दिल्लीविश्वविद्यालय

UNIVERSITY OF DELHI

Bachelor of Science Programme in Life Sciences
(CBCS)

(Botany Component)

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges, Non Collegiate Women's Education Board and School of Open Learning

List of Contents

Page No.

Preamble

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

The new curriculum of B.Sc. Life Sciences offer essential knowledge and technical skills to study plants in a holistic manner. Students would be trained in all areas of plant biology using a unique combination of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

The University of Delhi hopes the LOCF approach of the B.Sc. Programme in Life Sciences will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

B.Sc. Programme in Life Sciences (CBCS)
(Botany Component)

INTRODUCTION

B.Sc. Programme in Life Sciences is designed to afford a skeletal structure within which the programme can be developed to suit the need of the hour, in keeping with the emergence of new areas of life sciences through interdisciplinary approach. The B.Sc. Programme in Life Sciences programme covers a wide range of basic and applied aspects of botany, zoology and chemistry courses as well as courses of interdisciplinary nature. The core courses that are a part of the programme are designed to build knowledge base in the student, and furthermore, acquaints the students with the applied aspects of this fascinating discipline as well. The student is thus equipped to pursue higher studies, and to apply the skills learnt in the programme to solving practical societal problems. The programme offers a wide range of elective courses of botany, zoology and chemistry. These include skill enhancement courses that prepare the student for an eventual job in academia or industry.

CHOICE BASED CREDIT SYSTEM (CBCS):

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. It offers flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge of all aspects of the field. The Learning outcomes-based curriculum framework is designed around the CBCS and is intended to suit the present day needs of the student interms of securing their path towards higher studies or employment.

The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Design of Program:

The teaching-learning will involve theory classes (Lectures) of one hour duration and practical classes. The curriculum will be delivered through various methods including chalk and talk, power-point presentations, audio, video tools, E-learning/E-content,virtual labs, simulations, field trips/Industry visits, seminars (talks by experts), workshops, projects, models and class discussions. The assessment broadly will comprise of Internal Assessment (Continuous Evaluation) and End Semester Examination. The internal Assessment will be through MCQ, test, assignment, oral presentation, worksheets and short project.

Outline of Choice Based Credit System:

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2.Elective Course: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/ subject/ domain or nurtures the candidate's proficiency/skill is called an Elective Course.

2.1.Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

2.2 Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.

2.3 Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course: The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on -training, competencies, skills, etc.

3.1 AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.

3.2 AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

LEARNING OUTCOME–BASED APPROACH TO CURRICULUM PLANNING:

The Learning Outcomes-based Curriculum Framework (LOCF) for the B.Sc. degree in Life Sciences is designed to afford a skeletal structure within which the programme can be developed to suit the need of the hour, in keeping with the emergence of new areas of life sciences. The framework is architected to allow for flexibility in programme design and course content development, while at the same time maintaining a basic uniformity in

structure in comparison with other universities across the country. The B.Sc. Life Sciences programme covers a wide range of basic and applied aspects of botany, zoology and chemistry courses as well as courses of interdisciplinary nature. The core courses that are a part of the programme are designed to build sound knowledge in the student, and furthermore, acquaints the students with the applied aspects of this fascinating discipline as well. The student is thus equipped to pursue higher studies in an institution of her/his choice, and to apply the skills learnt in the programme to solving practical societal problems. The programme offers a wide range of elective courses to the student. These include skill enhancement courses that prepare the student for an eventual job in academia or industry.

LEARNING OUTCOME BASED CURRICULUM FRAMEWORK

Nature and extent of the B.Sc Programme in Life Sciences

Content: Botany is the broad discipline encompassing various subjects involved with the study of plants. The Programme imparts knowledge on various fields of plant biology through teaching, interactions and practical classes. Present trend has been shifted to frontier areas of plant sciences at the cost of traditional botany. There is need to maintain a balance of the traditional botany and modern science and applied approach. This syllabus has been drafted to enable the learners to prepare them for future employment in various fields including academics as well as competitive exams. Students would gain wide knowledge as follow:

