2 | 0 | 0 | 2 |
| BVF | 019 | Universal Human Values | 2 | 0 | 0 | 2 |
| BVF | 018 | Selected Writings of Great Authors - II | 2 | 0 | 0 | 2 |

**List of Vocational Course**

| Course Code | | Course Name | L | T | P | C* |
|---|---|---|---|---|---|---|
| VOC | 011L | Basic Dress Making | 0 | 0 | 4 | 2 |
| VOC | 005L | Dress Designing | 0 | 0 | 4 | 2 |
| VOC | 014 | Entrepreneurship - I | 2 | 0 | 0 | 2 |
| VOC | 015 | Entrepreneurship - II | 2 | 0 | 0 | 2 |
| VOC | 020 | Radio Production - I | 2 | 0 | 0 | 2 |
| VOC | 021 | Radio Production - II | 2 | 0 | 0 | 2 |
| VOC | 022 | Web Designing and Internet Technology-I | 1 | 0 | 0 | 1 |
| VOC | 022 L | Web Designing and Internet Technology-I Lab | 0 | 0 | 2 | 1 |
| VOC | 023 | Web Designing and Internet Technology-II | 1 | 0 | 0 | 1 |
| VOC | 023 L | Web Designing and Internet Technology-II Lab | 0 | 0 | 2 | 1 |
| VOC | 009 | Library Science - I | 1 | 0 | 2 | 2 |
| VOC | 009 L | Library Science - I Lab | | | | |
| VOC | 010 | Library Science - II | 0 | 0 | 2 | 2 |
| VOC | 010 L | Library Science - II Lab | | | | |
| VOC | 018 | Photography - I | 0 | 0 | 4 | 2 |
| VOC | 019 | Photography - II | 0 | 0 | 4 | 2 |
| VOC | 016 | Introduction to Artificial Intelligence-I | 2 | 0 | 0 | 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VOC | 017 | Introduction to Artificial Intelligence-II | 2 | 0 | 0 | 2 |
| VOC | 012 | Computer Assisted Learning and Teaching | 1 | 0 | 0 | 1 |
| VOC | 012 L | Computer Assisted Learning and Teaching - Lab | 0 | 0 | 2 | 5 |
| VOC | 013 | Emerging Technologies for Learning and Teaching | 2 | 0 | 0 | 2 |

***L - Lecture hrs/week ; T - Tutorial hrs/week;**

**P - Project/Practical/Lab/All other non-classroom academic activities, etc. hrs/week; C- Credit Points of the Course**

1. Student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester from Semesters III onwards with prior permission of respective heads and time table permiting.

2. Every Student shall also opt for:
   Five Fold Education: Physical Education I, Physical Education II,
   Five Fold Education: Aesthetic Education I, Aesthetic Education II,
   Five Fold Education: Practical Education I, Practical Education II
   one each semester

**Note:** Syllabus of Foundation and Vocational courses are available in separate booklet, "Curriculum Structure and Syllabus Foundation and Vocational Courses"

# Five Fold Activities

| Fine Arts | | Physical Education and Sports | |
|---|---|---|---|
| BVFF 101 | Classical Dance (Bharatnatyam) | BVFF 201 | Aerobics |
| BVFF 102 | Classical Dance (Kathak) | BVFF 202 | Archery |
| BVFF 103 | Classical Dance (Manipuri) | BVFF 203 | Athletics |
| BVFF 104 | Creative Art | BVFF 204 | Badminton |
| BVFF 105 | Folk Dance | BVFF 205 | Basketball |
| BVFF 106 | Music-Instrumental (Guitar) | BVFF 206 | Cricket |
| BVFF 107 | Music-Instrumental (Orchestra) | BVFF 207 | Equestrian |
| BVFF 108 | Music-Instrumental (Sarod) | BVFF 208 | Flying - Flight Radio Telephone Operator's Licence (Restricted) |
| BVFF 109 | Music-Instrumental (Sitar) | BVFF 209 | Flying - Student Pilot's Licence |
| BVFF 110 | Music-Instrumental (Tabla) | BVFF 229 | Aeromodelling |
| BVFF 111 | Music-Instrumental (Violin) | BVFF 210 | Football |
| BVFF 112 | Music-Vocal | BVFF 211 | Gymnastics |
| BVFF 113 | Theatre | BVFF 212 | Handball |
| | | BVFF 213 | Hockey |
| **Social Service and Extension Activities** | | BVFF 214 | Judo |
| BVFF 301 | BanasthaliSewa Dal | BVFF 215 | Kabaddi |
| BVFF 302 | Extension Programs for Women Empowerment | BVFF 216 | Karate – Do |
| BVFF 303 | FM Radio | BVFF 217 | Kho-Kho |
| BVFF 304 | Informal Education | BVFF 218 | Net Ball |
| BVFF 305 | National Service Scheme | BVFF 219 | Rope Mallakhamb |
| BVFF 306 | National Cadet Corps | BVFF 220 | Shooting |
| | | BVFF 221 | Soft Ball |
| | | BVFF 222 | Swimming |
| | | BVFF 223 | Table Tennis |
| | | BVFF 224 | Tennis |
| | | BVFF 225 | Throwball |
| | | BVFF 226 | Volleyball |
| | | BVFF 227 | Weight Training |
| | | BVFF 228 | Yoga |

## Evaluation Scheme and Grading System

| Continuous Assessment (CA) (Max. Marks) | | | | | End-Semester Assessment (ESA) (Max. Marks) | Grand Total (Max. Marks) |
|---|---|---|---|---|---|---|
| Assignment | | Periodical Test | | Total (CA) | | |
| I | II | I | II | | | |
| 10 | 10 | 10 | 10 | 40 | 60 | 100 |

In all theory, laboratory and other non classroom activities (project, dissertation, seminar, etc.), the Continuous and End-semester assessment will be of 40 and 60 marks respectively. However, for Reading Elective, only End semester exam of 100 marks will be held. Wherever desired, the detailed breakup of continuous assessment marks (40), for project, practical, dissertation, seminar, etc shall be announced by respective departments in respective student handouts.

Based on the cumulative performance in the continuous and end-semester assessments, the grade obtained by the student in each course shall be awarded. The classification of grades is as under:

| Letter Grade | Grade Point | Narration |
|---|---|---|
| O | 10 | Outstanding |
| A+ | 9 | Excellent |
| A | 8 | Very Good |
| B+ | 7 | Good |
| B | 6 | Above Average |
| C+ | 5 | Average |
| C | 4 | Below Average |
| D | 3 | Marginal |
| E | 2 | Exposed |
| NC | 0 | Not Cleared |

Based on the obtained grades, the Semester Grade Point Average shall be computed as under:

$$SGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ---- + CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ---- + CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of courses (with letter grading) registered in the semester, $CC_i$ are the course credits attached to the $i^{th}$ course with letter grading and $GP_i$ is the letter grade point obtained in the $i^{th}$ course. The courses which are given Non-Letter Grades are not considered in the calculation of SGPA.

The Cumulative Grade Point Average (CGPA) at the end of each semester shall be computed as under:

$$CGPA = \frac{CC_1 * GP_1 + CC_2 * GP_2 + CC_3 * GP_3 + ----+ CC_n * GP_n}{CC_1 + CC_2 + CC_3 + ----+ CC_n} = \frac{\sum_{i=1}^{n} CC_i * GP_i}{\sum_{i=1}^{n} CC_i}$$

Where n is the number of all the courses (with letter grading) that a student has taken up to the previous semester.

Student shall be required to maintain a minimum of 4.00 CGPA at the end of each semester. If a student's CGPA remains below 4.00 in two consecutive semesters, then the student will be placed under probation and the case will be referred to Academic Performance Review Committee (APRC) which will decide the course load of the student for successive semester till the student comes out of the probationary clause.

To clear a course of a degree program, a student should obtain letter grade C and above. However, D/E grade in two/one of the courses throughout the UG/PG degree program respectively shall be deemed to have cleared the respective course(s). The excess of two/one D/E course(s) in UG/PG degree program shall become the backlog course(s) and the student will be required to repeat and clear them in successive semester(s) by obtaining grade C or above.

**After successfully clearing all the courses of the degree program, the student shall be awarded division as per following table.**

| Division | CGPA |
|---|---|
| Distinction | 7.50 and above |
| First Division | 6.00 to 7.49 |
| Second Division | 5.00 to 5.99 |
| Pass | 4.00 to 4.99 |

**CGPA to % Conversion Formula: % of Marks Obtained = CGPA * 10**

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# First Semester

# BOTANY

## BOT 101 Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes::**

On completion of the course, students will be able to:

- Acquaint with the general characters and classification of cryptogams and phanerogames.
- Understand the evolutionary relationship among lower to higher plant species with differentiating characteristics.
- Appreciate and understand economic importance and application of every group of plants.

**Unit 1**

- Algae: Classification, general account with special reference to *Anabaena*, *Oscillatoria*, *Volvox*, *Chara*, *Oedogonium*, *Ectocarpus*, *Polysiphonia*. Economic importance of algae.

**Unit 2**

- Fungi: Classification, general account with special reference to *Albugo*, *Aspergillus*, *Puccinia*, *Ustilago* and *Alternaria*. Economic importance of fungi.

**Unit 3**

- Bryophytes: Classification, general account with special reference to important features in the life cycles of *Riccia*, *Marchantia*, *Anthoceros* and Mosses: *Funaria*, *Sphagnum*.

**Unit 4**

- Pteridophytes: Classification, general account, evolution of steler systems, apospory, apogamy and seed habit. Outline of life cycle of *Selaginella*, *Equisetum* and *Marsilea*.

**Unit 5**

- Gymnosperms: Classification and evolution, distribution with special reference to Indian gymnosperms. Special features in life cycle of *Cycas*, *Pinus* and *Ephedra*. Economic importance.

**Suggested Books:**


- Alam, A. (2015). *Text book of Bryophyta*. New Delhi: I K International Publishers.
- Alexopoulus, C. (1979). *Introductory Mycology*. New York: John Wiley & Sons.
- Bhatia, K. (1975). *A Treatise on Algae*. New Delhi: S. Chand & Company.
- Biswas, C., & Johri, B.M. (2010). *Gymnosperm*. Springer-Verlag Berlin and Heidelberg GmbH & Co. KG
- Chamberlian, C.J. (1919). *Morphology of Gymnosperms*. Allahabad: Central Book Depot.
- Chapman, V.J. (2013). *An Introduction to the Study of Algae*. UK: Cambridge University Press.
- Dubey, H.C. (2011). *Introduction to Fungi*. India: Vikas Publishing House.
- Dutta, S.C. (1967). *Introduction to Gymnosperms*. Asia Publishing House.
- Ganguli, H.C., Das, K.S., & Dutta C. (2011). *College Botany* Vol. I. India: New Central Book Agency.
- Kumar, H.D. (1999). *Introductory Phycology*. New Delhi: Affiliated East-West.
- Parihar, N.S. (1956). *Bryophyta Pteridophyta*. Allahabad: Central Book Depot.
- Rashid, A. (1999). *An Introduction to Pteridophyta*. New Delhi: Vikas publications.

- Saxena, S. (2000). *A text book of Botany* (Vol. I & II). Agra: Ratan Prakash Mandir.
- Sharma, O.P., & Gupta, R.C. (2010). *Text Book of Fungi.* IBH. New Delhi, India: Vedams eBooks (P) Ltd.
- Sporne, K.R. (1966). *Morphology of Pteridophytes*. London: Hutchinson University Library.
- Vashistha, B.R., & Sinha, A.K. (2010). *Botany for Degree Students-Algae*. New Delhi: S. Chand Publication.
- Vashistha, B.R., & Sinha, A.K. (2016). *Botany for Degree Students-Fungi*. New Delhi: S. Chand Publication.
- Vashistha, B.R., Sinha, A.K., & Kumar, A. (1987). *Botany for Degree classes- Gymnosperms*. New Delhi: S. Chand Publication.
- Vashistha, B.R., Sinha, A.K., & Kumar, A. (2010). *Botany for Degree Students-Bryophyta*. New Delhi: S. Chand Publication.
- Vashisthai, B.R., & Vashistha, P.C. (1987). *Botany for Degree Students Pteridophyta*. New Delhi: S. Chand Publication.
- Webster, J., & Weber, R. (2007) *Introduction to Fungi*. New York: Cambridge University Press.


**Suggested e-Resources:**

- **Bryophytes: General account, classification and structure**

  http://nsdl.niscair.res.in/jspui/bitstream/123456789/150/1/BRYOPHYTES%20.pdf

- **Gymnosperms**

  http://www-plb.ucdavis.edu/courses/bis/1c/text/Chapter24nf.pdf

**Pteridophytes**

http://nsdl.niscair.res.in/jspui/bitstream/123456789/556/1/PTERIDOPHYTES%20april609%20-%20formatted.pdf

## BOT 101L Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes::**

On completion of the course, students will be able to:

- Identify bryophyte and pteridophyte material for specimens of lower group of plants.
- Interpret the characteristics & life cycles of various lower plants.
- Learn about practical techniques in lab for detail study of plant structure and anatomy, reproduction.

1. Study of algae and fungi as mentioned in the syllabus (museum specimen of the affected plants and permanent prepared slides).
2. Study of vegetative and reproductive parts in *Selaginella*, *Equisetum* and *Marsilea*.
3. Study of vegetative and reproductive parts in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* by the preparation of temporary slides.
4. Gymnosperms: Study of *Cycas* (coralloid root, rachis, leaflet, male cone, megasporophyll), *Pinus* (needle, dwarf shoot, long shoot, male cone, female cone) *Ephedra* (morphology, stem, male cone, female cone) by the preparation of temporary slides.

**Suggested Books:**


- Bendre, A., & Kumar, A. (2009). *A Textbook of Practical Botany- I.* Meerut: Rastogi Publications.

# BIOTECHNOLOGY

## BT 102 Cell and Molecular Biology - I

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes::**

On completion of the course, students will be able to:

- Gain expertise in the ultra structural information of cell besides the detailed views of the cell interior.
- Understand the complex molecular mechanisms occurring in the cell.
- Describe types, structural organization and packaging of chromosomes.

**Unit 1**

- General introduction to the science of biotechnology, cell biology, molecular biology and their scope.
- Structural and functional organization of prokaryotic and eukaryotic cell, difference between prokaryotic and eukaryotic cell.
- Molecular structure of cell wall and plasma membrane of eukaryotic cell.
- Ultrastructural organization of cilia, flagella and basal bodies.
- Basic idea of different types of cell junctions.

**Unit 2**

- Transport across cell membrane: Passive transport (simple & facilitated diffusion) and active transport (primary & secondary).
- Role of extra cellular signals in cellular metabolism.
- Basic concept of receptors (GPCR, receptor tyrosine kinase and intracellular receptors) that mediate the response to extra cellular signals.

- Basic concept of signal transduction (adenylate cyclase pathway and inositol lipid pathway).
- Cell division, cell cycle & its regulation.

**Unit 3**

- A study of ultrastructural organization and functions of eukaryotic cell organelles:
  - Mitochondria.
  - Chloroplast.
  - Endoplasmic reticulum.
  - Golgi complex.
  - Lysosomes.
  - Peroxisomes.

**Unit 4**

- Ultrastructural organization of nucleus and nucleolus.
- Structural organization of chromosomes including lampbrush and polytene chromosomes. DNA packaging into chromosomes.
- Types of chromosomes based on number and position of centromere. Karyotype.
- Molecular structure and types of DNA, denaturation and renaturation, Tm value.
- Molecular structure and types of RNA.
- DNA replication in prokaryotes and eukaryotes.

**Unit 5**

- Mechanism of transcription in prokaryotes.
- Mechanism of transcription in eukaryotes, RNA processing.
- Genetic code.

- Mechanism of translation in prokaryotes and eukaryotes.
- Differences between translation of prokaryotes and eukaryotes.

**Suggested Books:**


- De Robertis, E.D.P., De Robertis, E.M.F. (1987). *Cell and Molecular Biology* (8th ed.). USA: Lea & Febiger.
- Gupta, P.K. (2005). *Cell and Molecular Biology*. Meerut: Rastogi Publications.
- Hardin, J., Bertoni, G.P. (2016). *Becker's World of the Cell* (9th ed.). USA: Pearson education.
- Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., Killian, D. (2018). *Concepts of Genetics* (12th ed.). USA: Pearson.
- Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. (2012). *Lewin's Genes XI* (11th ed.). USA: Jones and Bartlett Publishers.
- Lodish, H., Berk, A. Kaiser, C.A., Krieger, M. Scott, M.P. (2007). *Molecular Cell Biology* (6th ed.). USA: W H Freeman.
- Malacinski, G.M. (2015). *Freifelders Essentials of Molecular Biology* (4th ed.). USA: Jones & Bartlett.
- Paul, A. (2011). *Textbook of Cell & Molecular Biology*. Kolkata: Books & Allied Ltd.
- Powar, C.B. (2014). *Essentials of Cytology*. Mumbai: Himalaya Publishing House.
- Rastogi, V.B. (2010). *Fundamental of Molecular Biology*. New Delhi: ANE Books.
- Rastogi, V.B. (2016). *Introductory Cytology – Knrn*. Meerut: Kedar Nath Ram Nath Publishers.
- Singh, B.D. (2015). *Biotechnology*. New Delhi: Kalyani Publishers.
- Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education.

- Verma, P.S., Agarwal, V.K. (2004). *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology*. New Delhi: S. Chand Publisher.
- Weaver, R.F. (2011). *Molecular Biology* (5th ed.). USA: McGraw-Hill Education.


**Suggested e-Resources:**

- **Cell organelles**

  https://www.khanacademy.org/test-prep/mcat/cells/eukaryotic-cells/a/organelles-article

  https://www.ncbi.nlm.nih.gov/books/NBK21743/

- **DNA packaging**

  https://www.nature.com/scitable/topicpage/dna-packaging-nucleosomes-and-chromatin-310

- **Replication, transcription, translation**

  https://www.atdbio.com/content/14/Transcription-Translation-and-Replication

- **Signal transduction pathway**

  https://www.ncbi.nlm.nih.gov/books/NBK9870/

- **Cell biology**

  https://nptel.ac.in/courses/102103012/6

- **Cell biology & organelles**

  https://www.nicholls.edu/biol-ds/biol155/Lectures/Cell%20Biology.pdf

- **Molecular cell biology**

  https://nptel.ac.in/courses/102106025/

  https://nptel.ac.in/courses/122103039/22

## BT 102L Cell and Molecular Biology – I Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes::**

On completion of the course, students will be able to:

- Understand the basics of cell structure and transport mechanism.
- Gain knowledge about isolation and estimation of nucleic acid from cell.
- Perform analysis of chromosomes and types of cell division.

1. Organization and working of optical microscope: Dissecting and compound microscopes.
2. To examine the phenomenon of cell permeability using hypotonic, isotonic and hypertonic solutions.
3. Study of salivary gland chromosomes.
4. Preparation of various stages of mitosis and meiosis.
5. Cell counting (RBC) using hemocytometer.
6. Calibration of microscope using stage and ocular micrometer with the help of camera lucida.
7. Determination of DNA content by DPA method.
8. To determine the $\lambda_{max}$ for given DNA sample.
9. Double staining of *Calotropis* sp. stem, leaf material.
10. To observe cyclosis through temporary mount of a plant cell.
11. Preparation and precipitation of casein from buffalo milk.

**Suggested Books:**


- Ghose, K., & Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency.
- Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication.

# CHEMISTRY

## CHEM 102 Inorganic Chemistry-I

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- derive Schrodinger wave equation and quantum numbers, predict shapes of orbital from probability curves and apply Slater's rule for calculating $Z_{eff}$.
- explain periodic properties like atomic and ionic radii, ionization energy, electron affinity and electronegativity.
- demonstrate bonding theories including valence bond theory, valence shell electron pair repulsion and molecular orbital theory and its applications.
- determine ionic structure of solids with the help of radius ratio values for coordination numbers 3, 4 and 6 and have brief knowledge of metallic bond.
- acquire knowledge of characteristic properties of 3d series elements and it's comparison with 4d and 5d series.
- apply the Werner's coordination theory and its experimental verification; to solve numerical problems based on effective atomic number concept.

**Unit 1 Atomic Structure:**

Schrodinger wave equation, significance of $\Psi$ and $\Psi^2$, quantum numbers, radial and angular wave function and probability distribution curves, shapes of *s, p, d* orbitals. Aufbau and Pauli principles, Hund's multiplicity rule, exchange energy, pairing energy, symmetrical distribution of charge, extra stability of half-filled and completely-field orbitals, electronic configurations of elements up to atomic No. 71, effective nuclear charge, shielding effect, Slater's rules for evaluation of shielding constant.

**Periodic Properties:**

Atomic and ionic radii, ionization energy, electron affinity and electronegativity-definition, methods of determination or evaluation, trends in periodic table and application in predicting and explaining the chemical behavior

**Unit 2 Chemical Bonding:**

Covalent bond: resonance, valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions, valence shell electron pair repulsion (VSEPR) theory with reference to $BF_3$, $BF_4^-$, $NH_3$, $H_2O$, $H_3O^+$, $PCl_5$, $SF_4$, $CIF_3$, $I_3^-$, $SF_6$, $IF_7$, $ICI_2^-$, and $POCl_3$; MO theory, simple LCAO theory; sigma, pi and delta molecular orbitals; homonuclear and heteronuclear (CO and NO) diatomic molecules and their ions, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference.

**Ionic Solids:**

Ionic structure, radius ratio effect and coordination number, calculation of limiting radius ratio values for CN 3, 4 and 6; limitations of radius ratio rule, lattice defects, semi-conductors, lattice energy (excluding mathematical derivation), Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule, metallic bond: free electron, valence bond and band theories; weak interactions: hydrogen bonding, Van der Waals interactions.

**Unit 3 s-Block Elements:**

Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies and an introduction to alkalides and electrides, alkyls and aryls of *s*-block elements

**p-Block Elements:**

Comparative study (including diagonal realtionship) of groups 13 to17 elements, compounds like hydrides, oxides, oxyacids and halides of groups 13 to 16, hydrides of boron-diboranes and higher boranes, borazine, borohydride; fullerenes, carbides, flourocarbons, silicates (structural principle), tetrasulphur tetranitride, basic properties of halogens, interhalogens and polyhalides

**Chemistry of Noble Gases:**

Chemical properties of noble gases, chemistry of xenon, structure and bonding in xenon compounds.

**Unit 4 Chemistry of Elements of First Transition Series:**

Characteristic properties of *d*-block elements, properties of elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry.

**Chemistry of Elements of Second and Third Transition Series:**

General characteristics, comparative treatment with their 3*d*-analogues with respect to ionic radii, oxidation states, magnetic behaviour, spectral properties and stereochemistry.

**Unit 5 Valence Bond Theory:**

Introduction, Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes, limitations of VBT.

**Oxidation and Reduction:**

Use of redox potential data, analysis of redox cycle, redox stability in water, Frost, Latimer and Pourbaix diagrams, principles involved in the extraction of the elements.

**Acids and Bases:**

Arrhenius, Lewis, Bronsted-Lowry, Lux-Flood and solvent system concepts of acids and bases.

**Recommended Books:**

1. Lee, J. D. (1998). *Concise Inorganic Chemistry* (5th ed.). United Kingdom: Wiley/Oxford Publications.

2. Puri, B. R., Sharma, L. R. &. Kalia, K. C. (2017). *Principles of Inorganic Chemistry* (33rd ed.). India: Vishal Publications.

3. Cotton, F. A., & Wilkinson, G. (1994). *Basic Inorganic Chemistry* (3rd ed.). United Kingdom: John Wiley Publications**.**

4. Bhagchandani, P. (2017)**.** *Inorganic Chemistry*. India: Sahitya Bhawan Publications.

5. Malik, W. U., Tuli, G. D., & Madan, R. D. (2010). *Selected Topics in Inorganic Chemistry*. (Revised ed.).India: S. Chand Publications**.**

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

## CHEM 102L Inorganic Chemistry-I Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- understand the principles of working with laboratory equipments and ability to properly use them during chemistry experiments.
- prepare standard solution of various secondary standard salts.
- process purification of impure compounds by crystallization.
- calibrate lab equipments like pipettes and burettes.
- analyze, separate and identify inorganic ions from various groups.

1. **Semi-micro Analysis**: Anion and cation analysis, separation and identification of ions from groups Zero, I, II, III, IV, V and VI.

2. **Calibration**: fractional weights, pipettes and burettes, preparation of standard solutions (0.1 M to 0.001 M).

3. **Volumetric Analysis**

(a) Determination of acetic acid in commercial vinegar using NaOH.

(b) Determination of alkali content in antacid tablet using HCl.

(c) Estimation of calcium content in chalk as calcium oxalate by permanganometry.

(d) Estimation of copper using thiosulphate.

**Recommended Books:**

1. Gurdeep, R. (2016*), Advanced Practical Inorganic Chemistry*, revised Ed., Krishna Prakashan publication.

2. Svehla, G. (2010), Vogel's *Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall.

3. Gurtu, J. N. and Gurtu , A (2011), *Physical Chemistry Vol – I*, Pragati Prakashan publication.

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

# Second Semester

# BIOTECHNOLOGY

## BT 103 Biostatistics, Bioinformatics and Instrumentation

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Gain fundamental knowledge of biostatistics including sampling, data collection, measures of central tendency and dispersion.
- Gain introductory knowledge of bioinformatics including biological databases, protein structure prediction and phylogenetic analysis.
- Understand the working principle and applications of various analytical instruments to explore biological activities.

**Unit 1**

- Introduction to biostatistics and its scope.
- Sampling techniques.
- Collection of data, frequency distribution, tabulation, graphical representation of data by histogram, frequency polygon, frequency curve and cumulative frequency curve.
- Measures of central tendency: Mean, median, mode.
- Measures of dispersion: Mean deviation, standard deviation and variance.

**Unit 2**

- Correlation and regression analysis.
- Law of probability, concept and calculation.
- Introduction to computers; hardware and software.

- Data representation.
- Number systems; binary, octal, decimal and hexadecimal.
- Computer programming; Algorithm and flowchart.

**Unit 3**

- Introduction and scope of bioinformatics.
- Introduction to biological database.
- Databases at NCBI; nucleotide, gene protein, MMDB, Pubmed and Bookshelf.
- Introduction to sequence alignment; dot plot method.
- Concept of phylogenetics tree; sequence analysis based phylogenetics.

**Unit 4**

- Introduction to protein secondary structure prediction; Chou-Fasman method.
- A brief introduction to computational drug design.
- Working principle and applications of:
  - Colorimeter and spectrophotometer (UV-VIS) and fluorimetry.
  - Microscopy (compound, phase contrast and electron).

**Unit 5**

- Working principle and applications of:
  - Centrifuge.
  - Chromatography: Paper, TLC, brief idea about different types of columns.
  - Electrophoresis: Paper, PAGE (native and SDS), agarose gel.

**Suggested Books:**


- Attwood, T. (2007). *Introduction to Bioinformatics*. USA: Pearson Education.
- Barker, K. (2004). *At the Helm: A Laboratory Navigator*. New Delhi: I K International Publishing House.
- Bhuyan, K.C. (2017). *Advanced Biostatistics*. Kolkata: New Central Book Agency.
- Chatwal, G.R., Anand, S. (2011). *Instrumental Methods of Chemical Analysis*. Mumbai: Himalaya Publishing House.
- Datta, A.K. (2014). *Basic Biostatistics and Application*. Kolkata: New Central Book Agency.
- Freifelder, D.M. (1983). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology*. USA: W. H. Freeman.
- Gupta, S.P. (2018). *Statistical Methods* (45th ed.). New Delhi: Sultan Chand & Sons.
- Pandey, M. (2015*). Biostatistics: Basic and Advanced*. New Delhi: MV Learning.
- Rana, S.V.S. (2012). *Biotechniques: Theory & Practice* (3rd ed.). Meerut: Rastogi Publications.
- Rao, P.H., & Janardhan, K. (2014). *Fundamentals of Biostatistics*. New Delhi: I. K. International Publishing House.
- Rastogi, S.C., Mendiratta, N., & Rastogi, P. (2018). *Bioinformatics: Concepts, Skills & Applications* (2nd ed.). New Delhi: CBS Publishers & Distributors.
- Sharma, B.K. (2011). *Instrumental Methods of Chemical Analysis*. Mumbai: Meerut: Goel Publishing House.
- Sharma, V., Munjal, A., & Shanker, A. (2008). *A Text Book of Bioinformatics*. Meerut: Rastogi Publications.
- Sinha, P.K., & Sinha, P. (2004). *Computer Fundamentals* (6th ed.). New Delhi: BPB Publications.

- Walker, J,M., & Wilson, K. (2000). *Practical Biochemistry Principles and Techniques* (5th ed.). New Delhi: Cambridge University Press.


**Suggested e-Resources:**

- **Analytical techniques**

  https://nptel.ac.in/courses/102107028/

  http://www.tulane.edu/~wiser/methods/notes.pdf

- **Basic bioinformatics**

  https://courses.cs.ut.ee/MTAT.03.242/2017_fall/uploads/Main/Basics_of_Bioinformatics.pdf

- **Analytical techniques & bioinformatics**

  https://nptel.ac.in/courses/102103044/38

- **Biostatistics**

  https://nptel.ac.in/courses/102106051/

  https://nptel.ac.in/courses/102101056/

- **Measures of central tendency**

  https://www.tutorialspoint.com/statistics/arithmetic_mean.htm

## BT 103L Biostatistics, Bioinformatics and Instrumentation Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Separate the obtained biological data and make valid inferences that can be used to solve problems in various disciplines of science and technology.

- Learn sequence analysis and molecular visualization using bioinformatics tools.
- Safety measures in laboratory, handling and care of instruments.

1. Demonstration including working principle and applications of the following instruments:
    i. pH meter
    ii. Balance
    iii. Centrifuge
    iv. Autoclave
    v. Different types of microscopes
    vi. Incubator and oven
    vii. Shaker
    viii. Spectrophotometer/Colorimeter
    ix. Server
2. Statistical problems (exercise on mean, mode, median, standard deviation, standard error).
3. Bioinformatics exercise:
    - Dot plot; palindrome and repeat sequence identification.
    - Visualization of biomolecular structures; PyMol.
4. Preparation of solutions of different of molarities. Concept of buffers- preparations of few buffers e.g. Tris (alkaline range), acetate/ citrate (acidic range).
5. To determine the pH of five aliquots of the given soil sample and plot a graph of the same.
6. Separation of cell organelles using sucrose density gradient.

7. Separation of amino acids by paper chromatography and thin layer chromatography.

8. Demonstration of SDS-PAGE for separation of proteins.

9. To prepare standard curve of ammonium sulfate.

**Suggested Books:**


- Boya, R.F. (2006). *Modern Experimental Biochemistry* (3rd ed.). Noida: Pearson Education.
- Ghose, K., & Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency.
- Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication.
- Sharma, S., & Sharma, R. (2016). *Practical Manual of Biochemistry* (2nd ed.). New Delhi: Medtech.


# ZOOLOGY

## ZOO 101 Non-Chordates and Proto-Chordates

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Describe the habit, habitat, morphology, structure and functions of important animals of different major phyla of invertebrates and lower chordates.
- Understand the economic importance of various invertebrate phyla and affinities of lower chordate animals.
- Gain a high degree of competence in its field of specialization in response to the changing demands of the times.

**Unit 1**

**Protozoa**

- Habitat, habits, external features, locomotion, osmoregulation, nutrition, reproduction and life cycle of *Euglena, Paramecium* and *Monocystis.*
- Economic importance of protozoans.

**Porifera**

- Habitat, habits, structural organization, canal system, reproduction and development of *Sycon* including evolution of canal system in sponges.
- Economic importance of sponges.

**Unit 2**

**Coelenterata**

- Habitat, habits, external features, nutrition, structural organization, reproduction and life cycle of *Obelia*.
- Corals and coral reefs.

**Helminthes**

- Habitat, habits, external features, different systems and life history of following animal types: *Fasciola, Taenia* and *Ascaris.*
- Parasitic adaptations and diseases caused by helminthes.

**Unit 3**

**Annelida**

- Habitat, habits, external features, different systems and development of *Pheretima*.
- Habitat, habits, external features and life history of *Neanthes*.

**Arthropoda**

- Habitat, habits, external features and different systems of *Palaemone.*
- Economic importance of insecta.

**Unit 4**

**Mollusca**

- Habitat, habits, external features, various organs and organ systems of *Pila* and *Unio;* pearl formation.
- Economic importance of mollusca.

**Echinodermata**

- Habitat, habits, external features and water-vascular system of *Asterias*.
- Larval forms of echinoderms.

**Hemichordata**

- Habitat, habits, external features and different system of *Balanoglossus.*
- Affinities of hemichordates.

**Unit 5**

**Urochordata**

- Habitat, habits, structural organisation and various systems of *Herdmania.*
- Tadpole larva and retrogressive metamorphosis in *Herdmania*.

**Cephalochordata**

- Habitat, habits, morphology, different systems and affinities of *Amphioxus.*
- Development of coelom and atrium of *Amphioxus.*

**Suggested Books:**


- Chaki, K.K., Kundu, G., & Sarkar, S. (2014). *Introduction to Economic Zoology*. Kolkata: New Central Book Agency.
- Chaki, K.K., Kundu, G., & Sarkar, S. (2015). *Introduction to General Zoology* Vol-I. Kolkata: New Central Book Agency.

- Dhami P.S., & Dhami, J.K. (2015). *Invertebrate Zoology*. New Delhi: R. Chand and Co.
- Hyman, L.H. *The Invertebrtaes*. Vol-I-IX. New York: McGraw Hill.
- Jordan, E.L., & Verma, P.S. (2018). *Invertebrate Zoology*. New Delhi: S. Chand & Company Ltd.
- Kotpal, R.L. (2014). *Modern Textbook of Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publications.
- Kotpal, R.L. (2018). *Modern Text book of Zoology: Vertebrates* (4th ed.). Meerut: Rastogi Publications.
- Lahiri, B.K. (2013). *College Zoology* Vol-I. Mumbai: Himalaya Publishing House.
- Majupuria, T.C. (1962). *A textbook of invertebrate Zoology* (1st ed.). Jullundur City: S. Nagin Publishers.
- Nigam, H.C. (2013). *Biology of Non-Chordates.* New Delhi: Vishal Publishing Co.
- Pechenik, J.A. (2015). *Biology of the Invertebrates* (7th ed.). New Delhi: Mc Graw Hill Education.
- Prasad, S.N., & Kashyap, V. (2012). *A Textbook of Invertebrate Zoology* (XIV Ed.). New Delhi: New Age International (P) Limited.
- Rastogi, V.B. (2017). *Invertebrate Zoology*. Meerut: Kedar Nath Ram Nath.
- Shukla, G.S., & Upadhyay, V.B. (2017). *Economic Zoology* (5th ed.). Meerut: Rastogi Publication.


**Suggested e-Resources:**

- **Corals**

  https://www.icriforum.org/about-coral-reefs/what-are-corals

- ***Paramecium***

  https://www.microscopemaster.com/paramecium.html

- **Prawn**

  http://www.biologydiscussion.com/invertebrate-zoology/phylum-arthropoda/study-notes-on-prawn/33417

- ***Amphioxus***

  https://embryology.med.unsw.edu.au/embryology/index.php/Book_-_Text-Book_of_Embryology_4

- **Invertebrate animals**

  http://www.iaszoology.com/category/animal-diversity-nonchordata/

- **Non chordate animals**

  https://www.slideshare.net/godhxbwnkkdn/animal-diversity-zoology-notes

  http://abacus.bates.edu/acad/depts/biobook/AnimPhyl.pdf

## ZOO 103L Non-Chordates and Proto-Chordates Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Identify and characterize different organisms of invertebrate based on the external features.
- Describe different organ systems of important invertebrate animals like *Palaemone*, *Pila* and *Asterias*.
- Gain practical understanding of preparation of permanent slide and study of internal structures of higher invertebrate animals through microscopic study of prepared slides.
- Understand the collection of certain arthropods from their natural habitat and develop the skills of vermiculture.

1. **Study of museum specimens:**

- Porifera: *Euplectella*, *Chalina*, *Grantia* and *Spongilla*.
- Coelenterata: *Physalia*, *Aurelia*, *Millipora*, *Tubipora*, *Corallium*, *Antipathes* (black only), *Fungia* (mushroom coral).
- Platyhelminthes: *Schistosoma* and *Taenia*.
- Nemathelminthes: Male and female *Ascaris.*
- Annelida: *Nereis*, *Chaetopterus*, *Sabella*, *Arenicola*, *Hirudinaria*.
- Arthropoda: *Balanus*, *Squilla*, *Julus*, *Scolopendra*, Locust, Butterfly, *Cimex*, Scorpion, Spider.
- Mollusca: *Patella*, *Cyprea*, *Pecten*, *Octopus*, Pearl oyster, *Nautilus*.
- Echinodermata: *Antedon*, *Clypeaster*, Cucumara, *Ophiothrix.*
- Hemichordata: *Balanoglossus*.
- Protochordata: *Ciona* and *Salpa*.

2. **Study of microscopic slides:**

- Protozoa: *Amoeba*, *Polystomella*, *Monocystis*, Binary fission and conjugation in *Paramecium*.
- Porifera: T.S. and L.S. of *Sycon*, Spicules of sponge, Canal system of sponge.
- Coelenterata: *Obelia.*
- Platyhelminthes: W.M. of miracidium, sporocyst, redia, cercaria and metacercaria larva of *Fasciola*.
- Annelida: T.S. of *Nereis* through trunk region, T.S. of *Pheretima posthuma* through gizzard, typhlosolar region, prostrate glands and seminal vesicles.
- Arthropoda: V.S. of compound eye, *Pediculus.*
- Mollusca: T.S. of gill of *Unio*, Glochidium larva.

- Echinodermata: Larval forms (Bipinnaria, Echinopluteus, Ophiopluteus).
- Hemichordata: T.S. of *Balanoglossus* through proboscis, collar and trunk region.
- Protochordata: W.M. velum and pharyngeal wall of *Amphioxus*, T.S. of *Amphioxus* through various regions; tadpole larva of *Ascidia*.

**3. Anatomy:**

- Anatomical study of various systems with the help of chart/model/CD.

***Palaemon***

1. Appendages
2. Digestive system
3. Nervous system

***Pila globosa***

1. Digestive system
2. Structure of radula
3. Nervous system

***Asterias***

1. Water vascular system

**4.** To study methods of preservation of museum specimens.

**5. Preparation of permanent slides**

- Protozoa: *Paramecium*.
- Porifera: Spongin fibers and gemmule.
- Coelenterata: *Obelia* colony and medusa of *Obelia*.
- Annelida: Parapodium of heteronereis.
- Arthropoda: Crustacean larva (nauplius, metanauplius, megalopa, Zoea).

- Mollusca: Glochidium larva of *Unio*.
- Echinodermata: Tube feet of *Asterias*.

**6. Collection and culture methods**

(i) Collection of animals from their natural habitat: *Pheretima*, *Daphnia*, *Cyclops*, house flies, mosquitoes.

(ii) Culture of *Pheretima*.

**7.** Preparation of permanent mount of mouth parts of cockroach/housefly.

**Suggested Books:**


- Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication.
- Verma, P.S. (2010). *A Manual of Practical Zoology: Invertebrates* (11th ed.). New Delhi: S Chand Publishing.


# CHEMISTRY

## CHEM 103 Organic Chemistry-I

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- explain the organic reactions and their mechanisms.
- explain the stereochemistry of the organic compounds including their optical activity, conformations and configurations.
- explain physical and chemical properties of the hydrocarbons, alcohols, carbonyl compounds and carboxylic acids.
- understand the basics of chemistry of aromatic compounds.

**Unit 1 Organic Reactions and their Mechanisms:**

Nature of fission of covalent bonds, notations of bond fission, types of reagents, types of organic reactions and energy considerations.

**Reactive intermediates:**

Carbocation, carbanion, free radical, carbene and nitrene.

**Organomatellic Compound:**

Structure, synthesis and applications of Grignard reagent.

**Unit 2 Setereochemistry of Organic Compounds:**

Concept of isomerism, types of isomerism.

**Geometrical Isomerism:** *cis*- and *trans*- isomerism, E & Z system of nomenclature, determination of configuration of geometrical isomers, geometrical isomerism in oximes and alicyclic compounds.

**Optical Isomerism:** elements of symmetry, molecular chirality, stereogenic centre, optical activity, chiral and achiral molecules with two stereogenic centres- enantiomers, diastereoisomers, threo and erythro diastereoisomers, meso compounds; relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature; inversion, retention and racemization; resolution of enantiomers.

**Confomational Isomerism:** projection formulae (Fischer, sawhorse, Newman and flying wedge formulae), interconversion of projection formulae, difference between configuration and conformation, conformational analysis of ethane and n-butane, conformations of cyclohexane, axial and equatorial bonds, conformation of monosubstituted cyclohexane derivatives.

**Unit 3 Alkanes and Cycloalkanes:**

**(a) Alkanes:** Nomenclature, isomerism, methods of preparation (with special reference to Wurtz reaction, Corey-House reaction, Kolbe reaction and decarboxylation of carboxylic acids), physical properties, mechanism of free radical halogenation of alkanes, reactivity and selectivity.

**(b) Cycloalkanes:** Ring strain in cyclopropane and cyclobutane,

Baeyer's strain theory and its limitation, theory of strainless rings with special reference to cyclopropane ring.

**Alkenes:**

Nomenclature, isomerism, relative stabilities, methods of preparation: dehydration of alcohols, dehydrohalogenation of alkyl halides, dehalogenation of vic-dihalides, pyrolysis of quarternary ammonium hydroxides; physical properties, chemical reactions: catalytic hydrogenation, addition of hydrogen halides, hydroboration-oxidation, oxymercuration-reduction, epoxidation, ozonolysis, hydration, hydroxylation with $KMnO_4$, substitution reactions at the allylic and vinylic positions, polymerization; regioselectivity in alcohol dehydration, Saytzeff and Hofmann rules for elimination; industrial applications of ethylene and propene.

**Dienes:**

Classification, structure of allene and butadiene, chemical reactions:- electrophilic and free radical addition, polymerization, Diels-Alder reaction.