1. Diversity of plants and microbes their habitat, morphology, and reproduction.
2. Genetics and molecular biology of plants
3. Fungi and disease causing microbes and fungi
4. Economic value of plants and their use in Biotechnology

Plants are relevant to humans as they provide us with food, shelter, clothing, energy, health, aesthetic beauty, environment and even economy. This paper is relevant to ALL students. Introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi and to various plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms) and information on the Ecological and Economic Importance of Microbes, Fungi and various plant groups to enable students understand and appreciate relevance of Microbes and Plants to environment and human well-being. Insight into the line of Plant Evolution on Earth and the consequent Biodiversity is instrumental in creating Awareness on the threats to biodiversity and sensitize young minds towards the Biodiversity Conservation for sustainable development. Combination of Theoretical and Practical components will provide comprehensive information and insight into the

1. Fascinating world of Microbes and Plants.
2. Hands on Training will help students learn use of microscope, mounting, section-cutting and staining techniques for the study of plant materials.
3. Making Drawings in Practical Records will enhance understanding morphological and structural details and related functional aspects in diverse plant groups.
4. Use of Illustrations, Photographs, Charts, Permanent Slides, Museum and Herbarium Specimens along with ICT Methods will provide an interesting insight into the beautiful world of microbes and plants.
5. Scope of Biodiversity includes Medicinal field, Industry, Agriculture, Research and Study, Job Opportunities and Environmental Conservation. This paper is both informative and

interesting and will enable students to learn about Biodiversity not only as a plant or nature lover, but also for higher academic pursuits, particularly in the field of Biological Sciences, Environment and Biodiversity Conservation.
6. The relationship between the properties of macromolecules, their cellular activities and biological responses.
7. Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelles.
8. Contemporary approaches in modern cell and molecular biology.
9. Understand how plant sciences and microbiology is applied in manufacturing of industrial products
10. Know about design of bioreactors, factors affecting growth and production
11. Comprehend the techniques and the underlying principles in upstream and down- stream processing
12. Learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
13. Understand various biogeochemical cycles – Carbon and Nitrogen, and microbes involved
14. Understand the basic principles of organism and environment interation and application of the same in solving environmental problems – waste water treatment and bioremediation
15. Learn the basic concepts, principles and processes in plant biotechnology.
16. Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.
17. Use basic biotechnological techniques to explore molecular biology of plants Explain how biotechnology is used to for plant improvement and discuss the biosefty concern and ethical issue of that use.

Aims of B.SC. Programme in Life Sciences

Content: 1. Provide an introduction to Biodiversity ranging from Microbes (Viruses and Bacteria), to Fungi, including diverse plant groups (Algae and Archegoniates-Bryophytes, Pteridophytes and Gymnosperms).

2. To enable students to understand and appreciate the relevance of Microbes and Plants to environment (ecological significance) and human well-being (economic importance).

3. Develop an understandingof Evolution of Plant formsand the consequent Biodiversity. These are instrumental in creating awareness on the threats to biodiversity and sensitizestudents towards the Conservation of Biodiversity for sustainable development.

4. To study the organization of cell, cell organelles and biomolecules (i.e protein, carbohydrate, lipid and nucleic acid) to gain knowledge on the activities in which the diverse macro molecules and microscopic structures inhabiting the cellular world of life are engaged. This will enable the students to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life.

5. To introduce students to application of microbes in Industrial production and Environmental remediation strategies.

6. New knowledge and widening of the knowledge acquired in by handling of classical and modern plant biotechnology processes, including tissue culture for healthy plants, plants with improved characteristics.

7. To explore the natural genetic variation in plants and to understand how diverse factors (at the cellular level) contribute to the expression of genotypes and hence to phenotypic variation.

8. Understanding of biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals (vaccines, antibodies, antibiotics etc.), food industry (transgenic crops with improved qualities (nutraceuticals, industrial enzymes etc.), agriculture (biotic and abiotic stress tolerant plants, disease and pest resistant plants, improved horticultural varieties etc.), ecology (plants role in bioremediation). This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.

9. In the laboratory classes, students will perform some of the techniques currently used to generate information and detect genetic variation.

10. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various plants groups.

11. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system.

12. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and in the application of statistics to biological data

13. To provide new information, enhance core competency and discovery/inquiry based learning of learners. A botany graduate would be competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

14. To make students aware of most basic domain-independent knowledge, including critical thinking and communication.

15. To enable the graduate to prepare for national and International competitive examinations for employment.

GRADUATE ATTRIBUTES:

Some of the characteristic attributes ofB.ScProgramme in Life Sciences include:

• Knowledge acquisition: gathers in-depth knowledge of basic and applied areas of Botany, zoology and Chemistry.

• Core subjects laboratory skills: understands various methods of safe handling, culturing and storage of plant and animal specimens and chemicals in the laboratory.

•Interdisciplinary approach: becomes aware of the role of life sciences in interdisciplinary research as well as in daily life.

•Environmental literacy: develops a basic understanding of the principles of life sciences that have environmental implications, and gains an awareness of regulatory requirements and their compliance in biotechnology and microbiological research.

•Scientific logic: develops scientific logic and approaches a problem with critical reasoning.

•Independence in thought: cultivates independent thinking and is able to integrate knowledge from other disciplines and fit that knowledge into the context of loife sciences.

•Team work: understands the importance and strengths of interacting with and working alongside people from diverse backgrounds.

•Global perspective: becomes acquainted with standard international practices and emerging technologies used to study plants, animals and their structural components.

•Communication skills: develops effective communication skills through oral presentations of ongoing developments in the field and the compiling of information in the form of reports.

•Ethics: acquires anawareness of work ethics and ethical issues in scientific research as well as plagiarism policies.

•Self-motivation: develops self-discipline, planning and organization skills, and time management skills.

Qualification description: The qualification description for B.Sc. programme in Life Science include:

•Demonstration of a clear and exhaustive understanding of the basic concepts of Zoology, Botany and Chemistry, and an awareness of the emerging areas of the field.

•Acquisition of in-depth comprehension of the applied aspects of Zoology, botany and chemistry in day-to-day life.

•Enhancement of ability to read, assimilate and discuss scholarly articles and research papers showcasing subject of life sciences as well as interdisciplinary areas of life sciences.

•Sharpening of critical thinking skills facilitating the application of knowledge gained in the field of life sciences in the classroom to the practicalsolving of societal problems.

•Development of intellectual capabilities promoting the ability to formulate and test a hypothesis.

•Acquisition of practical laboratory skills, enabling the accurate design of an experiment and systematic collection of experimental data.

•Exhibition of ability to interpret and quantitatively analyze experimental data and maintain records of the same.

•Development of strong oral and written communication skills promoting the ability to present studies in the field of zoology, botany and chemistry using the concepts and knowledge acquired.

•Demonstration of the ability to work effectively and productively, independently or as part of a team.

QUALIFICATION DESCRIPTORS

For a graduate student in Life Sciences the qualification descriptors may include following:
(i) To show a systematic, extensive, coherent knowledge and understanding of academic subjects and their applications, including critical understanding of the established theories, principles and concepts of a number of advanced and emerging issues in the field of Botany;
(ii) To gain knowledge to produce professionals in the field of plant sciences in research and development, academics (teaching in Schools, Colleges and University), government and public services e.g. conservationist, plant explorer, ecologist, horticulturist, plant biochemist, genetics, nursery manager, molecular biologist, plant pathologist, taxonomist, farming consultant and environmental consultant. Further application of knowledge can enhance productivity of several economically important products. Knowledge of plant sciences is also necessary for the development and management of forests, parks, wastelands and sea wealth
(iii) Display skills and ability to use knowledge efficiently in areas related to specializations and current updates in the subject.
(iv) Provide knowledge about plants, current research, scholarly and professional literature of advanced learning areas of plant sciences
(v) Use knowledge understanding and skills for critical assessment of wide range of ideas and problems in the field of Botany
(vi) Communicate the outcomes of studies in the academic field of Botany through print and digital media.
(vii) Apply one's knowledge and understanding of Botany to new/unfamiliar contexts and to identify problems and solutions in daily life
(viii) Design and apply the knowledge of plant sciences in identifying the problems which can be solved through the use of plants
(ix) To think of adopting expertise in plant structure, functions and solve the problems of environment, ecology, sustainable development and enhancing productivity.
(x) Concept and significance of sustainable development and use of the plant resources