**Alkynes:**

Nomenclature, isomerism, structure and bonding in alkynes, methods of preparation, physical properties, chemical reactions-addition of hydrogen, mechanism of electrophilic and nucleophilic addition, acidity of alkynes, hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization**.**

**Unit 4 Aromaticity:**

Nomenclature of benzene derivatives, aromatic nucleus, side chain, aryl group, structure of benzene: Kekule structure, MO diagram; aromaticity: Huckel rule, aromatic, anti-aromatic and non-aromatic compounds.

**Aromatic Electrophilic Substitution Reactions:** General mechanism, role of σ-and π-complexes, mechanism of nitration, halogenation, sulphonation, and Friedel-Crafts reaction; activating and deactivating substituents, *ortho*/*para* ratio, orientation and methods of determination of the orientation.

**Alky Halides and Aryl Halides:**

**Alkyl Halides:** Nomenclature, classification and methods of preparation, chemical reactions: nucleophilic substitution and elimination reactions.

**Aryl Halides:** Nomenclature, classification, methods of preparation, chemical reactions: nucleophilic aromatic substitution reactions, low reactivity of vinyl and aryl halides, and high reactivity of allyl and benzyl halides; DDT and BHC.

**Alcohols and Phenols:**

**Alcohols:** Nomenclature and classification, dihydric alcohols: methods of preparation, physical properties, chemical reactions of vicinal glycols: acidic nature, reaction with phosphorous halides, reaction with HCl, esterification, oxidative cleavage [$Pb(OAc)_4$ and $HIO_4$] and pinacol-pinacolone rearrangement; trihydric alcohols: methods of preparation, physical properties, chemical reactions of glycerol.

**Phenols:** Nomenclature, classification, structure and bonding, preparation of phenols, physical properties, chemical reactions: acidic character, comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion, electrophilic aromatic substitution, acylation and carboxylation, Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Lederer-Manasse reaction and Reimer-Tiemann reaction.

**Unit 5 Aldehydes and Ketones:**

**Aldehydes and Ketones:**

Nomenclature, structure of the carbonyl group, synthesis of aldehydes and ketones with particular reference to synthesis of aldehydes and ketones using acid chlorides and 1, 3-dithianes, synthesis of ketones from nitrile and carboxylic acids; physical properties; mechanism of nucleophilic additions to carbonyl group with particular emphasis on aldol, Perkin, Cannizzaro and Knoevenagel condensations; reactions with ammonia and its derivatives; Wittig reaction, Mannich reaction, Clemmenson reduction and Wolf-Kishner reduction; oxidation of aldehydes (reactions with Tollen’s reagents, Fehling’s solution and Benedict’s solution) and ketones (Baeyer-Villiger oxidation).

**Carboxylic Acids:**

Nomenclature, structure and bonding, preparation, physical properties, effects of substituents on acid strength, chemical reactions of carboxylic acids: salt formation, formation of acid derivatives, reduction, reaction with Grignard reagent, decrboxylation and halogenation (Hell-Volhard-Zelinsky reaction).

**Recommended Books:**


1. Clayden, J., Greeves, N., Warren, S., & Wothers, P., (2001). *Organic Chemistry.* (2nd ed.).Oxford University Press.
2. Sykes, P. (1986). *A guide book to mechanism in organic chemistry* (6th ed.). Pearson.
3. Ingold, C. K. (1970). *Structure and mechanism in organic chemistry*. Cornell University Press.
4. Morrison, R.T., Boyd, R.N. (2002). *Organic chemistry* (6th ed.). PrentlceHall: Englewood Cliffs, NJ.
5. Nasipuri, D. (1994). *Stereochemistry of organic compounds.* (2nd ed.). New Age International
6. Singh, M.S. (2005). *Advanced organic chemistry-reactions and mechanisms*. Pearson Education (Singapore) Pvt. Ltd.
7. Wade, L.G., Singh, M.S. (2008). *Organic chemistry*. Pearson Education, Dorling Kindersley Pvt. Ltd.
8. Singh, M.S. (2014). *Reactive intermediates in organic chemistry-structure, mechanism and reactions*. Wiley, VCH, & Weinheim.
9. Eliel E. L., Wilen S. H., Manden L. N. (2005). *Stereochemistry of Carbon compounds*. Wiley & sons.


**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

# CHEM 103L Organic Chemistry Lab-I

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Laboratory Techniques:**

- To calibrate the thermometer using naphthalene (80-82°C), acetanilide (113.5-114ºC), urea (132.5-133ºC), water (100ºC) as reference materials.
- To Determine the boiling point of ethanol, cyclohexane, toluene, benzene.
- To determine the mixed melting point of Urea-cinnamic acid mixture of various compositions (1:4, 1:1, 4:1).

**Distillation**

- Simple distillation of ethanol-water mixture using water condenser.
- Distillation of nitrobenzene and aniline using air condenser.

**Crystallization**

- Concept of introduction of crystallization
- Phthalic acid from hot water (using fluted filter paper and steamless funnel)
- Acetanilide from boiling water
- Naphthalene from ethanol
- Benzoic acid from water

**Decolorisation and Crystallization using Charcoal**

- Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration.
- Crystallization and decolorisation of impure naphthalene.

**Sublimation (Simple and Vacuum)**

**Qualitative Analysis:**

- **Part-I** Detection of extra elements (N, S and halogens) and functional groups (carboxylic, alcoholic, phenolic, carbonyl, ester, carbohydrate, amine, amide and nitro) in simple organic compounds
- **Part-II** Identification of an organic compound through the functional group analysis, determination of melting points and preparation of suitable derivatives.

**Stereochemical Study of Organic Compounds via Models:**

- R and S configuration of optical isomers.
- E and Z configuration of geometrical isomers.
- Conformational analysis of cyclohexanes and substituted cyclohexanes.

**Paper Chromatography: Ascending and Circular:**

- Determination of $R_f$ values and identification of organic compounds.
- Separation of monosaccharides (a mixture of D-galactose and D-fructose) using n-butanol, acetone and water in 4:5:1 ratio, and spray reagent (aniline hydrogen phthalate).

**Recommended Books:**

1. Leonard, J., Lygo, B., Procter, G. (2013). *Advanced Practical Organic Chemistry* (3rd ed.). CRC Press, Taylor & Francis Group.
2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (1989). *Practical Organic Chemistry* (5th ed.). New York, John Wiley & Sons, Inc.

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in
2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM

   https://swayam.gov.in

# Third Semester

# BOTANY

## BOT 201 Angiosperms Taxonomy and Economic Botany

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Identify characteristic features of angiosperm families and their interdisciplinary approaches.
- Understand plant morphology terminologies and distinguishing features with morphological peculiarities.
- Know the economic importance of angiosperms and its use in various industries.

**Unit-I**

- International code of nomenclature for algae, fungi and plants- history, rules, principles. Concept of family, genus and species, citation of author's name.
- Numerical taxonomy and chemical taxonomy (brief ideas only).
- A brief account of national herbaria and botanical gardens of India.

**Unit 2**

- Classification: System of Bentham and Hooker, a brief account of classification by Engler and Prantl, Hutchinson and Takhtajan, merits and demerits.
- Study of following families with emphasis on their diagnostic features:
    - Ranunculaceae
    - Papaveraceae

- Capparidaceae
- Caryophyllaceae
- Rutaceae
- Myrtaceae
- Malvaceae

**Unit 3**

- Study of following families with emphasis on their diagnostic features:
  - Cucurbitaceae
  - Rubiaceae
  - Asclepiadaceae
  - Apocynaceae
  - Asteraceae
  - Amaranthaceae
  - Acanthaceae
  - Solanaceae
  - Apiaceae
  - Lamiaceae
  - Euphorbiaceae
  - Brassicaceae
  - Fabaceae
  - Caesalpinaceae
  - Mimosaceae
  - Poaceae
  - Arecaceae
  - Liliaceae

**Unit 4**

- Food plants: Maize, bajra, wheat, legumes, potato, sugarcane.
- Spices: General account (coriander, turmeric, chillies, *Cumin*, fennel, *Asafoetida*).
- Beverages: Tea and coffee.
- Fatty oils: Mustard, groundnut, sesame, coconut.

**Unit** 5

- Fibre plants: *Gossypium, Corchorus, Saccharaum munja*.
- Drug plants: *Cinchona, Rauwolfia, Papaver, Digitalis*.
- Timber plants: *Tectona, Dalbergia, Pinus.* Rubber: *Hevea brasiliensis.*

**Suggested Books:**


- Alam, A., & Sharma, V. (2012). *Economic Botany*. Jaipur: Pointer Publishers.
- Dutta, S. (2009). *A Hand Book of Systematic Botany*. New Delhi: New Age International (P) Limited.
- Khetrapal, Y.T. *An Introduction to the Taxonomy of Angiosperms*. Jaipur: Ramesh Book Depot.
- Kochhar, S.L. (2016). *Economic Botany of the Tropics*. London: Macmillan India Limited
- Kumar, A., & Bendra, A. (1983). *Economic Botany: for university students*. Meerut: Rastogi Publications.
- Lawrence, G.H.M. (2017). *Taxonomy of vascular plants*. Jodhpur: Scientific publisher
- Radford, A.R., & Caddell, G.M. (1986). *Fundamentals of Plant systematics*. USA: Harper & Row Publishers.
- Sharma, O.P. (2011).*Taxonomy of Angiosperm*. New Delhi: TATA McGraw-Hill.

- Singh, V., & Jain, D.K. (2010).*Taxonomy of Angiosperm*. Meerut: Rastogi Publication.
- Verma, V. (2010). *A text book of economic botany*. New Delhi: Emkay publications.


**Suggested e-Resources:**

- **Angiosperms: APG system of classification**

  https://academic.oup.com/botlinnean/article/181/1/1/2416499

- **Angiosperms: Classification and reproduction**

  https://www.toppr.com/guides/biology/plant-kingdom/angiosperms/

- **Economic botany**

  http://nsdl.niscair.res.in/jspui/bitstream/123456789/130/1/beverages.pdf

## BOT 201L Angiosperms Taxonomy and Economic Botany Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Develop skills for plant identification, with reference to systematic position, morphological characters, floral formula and floral diagram.
- Diagnose the structural features of plant organs and differentiate microscopically their tissue elements.
- Study fiber, gum, resin, timber, spices and medicinal plants and its applications.

1. Study of locally available plants of the families mentioned in the syllabus.

2. Study of economically important plant products as mentioned in the syllabus.
3. Preparation of herbarium.

**Suggested Books:**


- Sahu, A.C. (2015). *Text book of Practical Botany*. New Delhi: Kalyani Publishers.


# BIOTECHNOLOGY

## BT 202 Biochemistry, Biophysics and Enzymology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- To demonstrate an understanding of fundamental biochemical principles, such as the structure/function of biomolecules, metabolic pathways, and the regulation of biological/biochemical processes.
- Gain knowledge of basic energy metabolism of cells and identify some of common reaction mechanisms in biochemical processes.
- Describe structure, functions, kinetics, regulation and the mechanisms of action of enzymes.
- Explain chemical messenger molecules of the nervous system including neurotransmitters and synaptic neurotransmission.

**Unit 1**

- Structure and colligative properties of water.
- pH, pK, acids, bases, buffers. Ionic product of water, Henderson-Hasselbalch equation.
- Carbohydrates-Classification, structure, properties and functions.

- Amino acids and proteins-Classification, structure, properties and functions.
- Lipids-Classification, structure, properties and functions.

**Unit 2**

- Bioenergetics-Energy and its forms, principles of thermodynamics.
- Energy rich biomolecules-(ATP, NADP and other phosphorylated compounds).
- Coordinated control of metabolism: Various techniques used to study metabolism. Some key metabolic pathways: Glycolysis, citric acid cycle and pentose phosphate pathway.
- Metabolism of tryptophan, palmitic acid, purine and pyrimidines.

**Unit 3**

- Classification, structure and functions of coenzymes.
- Vitamins: Classification, structure and functions.
- Classification, properties and metabolic significance of secondary metabolites (terpenoids, alkaloids, phenols).
- Three dimensional structure of proteins: Peptide bonds, disulphide cross links, α-helix, β-sheet, helix-coil transitions. Ramachandran plots.

**Unit 4**

- Nucleic acids-Various confirmations of nucleotides, glycosidic bond rotation. Base stacking.
- Electrical properties of biological compartments, electrochemical gradients, membrane potential.
- Mechanism of ATP synthesis: Oxidative phosphorylation, chemiosmotic hypothesis and photophosphorylation.
- Nerve transmission: Resting membrane potential, propagation of nerve impulse and an idea about neurotransmitters.

- Structure of striated muscles, muscle proteins and biophysical events of muscle contraction.

**Unit 5**

- Classification, nomenclature and general properties of enzymes.
- Introduction to mechanism of enzyme action (lock and key hypothesis, induced fit hypothesis).
- Enzyme inhibition: competitive, non- competitive and uncompetitive.
- Isolation and purification of enzymes.
- Kinetics of enzyme catalyzed reaction (Michaelis-Menten law), double reciprocal plot.

**Suggested Books:**


- Berg, J.M., Stryer, L. Tymoczko, J.L. & Gatto, G.J. (2015). *Biochemistry* (8th ed.). New York, USA: WH Freeman.
- Cantor, C.R., & Schimmel, P.R. (1980). *Biophysical Chemistry, Part 2: Techniques for the Study of Biological Structure and Function* (1st ed.). New York, USA: W. H. Freeman and Company.
- Cantor, C.R., & Schimmel, P.R. (1980). *Biophysical Chemistry: Part 1: The Conformation of Biological Macromolecules*. New York, USA: W. H. Freeman and Company.
- Cantor, C.R., & Schimmel, P.R. (1980). *Biophysical Chemistry: Part 3: The Behaviour of Biological Macromolecules*. New York, USA: W. H. Freeman and Company.
- Conn, E.E., Stumpf, P.K., & Bruening, G. (2006). *Outlines of Biochemistry* (5th ed.). New Jersey: Wiley-Blackwell.
- Copeland, R.A. (2008). *Enzymes: A Practical Introduction to Structure, Mechanism & Data Analysis* (2nd ed.). India: Wiley-VCH.
- Daune, M., Duffin, W.J., & Blow, D. (1999). *Molecular Biophysics: Structures in Motion*. UK: UK: Oxford University Press.

- Gupta, S.N. (2015). *Biochemistry* (2nd ed.). Meerut: Rastogi Publication.
- Jain, J.L., Jain, S., & Jain, N. (2016). *Fundamentals of Biochemistry* (7th ed.). New Delhi: S Chand.
- Mathews, C.K., Van Holde, K.E., Appling, D.R., & Anthony-Cahill, S.J. (2012). *Biochemistry* (4th ed.). London, UK: Pearson Education.
- Narayanan, P. (2007). *Essentials of Biophysics* (2nd ed.). New Delhi: New Age Internationals.
- Nelson, D.L., & Cox, M.M. (2017). *Lehninger Principles of Biochemistry* (7th ed.). USA: W H Freeman & Co.
- Palmer, T. (2001). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry* (V Ed.). Cambridge: Horwood Publishing Ltd.
- Rajeswari, M.R. (2013). *An Introduction to Biophysics* (1st ed.). Meerut: Rastogi Publication.
- Rodwell, V., Bender, D., Kennelly, P., & Weil, P.A. (2015). *Harpers Illustrated Biochemistry* (30th ed.). New York, USA: McGraw-Hill Education / Medical.
- Satyanarayana, U., & Chakrapani, U. (2017). *Essentials of Biochemistry* (end ed.). Kolkata: Booka & Allied Ltd.
- Voet, D., & Voet, J.G. (2010). *Biochemistry* (4th ed.). New York, USA: John Wiley & Sons Inc.
- Zubay, G., Parson, W.W., & Vance, D.E. (1995). *Principles of Biochemistry*. USA: Brown (William C.) Co.


**Suggested e-Resources:**

- **Enzymology**

  https://nptel.ac.in/courses/102102033/14

- **Biomolecules**

  http://www.biologie.ens.fr/~mthomas/L3/intro_biologie/2-sucres-lipides-acides-nucleiques.pdf

- **ETC**

  https://www.khanacademy.org/science/biology/cellular-respiration-and-fermentation/oxidative-phosphorylation/a/oxidative-phosphorylation-etc

  http://courses.chem.indiana.edu/c483/documents/lecture23.pdf

- **Biochemistry**

  https://nptel.ac.in/courses/102105034/3

- **Muscle structure & contraction**

  https://opentextbc.ca/biology/chapter/19-4-muscle-contraction-and-locomotion/

## BT 209L Biochemistry, Biophysics and Enzymology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Apply the scientific method to the biochemical processes of experimentation and hypothesis testing.
- Identify and distinguish the carbohydrates, proteins and lipids based on specific biochemical tests.
- Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.
- Gain an understanding of the preparation of crude protein lysate, enzymatic assay, effect of time and enzyme concentration on its activity.

1. To find out the $\lambda_{max}$ of protein (BSA).
2. Qualitative analysis of carbohydrates (reducing and non Reducing): Molisch's test, Benedict's test, Fehling's test, Tollen's phloroglucinol, Barfoed's test, Seliwanoff's test, acidic hydrolysis test for sucrose.

3. Qualitative test for proteins: Biuret's test, Ninhydrin test, Xanthoproteic test, Million's test, Sakaguchi test, Fohl's test.
4. Qualitative analysis of lipids: Solubility test, Grease spot test, Emulsification test, Saponification test, Unsaturation test, Acrolein test, Salkowski test, Lieberman-Burchard's test.
5. Determination of iodine number.
6. Determination of the acid value of lipid.
7. Determination of saponification value of fats and oil.
8. Titration curve of glycine (determination of isoelectric point).
9. Preparation of enzyme extract from horse gram seeds and determination of urease activity.
10. To check time linearity and protein linearity of urease catalyzed reaction.
11. Determination of salivary amylase activity.
12. Stability of salivary amylase with respect to temperature and pH.

**Suggested Books:**


- Deb, A.C. (2013). *Comprehensible Viva & Practical Biochemistry* (2nd ed.). Kolkata: New Central Book Agency.
- Kumar, A., Grg, S., & Garg, N. (2017). *Biochemical Tests: Principles & Protocols*. New Delhi: Viva Books.
- Rao, B.S., & Deshpande, V. (2012). *Experimental Biochemistry*. New Delhi: I.K. International Publisher.
- Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods* (2nd ed.). New Delhi: New Age International Publishers.
- Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers.
- Sharma, S. (2007). *Experiments and Techniques in Biochemistry* (1st ed.). New Delhi: Galgotia Publication.

# Third Semester

# CHEMISTRY

## CHEM 202 Physical Chemistry-I

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- explain the basic principles of thermodynamics and thermochemistry.
- describe the states of matter.
- explain the concepts of chemical kinetics and catalysis.
- apply the concept of thermodynamics to determine the heat of neutralization of chemical reaction.
- explain the concept of colloids.

**Unit 1 Chemical kinetics and Catalysis:**

Introduction, measurement of reaction rate, integration and determination of rate laws, rate constant, unit of rate constant for zero order, first order and second order reactions, order of reaction, molecularity of reaction, difference between order and molecularity of reaction, chemical kinetics and its scope, factors influencing the rate of a reaction-concentration, temperature, pressure, solvent, light, catalyst; concentration dependence of rates, mathematical characteristics of simple chemical reactions-zero order, first order, second order, pseudo order; half-life and mean life; determination of the order of reaction-differential method, graphical method, method of integration, method of half-life period and isolation method, radioactive decay as a first order phenomenon.

**Theories of chemical kinetics:**

Effect of temperature on rate of reaction, temperature co-efficient, Arrhenius equation, concept of activation energy, transition state theory (equilibrium hypothesis), expression for the rate constant based on equilibrium constant and thermodynamic aspects.

**Unit 2 Thermodynamics-I:**

Definition, significance and limitations, classical versus statistical thermodynamics, different thermodynamic terms: system, surroundings, types of systems, intensive and extensive properties, state and path functions, and their differentials, Eular reciprocity relation and cyclic rule, thermodynamic process, concept of heat and work.

First law of Thermodynamics: statement, definition of internal energy and enthalpy, heat capacity: heat capacities at constant volume and pressure and their relationship, Joule's law, Joule-Thomson coefficient and inversion temperature, calculation of w, q, dU and ΔH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process, application of first law of thermodynamics, zeroth law of thermodynamics and the absolute temperature scale.

**Thermo-Chemistry:**

Standard state, standard enthalpy of formation: Hess's law of heat summation and its applications, heat of reaction at constant pressure and at constant volume, various types of enthalpies of reaction: enthalpy of formation, enthalpy of combustion, enthalpy of solution, enthalpy of dilution, enthalpy of hydration and enthalpy of neutralization, bond dissociation energy and its calculation from thermochemical data, calculation of lattice energy from Born-Haber’s cycle, temperature dependence of enthalpy, Kirchhoff's equation, adiabatic flame temperature.

**Unit 3 Thermodynamics-II:**

Second law of thermodynamics: need for the law, different statements of the law, Carnot cycle and its efficiency, Carnot theorem, thermodynamic scale of temperature and its identity with ideal gas temperature scale.

Concept of entropy: entropy as a state function, characteristics of entropy function and Maxwell relations, entropy as a function of V and T, entropy as a function of P and T, entropy change in physical change, Clausius inequality and its application to an isolated system, entropy as a criteria of spontaneity and equilibrium, entropy change in ideal gases: temperature and volume, temperature and pressure variations, standard entropy and entropy of mixing of ideal gases.

**Chemical Equilibrium:**

Free energy of spontaneous reactions and the role of temperature, equilibrium constant and free energy, thermodynamic derivation of law of mass action, Van't Hoff reaction isotherm, factors affecting the state of equilibrium, Le-Chatelier's principle and its applications to physical and chemical equilibrium, reaction isotherm and reaction isochore, Clapeyron and Clausius-Clapeyron equations and its applications for lquid-vapor, solid-vapor and solid-liquid equilibrium.

**Unit 4 Gaseous State:**

Postulates of kinetic theory of gases, deviation from ideal behavior, Van der waals equation of state, critical phenomena, PV isotherms of real gases, continuity of states, the isotherms of Van der waals constants, the law of corresponding states and reduced equation of state.

Molecular velocities: root mean square, average and most probable velocities, qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter, liquification of gases (based on Joule-Thomson effect).

**Liquid State:**

Intermolecular forces, structure of liquids (a qualitative description), structural differences between solids, liquids and gases; liquid crystals: difference between solid crystals and liquid crystals; classification, structure of nematic and cholestric phases, thermography and seven-segment cell.

**Unit 5 Colloidal State:**

Definition and classification of colloids, solid in liquid (sol): properties-kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number, liquid in liquid (emulsion): types and preparation of emulsions, emulsifier, liquid in solid (gel): classification, preparation and properties, inhibition and general applications of colloids.

**Solid State:**

Solids-classification, properties:-electrical and magnetic; crystals– external features, symmetry, lattice point, unit cell, classification; ionic crystals - packing of constituents in crystals, relationship between edge length and ionic radii, packing efficiency, co-ordination number, interstitial voids-trigonal voids, tetrahedral voids, octahedral voids and cubic voids, radius ratio of voids.

**Defects in Solids:**

Definition, classification, stoichiometric and non-stoichiometric defects, consequences of defects.

**Recommended Books:**

1. Atkins, P., Julio, P. D. (2014). *Physical Chemistry* (10th Ed.), United Kingdom: Oxford University Press.
2. Castellan, G.W. (1983). *Physical Chemistry* (3rd Ed.), United State of America: Addision-Wesley Publishing Company.
3. West, A. R. (2014). *Solid State Chemistry and its Applications* (2nd Ed.), John Wiley &Sons Ltd.
4. Puri, B.R., Sharma, L.R., Pathania, M.S.(2016). *Principle of Physcial Chemistry* (47th Ed.), India: Vishal Publishing Company.
5. Laider, K.J.(1965). *Chemical Kinetics* (2nd Ed.), New York: McGraw Hill Book Company.

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

# CHEM 202L Physical Chemistry-I Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- determine the percentage composition of unknown mixture by viscosity and surface tension methods.
- measure kinetics parameters of chemical reaction.
- evaluate the enthalpy of neutralization.
- calculate the lattice energy of $CaCl_2$ and solubility of benzoic acid at different temperatures.

**Surface Tension and Viscosity:**

1. To find the relative and absolute viscosity of the given liquid at room temperature.
2. To determine the percentage composition of given mixture (non-interacting systems) by viscosity method.
3. To find the surface tension of given liquid by drop number method at room temperature.
4. To determine the percentage composition of given binary mixture by surface tension method (acetone and ethyl/methyl ketone).

**Chemical Kinetics:**

1. To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at room temperature.
2. To study the effect of acid strength on the hydrolysis of an ester.
3. To compare the strengths of HCl and $H_2SO_4$ by studying the kinetics of ethyl acetate.
4. To study the reaction rate of decomposition of iodide by $H_2O_2$ kinetically.

**Colloids:**

1. To prepare arsenious sulfide sol and compare the precipitating power of mono-, bi- and trivalent anions.

**Transition Temperature:**

1. Determination of the transition temperature of given substance by thermometric method (e.g. $MnCl_2.4H_2O$/ $SrBr_2.2H_2O$).

**Thermo-Chemistry:**

1. To determine the solubility and heat of reaction of benzoic acid at different temperatures.
2. To determine the enthalpy of neutralization of strong acid and strong base.
3. To determine the enthalpy of neutralization of weak acid and strong base.
4. To determine the enthalpy of solution of solid calcium chloride and calculate it's lattice energy using Born-Haber cycle.
5. Determination of heat of reaction and verification of Hess's law.

**Partition Coefficient:**

1. To find the partition coefficient of $I_2$ between $CCl_4$ and $H_2O$.

**Recommended Books:**

1. Gurtu, G.N., Gurtu, A. (2014). *Avanced Physical Chemistry*, India: Pragati Prakashan .
2. Sindhu, P.S. (2005). *Practicals in Physical Chemistry*, India: Macmillan Publishers.

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

# Fourth Semester

# BIOTECHNOLOGY

## BT 207 Genetics, Microbiology and Immunology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Learn fundamental molecular principles of genetics and relationship between phenotype and genotype in human genetic traits.
- Understand the characteristic features and ultrastructure of bacteria, fungi, yeast and viruses.
- Gain theoretical knowledge of techniques in microbiology.
- Understand about the immune system and various related mechanisms of cells and molecules involved in fighting pathogens.

**Unit 1**

- An overview of Mendel's law of inheritance.
- Gene-gene interaction, multiple alleles.
- Linkage and crossing over.
- Sex determination, sex linked inheritance.
- Cytoplasmic inheritance.
- Human genetics: Pedigree analysis.

**Unit 2**

- Chromosomal aberrations: Structural and numerical.
- Mutation: Spontaneous and induced, chemical and physical mutagens, induced mutations in plants, animals and microbes for economic benefit of human.

- Regulation of gene expression in prokaryotes: Lac and Trp operons.
- Population genetics: Hardy Weinberg law.

**Unit 3**

- Characteristic features and ultrastructure of bacteria.
- General account of different groups: Cyanobacteria, fungi, yeast, viruses, *Mycoplasma* and actinomycetes.
- General characteristics of bacteriophage ($T_4$, $\lambda$ and phi x 174).
- Industrial applications of microorganisms in food and medicines.

**Unit 4**

- Bacterial genetics: Brief idea of plasmids, transposable elements, transformation, transduction, conjugation.
- Techniques in microbiology: Media preparation, sterilization methods, isolation and pure culture techniques, staining techniques (Gram's, negative and endospore staining), preservation and maintenance of culture.
- An introduction to science of immunology.
- Innate and acquired immunity, active and passive immunity.

**Unit 5**

- Phylogeny and ontogeny of immune system: Cells of immune system and preliminary idea about their differentiation, organization and structure of lymphoid organs.
- Nature of antigens: Antigenicity and immunogenicity, factors affecting them, epitopes and haptens.
- Structure and function of antibodies: Classes and subclasses.
- Nature of immune response: Humoral and cell mediated immune response.
- General idea of Major Histocompatibility Complex (MHC) and their significance. Monoclonal antibodies and their applications.

**Suggested Books:**


- Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005). *Principles of Genetics* (8th ed.). New Jersey, USA: John Wiley & Sons Ltd.
- Hartl, D.L. & Jones, E.W. (1998). *Genetics: Principles & Analysis* (4th ed.). Canada: Jones and Barlett Publishers.
- Hartwell (2010). *Genetics-From Genes to Genomes* (4th ed.) USA: McGraw-Hill Education.
- Khan, F. H. (2009). *Elements of Immunology* (1st ed.). Pearson Education India.
- Kindt, T.J., Osborne, B.A., & Goldsby, R.A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W. H. Freeman & Company.
- Klug, W.S., Cummings, M.R., Spencer, C.A. & Palladino, M.A. (2015). *Essential of Genetics* (9th ed.). Noida: Pearson Education India.
- Madigan, M. T., Martinko, J. M., Dunlap, P. V., & Clark, D. P. (2005). *Brock Biology of Microorganisms* (12th ed.). San Fransisco: Benjamin Cummings.
- Maloy, S.R., Cronan, J.E., & Friefelder, D. (1994). *Microbial Genetics* (2nd ed.). USA: Jones and Bartlett.
- Owen, J., Punt, J., Stranford, S., & Jones, P. (2018). *Kuby Immunology* (7th ed.). USA: W. H. Freeman and Company.
- Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (2007). *Microbiology* (5th ed.). New York, U.S.: Tata McGraw-Hill Inc.
- Rastogi, V.B. (2018). *Genetics* (4th ed.). Medtech.
- Shetty, N. (2005). Immunology: Introductory Textbook. New Delhi: New Age International Publishers.
- Singh, B.D. (2014). *Fundamentals of Genetics* (332nd ed.). New Delhi: Kalyani Publishers.
- Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education.

- Tizard, I.R. (1995). *Immunology: Introduction* (4th ed.). Philadelphia: Saunders College Publishing.
- Tortora, G.J., Funke, B.R., & Case, C.L. (2016) *Microbiology: An Introduction* (12th ed.). London, UK: Pearson.
- Verma, P.S. & Agarwal, V.K. (2010). *Genetics* (9th ed.). New Delhi: S. Chand and company.
- Weaver, R.F. (2011). *Molecular Biology* (5th ed.). New York, USA: McGraw-Hill Education.
- Willey, J.M., Sherwood, L., & Woolverton, C.J. (2007). *Prescott, Harley and Klein's Microbiology,* (7th ed.). USA: Mc Graw Hill Higher Education.


**Suggested e-Resources:**

- **Immunology**

  https://nptel.ac.in/courses/102103038/3

- **Immunity**

  https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-immune-system/a/hs-the-immune-system-review

- **Microbiology**

  https://nptel.ac.in/courses/102103015/

- **Structure of bacteria & viruses**

  https://instruct.uwo.ca/biology/090b/1290b%201-7.pdf

  http://ocw.jhsph.edu/courses/EpiInfectiousDisease/PDFs/EID_lec2_Dick.pdf

- **Mendelian Genetics & Deviation**

  https://www.khanacademy.org/science/biology/classical-genetics/variations-on-mendelian-genetics/a/multiple-alleles-incomplete-dominance-and-codominance

  http://download.nos.org/srsec314newE/PDFBIO.EL21.pdf

## BT 210L Genetics, Microbiology and Immunology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the clinical relevance of genetic concepts, inheritance and expression of human blood groups.
- Acquire and demonstrate competency in routine microbiological laboratory skills applicable to microbiological research and clinical methods.
- Explain basic immunological laboratory techniques and use immunoassays to analyze unknown samples successfully.

1. To prepare basic liquid media, solid media, agar slants and agar deep tube for the routine cultivation of bacteria and fungi.
2. Isolation of pure culture by streak plate method.
3. Isolation of microorganisms from soil by serial dilution and determination of CFU.
4. Isolation of microorganisms from air by direct plate exposure method.
5. Preservation of microbial cultures by making glycerol stock and revival of culture.
6. To perform Gram's staining, endospore staining and negative staining of bacteria.
7. Assessment of bacterial motility by hanging drop method.
8. Antibiotic sensitivity test using *Bacillus subtilis*.
9. Lactic acid estimation.
10. Study of chiasma formation and calculation of chiasma frequency in meiosis.
11. Problems of genetics:

- Mendel's law and its deviation.
- Human genetics: Widow's peak, earlobe, index finger, straight and curly hair, rolling of tongue.

12. Testing of blood groups including Rh factors to observe the phenomenon of agglutination.
13. To study the various lymphoid glands (spleen and thymus).
14. To study different type of cells participating in non-specific immunity.
15. Immuno precipitation by double diffusion technique.

**Suggested Books:**


- Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (2nd ed.). New Delhi: Wishwa Prakashan.
- Ghose, K., & Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency.
- Kumar, V. (2011). *Laboratory Manual of Microbiology*. New Delhi: Scientific Publishers.
- Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1st ed.). New Delhi: Vayu Education of India.


# ZOOLOGY

## ZOO 202 Comparative Anatomy and Embryology of Chordates

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the comparative anatomy of various organ systems with special reference to *Scoliodon*, *Rana*, *Uromastix*, *Columba* and *Oryctolagus*.
- Gain the fundamental knowledge about the development of frog, Hen's egg and chick to understand the principles of developmental biology.
- Gain an elementary idea about reproductive biology.

**Unit 1**

Comparative anatomy with special reference to *Scoliodon*, *Rana*, *Uromastix*, *Columba* and *Oryctolagus*:

- Integumentary system: Skin and its derivatives.
- Skeleton System: Development of chondrocranium and Vertebra; Jaw suspension.
- Digestive system: Alimentary canal and associated glands.

**Unit 2**

Comparative anatomy with special reference to *Scoliodon*, *Rana*, *Uromastix*, *Columba* and *Oryctolagus*:

- Respiratory system: Respiratory organs.
- Circulatory system: Evolution of heart and aortic arches.
- Urinogenital system: Evolution of kidney and urinogential ducts.

**Unit 3**

Comparative anatomy with special reference to *Scoliodon*, *Rana*, *Uromastix*, *Columba* and *Oryctolagus*:

- Nervous system: Brain and Spinal Cord.
- Eye.
- Ear.

**Unit 4**

- Elementary idea about the formation of egg and sperm.
- Fertilization, parthenogenesis, induction and regeneration
- Development of Frog upto the end of neurulation, Tadpole larva and its metamorphosis.

**Unit 5**

- Detailed structure of Hen's egg and its development upto 4th somite stage.
- Structure, development and functions of extra embryonic membranes in chick.
- Definition of placenta, types and functions of mammalian placenta.

**Suggested Books:**


- Balinsky, B.I. (2012). *An Introduction to Embryology* (5th ed.). New Delhi: Cengage Learning India.
- Chaki, K.K., Kundu, G., & Sarkar, S. (2016). *Introduction to General Zoology* Vol-II. Kolkata: New Central Book Agency.
- Dhami P.S., & Dhami, J.K. (2015). *Chordate Zoology.* New Delhi: R. Chand and Co.
- Jain, P.C. (2013). *Elements of Developmental Biology* (Chordate Embryology) (7th ed.). New Delhi: Vishal Publishing Co.
- Kardong, K.V. (2011). *Vertebrates: Comparative Anatomy, Function, Evolution* (6th ed.). McGraw-Hill Education**.**
- Kent, G. C., & Carr, R. K. (2000). *Comparative Anatomy of the Vertebrates* (9th ed.). Europe: McGraw-Hill Science.
- Kotpal, R.L. (2018). *Modern Text book of Zoology: Vertebrates* (4th ed.). Meerut: Rastogi Publications.
- Kotpal, R.L., Sastry, K.V., & Shukla, V. (2017). *Comparative Anatomy & Developmental Biology*. Meerut: Rastogi Publication.

- Lahiri, B.K. (2014). *College Zoology* Vol-II. Mumbai: Himalaya Publishing House.
- Prasad, S.N., & Kashyap, V. (2010). *A text book of Vertebrate Zoology* (14th ed.). New Delhi: New Age International (P) Limited.
- Sastry, K.V., & Shukla, V. (2017). *Developmental Biology*. Meerut: Rastogi Publications.
- Saxena, R.K. & Saxena, S. (2016*). Comparative Anatomy of Vertebrates* (2nd ed.). Viva Books Private Limited.
- Srivastava, M.L. (1985). *An Introduction to the Comparative Anatomy of Vertebrates*. Allahabad: Central Book Depot.
- Verma, P.S., & Agrawal, V.K. (2017). *Chordate Embryology: Developmental Biology*. New Delhi: S Chand.


**Suggested e-Resources:**

- **Comparative anatomy**

  http://www.iaszoology.com/category/comparative-anatomy/

- **Chick development**

  http://www.notesonzoology.com/vertebrates/chick/development-of-chick-with-diagram-vertebrates-chordata-zoology/8645

  http://www.macollege.in/app/webroot/uploads/department_materials/doc_139.pdf

- **Developmental biology**

  https://www.shomusbiology.com/developmental-biology.html

- **Frog development**

  http://www.notesonzoology.com/frog/development-of-frog-with-diagram-vertebrates-chordata-zoology/8626

## ZOO 202L Comparative Anatomy and Embryology of Chordates Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Identify higher chordate animals based on the external features.
- Identify and distinguish bones of Rana, Varanus, Fowl and Oryctolagus.
- Understand histology of organs and endocrine glands through microscopic study of slides.
- Understand the development of frog and chick through microscopic slides.

1. Permanent mountings:
   i. Placoid and ctenoid scales
   ii. Cartilage and striated muscle fibres of amphibian.
   iii. Filoplumes.
   iv. Blood film of mammal.
2. Osteology: A comparative study of articulated and disarticulated bones of *Rana*, *Varanus*, Fowl and *Oryctolagus*.
3. Comparative study of microscopic slides with special reference to amphibian and mammal:
   i. V.S. of skin, oesophagus, stomach, intestine, liver, pancreas, lung, kidney, testis, ovary, spinal cord.
   ii. T.S. of endocrine glands of a mammal (pituitary, thyroid, parathyroid, adrenal).

4. Study of museum specimens:

   i. Cyclostomata: Amnocoete larva, *Petromyzon*, *Myxine* and *Bdellostoma*.

   ii. Pisces: *Sphyrna*, *Torpedo*, *Pristis*, Stingray, *Chimaera*, *Acipensor*, *Amia*, *Labeo*, *Wallago*, *Saccobranclus*, *Anguilla*, *Exocoetus*, *Belone*, *Hippocampus*, *Syngnathus*, *Echeries*, *Porcupine and Protopterus*.

   iii. Amphibia: *Ichthyophis*, *Ambystoma*, Axolotal larva, *Salamandra*, *Necturus*, *Siren*, *Alytes*, *Pipa*, *Hyla* and *Rhacophorus*.

   iv. Reptilia: *Chelone*, Turtle, *Testudo*, *Sphenodon*, *Phrynosoma*, *Chaemeleon*, *Calotes*, *Hemidactylus*, *Draco*, *Hydrophis*, *Eryx*, *Python*, *Naja*, *Viper*, *Bungarus* and *Crocodilus*.

   v. Aves: *Archaeopteryx*, *Psittaculla*, *Passer*, *Columba* and *Pavo*.

   vi. Mammalia: *Ornithorynchus*, *Tachyglossus*, *Pteropus*, *Funambulus*, *Hedgehog*, Mongoose and *Oryctolagus*.

5. Development of Chordates:

   i. Study of the development and metamorphosis of frog with the aid of permanent prepared slides.

   ii. W.M. of primitive steak, head folds, 18hrs, 24hrs and 33hrs of chick embryo, T.S. of chick embryo through various regions upto 4th somite state with aid of permanent prepared slides.

**Suggested Books:**


- Ghose, K., & Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency.
- Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication.
- Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited.
- Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.

# CHEMISTRY

## CHEM 201 Inorganic Chemistry-II

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- apply crystal field theory on different geometries and correlate it with stability.
- elucidate the nomenclature, structures, magnetic properties and reactivity of transition metal complexes.
- apply the concept of L-S coupling for the determination of term symbols of different spectroscopic states and appreciate its utility.
- elaborate the thermodynamic and kinetic stability of metal complexes.
- demonstrate the structure, bonding and reactivity of organometallic compounds.
- discuss a concise treatment of the important inorganic non-aqueous solvents and its application in various known reactions.
- apply HSAB principle on stability of molecules.

**Unit 1 Crystal Field Theory:**

Introduction, crystal field splitting in octahedral, tetrahedral, square planar, and trigonal bipyramidal complexes, factors affecting the crystal-field parameters, Jahn-Teller distortions, applications and limitations of crystal field theory.

**Magnetic Properties of Transition Metal Complexes:**

Types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of $\mu_S$ and $\mu_{eff}$ values, orbital contribution to magnetic moments, applications of magnetic data for 3*d*-metal complexes.

**Unit 2 Electronic Spectra of Transition Metal Complexes:**

Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel energy level diagram for $d^1$ and $d^9$ states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.

**Thermodynamic and Kinetic Aspects of Metal Complexes:**

Lability and inertness of complexes, brief outline of thermodynamic and kinetic stability of metal complexes and factors affecting the stability, substitution reactions of square planar complexes.

**Unit 3 Chemistry of Lanthanides:**

Electronic structure, oxidation states, ionic radii, lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds, spectral and magnetic properties.

**Chemistry of Actinides:**

General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, similarities between the later actinides and the later lanthanides.

**Unit 4 Non-aqueous Solvent:**

Classification of solvents, physical properties of solvents, reactions in non-aqueous solvents with reference to liquid $NH_3$ liquid HF and liquid $SO_2$.

**Hard and Soft Acids and Bases (HSAB):**

Classification of acids and bases as hard and soft, Pearson's HSAB concept, acid-base strength and hardness and softness, symbiosis, theoretical basis of hardness and softness.

**Unit 5 Bio-Inorganic Chemistry:**

Essential and trace elements in biological processes, metalloporphyrins: hemoglobin, myoglobin, hemocyanin and hemerythrin; biological role of alkali and alkaline earth metal ions with special reference to $Ca^{2+}$ in muscle contraction, nitrogen fixation.

**Organometallic Chemistry:**

Definition, nomenclature and classification of organometallic compounds, preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti, a brief account of metal-ethylenic complexes, mononuclear carbonyls and the nature of bonding in metal carbonyls.