PROGRAM LEARNING OUTCOMES:

• Students of the B.Sc. Life Sciences programme will learn to use scientific logic as they explore a wide range of contemporary subjects spanning various basic and applied aspects life sciences

• Students will appreciate the biological diversity of plant and animals and compounds in them to be able to describe/explain the processes used by microorganisms for their replication, survival, and interaction with their environment, hosts, and host populations. They will become aware of the important role of plant and animals in ecosystem functioning.

•Students will gain knowledge of various biotechnological applications of plants and animals and will learn of industrially important natural products produced by them.

•Students will become familiar with scientific methodology, hypothesis generation and testing, design and execution of experiments. Students will develop the ability to think critically and to read and analyze scientific literature.

•Students will acquire and demonstrate proficiency in good laboratory practices in biological sciences and be able to explain the theoretical basis and practical skills of the tools/technologies commonly used to study this field.

•Students will develop proficiency in the quantitative skills necessary to analyze biologicalproblems (e.g., arithmetic, algebra, and statistical methods as applied to biology)

•Students will develop strong oral and written communication skills through the effective Presentation of experimental results as well as through seminars.

•Graduates of the B.Sc. programme in Life Sciences will make the students to understand and evaluate the impact of new research discoveries in the life sciences, and will be able to stimulate to think on wide range of careers, including biological and medical research in higher education institutions as well as careers in public and global health, scientific writing, environmental organizations, and food, pharmaceuticals and biotechnology industries.

STRUCTURE B.SC. PROGRAMME IN LIFE SCIENCES

Credit Distribution

Course	*Credits	
	Theory+ Practical	Theory+Tutorials
I. Core Course (12 Papers) 04 Courses from each of the 03 disciplines of choice	12X4= 48	12X5=60
Core Course Practical / Tutorial* (12 Practical/ Tutorials*) 04 Courses from each of the 03 Disciplines of choice	12X2=24	12X1=12
II. Elective Course (6 Papers) Two papers from each discipline of choiceincluding paper of interdisciplinary nature.	6x4=24	6X5=30
Elective Course Practical / Tutorials* (6 Practical / Tutorials*) Two Papers from each discipline of choice including paper of interdisciplinary nature	6 X 2=12	6X1=6
•Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester		
III. Ability Enhancement Courses		
1. Ability Enhancement Compulsory (2 Papers of 2 credits each) Environmental Science English/MIL Communication	2X 2=4	2X2=4
2. Ability Enhancement Elective (Skill Based) (4 Papers of 2 credits each)	4 X 2=8	4 X 2=8
	Total credit= 120	Total credit= 120

Institute should evolve a system/policy about ECA/ General Interest/ Hobby/ Sports/ NCC/ NSS/ related courses on its own.

*wherever there is practical there will be no tutorials and vice -versa

Semester wise distribution of Courses of B.Sc. Life Science under CBCS

[BOTANY COMPONENT]

Semester	Core Course	Ability Enhancement Compulsory Courses	Skill Enhancement Courses SEC 4	Discipline Specific Elective DSE(4)
I	Botany I: CC Biodiversity (Microbes, Algae, Fungi and Archegoniatae) CC Zoology I CC Chemistry I	English/MIL Communication/ Environmental Science		
II	Botany II: CC Plant Ecology and Taxonomy CC Zoology II CC Chemistry II	English/MIL Communication/ Environmental Science		
III	Botany III: CC Plant Anatomy and Embryology CC Zoology III CC Chemistry III		SEC –I 1. Biofertilizers	
IV	Botany IV: CC Plant Physiology and Metabolism CC Zoology III CC Chemistry III		SEC –II 2. Medicinal Botany	
V			3. Ethnobotany	DSE-I Botany (Any one) l.Cell and Molecular Biology 2. Bioinformatics
VI			4. Intellectual Property Right	DSE-II Botany (Any one) 3. Economic Botany and Biotechnology 4. Analytical Techniques in Plant Sciences