**Recommended Books:**


1. Lee, J.D (1998). *Concise Inorganic Chemistry*, (5th ed.). Oxford Publications.
2. Puri, B.R, Sharma, L.R., Kalia, K.C. (2017). *Principles of Inorganic Chemistry*, (3rd ed.). Vishal Publications.
3. Cotton, F. A., Wilkinson, G. (1994). *Basic Inorganic Chemistry*, (3rd ed.). John Wiley Publications
4. *Huheey, J.E., Keiter, J.A.* & *Keiter, R.L. (*1997*), Inorganic Chemistry: Principles of Structure and Reactivity*, 4th (ed.) Pearson Publications.
5. Bhagchandani, P. (2017), *Inorganic Chemistry*, Sahitya Bhawan Publications.
6. Malik, W.U., Tuli, G.D. & Madan, R.D. (2010), *Selected Topics in Inorganic Chemistry*, Revised Ed., S. Chand Publications.


**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

# CHEM 201L Inorganic Chemistry-II Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- perform the proper procedures and have the knowledge of regulations for safe handling and use of chemicals.
- predict chemical bonding or molecular geometry of various complexes based on accepted models.
- synthesize various transition metal complexes.
- Handle instruments like calorimeter and potentiometer.

Analysis of the following by Volumetrically/Gravimetrically:

1. Estimation of Barium (as sulphate)
2. Estimation of Lead (as sulphate)
3. Estimation of Zinc (as ammonium sulphate)
4. Estimation of Magnesium (as magnesium hydrogen phosphate)
5. Estimation of Copper (as thiocynate)
6. Estimation of Nickle (as nickel dimethyl glyoximate)

**Complexometric Titrations using Disodium Salt of EDTA:**

1. Estimation of $Mg^{2+}$ and $Zn^{2+}$
2. Estimation of $Ca^{2+}$ by substitution method

**Preparation and Purification of following Complexes:**

1. Sodium trioxalatoferrate (III)
2. Tetraamminecopper (II) sulphate
3. Sodium trioxalatochromate (III)
4. cis- and trans-diaquadioxalatochromate (III) ion

**Colorimetric Estimation:**

1. Job's method
2. Mole-ratio method

**Adulteration Analysis (any one of the following):**

1. Food stuffs
2. Effluents

**Solvent Extraction:**

1. Separation and estimation of Mg (II) and Fe (II)

**Recommended Books:**

1. Gurdeep, R. (2016*). Advanced Practical Inorganic Chemistry*, Krishna Prakashan publication.
2. Svehla, G. (2010). Vogel's *Qualitative Inorganic Analysis*, (7th ed.). Prentice Hall.
3. Gurtu, J. N. and Gurtu , A(2011), *Physical Chemistry Vol – I,* Pragati Prakashan publication.

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

# Fifth Semester

# Discipline Elective Courses-I

# BOTANY

## BOT 302 Introduction to Genetics and Genetic Engineering

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Acquire knowledge of the structure and arrangement of the genome in living organisms.
- Understand the biochemical nature of nucleic acids, their role in living systems.
- Impart basic genetic manipulation techniques and their application for human welfare.
- Translate concepts in genetic engineering to their own research.

**Unit 1**

- Organization of eukaryotic chromosomes.
- Bacterial genetics.
- Cell cycle, mitosis and meiosis.
- Eugenics and genetic counseling.

**Unit 2**

- Genetic terminology, Mendel's experiments: Laws of inheritance, interaction of factors (Modified dihybrid ratios).
- Quantitative inheritance, linkage, crossing over, multiple alleles.

- Sex determination and sex linked inheritance.
- Extra chromosomal inheritance.

**Unit 3**

- Chromosomal aberrations- structural and numerical.
- Mutations.
- Gene: Basic concept.
- Isolation of eukaryotic mRNA, cDNA synthesis and library.
- Genomic library.

**Unit 4**

- Restriction enzymes.
- Vectors- plasmids, phages, cosmids.
- Construction of recombinant DNA.
- Screening and selection of recombinant clones.

**Unit 5**

- Isolation of DNA- plasmid, plant genomic DNA, phage DNA.
- General idea of patents and bio safety guidelines.
- Biotechnology: Definition, application of biotechnology, basic concept of biotechnological processes.
- Edible vaccines.

**Suggested Books:**


- Borem, A., Santos, F.R., & Bowen, D.E. (2003). *Understanding Biotechnology* (1st d.). USA: Prentice Hall.
- Brown, T. (2011). *Introduction to Genetics –A molecular approach* (1st ed.). USA: Garland Science.
- Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6th ed.). USA: Wiley-Blackwell.

- Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005). *Principles of Genetics* (8th ed.). New Jersey, USA: John Wiley & Sons Ltd.
- Glick, B.R., & Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). USA: American Society for Microbiology Press.
- Griffiths, A.J.F., Miller, J.H., Suzuki, D.T., Lewonith, R.C. & Gelbert, W.M. (2000). *An Introduction to Genetic Ananlysis* (7th ed.). New York, U.S.: W. H. Freeman.
- Gupta, P.K. (2009). *Genetics.* Meerut: Rastogi Publications.
- Gupta, P.K. (2010). *Plant biotechnology*. Meerut: Rastogi Publications.
- Hartl, D.L. & Jones, E.W. (1997). *Genetics: Analysis of Genes and Genome* (9th ed.). Canada: Jones and Barlett Publishers.
- Hartwell, L., Hood., Goldberg, M., Reynolds, A.E., & Silver, L. (2010). *Genetics: From Genes to Genomes* (4th ed.). New York: McGraw-Hill Education.
- Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., Killian, D. (2018). *Concepts of Genetics* (12th ed.). USA: Pearson Education.
- Krebs, J.E., Goldstein, E.S., & Kilpatrick, S.T. (2012). *Lewin's Genes XI* (11th ed.). USA: Jones and Bartlett Publishers.
- Maloy, S.R., Cronan, J.E., & Friefelder, D. (1994). *Microbial Genetics* (2nd ed.). USA: Jones and Bartlett.
- Primrose, S.B., & Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.) UK: Oxford University Press.
- Singh, B.D. (2015). *Biotechnology*. New Delhi: Kalyani Publishers.
- Strickberger, M.W. (1995). *Genetics* (3rd ed.). New Delhi: Prentice Hall India Learning Private Limited.
- Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education.
- Watson, J.D., Tania, A.B., & Stephen, P.B. (2017). *Molecular Biology of the Gene* (7th ed.). USA: Pearson Education.

- Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH.

**Suggested e- Resources:**

- **Genetics**

  https://www.britannica.com/science/genetics

- **Recombinant-DNA-technology**

  https://www.britannica.com/science/recombinant-DNA-technology

  https://nptel.ac.in/courses/102103013/4

  http://www.agbioworld.org/biotech-info/topics/dev-world/policies4.html

- **Principles & processes of recombinant-DNA-technology**

  https://www.toppr.com/guides/biology/biotechnology-principles-and-process/processes-of-recombinant-dna-technology/

- **Vectors used in genetic engineering**

  http://www.biologydiscussion.com/genetic-engineering/vectors-used-in-genetic-engineering-biotechnology/61382

- **Patent rights in India**

  https://www.hg.org/legal-articles/patent-rights-in-india-4995

## BOT 302L Introduction to Genetics and Genetic Engineering Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Develop skills and understanding about different techniques used in genetics and genetic engineering

- Critically analyze and interpret data generated from each practical
- Develop knowledge about genetic problems such as genetic mapping, test cross etc.

1. Problems of genetics.
2. Models based on Mendel's law.
3. Human genetics: Tongue rolling, widow's peak, ear lobes, little finger.
4. Estimation of standard DNA by DPA method.
5. Determination of purity of standard DNA.
6. Determination of $\lambda_{max}$ of standard DNA.
7. Isolation of DNA from plant cells.
8. Restriction digestion of DNA.
9. Agarose gel electrophoresis of DNA.
10. Basic biosafety guidelines in the laboratory.

**Suggested Books:**


- Purohit, S.D. (2007). *Molecular Biology and Biotechnology: A Practical Manual.* Udaipur: Apex Publishing House.
- Vats, S. (2015). *A Laboratory Textbook of Biochemistry, Molecular biology and Microbiology.* GRIN Verlag.


## BOT 303 Plant Physiology and Ecology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Comprehend about life processes happening inside plants and how they cope with varied biotic and abiotic factors.

- Understand maintenance of ecological balance and role of man in the degradation of the environment and to suggest remedies.
- Highlight the potential of these studies to become an entrepreneur.

**Unit 1**

- Plant water relations: Importance of water to plant life; movement of water across the membranes, ascent of sap; transpiration.
- Mineral nutrition: Methods to study the availability of macro and micro elements, uptake and roles of mineral elements.
- Translocation of organic substances: General principle and mechanism.

**Unit 2**

- Photosynthesis: Photosynthetic pigments, factors affecting photosynthesis, mechanism of photosynthesis, role of light, carbon fixation in plants, Photophosphorylation.
- Respiration: Significance and mechanism, factors affecting respiration, release and utilization of biochemical energy, ATP synthesis.

**Unit 3**

- Fat Metabolism: Mechanism of synthesis and break down of fats.
- Nitrogen metabolism: Nitrate assimilation, nitrogen fixation, amino acid synthesis and nitrogen cycle.
- Growth and development: Physiology of dormancy and seed germination, vegetative and reproductive growth, vernalization and photoperiodism.
- Growth regulators: Auxins, gibberellins, cytokinins, ethylene and abscissic acid, their physiological importance.

**Unit 4**

- Ecology.
- Plant environment: Climatic, edaphic, topographic and biotic factors.

- Ecosystem: Brief concept, food chains, ecological pyramids (pyramids of number, mass and energy), energetics, biochemical cycling.

**Unit 5**

- Plant communities: Structure, classification, diversity, dynamics.
- Applied ecology: Introduction to restoration ecology.
- Environmental pollution (air, water, noise and radioactive), Conservation, plant indicators.

**Suggested Books:**


- Ambhast, R.S. (2008). *Plant Ecology*. New Delhi: CBS.
- Dutta, S.C. (2012). *Plant Physiology*. New Delhi: New age International Publishers.
- Hopkins, W.G., & Huner, N.P.A. (2008). *Introduction to Plant Physiology*. New Jersey: John Wiley and Sons Inc.
- Narst, V., Devlin & Witham. (1974) *Plant Physiology*. New Delhi: East West Press.
- Noggle, G.R., & Fritz, G.J. (1992). *Introductory Plant Physiology*. New Delhi: Prentice Hall of India.
- Odum, E.P. (2004). *Fundamentals of Ecology*. Dehradun: Natraj Publishers.
- Pandey, S.N., & Sinha, B.K. (2015). *Plant Physiology*. New Delhi: Vikas Publishing House.
- Salisbury & Ross. (2012). *Plant Physiology*. New Delhi: Prentice Hall of India.
- Sharma, P.D. (2003). *Ecology & Environment*. Meerut: Rastogi Publications.
- Srivastava, H.S. (2005). *Plant Physiology*: Meerut: Rastogi Publications.
- Taiz, L., & Zeiger, E. (2010). *Plant Physiology*. London: Sinauer Associates.

**Suggested e- Resources:**

- **Plant Physiology**

  https://www.udemy.com/plant-physiology/?siteID=zOCYiUhWwNM-1RExiYvhsJfnMd_rZR_ivg&LSNPUBID=zOCYiUhWwNM

- **Ecological communities**

  http://www-plb.ucdavis.edu/courses/bis/1c/text/Chapter27nf.pdf

## BOT 303L Plant Physiology and Ecology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the physiological details of photosynthesis and respiration.
- Design experiments, collect and analyze data, critically evaluate and present the data produced in physiology or ecology.
- Demonstrate skills related to laboratory as well as field based studies.

**A. List of Physiology experiments**

1. Osmosis
   a. Grapes and dried raisins.
   b. Potato osmoscope and semi permeable membrane.
   c. Plasmolysis and deplasmolysis.
2. Root pressure
   a. An experiment on root pressure.

3. Transpiration
    a. Ganong's potometer and Farmer's photometer.
    b. Unequal transpiration from two surfaces of a leaf
        i. Cobalt chloride paper method.
        ii. Four leaf method with greased surface.
    c. Demonstration of water lifting power of transpiration (suction force).
    d. Ringing experiment.
    e. Study of stomata
4. Photosynthesis
    a. Oxygen is given off during photosynthesis (Wilmott's bubbler apparatus).
    b. Light is necessary for photosynthesis.
    c. Chlorophyll is necessary for photosynthesis.
    d. $CO_2$ is necessary for photosynthesis.
    e. RQ by Ganong's respirometer (Demonstration).
5. Respiration
    a. $CO_2$ is produced during respiration.
    b. Loss of dry weight in respiration.
    c. Anaerobic respiration.

**B. List of Ecological experiments**

1. To determine the soil temperature by soil thermometer.
2. To measure relative humidity of the atmosphere by wet and dry–bulb thermometer or psychrometer.
3. To determine soil texture.

4. To test the presence of carbonate, nitrate, pH value and base deficiency in soil.
5. To measure the light intensity.
6. To study the structure of the plant community of an area by quadrat method and to determine the plant density, abundance and frequency.
7. To determine the water holding capacity of different soils.

**Suggested Books:**


- Bendre, A., & Kumar, A. (2010). *A Textbook of Practical Botany- II*. Meerut: Rastogi Publications.


## BOT 304 Ethnobotany

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the science of ethnobotany, its concept, scope and objectives
- Know the types, distribution and life style of ethnic groups in India.
- Know the importance of tribals in present era.
- Know the various uses of plants by the ethnic people in their daily life.
- Know the miscellaneous uses of plants
- Understand the methodology of ethnobotanical work
- Know the medicinal uses of plants in crude ways.
- Aware about the legal aspects associated with ethnobotany.

**Unit 1: Ethnobotany**

- Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science.
- The relevance of ethnobotany in the present context.
- Major and minor ethnic groups or Tribals of India, and their life styles.

**Unit 2: Ethnobotanical Uses**

- Plants used by the tribals: a) Food plants b) Fodder c) intoxicants and beverages d) Resins and oils and miscellaneous uses.
- Plants of mythological and religious.
- Plants mentioned in Folklore and Folk songs.
- Plants as totems, taboos and superstition.

**Unit 3: Methodology of Ethnobotanical studies**

- Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.
- Major centers of Ethnobotany in India.

**Unit 4: Role of ethnobotany in modern Medicine**

- Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology): (a) *Azadirachta indica* (b) *Ocimum sanctum* (c) *Vitex negundo* (d) *Gloriosa superba* (e) *Tribulus terrestris* (f) *Pongamia pinnata* (g) *Cassia auriculata* (h) *Indigofera tinctoria*.
- Role of ethnobotany in modern medicine with special example *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia, Withania*.
- Role of ethnic groups in conservation of plant genetic resources.
- Endangered taxa and forest management (participatory forest management).

**Unit 5: Ethnobotany and legal aspects**

- Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India.
- Biopiracy, Intellectual Property Rights and Traditional Knowledge.

**Suggested Readings:**


- Colton C.M. 1997. *Ethnobotany – Principles and applications*. John Wiley and sons, Chichester
- Sharma V. and Alam A., *Ethnobotany*. Rastogi Publishing House, Meerut
- Faulks, P.J. 1958. *An introduction to Ethnobotany*, Moredale pub. Ltd.
- Jain S.K. (1990). *Contributions of Indian ethnobotany*. Scientific publishers, Jodhpur.
- Jain S.K. (1995). *Glimpses of Indian. Ethnobotny*, Oxford and I B H, New Delhi – 1981
- Jain S.K. (1995). *Manual of Ethnobotany*, Scientific Publishers, Jodhpur, 1995.
- Jain S.K. (ed.) (1989). *Methods and approaches in ethnobotany*. Society of ethnobotanists, Lucknow, India.
- Lone et al. (1980). *Palaeoethnobotany*, Oxford and I B H, New Delhi – 1981
- Rajiv K. Sinha (1996). *Ethnobotany The Renaissance of Traditional Herbal Medicine* – INA –SHREE Publishers, Jaipur
- Rama Ro, N and Henry A.N. (1996). *The Ethnobotany of Eastern Ghats in Andhra Pradesh*, India.Botanical Survey of India. Howrah.


**Suggested e- Resources:**

http://botanicaldimensions.org/what-is-ethnobotany/

https://www.plantsnap.com/blog/casual-ethnobotany/

https://trove.nla.gov.au/work/36470887?selectedversion=NBD44743330

## BOT 304L Ethnobotany Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the methodology of ethnobotanical work.
- Know the miscellaneous uses of plants.
- Learn the preparation of herbarium.
- Understand the details of ethnic groups through the photographs and other available scientific literatures.

1. Study of wild plants of different families at taxonomical level.
2. Collection of locally growing plants of ethnic importance.
3. Herbarium preparation.
4. Study of ethnic groups through photographs and available literature.
5. Preparation of plants extract.
6. Analysis of phytochemicals.

## BOT 305 Horticulture

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the basic technique of plant propagation.
- Perform cutting, grafting, budding, layering etc.
- Grow plants in the absence of soil medium.

- Start bonsai creation.
- Know various aspects of Green House Technology.
- Start commercial cultivation of fruits and vegetables.

**Unit 1**

- Basic horticultural techniques (soil preparation, bed preparation, transplantation & pruning).
- Vegetative propagation of plants (a) cutting (b) grafting (c) budding (d) layering (e) other special structures.

**Unit 2**

- Soil less culture (hydroponic, Aeroponics).
- Application of Coco peat, Perlite, Vermiculite and Peat moss in horticultural practices.
- Indoor and outdoor plants.
- Bonsai: Types, forms, structure and styles.

**Unit 3**

- Greenhouse Technology: Importance, types and operation techniques.
- Commercial uses of Green House Technology.
- Benefits and Risks associated with Green House Technology.

**Unit 4**

- Commercial cultivation of cut flowers (Roses, Gerberas & Carnations).
- Study of foliage plants (*Ficus*, Croton & Coleus).
- Study of one locally available vegetables (root, leafy, cole crops).

**Unit 5**

- Study of tropical fruits (Mango, Amla, Date palm).

- Study of temperate fruits (Apple).
- Commercial cultivation of exotic fruits.

**Suggested Books:**


- Ankur: (Magazine).
- Bajaj, Y.P.S. & Narosa. *Biotechnology in agriculture and forestry*.
- Chalam, Venkateshwarlu, G.V.I. *Introduction to Agricultural Botany in India*. Asia Publishing House, New Delhi.
- Hartmann and Kester. *Plant Propagation*.
- Jain, S.K. & Rao, R.R. *A Hand book of Field & Herbarium Methods*. Today & Tomorrow's Printers & Publications, New Delhi.
- Sandhu, M.K. *Plant Propagation*.


**Suggested e- Resources:**

https://icar.org.in/content/horticultural_division

http://tnhorticulture.tn.gov.in/horti/

https://www.onionseek.com/in/search/web/?pk=nQMhNzQd8g9IZLslSBEH6g&q=Online%20Horticulture%20Degree%20Program&id_event=5cc7d0693778ea7e85ea4bc6

https://www.longdom.org/horticulture.html

## BOT 305L Horticulture Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the methodology of plant propagation.
- Demonstrate cutting, grafting, budding, layering etc.

- Grow plants in the absence of soil medium.
- Know various aspects of Green House Technology.
- Learn the cultivation of fruits and vegetables.
- Demonstrate the technique of compost production.

1. Layout of kitchen garden.
2. Vegetative propagation by cutting and grafting.
3. Herbarium preparation.
4. Vegetative propagation by budding and layering (Gootee).
5. To perform emasculation & hybridization.
6. Preparation of compost.

# Sixth Semester

# Discipline Elective Courses- II

# ZOOLOGY

## ZOO 301 Animal Physiology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Gain basic understanding of structure and functions of each physiological system of human.
- Describe principles and pathway of metabolism of carbohydrate, protein and lipids.
- Develop an understanding about principles of human anatomy and physiology.

**Unit 1**

- Physiology of Digestion: Various kinds of digestive enzymes (carbohydrases, proteinases and lipases) and their digestive action to corresponding food stuffs in the alimentary canal of mammals; hormonal control of digestive functions; mechanism of absorption of various end-products of digestion and other materials such as vitamins, minerals and trace elements.
- Physiology of respiration in mammals: Mechanism and control of breathing; transport of oxygen and carbon dioxide; oxygen dissociation curves of hemoglobin, Bohr effect, chloride shift, Haldane effect, lung volumes and capacities, regulation of respiration, respiration at cellular level.

**Unit 2**

- Metabolism: (structure formula of metabolites not essential) Carbohydrate metabolism oxidation of glucose (glycolysis); Embden–Meyerhof-Parnas pathway, tricarboxylic acid cycle and oxidative phosphorylation, shuttle mechanisms (malate-aspartate and glycerol-phosphate), glycogenolysis and glycogenesis; gluconeogenesis and the role of dicarboxylic acid shuttle, role of insulin and glucagons on carbohydrate metabolism.

- Protein metabolism: Essential and non-essential amino-acids, oxidative deamination, transamination and decarboxylation of amino acids, fate of glucogenic and ketogenic amino acids, role of hormones in protein metabolism.