Courses for Programme under B.Sc. Life Sciences

Core Courses —Botany

1. Biodiversity (Microbes, Algae, Fungi and Archegoniatae)
2. Plant Ecology and Taxonomy
3. Plant Anatomy and Embryology
4. Plant Physiology and Metabolism

Discipline Specific Electives-Botany (Any two)

Semester V DSE-I	DSE-I (Any one) l.Cell and Molecular Biology 2. Bioinformatics
Semester VI DSL-II	DSE-II (Any one) 3. Economic Botany and Biotechnology 4. Analytical Techniques in Plant Sciences
Ability Enhancement Compulsory Courses	
1. Environmental Science 2. English/M1L Communication	
Skill Enhancement Courses (four)	
Semester III SEC-I	1. Biofertilizers
Semester IV SEC-II	2. Medicinal Botany
Semester V SEC- III	3. Ethnobotany
Semester VI SEC-IV	4. Intellectual Property Right

COURSE LEARNING OBJECTIVES

The progamme is designed to equip students with essential knowledge and technical skills to study plants and related subjects in a holistic manner. hteh main aim is to train the learners in all areas of plant biology using appropriate combinations of core and elective papers with significant inter-disciplinary components. Students would be exposed to cutting-edge technologies that are currently used in the study of plant life forms, their evolution and interactions with other organisms within the ecosystem. Students would also become aware of the social and environmental significance of plants and their relevance to the national economy.

COURSE LEARNING OUTCOME

The course learning outcomes are aligned with program learning outcomes but these are specific-to-specific courses offered in a program. The course level learning shall be reflected as program level learning. The core courses shall be the backbone of this framework whereas discipline electives, generic electives and skill enhancement courses would add academic excellence in the subject together with multi-dimensional and multidisciplinary approach.

1. Understanding of plant classification systematics, evolution, ecology, developmental biology, physiology, biochemistry, plant interactions with microbes and insects, morphology, anatomy, reproduction, genetics and molecular biology of various life-forms. Understanding of various analytical techniques of plant sciences, use of plants as industrial resources or as human livelihood support system and is well versed with the use of transgenic technologies for basic and applied research in plants.

2. Understanding of various life forms of plants, morphology, anatomy, reproduction, genetics, microbiology, molecular biology, recombinant DNA technology, transgenic technology and use of bioinformatics tools and databases and the application of statistics to biological data.

TEACHING-LEARNING PROCESS:

The B.Sc. programme in Life Sciences aims to make the student proficient in biology through the transfer of knowledge in the classroom as well as in the laboratory. In the classroom this will be done through blackboard and chalk lectures, charts, powerpoint presentations, and the use of audio-visual resources that are available on the internetsuch as virtual lab. An interactive mode of teaching will be used. The student will be encouraged to participate in discussions and deliver seminars on some topics. A problem-solving approach will be adopted wherever suitable. In the laboratory the student will first learn good laboratory practices and then get hands-on training on basic microbiological techniques and methods. Emphasis on laboratory work is particularly important keeping in mind the practical nature of the subject, and the time devoted to practicals will enable the student to better understand the applications of the different courses. Field exercises and field trips will be organized to nature and industries that will facilitate understanding of students on applied aspects of the subject and enable him to gain exposure to future places/areas of employment.

Assessment methods:

The student will be assessed over the duration of the programme by many different methods. These include short objectives-type quizzes, assignments, written and oral examinations, group discussions and presentations, problem-solving exercises, case study presentations, experimental design planning, execution of experiments, seminars, preparation of reports, and presentation of practical records. The wide range of assessment tasks aim to break the monotony of having a single assessment method

KEYWORDS

Plant Sciences, Biology, biodiversity, biotechnology, botany, bryophytes, fungi, algae, mocrobes, bacteria, plant pathology, plant reproduction, anatomy, developmental biology, molecular biology, genetics, systematics, taxonomy, plant physiology, biostatistics, bioinformatics, ecology, biochemistry,