- Fat metabolism: Oxidation of fatty acids (β-oxidation), glycerol, and unsaturated fatty acids; fate of Acetyl CoA; synthesis of fatty acids & lipids; role of hormones in fat metabolism.

**Unit 3**

- Physiology of excretion: Kinds of nitrogenous excretory products, structure of kidney, role of liver in the formation of urea; composition and formation of urine; role of hormones in urine formation; micturition.

- Physiology of vascular system: Composition and functions of blood; lymph & lymphatic system; blood groups, Rh factor; platelet plug formation; blood clotting mechanism and its significance; structure and functions of hemoglobin. Blood pressure & its regulation; origin, conduction and regulation of heart beat; nervous and hormonal regulation of heart beat; cardiac cycle.

**Unit 4**

- Physiology of muscle contraction: Functional architecture of smooth, skeletal and cardiac muscles; mechanism of muscle contractions (skeletal muscle). Fuel for muscle contraction, mechanical properties of muscle: simple muscle twitch; wave summation, tetanus and muscle fatigue.

- Physiology of nerve impulse and reflex action: Functional architecture and classification of neuron; nature, origin and propagation of nerve

impulse along a neuron (myelinated and unmyelinated), synapse; reflex arc, reflex action and its central control.

**Unit 5**

- Physiology of endocrine glands: Structure and functions of hypothalamus; pituitary; thyroid; parathyroid; adrenal and pancreas.
- An elementary idea about neuro-secretion.
- Physiology of reproduction: Structure and physiology of human male and female reproductive system; spermatogenesis and oogenesis; reproductive cycles- estrous and menstrual cycle.
- Hormonal regulation of ovulation, fertilization, implantation, abortion, gestation, parturition and lactation.

**Suggested Books:**


- Chaterjee, C.C. (2005). *Human Physiology* Vol-II (11th ed.).
- Chaterjee, C.C. (2018). *Human Physiology* Vol-I (12th ed.). New Delhi: CBS Publishers & Distributors.
- Guyton, A.C., & Hall, J.E. (2015). *Textbook of Medical Physiology* (13th ed.). USA: Saunders.
- Jurd, R.D. (2003). *Instant notes in Animal Biology*. New Delhi: Viva Books Pvt. Ltd.
- Kumar, N. (2016). *Animal Physiology*. Jaipur: RSBA Publishers.
- Pandey, K., & Shukla, J.P. (2005). *Regulatory Mechanism in Vertebrates*. Meerut: Rastogi Publications.
- Randall, D., Burggren, W., & French, K. (2001). *Eckert Animal Physiology* (5th ed.). W. H. Freeman.
- Roy, R.N. (2018). *Textbook of Physiology: with Biochemistry & Biophysics* Vol-I. Kolkata: New Central Book Agency.

- Tortora, G.J., & Grabowski. (2003). *Principles of Anatomy & Physiology* (10th ed.). New Jersey, USA: John Wiley & Sons.
- Verma, P.S., Tyagi, B.S., & Agarwal, V.K. (2000). *Animal Physiology*. New Delhi: S. Chand publisher.


**Suggested e-Resources:**

- **Digestive system**

  https://www2.estrellamountain.edu/faculty/farabee/biobk/BioBookDIGEST.html

- **Unsaturated fatty acid oxidation**

  https://pharmaxchange.info/2013/10/oxidation-of-unsaturated-fatty-acids/

- **Urine formation**

  http://medschool.slu.edu/gpbs/syllabus/2008/renal2/Kidney%20Lecture-2%20Core%202008.pdf

- **Muscles**

  http://www.onlinebiologynotes.com/muscular-tissue-skeletal-smooth-cardiac-muscle/

- **Endocrine glands**

  http://what-when-how.com/nursing/the-endocrine-system-structure-and-function-nursing-part-1/

- **Physiological systems**

  https://nptel.ac.in/courses/102104042/

  https://nptel.ac.in/courses/122103039/18

## ZOO 301L Animal Physiology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Gain hands on experience in hematological tests such as counting of RBCs, WBCs, preparation of haemin crystals, determination of blood haemoglobin, calcium, cholesterol, sugar, protein, cloting time.
- Demonstrate the skills of pathological analysis of urine through the detection glucose and albumin.

1. To prepare Haemin Crystals.
2. Estimation of Haemoglobin percentage by Haemometer.
3. Enumeration of the total number of red blood corpuscles (R.B.C.)
4. Enumeration of the total number for white blood corpuscles (W.B.C.)
5. Determination of ABO blood groups and Rh factor.
6. Study of effect of isotonic, hypotonic and hypertonic solutions on R.B.C.
7. Determination of the presence of sugar and albumin in the urine sample.
8. Determination of blood sugar content.
9. Estimation of total protein from blood.
10. Estimation of total calcium from blood.
11. Estimation of total cholesterol from blood.
12. Determination of the clotting time of blood.

**Suggested Books:**


- Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited.
- Sharma, S. (2007). *Experiments and Techniques in Biochemistry* (1st ed.). New Delhi: Galgotia Publication.
- Sharma, S., & Sharma, R. (2016). *Practical Manual of Biochemistry* (2nd ed.). New Delhi: Medtech.


## ZOO 305 Environmental Biology and Biostatistics

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the physical and biological characters of the environment and the interrelationship between biotic and abiotic components of nature as well as relationship among the individuals of the biotic components.
- Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
- Understand the basic principles of population and community ecology.
- Understand the fundamental principles of biostatistics and its role in the data analysis generated by scientific research.

**Unit 1**

- Terminology and scope of ecology.
- Environment:

  i. Biosphere -Lithosphere, hydrosphere and atmosphere.

ii. Physical factors-with special reference to temperature, light and water.

iii. Biotic factors -Intra and inter specific relationship among animals.

iv. Principles of limiting factors-Leibig's law of minimum, Shelford's law of tolerance, combined concept of limiting factors.

- Biogeochemical cycles: Carbon, oxygen, nitrogen and phosphorus cycles.

**Unit 2**

- Ecosystem ecology: Structure and dynamics of the ecosystem including food chain, food webs trophic levels, productivity and energetics.
- Fresh water ecosystem: Physiochemical factors, biotic communities and lake eutrophication.
- Marine ecosystem: Zonation factors and biotic communities of deep sea only.
- Terrestrial ecosystem: Salient features of grass land, forest and desert ecosystem.

**Unit 3**

- Population ecology:

i. Definition and attributes of animal population: Population density and its measurement, natality, mortality, growth form, age distribution, age pyramids, sex ratio, dispersal and dispersion.

ii. Regulation of population density: Population fluctuations and interactions.

- Community ecology:

i. Definition of types of communities (micro and macro communities).

ii. Community dominance and species diversity.

iii. Ecotone, edge effect and ecological niche.

iv. Succession and climax.

**Unit 4**

- Applied ecology:
  i. Conservation of natural resources.
  ii. Wild life management.
  iii. National parks and wild life sanctuaries in India.
  iv. Extinction in animals.
  v. Zoogeographical regions of the world along with the boundaries and fauna.

**Unit 5**

- Biostatistics:
  i. Introduction, scope and applications.
  ii. Sampling, data collection and presentation.
  iii. Types of data, methods of collection of primary and secondary data, data presentation-Histogram, polygon, bar diagram, pie diagram.
  iv. Frequency distribution. Measures of central tendency-Mean, median, mode.
  v. Measures of variability-Standard deviation, standard error.

**Suggested Books:**


- Alllee W.C., Emerson, A.E., Park, O., Parl, T., & Schmidt, K.P. (1967). *Principles of Animal Ecology*. USA: W.B. Saunders Company.
- Banerjee, P.K. (2007). *Introduction to Biostatistics* (3rd ed.). New Delhi: S Chand and company Pvt. Ltd.
- Bhuyan, K.C. (2017). *Advanced Biostatistics*. Kolkata: New Central Book Agency.
- Chaudhary, B.L., & Pandey, J. (2007). *Fundamentals of Ecology & Environment*. Jaipur: Apex Publishing House.

- Clarke, G.L. (1965). *Elements of Ecology.* New Jersey: John Wiley & Sons Inc.
- Datta, A.K. (2014). *Basic Biostatistics and Application*. Kolkata: New Central Book Agency.
- Hillary, E. (1984). *Ecology 2000: The Changing Face of Earth*. Michael Joseph Ltd.
- Kendeigh, S.C. (1974). *Ecology with special reference to animal and man*. New Jersey: Prentice Hall.
- Krebs, C.J. (2001). *Ecology* (5th ed.). San Francisco, USA: Benjamin Cummings.
- Kumar, A. (2015). *Biodiversity & Conservation*. New Delhi: APH Publishing Corporation.
- Miller, G.T. (2004). *Environmental Science: Working with the Earth* (10th ed.). Singapore: Thomson Asia.
- Misra, S.P., & Pandey, S.N. (2016). *Essentials of Environmental Sciences* (4th ed.). New Delhi: Ane Books Pvt. Ltd.
- Odum, E.P. (1965). *Ecology*, New Delhi: Amerind Publishing.
- Pandey, M. (2015*). Biostatistics: Basic and Advanced*. New Delhi: MV Learning.
- Saxena, M.M. (1990). *Environmental Analysis*: Bikaner: Agro Botanical.
- Sharma, P.D. (2011). *Ecology and Environment*. Meerut: Rastogi Publication.
- Singh, S.P. (2005.). *Animal Ecology*. Meerut: Rastogi Publications.
- Tripathi, G. (2002). *Modern Trends in Environmental Biology*. New Delhi: CBS Publishers & Distributors.


**Suggested e-Resources:**

- **Aquatic ecology**

  https://nptel.ac.in/courses/120108002/

- **Ecosystem**

  https://nptel.ac.in/courses/122103039/38

- **Biostatistics**

  https://nptel.ac.in/courses/102101056/

- **Measures of central tendency**

  https://www.tutorialspoint.com/statistics/arithmetic_mean.htm

- **Population characteristics**

  http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.534.5462&rep=rep1&type=pdf

## ZOO 305L Environmental Biology and Biostatistics Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Demonstrate skills in the quality assessment of water through testing of water for $CO_2$, $O_2$, chloride and hardness.
- Gain an understanding of parasitic, aquatic, desert and aerial adaptations of animals with the help of charts and specimens.
- Describe symbiosis, commensalism and socialization among organisms with the help of charts and specimens.
- Understand analysis of data by solving biostatistical problems.

1. To find the depth and visibility in a pond by Sachi disc method.
2. To determine the pH of water sample.
3. To determine the content of dissolved oxygen in the water sample.
4. To determine the chemical oxygen demand in the water sample.

5. To determine free $CO_2$ content in the water sample.
6. To determine the chloride content of the water sample.
7. To determine the total hardness of water.
8. To study the effect of environmental stimulation on *Paramecium*.
9. To study parasitic, desert, aquatic and aerial adaptations in animals:
    i. Parasite: *Hirudinaria, Taenia, Ascaris, Schistosoma, Fasciola, Pediculus*.
    ii. Desert: *Phrynosoma, Uromastix,* Camel, *Heloderma*, Rattle snake, Golden mole.
    iii. Aquatic: *Pleuronectus, Exocoetus,* Turtle, *Hippocampus, Dolphin, Hydrophis,* Duck, Crocodile.
    iv. Aerial: Any bird, *Draco*, bat.
10. To study different types of associations existing among living organisms.
    i. Symbiosis: *Chlorohydra*, termite and aphid.
    ii. Commensalism: Harmit-crab, sea anemone and gastropod shell, *Euplectella* and shrimps.
    iii. Socialization: Ants, termites and honey bees.
11. Draw a map of world and identify the Zoogeographical regions of the world along with their major fauna.
12. Biostatistics exercise-mean, median, mode, standard deviation and standard error.
13. Report on any current topic related to environmental biology.

**Suggested Books:**


- Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication.
- Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication.

- Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication.
- Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited.
- Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.


## ZOO 304 Developmental Biology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Gain expertise in explaining how a variety of interacting processes generate an organism's heterogeneous shapes, size and structural features that arise on the trajectory from embryo to adult or more generally throughout a life cycle.
- Gain an understanding of systematic and organized learning about the knowledge and concepts of growth and development of organisms.
- Demonstrate a rich array of material and conceptual practices that could be analysed to better understand the scientific reasoning exhibited in experimental life sciences.

**Unit 1: Introduction to developmental biology**

- History, scope and applications of developmental biology.
- Basic concepts: Phases of development, cell-cell interaction, pattern formation, differentiation and growth, differential gene expression, cytoplasmic determinants and asymmetric cell division.

- Gametogenesis: spermatogenesis and oogenesis. Polarity and gradients.
- Fertilization: Types, mechanism and theories.

**Unit 2: Early embryonic development**

- Cleavage: Definition, planes and patterns of cleavage, classification of cleavage based on distribution and amount of yolk.
- Morulation, blastulation and gastrulation in ambhibia and birds.
- Morphogenetic movements, embryonic induction and competence, primary organizers.

**Unit 3: Late embryonic development**

- Differentiation of germinal layers.
- Method of organ formation: an overview of neural tube formation, types of mesoderm, somite formation, endoderm and its derivatives in amphibians and birds.
- Extra-embryonic membranes in birds, their development and functions.
- Paedogenesis and neoteny in ambhibians.

**Unit 4: Post embryonic development**

- Metamorphic events and its hormonal regulations in amphibians.
- Regeneration: types, regeneration of limbs in salamanders, regeneration of lost tail in lizard.
- Introduction to senescence and apoptosis.

**Unit 5: Implications of developmental biology**

- Teratogenesis: Teratogenic agents and their effects on embryonic development.

- Embryonic stem cells and their applications.
- Cloning of animals: Nuclear transfer technique and embryo transfer technique.
- *In vitro* fertilization, artificial insemination in cattle, amniocentesis.

**Suggested Books:**


- Balinsky, B.I. & Fabian, B.C. (1981). *An Introduction to Embryology* (5th ed.). International Thompson Computer Press.
- Carlson, B.M. (1999). *Patten's foundations in embryology*. (6th ed.). New York, USA: McGraw Hill.
- Chattopadhyay, S. (2017). *An introduction to developmental Biology*. Kolkata, India: Books and Allied.
- Gilbert, S.F. (2010). *Developmental Biology* (9th ed.). Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
- Kalthoff (2008). *Analysis of Biological Development* (2nd ed.). McGraw-Hill Publishers.
- Lewis, Wolpert (2002). *Principles of Development* (2nd ed.). Oxford University Press.
- Rastogi, V.B. & Jayaraj, M.S. (2005). *Developmental Biology* (A Text book of embryology). Kedar Nath Ram Nath Publisher, Meerut.


**Suggested e-Resources:**

- **Developmental Biology**

  https://nptel.ac.in/courses/nptel_download.php?subjectid=102101068

  http://cmb.i-learn.unito.it/mod/book/tool/print/index.php?id=3288

# ZOO 304L Developmental Biology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the different stages of development of frog and chick through microscopic slides.
- Understand the development and life cycle of Drosophila through microscopic slides.

1. Study of whole mounts and sections of developmental stages of frog through permanent slides/charts/models: Eggs, cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages).
2. Study of whole mounts of developmental stages of chick through permanent slides/charts/models: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages).
3. Study of the developmental stages and life cycle of *Drosophila* with the help of chart/specimen/models.

**Suggested Books:**


- Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication.
- Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.

# ZOO 303 Applied Zoology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Explore the important of earthworms in agro-ecosystems and utilize gained knowledge for production of vermicompost in small scale for garden/household plant.
- Demonstrate their knowledge for setting up poultry farm, sericulture, apiculture, lacculture plant.
- Understand biology, life cycle and control measures of crop pests, stored grain pests and insects serve as vectors for human diseases.

**Unit-1**

- **Parasitic protozoans:** Life history and pathogenicity of *Entamoeba histolytica, Plasmodium vivax, Giardia, Leishmania* and *Trypanosoma gambiense*.
- **Parasitic helminthes:** Life history and pathogenicity of *Ancylostoma duodenale* and *Wuchereria bancrofti*.

**Unit-2**

- **Insects of agriculture importance:** Biology, control and damage caused by crop pests (*Helicoverpa armigera, Pyrilla perpusilla, Papilio demoleus*) and stored grain pests (*Callosobruchus chinensis, Sitophilus oryzae* and *Tribolium castaneum*).
- **Insects of medical importance and their control**: *Pediculus humanus corporis, Anopheles, Culex, Aedes, Xenopsylla cheopis*.

**Unit 3**

- **Apiculture:** Different species of honey bees, pollen calendar, bee keeping and management practices, honey extraction techniques, bee products, pests of honey bees and their control.

- **Sericulture:** Different silkworm species and their host plants, silkworm rearing and management practices, pests of silkworms and their control.
- **Lac culture:** Lac insect, culture practices, pests of lac insect and their control.

**Unit 4**

- **Aquaculture:** Types of fishery: Marine, inland. Composite fish culture, induced breeding and hybridization. Transportation of fish seed. Fish diseases and their control.
- **Prawn culture:** Culture practices of giant fresh water prawn (*Macrobrachium rosenbergii*), biology and life history.
- Pearl culture, pearl formation, composition, colour, size and quality of pearl.

**Unit 5**

- **Vermiculture:** Definition, scope and importance, culture methods: indoors and out door, monoculture and polyculture, vermicomposting.
- **Poultry farming:** Principles of poultry breeding, management of breeding stock and broilers, processing and preservation of eggs, diseases of poultry and their control.
- **Animal husbandry:** Preservation and artificial insemination in cattle, induction of early puberty and synchronization of estrus in cattle.

**Suggested Books:**


- Arora, D.R & Arora, B. (2001). *Medical Parasitology* (2nd ed.). CBS Publications and Distributors.
- Atwal, A.S. (1986). *Agricultural Pests of India and South East Asia*, Kalyani Publishers.
- Dennis, H. (2009). *Agricultural Entomology*. Timber Press (OR).

- Dunham R.A. (2004). *Aquaculture and Fisheries Biotechnology Genetic Approaches*. CABI publications, U.K.
- Hafez, E.S.E. (1962). *Reproduction in Farm Animals*. Lea & Fabiger Publisher.
- Kumar and Corton. *Pathological Basis of Diseases*.
- Pedigo, L.P. (2002). *Entomology and Pest Management*, Prentice Hall.
- Sarkar, S., Kundu, G. & Chaki, K.K. (2014). *Introduction to Economic Zoology*. Kolkata: New Central Book Agency (P) Ltd.
- Shukla & Upadhyaya (1999-2000). *Economic Zoology*. Meerut: Rastogi Publishers.
- Venkitaraman (1983). *Economic Zoology*. Sudarsana Publishers.


**Suggested e-Resources**

- **Sericulture**

  https://swayam.gov.in/courses/152-silkworm-crop-protection

## ZOO 303L Applied Zoology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the life cycle of protozoan and helminthes parasites through microscopic slides.
- Explore the knowledge of life cycle of honey bees, silk moths and lac insects for setting up apiculture, sericulture and lac culture farm.
- Gain an understanding of biology, life cycle and control of stored grain pests, crop pests and insect of medical importance.

1. Study of life cycle of *Plasmodium vivax, Entamoeba histolytica, Giardia, Leishmania, Trypanosoma gambiense, Ancylostoma duodenale* and *Wuchereria bancrofti* through permanent slides/photomicrographs or specimens.
2. Study of different types of bees (Queens, drones and worker bees) permanent slides/photomicrographs or specimens.
3. Study of different types of silk moths (*Bombyx, Samia and Antheraea*) through permanent slides/photomicrographs or specimens.
4. Study of *Tachardia lacca* through permanent slides/photomicrographs or specimens.
5. Study of different types of pearls through photomicrographs or specimens.
6. Study of arthropod vectors associated with human diseases: *Pediculus, Culex, Anopheles, Aedes* and *Xenopsylla* through permanent slides/photomicrographs or specimens.
7. Study of some stored grains insect pests through damaged products/photographs.
8. Identifying feature and economic importance of *Helicoverpa (Heliothis) armigera, Papilio demoleus, Pyrilla perpusilla* and *Callosobruchus chinensis.*
9. Aquarium design and maintenance.

# Fifth Semester & Sixth Semester

## Discipline Elective Courses-I & II

## BIOTECHNOLOGY

## BT 307 Genetic Engineering, rDNA Technology and Cell &Tissue Culture Technology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the various tools of recombinant DNA technology and their applications in different fields.
- Describe the principles, process of gene cloning and generation of recombinant libraries.
- Learn theoretical aspects of different cell culture techniques and their uses in therapeutic applications.
- Gain basic knowledge of patents and biosafety guidelines.

**Unit 1**

- Introduction and historical background of genetic engineering.
- Isolation and purification of DNA from bacterial, plant and animal cells.
- Vectors: plasmids, cosmids and phages.
- Restriction enzymes, ligases, S1 nucleases, DNA polymerases, reverse transcriptase.

**Unit 2**

- DNA primers, cDNA synthesis and cloning: mRNA enrichment, reverse transcription.

- cDNA library.
- Linkers, adaptors, blunt end ligation, homopolymer tailing.
- Genomic library construction and screening.

**Unit 3**

- Molecular markers- RAPD, RFLP, AFLP, SNP.
- Techniques used in identification of recombinant DNA clones.
- Cloning and expression of foreign genes in prokaryotes (*E. coli*).
- Cloning and expression of foreign genes in eukaryotes (e.g. yeast).
- Brief idea about gene cloning in plant and mammalian cells.
- Transposon mediated gene tagging.