CONTENTS OF COURSES OF THE PROGRAMME

Biodiversity (Microbes, Fungi, Algae and Archegoniatae)
(LSCC2)
Core Course - (CC) Credit:6

Course Objective (2-3)

This course aims at making a familiarity with special groups of Bacteria, Viruses, Fungi, algae and plants reproduction. Creating an understanding by observation and table study of representative members of phylogenetically important groups should be able to make students learn the process of evolution in a broad sense. Study of morphology, anatomy, reproduction and developmental changes thereinthrough typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants. To acquaint the students with external and internal basic structure and cellular composition of the Bacteria, Viruses, Fungi, Bryophytes and Pteridophytes and Gymnosperms.To gain knowledge of diversity, life forms, life cycles, morphology and importance of microoganisms (Bacteria and algae). To introduce students with various fungal groups and lichens, their ecology, classification, characteristics, reproduction and economic importance.

1. To introduce students with the phytopathology, its concepts and principles
2. To acquaint with various plant diseases, causal organisms and their control
3. To correlate structure with important functions of different organs of the organisms.Study of various tissue systems and their development and functions in plants

Course Learning Outcomes

The students will be made aware of the various groups of organisms, Bacteria, viruses, algae bryophytes, pteridophytes and gymnosperms that have given rise to land habit. Through field study they will be able to see these plants grow in nature and become familiar with the biodiversity. to my knowledge students should create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case they are able to find some rare structure or phenomenon related to these plants. Students would have understanding of the classification, characteristics features, cell structure and growth and reproduction in viruses, bacteria, and various groups of marine and fresh water algae and their ecological and economic importance.
Upon completion of this course, the students will be able to:

1. Understand the world of fungi, and pathogens of plants
2. Appreciate the characteristics of the fungi
3. Understand the ecological and economic significance of lichen
4. Understand the application of mycology in various fields of economic and ecological significance
5. Understand the economic and pathological importance of fungi, bacteria and viruses
6. Identify common plant diseases and their control measures

Unit 1

MICROBES (14 Lectures)
a) Viruses – Discovery; General Structure- RNA virus (TMV) and DNA virus (Tphage); Replication-Lytic and Lysogenic Cycle; Economic Importance.
b) Bacteria – Discovery; General Characteristics and Cell Structure; Reproduction-Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.

Unit 2

ALGAE (8 Lectures)
General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in Nostoc, Chlamydomonas, Vaucheria and Ectocarpus

Unit 3

FUNGI (8 Lectures)
General Characteristics; Outline Classification (Webster); Economic Importance; Thallus Organization and Reproduction in *Rhizopus, Penicillium, Alternaria and Puccinia*

Unit 4

ARCHEGONIATAE (30 Lectures)
a) Bryophytes (10 Lectures) General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure and Reproduction in *Marchantia, Anthoceros* and *Funaria*.

Unit 5

b) Pteridophytes (10 Lectures) General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella, Equisetum* and *Pteris*.

Unit 6

c) Gymnosperms (10 Lectures) General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus.*

Practical

MICROBES

a) Viruses- Structure of TMV and T-Phage (EMs/ Models/ Photographs); Lytic and Lysogenic Cycle (Line Drawings/ Photographs).
b) Bacteria-Types and Structure (Permanent Slides/ Photographs); EM Bacterium; Binary Fission and Conjugation (Photographs).
c) Chlamydomonas-E.M., *Nostoc*, *Vaucheria* and *Ectocarpus*- Study of Vegetative and Reproductive Structures through Temporary Preparations and Permanent Slides.
d) *Rhizopus*, *Penicillium* and *Alternaria*- Asexual Stage from Temporary/ Tease Mounts, *Puccinia*-Black Stem Rust of Wheat and Infected Barberry Leaves (Herbarium

Specimens/ Photographs), Tease Mounts of Spores on Wheat, Section of infected portion of Wheat and Barberry (Permanent Slides).

e) Bryophytes: *Marchantia*-Morphology of Thallus, W.M. Rhizoids, V.S. Thallus through Gemma Cup, W.M. Gemma (all Temporary Slides), L.S. Sporophyte (Permanent slide). *Anthoceros*- Morphology of Thallus, W.M. Rhizoids, L.S./ T.S. Capsule, W.M. Spores, W.M. Pseudoelaters, (all Temporary Slides), L.S. Sporophyte (Permanent slide). *Funaria*- Morphology of Gametophyte bearing Sporophyte, W.M. Rhizoids, W.M. Leaf, W.M. Operculum, W.M. Peristome, W.M. Spores (all Temporary Slides), L.S. Capsule (Permanent Slide).
f) Pteridophytes: *Selaginella*- Morphology, T.S. Stem, W.M. Strobilus, W.M. Microsporophyll and Megasporophyll (all Temporary Slides), L.S. Strobilus (Permanent Slide).*Equisetum*- Morphology, T.S. Stem (Internode), L.S./ T.S. Strobilus, W.M. Sporangiophore, W.M. Spores (Wet and Dry) (all Temporary Slides). *Pteris*- Morphology, V.S. Sporophyll, W.M. Sporangium, W.M. Spores (all Temporary Slides), W.M. Prothallus with Sex Organs (Permanent Slide).
g) Gymnosperms: *Cycas*- Morphology (Coralloid Roots, Leaf, Microsporophyll, Megasporophyll), T.S. Coralloid Root (Permanent Slide), V.S. Leaflet, V.S. Microsporophyll, W.M. Spores (all Temporary Slides), L.S. Ovule (Permanent Slide).*Pinus*- Morphology (Long and Dwarf Shoots, Male and Female Cones), W.M. Dwarf Shoot, T.S. Needle, L.S/ T.S. Male Cone, W.M. Microsporophyll, W.M. Microspores (all Temporary Slides), L.S Female Cone (Permanent Slide).

References

1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). *Introductory Mycology*. Singapore, Singapore: John Wiley and Sons (Asia). (Chapters 1,4.9.13,18,20 for Unit 2)
2. Kumar, H.D. (1999). *Introductory Phycology*. New Delhi,Delhi: Affiliated East-West. Press Pvt. Ltd. (Chapters 1,3,10,11,12,14 for Unit 3)
3. Kaur, I..D., Uniyal, P.L. (2019).*Text Book of Gymnosperms*. New Delhi,ND: Daya Publishing House, (Chapters 1,2,5, 6 for 4)
4. Parihar, N.S. (1972). *An Introduction to Embryophyta. Vol. II: Pteridophyta*. Allahabad, UP: Central Book depot. Chapters 1, 4, 5,9,for Unit 4)

Additional Resources:

1. Bhatnagar, S.P., Moitra, A. (1996). *Gymnosperms*. New Delhi, ND: New Age International (P) Ltd Publishers. (Chapters 1,6,13 for Unit 4)
2. Reece J.B., Urry L.A., Cain M.L., Wasserman S.A., Minorsky P.V., Jackson, R.B. (2011). *Biology 9th edition*. San Francisco, SF: Pearson Benjamin Cummings. (Chapters 19,27 for Unit 1¸ Chapter 31 for Unit 2; Chapter for Unit 3)))
3. Parihar, N.S. (1991). *An Introduction to Embryophyta. Vol. I. Bryophyta*. Allahabad, UP: Central Book Depot. (Chapters 1,3,6,9 for Unit 4)
4. Puri, P. (1985) *Bryophytes*. New Delhi, Delhi. Atma Ram and Sons, Delhi (Chapters 1,5,7,10 for Unit 4)
5. Tortora, G.J., Funke, B.R., Case, C.L. (2010). *Microbiology: An Introduction*. San Francisco, SF: Pearson Benjamin Cummings. (Chapters 13, 14 For Unit 1)
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). *Botany For Degree Students Pteridophyta*. New Delhi, Delhi: S. Chand Publication. (Chapters 1,4, 6, 9 for unit 4)