**Unit 4**

- Introduction, historical background and terminology used in cell culture, tissue culture lab: basic requirements, sterilization techniques.
- Media: Types, preparation and composition.
- Primary and established (including discontinuous and continuous) cell lines.
- Cytotoxicity and transformation/transfection of cells.
- Animal cell products.
- Patents and biosafety guidelines.

**Unit 5**

- Clonal propagation in plants.
- Somatic embryogenesis, protoplast isolation and culture, viability tests.
- Production of haploids and their applications.
- Zygotic embryo culture.
- Somaclonal variations.

**Suggested Books:**


- Bhojwani, S.S., & Razdan, M.K. (1996). *Plant Tissue Culture: Theory and Practice*. Netherlands: Elsevier Science.
- Boylan, M., & Brown, K.E. *Genetic Engineering: Science And Ethics On The New Frontier*.
- Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6th ed.). USA: Wiley-Blackwell.
- Chawla, H.S. (2009). *Introduction to Plant Biotechnology* (3rd ed.). USA: CRC Press.
- Glick, B.R., & Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). USA: American Society for Microbiology Press.
- Gupta, P.K. (2005). *Biotechnology and Genomics*. Meerut: Rastogi Publication.
- Gupta, P.K. (2017). *Animal Biotechnology*. Meerut: Rastogi Publication.
- Howe, C. (2007). *Gene Cloning & Manipulation* (2nd ed.). New Delhi: Cambridge University Press.
- Primrose, S.B., & Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.) UK: Oxford University Press.
- Razdan, M.K. (2003). *Introduction to Plant Tissue Culture* (2nd ed.). USA: Science Pub Inc.
- Shrivastava, S. (2012). *Molecular Techniques in Biochemistry & Biotechnology*. Kolkata: New Central Book Agency.
- Watson, J.D., Tania, A.B., & Stephen, P.B. (2017). *Molecular Biology of the Gene* (7th ed.). USA: Pearson Education.
- Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH.

**Suggested e-Resources:**

- **Cloning**

  https://nptel.ac.in/courses/102103045/

- **Molecular markers**

  http://www.biologydiscussion.com/plants/molecular-marker-study-notes/10883

- **Plant biotechnology**

  https://nptel.ac.in/courses/102103016/12

- **cDNA library**

  http://www.biotechnologynotes.com/dna-libraries/notes-on-cdna-library-dna-libraries/517

- **Genetic engineering**

  https://nptel.ac.in/courses/102103013/

- **Enzymes of genetic engineering**

  http://cec.nic.in/wpresources/module/Zoology/Paper-12/49/content/downloads/file1.pdf

- **Animal cell culture**

  https://nptel.ac.in/courses/102104059/

## BT 307L Genetic Engineering, rDNA Technology and Cell &Tissue Culture Technology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Learn all technicalities of setting up a plant tissue culture laboratory.

- Learn the techniques of isolation and estimation of nucleic acids.
- Gain practical knowledge about chromatographic purification of proteins.

1. Tissue culture, media preparation-MS/White media, slant preparation.
2. Aseptic techniques.
3. Excision of embryo/ovule/anther from the provided material and its inoculation.
4. Encapsulation of zygotic embryo.
5. Demonstration of column chromatography.
6. Extraction of proteins by phenol extraction.
7. Estimation of proteins by Popov's method.
8. To determine the melting curve and base composition of DNA.
9. Estimation of RNA content by orcinol method.
10. Isolation of plasmid from bacterial cell and determination of purity.
11. Cell immobilization (yeast).
12. Setting of a biotechnology laboratory, viz., tissue culture, fermentation, molecular biology, rDNA technology, biochemistry etc. (at least one).

**Suggested Books:**


- Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers.
- Sharma, R.K., & Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry & Molecular Biology*. New Delhi: I.K. International Publisher.
- Swamy, P.M. (2008). *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication.

# BT 301 Advances in Biotechnology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course students will be able to:

- Understand the different techniques of DNA sequencing, gene synthesis, gene silencing, PCR and blotting.
- Describe the industrial production of biopesticides, biopolymer and biopolysaccharides using fermentation techniques.
- Gain theoretical knowledge of cryopreservation, artificial insemination, IVF-ET technique, transgenic plants and transgenic animals.

**Unit 1**

- Techniques in molecular biology: Gene sequencing, solid phase automated synthesis of DNA.
- PCR and its variants: nested, inverse, real time, touch down and hot start.
- Northern, Southern and Western blotting, hybridization.
- Molecular probes and their applications.
- An overview of drug designing.
- Gene therapy: An overview of its types and vectors used.

**Unit 2**

- Fermentation processes, batch, fed batch and continuous.
- Bioreactor: Components, types of bioreactor-CSTR, loop reactor, fluidized bed reactor.
- Biopesticides-(*Bt* genes).
- Biopolymers (β-hydroxy butyrate).
- Biopolysaccharide (xanthum gum).

**Unit 3**

- Human genome project: History and salient features.
- *Arabidopsis* as a model plant for genetic engineering.
- Stem cells: Current status.
- Gene silencing: Antisense RNA technology and RNAi.
- Cassette vectors.
- Edible vaccines.
- DNA chips.

**Unit 4**

- Chloroplast engineering.
- A brief introduction of proteomics and metabolomics.
- Terminator seed technology.
- Seed storage proteins.
- Therapeutic proteins.
- Biosensor.

**Unit 5**

- Cryopreservation, transport of germplasm (semen, ovum, embryo).
- Artificial insemination, *in vitro* fertilization and embryo transfer.
- Transgenic plants: Resistance to herbicides, fungal and viral pathogens, environmental stress, male sterility, regulation of transgene expression, plants suitable for food processing, molecular farming.
- Biological nitrogen fixation and its genetic engineering.
- Transgenic animals.

**Suggested Books:**


- Balasubramanian, D., Bryce, C.F.A., Dharmalingam, K., Green, J., & Jayaraman, K. (2004). *Concepts in Biotechnology*. Hyderabad: University Press.
- Borem, A., Santos, F.R., & Bowen, D.E. (2003). *Understanding Biotechnology* (1st ed.). USA: Prentice Hall.
- Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (VI Ed.). USA: Wiley-Blackwell.
- Crueger, W., & Crueger, A. (2017). *Biotechnology: A Textbook of Industrial Microbiology* (3rd ed.). New York: Medtech.
- Gupta, P.K. (2005). *Biotechnology and Genomics*. Meerut: Rastogi Publication.
- Kumar, H.D. (1998). *Modern Concept of Biotechnology*. New Delhi: Vikas Publishing House.
- Owen, J., Punt, J., Stranford, S., & Jones, P. (2018). *Kuby Immunology* (8th ed.). USA: W. H. Freeman and Company.
- Shrivastava, S. (2012). *Molecular Techniques in Biochemistry & Biotechnology*. Kolkata: New Central Book Agency.
- Sudbery, P. (2010). *Human Molecular Genetics* (3rd ed.). USA: Pearson Education.


**Suggested e-Resources:**

- **Gene therapy**

  https://nptel.ac.in/courses/102103041/

- **Bioreactors**

  https://nptel.ac.in/courses/102106053/

- **PCR, hybridization & blotting technique**
  http://www.tulane.edu/~wiser/methods/notes.pdf

- **IVF-ET**

  https://www.urmc.rochester.edu/MediaLibraries/URMCMedia/fertility-center/documents/In-Vito-Fertilization-4-29-15-updated.pdf

- **Transgenic plants**

  https://popups.uliege.be/1780-4507/index.php?id=11844

- **RNAi**

  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC309050/

## BT 301L Advances in Biotechnology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Demonstrate the skills required for basic laboratory procedures and principles of reagent preparation.
- Design, conduct experiments, analyze and interpret data for investigating problems in biotechnology and allied fields.
- Understand the importance of the practical aspects of different techniques like electrophoresis, fermentation, and spectroscopy etc, currently used in biomedical research.

1. Isolation and estimation of genomic DNA from *E. coli*.
2. Agarose gel electrophoresis of DNA.
3. Seed germination under stress condition.
4. To find out absorption spectrum of the oxidized and reduced form of a molecular species (NAD and NADH).
5. To determine the $LD_{50}$ value of pesticide / weedicide.
6. Chlorophyll estimation from the given samples.

7. Extraction and estimation of total phenolic content using standard curve of gallic acid.
8. Isolation of protoplast and its culture using microchamber technique.
9. Demonstration of fermenter.
10. Determination of total hardness of water.
11. Submission of project report based on any topic related to Biotechnology.

**Suggested Books:**


- Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers.
- Sharma, R.K., & Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry & Molecular Biology*. New Delhi: I.K. International Publisher.
- Swamy, P.M. (2008). *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication.
- Vats, S. (2015). *A laboratory Text book of Biochemistry, Molecular Biology and Microbiology*. Germany: GRIN Verlag.


## BT 313 Animal and Plant Biotechnology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Gain knowledge of assisted reproductive technology, transgenic animal production and applications.
- Gain an understanding of current scenario of stem cells and their applications.

- Explain applications of tissue engineering in bioartificial organs development and transplantation.
- Explain various techniques used in plant biotechnology.

**Unit-I**

- Animal propagation: Induction of superovulation, embryo collection and evaluation, embryo splitting, embryo sexing, artificial insemination (IUI, ICSI) and embryo transfer techniques in cattle.
- Animal clones, nuclear transplantation, cloning for conservation of endangered species.
- *In vitro* fertilization and embryo transfer: Composition of IVF media, steps involved in IVF.

**Unit-II**

- Gene transfer methods in animals: Calcium phosphate, DEAE-dextran, lipofection, electroporation, microinjection, embryonic stem cell transfer, retrovirus.
- Transgenic animals and their applications with reference to transgenic mice, cattle, sheep, goats, pigs, chicken and fish.
- Stem cells: Definition, classification, characteristics and therapeutic applications.

**Unit-III**

- Recombinant protein vaccine production by cultured animal cells.
- Basics of tissue engineering: Cell-ECM interaction, Biomaterials in tissue engineering. Bioartificial organs-sources of cells, scaffold material, mode of transplantation.
- Shoot tip and meristem culture and production of virus-free plants.
- Protoplast studies: Isolation, culture, fusion and selection of hybrid cells, somatic hybrids and cybrids and applications.

**Unit-IV**

- Artificial seeds: Production, applications and limitations.
- Genetic transformation methods: Vector (*Agrobacterium tumefaciens*) mediated genetic transformation. T-DNA transfer mechanism. Physical gene transfer methods: Particle bombardment, electroporation and microinjection.
- Genetic engineering of crops for improved nutritional quality: Vitamin-A, iron, zinc, protein quality.

**Unit-V**

- Genetic engineering in plants: Selectable markers, reporter genes and promoters used in plant vectors.
- Genetic engineering of plants for disease resistance, pest and herbicide resistance.
- Molecular pharming: Concept of plants as biofactories, production of antibodies, viral antigens, peptide hormones and biodegradable plastics.

**Suggested Books:**


- Chawla, H.S. (2009). *Plant Biotechnology* (3rd ed.). New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd.
- Kumaresan, V. (2008). *Applied animal biotechnology*. Tamil Nadu, India: Saras Publication.
- Lanza, R., Gearhart, J., & Hogan, B. *Essentials of stem cell biology* (2nd ed.). London, UK: Academic Press.
- Lanza, R., Langer, R., & Vacanti, J. *Principles of tissue engineering* (4th ed.). London, UK: Academic Press.
- Peter, K.V., & Keshavachandran, R. (2008). *Plant Biotechnology: Methods in Tissue Culture and Gene Transfer*. India: Universities Press.

- Singh, B., Gautam, S.K., & Chauhan, M.S. (2015). *Textbook of animal biotechnology*. New Delhi, India:Teri Publication.
- Singh, B.D. (2011). *Plant Biotechnology* (2nd ed.). New Delhi, India: Kalyani Publisher.
- Singh, B.S. (2007). *Fundamentals of Plant Biotechnology*. New Delhi, India: Satish Serial Publishing House.
- Slater, A. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nded.). Oxford, UK: Oxford Publisher.


**Suggested e- resources**

- **Plant Biotechnology**

  https://nptel.ac.in/courses/102103016/

- **Tissue engineering**

  https://nptel.ac.in/courses/102106036/

## BT 313L Animal and Plant Biotechnology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Gain hands on training on plant & animal tissue culture and biotechnology.
- Learn the technique of genomic DNA isolation, its electrophoresis and SDS-PAGE.

1. Introduction to the laboratory and general safety practices for plant and animal cell culture.
2. Aseptic culture techniques for establishment and maintenance of cultures.

3. Prepare culture media with various supplements for plant and animal tissue culture.
4. To select, prune, sterilize and prepare an explant for culture.
5. Establishment of callus cultures.
6. Cell suspension cultures.
7. Isolation and culture of protoplast.
8. Isolation of plant genomic DNA by modified CTAB method.
9. Isolation of DNA from animal tissue.
10. Quantification of DNA by spectrophotometeric method.
11. Size analysis of DNA by agarose electrophoresis.
12. Effect of different light wavelengths and temperature on germinating embryos.
13. Separation of plant proteins by SDS-gel electrophoresis.

**Suggested Books:**


- Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers.
- Swamy, P.M. (2008). *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication.

## BT 315 Environmental Biotechnology

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Understand the importance of microorganisms as pesticides.
- Understand the basic concept of bioleaching, biodesulphurization, bioplastics, biosurfactants and bioemulsifiers.
- Understand different waste management processes and generation of energy from waste.
- Describe various roles played by microbes in biodegradation, bioremediation and plant growth promotion.

**Unit-I**

- Solid waste management: Waste generation, handling, storage, processing, transport, bailing, composting-incineration, pyrolysis, land farming – waste disposal by sanitary land filling (aerobic and anaerobic degradation), recycling and product re-use.
- Microbial leaching and biomining: Types and methods of bioleaching, chemistry and microbiology of bioleaching, *in situ* and *ex situ* leaching process of copper and uranium, plasmids and genes in biomining.

**Unit-II**

- Bioremediation of soil and water contaminated with oil spills, heavy metals and detergents.
- Microbial degradation of pesticides and xenobiotic compounds, metabolism and mechanism of degradation, degradative plasmids, microbes and cloning strategies.
- Phyto-remediation: Basic concept, types (phytoaccumulation, phytovolatilization, rhizofiltration and phytostabilization) and applications.

**Unit-III**

- Bioinsecticides: *Bacillus thuringiensis*, baculoviruses, genetic modifications and aspects of safety in their use. Biofungicides: Mode of actions and mechanism (*Trichoderma*).
- Biofertilizers: Algal fertilizers, nitrogen fixing bacteria, phosphate solubilising microbes, VAM, plant growth promoting rhizobacteria (PGPR).
- Earthworm as biofertilizer.

**Unit-IV**

- Biodesulphurization of coal/petroleum/diesel: Bioprocessing of coal, mechanism of inorganic sulphur removal, organic sulphur removal by Kodama pathway and 4 S pathways.
- Sewage treatment: Primary, secondary (Aerobic and anaerobic treatment) and tertiary.
- An introduction of biodelignification.

**Unit-V**

- Bioindicators and biosensers for detection of environmental pollution.
- Biofuels: Biogas, bioethanol, biodiesel, biohydrogen.
- A brief introduction of bioplastics, biosurfactants and bioemulsifiers.

**Suggested Books:**


- Allen, K. (2016). *Environmental Biotechnology*. New Delhi, India: CBS Publishers.
- Evans, G.M. & Furlong, J.C. (2003). *Environmental Biotechnology: Theory and Applications*. Wiley Publishers.
- Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer.
- Scragg A. (2005). *Environmental Biotechnology*. Pearson Education Limited.

## BT 315L Environmental Biotechnology Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of the course, students will be able to:

- Gain practical experience in quality determination of water with easy to run experiments such as dissolved oxygen, hardness and alkalinity.
- Gain practical understanding in the role of biofertlizers and biopesticides in the cleaning of environment.
- Gain practical experience in quality determination of water with easy to run experiments such as dissolved oxygen, hardness and alkalinity.

1. Isolation of biofertilizer microbes by biological enrichment method.
2. Estimation of BOD in water sample.
3. Estimation of COD in water sample.
4. Determination of total hardness of water.
5. Determination of total alkalinity of water.
6. Production of microbial biofertilizers.
7. Efficacy testing for biofertilizers.
8. Testing for microbiological quality of potable water (Coli form test).
9. Microbial degradation of heavy metals.
10. Effect of heavy metal toxicity on seed germination and plant growth.
11. Alcohol fermentation by using Baker’s yeast and its quantification by dichromate method.

# Discipline Elective Courses- I & II

# CHEMISTRY

## CHEM 302 Organic Chemistry-II

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- explain the structures and properties of biomolecules: carbohydrates, amino acids, proteins and nucleic acids.
- explain the structures, synthesis and properties of different class of organic compounds: nitro compounds, amines, diazonium salts, enolates, pyrrole, thiophene, furan, pyridine, indole, quinoline and isoquinoline.
- discuss the basic principles of UV-visible, IR and NMR spectroscopy.
- elucidate the structure of organic compounds using UV-visible, IR and NMR spectral data.

**Unit 1 Carbohydrates:**

Classification and nomenclature, monosaccharides: chain lengthening and chain shortening of aldoses, configuration, mechanism of osazone formation, mechanism of mutarotation, interconversion of glucose and fructose, epimerization (conversion of glucose into mannose), determination of ring size of D (+)-glucose and fructose; disaccharides: - sucrose, lactose and maltose (without involving structure determination); polysaccharides: starch and cellulose (without involving structure determination).

**Biomolecules:**

**(a) Amino acids:** Classification, structure, acid-base behaviour, isoelectric point; preparation, physical properties and chemical reactions of $\alpha$-amino acids.

**(b) Peptides and Proteins:** Classification, structure determination, and end group analysis, selective hydrolysis of peptides, solid-phase peptide synthesis.

**(c) Nucleic acids:** Introduction, constituents of nucleic acids, ribonucleosides and ribonucleotides, double helical structure of DNA.

**Unit 2 UV-visible Spectroscopy:**

Introduction to electromagnetic spectrum, basic principle, types of electronic transitions, factors affecting the position of absorption bands: conjugation and solvent; concept of chromophore and auxochrome; bathochromic, hypsochromic, hyperchromic and hypochromic shifts; UV-visible spectra of conjugated enes and enones: Woodward and Fieser rules, calculation of $\lambda_{max}$ of simple molecules; applications: strength of hydrogen bond, geometrical isomerism, keto-enol tautomerism.

**Infrared Spectroscopy:**

Basic principle, molecular vibrations, Hooke's law, selection rule, intensity and position of IR bands, factors affecting vibrational frequencies: coupled vibrations, Fermi resonance, electronic effects, hydrogen bonding and angle strain; fingerprint region, characteristic absorptions of various functional groups, interpretation of IR spectra of simple organic compounds, applications of IR spectroscopy.

**Unit 3 Organic Compounds of Nitrogen:**

**(a) Nitro Compounds:** Nomenclature, preparation of nitroalkanes and nitroarenes, physical properties, chemical reactions of nitroalkanes: acidic character, mechanism of nucleophilic and electrophilic substitution, reduction; chemical reactions of nitroarenes: mechanism of nucleophilic and electrophilic substitution, reduction in acidic, neutral and alkaline media, picric acid: methods of preparation, physical and chemical properties, halonitroarenes: methods of preparation and reactivity.

**(b) Amines:** Nomenclature and structure, stereochemistry, separation of mixture of amines, preparation of amines: reduction of nitro compounds, Gabriel-phthalimide reaction, Hofmann bromamide reaction, Curtius, Schmidt and Lossen rearrangements, physical

properties, chemical reactions: structural features affecting basicity of amines, amine salts as phase-transfer catalysts, electrophilic aromatic substitution, diazotization.

**(c) Diazonium Salts:** Nomenclature and structure, preparation, physical properties, chemical reactions: replacement of diazo group by H, OH, F, Cl, Br, I, $NO_2$, CN and aryl group; synthetic applications.

**Unit 4 Heterocyclic Compounds:**

Introduction, classification, nomenclature of five and six-membered rings, molecular orbital picture and aromatic characterstics of pyrrole, furan, thiophene and pyridine; methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution; mechanism of nucleophilic substitution reactions in pyridine derivatives; comparison of basicity of pyridine, piperidine and pyrrole.

Introduction of condensed five and six membered heterocycles; preparation and reactions of indole, quinoline and isoquinoline with special reference to Fischer-indole synthesis, Skraup synthesis and Bischier-Napieralski synthesis; mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

**Unit 5 Organic Synthesis via Enolates:**

Introduction, acidity of α-hydrogens, reactive methylene group-alkylation of diethyl malonate and ethyl acetoacetate, synthesis and reaction of ethyl acetoacetate, Keto-enol tautomerism of ethyl aectoacetate, alkylation of 1,3-dithianes, alkylation and acylation of enamines.

**Nuclear Magnetic Resonance Spectroscopy:**

Introduction, basic principle, chemical shift, chemical shift parameters, factors affecting the chemical shift, equivalence and non-equivalence protons, spin-spin coupling, coupling constant, interpretation of PMR spectra of simple organic molecules such as ethyl bromide, n-propyl bromide, isopropyl bromide, 1,1-dibromoethene, 1,1,2-tribromoethene, ethyl alcohol, ethyl acetate, acetaldehyde, benzaldehyde, toluene and acetophenone.

**Recommended Books:**


1. Clayden, J., Greeves, N., Warren, S., & Wothers, P. (2001). *Organic chemistry*. (2nd ed.). Oxford University Press.
2. Sykes, P. (1986). *A guide book to mechanism in organic chemistry* (6th ed.).Pearson.
3. Ingold, C. K.(1970). *Structure and mechanism in organic chemistry*. Cornell University Press.
4. Morrison, R.T., & Boyd, R.N. (2002). *Organic chemistry* (6th ed.). Prentlce Hall.
5. Nasipuri, D. (1994). *Stereochemistry of organic compounds.* (2nd ed.). New Age International
6. Singh, M.S. (2005). *Advanced organic chemistry-reactions and mechanisms*. Pearson Education, Singapore.
7. Wade, L.G., & Singh, M. S. (2008). *Organic chemistry*. Pearson Education.
8. Singh, M.S. (2014). *Reactive intermediates in organic chemistry-structure, mechanism and reactions*. Wiley, VCH & Weinheim
9. Kemp, W. (1991). *Organic Spectroscopy*. (3rd ed.).Palgrave Houndmills. New York.
10. Mohan, J. (2001). *Organic Spectroscopy:* Principles and Applications. Narosa Publication, New Delhi.
11. Kalsi, P. S., (2016). *Organic Spectroscopy*. (7th ed.). New Age International Publishers, New Delhi
12. Silverstein, R. M., Webster, F. X. & Kiemle, D., (2005). *Spectrometric Identification of Organic Compounds*. (7th ed.). John Wiley & Sons.


**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning
   https://nptel.ac.in
2. Online Chemistry Courses
   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM
   https://swayam.gov.in

# CHEM 302L Organic Chemistry-II Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- separate compounds by steam distillation.
- understand concept of chromatography (TLC) by separation of green leaf pigment, mixture of dyes and organic compounds.
- separate organic mixture containing two solid components and their qualitative analysis.
- synthesize organic compounds by synthetic methods: acetylation, benzoylation, diazotization or coupling reaction and electrophilic substitution.

**Steam Distillation (any one of the following)**

1. Naphthalene from its suspension in water.
2. Clove oil from clove.
3. Separation of o and p-nitrophenols.

Thin Layer Chromatography

Determination of $R_f$ values and identification of organic compounds:

1. Separation of green leaf pigment (spinach leaves may be used).
2. Preparation and separation of 2,4-dinitrophenyl hydrazones of acetone, 2-butanone, hexan-2 and 3-one using toluene and light petroleum (40:60).
3. Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).

**Qualitative Analysis**

Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives.

**Synthesis of Organic Compounds** (any two of the following)

**(i) Acetylation**

- Salicyclic acid
- Aniline
- Glucose
- Hydroquinone

**(ii) Aliphatic Electrophilic Substitution**

- Preparation of iodoform from ethanol and acetone

**(iii) Aromatic Electrophilic Substitution**

- Nitration:

  Preparation of m-dinitrobenzene

  Preparation of p-nitroacetanilide

- Halogenation:

  Preparation of p-bromoacetanilide

  Preparation of 2, 4, 6-tribromophenol

**(iv) Diazoitization / Coupling**

- Preparation of methyl orange and methyl red

**(v) Oxidation**

- Preparation of benzoic acid from toluene

**(viii) Reduction**

- Preparation of aniline from nitrobenzene
- Preparation of m-nitroaniline from m-dinitrobenzene

**Recommended Books:**

1. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. (1989). *Practical Organic Chemistry* (5th ed.), John Wiley & Sons, Inc., New York.

**Suggested e-Sources:**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

## CHEM 305 Molecular Modeling and Drug Design

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- describe and comprehend the fundamental concepts of molecular modeling and computational-driven drug discovery.
- understand the physicochemical properties of drugs including solubility, distribution, adsorption, and stability.
- understand the Molecular modeling and computer graphics
- develop the theoretical and practical aspects of molecular modeling

**Unit 1.** **Introduction to Molecular Modeling:** Useful Concepts in molecular modeling: Coordinate Systems, Potential Energy Surfaces, Molecular Graphics, Computer Hardware and Software.

**Force Fields:** Fields, Bond Stretching, Angle Bending, Introduction to nonbonded interactions, Electrostatic interactions, van der Waals Interactions, Hydrogen bonding in Molecular Mechanics, Force Field Models for the Simulation of Liquid Water.

**Unit 2.** **Energy Minimization and Computer Simulation:** Minimization and related methods for exploring the energy surface, Non-derivative method, First and second order minimization methods, Computer simulation methods, Simple thermodynamic properties and Phase Space, Boundaries, Analyzing the results of a simulation and estimating Errors.

**Unit 3.** **Molecular Dynamics and Monte Carlo Simulation:** Molecular Dynamics Simulation Methods, Molecular Dynamics using simple models, Molecular Dynamics with continuous potentials, Molecular Dynamics at constant temperature and pressure, Metropolis method, Monte Carlo simulation of molecules, Models used in Monte Carlo simulations of polymers.

**Unit 4.** **Structure Prediction and Drug Design:** Structure prediction - Introduction to comparative Modeling, Sequence alignment, Constructing and evaluating a comparative model, Predicting protein structures by 'Threading', Molecular docking, Structure based de novo ligand design, Drug Discovery - Chemoinformatics -QSAR.

**Unit 5.** **Pharmaceutical Compounds:** Structure and Importance Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis), artemisinin, An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

**Recommended Books:**

1. Leach, A.R. (2001). *Molecular Modelling Principles and Application*, Longman.
2. Haile, J.M. (1997). *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons.
3. Gupta, S.P. (2008). *QSAR and Molecular Modeling*, Springer - Anamaya Publishers.

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

## CHEM 305L Molecular Modeling and Drug Design Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- describe and comprehend the fundamental concepts of molecular modeling and computational-driven drug discovery.
- understand the physicochemical properties of drugs including solubility, distribution, adsorption, and stability.
- understand the Molecular modeling and computer graphics
- develop the theoretical and practical aspects of molecular modeling

1. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine π bonds.
2. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of cis and trans 2-butene.
3. Visualize the electron density and electrostatic potential maps for LiH, HF, $N_2$, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules.

4. (a) Relate the charge on the hydrogen atom in hydrogen halides with their acid character. (b) Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine.

5. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show how the shapes affect the trend in boiling points: (118 ºC, 100 ºC, 108 ºC, 82 ºC, respectively).

6. Build and minimize organic compounds of your choice containing the following functional groups. Note the dipole moment of each compound: (a) alkyl halide (b) aldehyde (c) ketone (d) amine (e) ether (f) nitrile (g) thiol (h) carboxylic acid (i) ester (j) amide.

7. (a) Determine the heat of hydration of ethylene. (b) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.

8. Arrange 1-hexene, 2-methyl-2-pentene, (E)-3-methyl-2-pentene, (Z)-3-methyl-2- pentene, and 2,3-dimethyl-2-butene in order of increasing stability.

9. (a) Compare the optimized bond angles $H_2O$, $H_2S$, $H_2Se$. (b) Compare the HAH bond angles for the second row dihydrides and compare with the results from qualitative MO theory.

10. Titrimetric estimation of drugs: Paracetamol, Ascorbic acid, Aspirin, etc.

    **Note:** Software: ChemSketch, ArgusLab (www.planaria-software.com), TINKER 6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similar software.

**Recommended Books:**

1. Leach, A.R. (2001). *Molecular Modelling Principles and Application*, Longman.

2. Haile, J.M. (1997). *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons.

3. Gupta, S.P. (2008). *QSAR and Molecular Modeling,* Springer - Anamaya Publishers.

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

## CHEM 303 Physical Chemistry-II

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- explain the basic principles of nuclear chemistry.
- discuss the surface phenomenon, surface properties of solid and calculate the surface area of the adsorbent.
- discuss conductance, Arrhenius theory, Debye-Huckel-Onseger's equation and Nernst equation.
- explain the concept of corrosion and factors affecting corrosion.
- explain the colligative properties of solution.
- Understand the congruent and non-congruent melting points, and azeotropic mixtures.

**Unit 1. Nuclear Chemistry:**

Nuclear particles, nuclear size, nuclear spin, nuclear magnetic moment, of a nucleus, discovery of radioactivity, decay processes-average life, half life; Rutherford and Soddy transformation, nuclear forces, packing fraction, binding energy, nuclear shell model, liquid drop model, applications of radioisotopes, hot atom chemistry-Szilard-Chalmers reaction.

**Surface Chemistry:**

General terms used in adsorption, adsorption of gases by solids, factors effecting adsorption, mono and multi layer adsorption, heat of adsorption Freundlich adsorption isotherm, Langmuirs adsorption isotherm and its limitations, determination of surface area of adsorbents, change in enthalpy, entropy and free energy of adsorption, competitive adsorption, mechanism of surface reaction and activation energy.

**Unit 2 Solutions, Dilute Solutions and Colligative Properties:**

Ideal and non-ideal solutions, deviation from ideal behaviour, method of expressing concentrations of solutions: - normality, molarity, molality, formality, mole fraction, percentage by mass, parts per million (ppm), activity and activity coefficient, dilute solution, Roult's law, colligative properties: relative lowering of vapour pressure, measurement of vapour pressure lowering, molecular weight determination, osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure, relationship between osmotic pressure and vapor pressure, lowering of an ideal solution, measurement of osmotic pressure (The Morse-Frazer method, the Berkeley-Hartley method), elevation in boiling point, depression in freezing point, thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point, experimental methods for determining various colligative properties, abnormal molar mass and Van't Haff factor, degree of dissociation and association of solutes.

**Unit 3 Electrochemistry-I:**

Electric transport in electrolytic solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution, migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation, its uses and limitations, weak and strong electrolytes, Ostwald's dilution law and its uses and limitations, Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only), transport number, definition and determination by Hittorf method and moving boundary method, applications of conductivity measurement: determination of degree of dissociation, determination of $K_a$ of acids, determination of solubility product of sparingly soluble salt, conductometric titrations.

**Unit 4 Electrochemistry-II:**

Types of reversible electrodes:-gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrode reactions, relationship between EMF and equilibrium constant, Nernst equation, effect of electrolytic concentration on electrode potential, standard hydrogen electrode, reference electrode, standard electrode potential, derivation of cell EMF and single electrode potential, sign conventions, electrochemical series and its significance.

**Electrolytic and Galvanic Cells:** reversible and irreversible cells, conventional representation of electrochemical cells, EMF of a cell and its measurements, calculation of thermodynamic quantities of cell reactions ($\Delta G$, $\Delta H$ and K), irreversible electrode potentials-polarization, over potential and its applications, hydrogen over voltage, concentration cell with and without transport, liquid junction potential, applications of concentration cells, valency of ions in doubtful cases, solubility, solubility product and activity coefficient; potentiometric, acid-base, precipitation and redox titrations; brief introduction of redox indicators, definition of pH and $pK_a$, determination of pH potentiometric methods.

**Corrosion**: types, theory, factors affecting corrosion and methods of combating of iron against corrosion.

**Unit 5 Phase Equilibrium:**

Introduction, terminology: phase, component, degree of freedom or variance, criteria of phase equilibrium, dynamic equilibrium, metastable equilibrium, statement of phase rule; solid solutions: compound formation with congruent melting point (Benzophenone-Diphenylamine) and incongruent melting point (Benzene-Picric acid); liquid-liquid mixtures: ideal liquid mixtures, Raoult's and Henry's laws, non-ideal system; azeotropes: - HCl-$H_2O$ and ethanol-water systems; partially miscible liquids: -phenol-water, trimethylamine-water, nicotine-water systems; lower and upper consulate temperature, effect of impurity on consulate temperature.

**Distribution Law:** thermodynamic derivation, association, dissociation and chemical combination of solute, applications**.**

**Recommended Books:**


1. Atkins, P., Julio, P. D. (2014). *Physical Chemistry* (10th Ed), United Kingdom: Oxford University Press.
2. Castellan, G.W. (1983). *Physical Chemistry* (3rd Ed), United State of America: Addision-Wesley Publishing Company.
3. West, A. R. (2014). *Solid State Chemistry and its Applications* (2nd Ed), John Wiley &Sons .Ltd
4. Puri, B.R., Sharma, L.R., Pathania, M.S. (2016). *Principle of Physcial Chemistry* (47th Ed). India: Vishal Publishing Company.
5. Arniker, H. J. (2005). *Essentials of Nuclear Chemistry* (4th Ed), India: New Age International Ltd. Publisher.


**Suggested e-Sources:**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in

2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry

3. Free Online Education SWAYAM

   https://swayam.gov.in

## CHEM 303L Physical Chemistry-II Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- handle instruments like calorimeter, conductometer and potentiometer.
- perform the proper procedures and have the knowledge of regulations for safe handling and use of chemicals.
- evaluate physical properties of analytes viz. the molecular weight, conductivity, optical rotation.

**Colorimetry**

1. To verify Beer-Lambert law for $KMnO_4/K_2Cr_2O_7$ and determine the concentration of the given solution of the substance.

**Conductometry** (any two)

1. To determine the strength of the given acid conductometrically using standard alkali solution.
2. To determine the solubility and solubility product of a sparingly soluble electrolyte conducotometrically.
3. To study the saponification of ethyl acetate conductometrically.
4. To determine the ionization constant of a weak acid conductometrically.

**Potentiometry**

1. To titrate potentiometrically the given ferrous ammonium sulphate solution using $KMnO_4/K_2Cr_2O_7$ as titrant and calculate the redox-potential of $Fe^{2+}$ / $Fe^{3+}$ on system on the hydrogen scale.

**Molecular Weight Determination** (one of the following)

1. Determine of molecular weight of a non-volatile solute by Rast method/Beckmann freezing point method.
2. Determination of the apparent degree of dissociation of an electrolyte (e.g. NaCl) in aqueous solution at different concentrations by ebullioscopy.

**Refractometry and Polarimetry** (one of the following)

1. To verify the law of refraction of mixtures (e.g. of glycerol and water) using Abb's refractometer.
2. To determine the specific rotation of a given optically active compound.

**Recommended Books:**

1. Gurtu, G.N., Gurtu, A. (2014). *Avanced Physical Chemistry*, India: Pragati Prakashan .
2. Sindhu, P.S. (2005). *Practicals in Physical Chemistry*, India: Macmillan Publishers.

**Suggested e-Sources**

1. National Programme on Technology Enhanced Learning

   https://nptel.ac.in
2. Online Chemistry Courses

   https://www.edx.org/learn/chemistry
3. Free Online Education SWAYAM

   https://swayam.gov.in

# CHEM 304 Analytical Methods in Chemistry

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **6** | **0** | **0** | **6** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- apply knowledge of basic statistics to validate the results of analysis.
- understand various chromatographic techniques and it's applications in separation of mixtures, purification of samples, and qualitative and quantitative analysis.
- understand the basic principles of optical, thermal and electro analytical methods and apply its concepts to interpretation of compounds.
- explain the principle and applications of thermal methods of analysis and atomic spectroscopy

**Unit 1.** **Qualitative and Quantitative aspects of analysis:** Sampling, evaluation of analytical data, errors, accuracy and precision:, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q, and T test, rejection of data, and confidence intervals. Steps involved in chemical analysis, Principles of volumetric analysis: Theories of acid-base, redox, complexometric, iodometric and precipitation titrations - choice of indicators for these titrations, Principles of gravimetric analysis: precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration and washing of precipitate, drying and ignition.

**Unit 2.** **Optical methods of analysis:** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principle of quantitative analysis: estimation of metal ions from aqueous solution. Determination of composition of metal complexes using

Job's method of continuous variation and mole ratio method. Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Effect and importance of isotopic substitution

**Unit 3.** **Thermal and Atomic Absorption methods of analysis:** Theory of thermogravimetry (TG),basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. Atomic Absorption Spectrometry: Introduction, Principal of AAS. Classification of atomic spectroscopic methods, Advantages and disadvantages of AAS. Measurement of atomic absorption, Instrumentation for atomic absorption spectrometer and application of AAS.

**Unit 4.** **Electro analytical methods**: Classification of electroanalytical methods, Types of reversible electrodes:-gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrode reactions, basic principle of pH metric: determination of streingth of unknown acids (Strong, Weak and mixture), potentiometric: principle, instrumrntation and application (determination of transport number. Detternimation of valency of an ions in doubtful cases, solubility, solubility product and activity coefficient, acid-base, precipitation and redox titrations), definition of pH and $pK_a$, determination of pH by potentiometric methods and conductometric titrations. Electrophoreses: principle, instrumentation and types of electrophoreses methods. Electro osmosis: principle and instrumentation.

**Unit 5.** **Separation Techniques**: Chromatography: Classification of chromatography methods, principles of differential migration adsorption phenomenon, Nature of adsorbents, solvent systems, Rf values, factors effecting Rf values. Paper Chromatography: Principles, Rf values, experimental procedures, choice of paper and solvent systems, developments of chromatogram - ascending, descending and radial. Two dimensional chromatography, applications. Thin layer Chromatography (TLC): Advantages. Principles, factors effecting Rf values. Experimental procedures. Adsorbents and solvents.

Preparation of plates. Development of the chromatogram. Detection of the spots. Applications. Column Chromatography: Principles, experimental procedures, Stationary and mobile Phases, Separation technique and Applications.

**Recommended Books:**

1. Christian, G. D., *Analytical Chemistry*, John wiley; 6th edition.
2. Skoog, D. A., West, D. M., Hollar, F. J. and Crouch S. R.; *Fundamentals of Analytical Chemistry*, Cengage Learning; 9 ed.
3. Willard, H. L., Merritt, Dean, J. A. and Settle, F. A. (2004) *Instrumental Methods of Analysis*; HCBS publishing New Delhi: 7th ed.
4. Ewing, G. W. Ewing, *Instrumental Methods of Chemical Analysis*, Mcgraw-Hill Int 5th ed.
5. Holler, F. J., Skoog, D. A. and Crouch, S. R. *Principles of Instrumental Analysis*, Thomson Books/Cole , 6th ed..
6. Willard, H. H., Merritt, J. A., Dean, l. l. and Settle, F. A. *Instrumental methods of Analysis*, CBS Publishing New Delhi, 7th ed.
7. Kaur, H., (2010). Spectroscopy, Pragati Prakashan, India.

**Suggested e-Sources:**

1. National programme on technology enhanced learning

   https://nptel.ac.in

2. Online chemistry courses

   https://www.edx.org/learn/chemistry

3. Free online education swayam

   https://swayam.gov.in

# CHEM 304L Analytical Methods in Chemistry Lab

| **Max. Marks : 100** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|
| **(CA: 40 + ESA: 60)** | **0** | **0** | **4** | **2** |

**Learning Outcomes:**

On completion of course, the students will be able to:

- develop their skills for qualitative and quantitative research in different fields.
- perform various analytical operations to qualify and quantify different analytes.
- outline synthetic strategies for important chemicals.
- check the purity of synthesized compounds through TLC, UV, FT-IR spectral data
- analysis of soil through determination pH, estimation of ions and by total dissolve salts.
- able to determine the Chemical and biological oxygen demand by spectroscopic techniques.

**Separation Techniques**

**1. Chromatography:**

(a) Separation of mixtures

(i). Paper chromatographic separation of Fe3+, Al3+, and Cr3+.

(ii). Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC.

**2. Solvent Extractions:**

(a) To separate a mixture of Ni2+ & Fe2+ by complexation with DMG and extracting the Ni2+- DMG complex in chloroform, and determine its concentration by spectrophotometry.

(b) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.

(c) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

(d) Determination of Na, Ca, Li in cola drinks and fruit juices using fame photometric techniques.

(e) Analysis of soil:

(i). Determination of pH of soil.

(ii). Total soluble salt

(iii). Estimation of calcium, magnesium, phosphate, nitrate

(f) Ion exchange:

(i). Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii). Separation of metal ions from their binary mixture.

(iii). Separation of amino acids from organic acids by ion exchange chromatography.

**Spectrophotometry**

1. Determination of pKa values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of dissolved oxygen in water.
4. Determination of chemical oxygen demand (COD).
5. Determination of Biological oxygen demand (BOD).

6. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

**Recommended Books:**


1. Gurdeep, R (2016*), Advanced Practical Inorganic Chemistry*, revised Ed., Krishna Prakashan publication.
2. Svehla, G. (2010), Vogel's *Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall.
3. Gurtu, J. N. and Gurtu, A(2011), *Physical Chemistry Vol – I,* Pragati Prakashan publication.
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. (1989). *Practical Organic Chemistry* (5th ed.). New York, John Wiley & Sons, Inc.
5. Christian, Gary D. (2004*), Analytical Chemistry*, New York, 6th Ed. John Wiley & Sons.
6. Khopkar, S.M. (2009), *Basic Concepts of Analytical Chemistry*, New Age, International Publisher.
7. Christian, Gary D. (2004), *Analytical Chemistry*, New York , 6th Ed. John Wiley & Sons.


**Suggested e-Sources**

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