7. Vashistha, B.R., Sinha, A.K., Kumar, A. (2011). *Botany For Degree Students, Bryophyta*. New Delhi, Delhi: S Chand Publication.(Chapters 1,5,14, 18 for Unit 4)
8. Webster, J. and Weber, R. (2007). *Introduction to Fungi*. Cambridge, Cambridge University Press. Chapters 1,5, 7,22 Unit 2)

Teaching Learning Process

Visual media would be used for teaching. Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. College teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process
Weekly lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit II
Week 7: Unit III
Week 8: Unit III
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit IV
Week 14: Unit IV

Assessment Methods

Making drawings form the temporary preparations as practical record books. We may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	a) **Viruses** – Discovery; General Structure- RNA virus (TMV) and DNA virus (T-phage); Replication-Lytic and Lysogenic Cycle; Economic Importance. b) **Bacteria**– Discovery; General Characteristics and Cell Structure; Reproduction-Vegetative, Asexual and Genetic Recombination (Conjugation, Transformation and Transduction); Economic Importance.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	**FUNGI:** General Characteristics; Outline Classification (Webster); Economic Importance;	Class room lectures and	Hands on exercises, PPT,

	Thallus Organization and Reproduction in *Rhizopus, Penicillium, Alternaria* and *Puccinia*.	Practical demonstration, experiments	assignments, tests
Unit III:	**ALGAE:** General Characteristics; Outline Classification (Fritsch); Economic Importance; Thallus Organization and Reproduction in *Nostoc, Chlamydomonas, Vaucheria* and *Ectocarpus*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	**Bryophytes :**General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure and Reproduction in *Marchantia*, *Anthoceros* and *Funaria*. b) **Pteridophytes:** General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella, Equisetum* and *Pteris*. c) **Gymnosperms G**eneral Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Cycas* and *Pinus*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Bacteria,Viruses, Algae , Cyanobacteria, algal reproduction, viroids, bacterial reproduction, Fungi, Ascomycota,*Puccinia,Agaricus*,slime molds,symbiotic association,economic importance, Fungal disease, Bacterial disease, TMV

Plant Anatomy and Embryology
(LSCL4)
Core Course - (CC) Credit:6

Course Objective (2-3)

The Objective of this paper is to provide basic knowledge of plant internal architecture and cellular composition and reproduction. This will help them to understand how different plant tissue structures evolve and modify their functions with respect to their environment.

Course Learning Outcomes

Knowledge regarding anatomy equipped the students to identify different types of tissues and make them able to correlate their physiology in a better away. This will also help them to understand how different plant tissue evolve and modify their structure and functions with respect to their environment. Knowledge regarding embryology make them understand how reproduction play significant role in defining population structure, natural diversity and sustainability of ecosystem in a better way.

Unit 1

Meristematic and permanent tissues (8 lectures)
Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-Kappe theory)

Unit 2

Organs (4 lectures)
Structure of dicot and monocot stem (include types of vascular bundles), root and leaf (including Kranz anatomy).

Unit 3

Secondary Growth (8 lectures)
Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood; Ring and diffuse porous wood; Early and late wood)

Unit 4

Adaptive and protective systems (8 lectures)

Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification); General account of adaptations in xerophytes and hydrophytes (Examples may be cited from *Nerium*, *Opuntia*, *Hydrilla* and *Nymphaea*).

Unit 5

Introduction to Plant Reproduction (5 lectures)
Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction. History (contributions of G.B. Amici, W. Hofmeister, E. Strasburger, S.G. Nawaschin, P. Maheshwari, B.M. Johri, W.A. Jensen, J. Heslop-Harrison, and scope, Significance of Reproductive Biology studies.

Unit 6

Structural organization of flower (10 lectures)
Organization of flower; Structure: Anther (No developmental stage) and development of Pollen grains; Ovules: Structure and types; Embryo sac Types (monosporic, bisporic and tetrasporic) and development (with special reference to *Polygonum* type).

Unit 7
Pollination and fertilization (10 lectures)
Pollination types and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms (–Autochory, Anemochory, Hydrochory, Zoochory with 1 example each) Adaptations (aril, caruncle).

Unit 8:
Embryo and endosperm (10 lectures)
Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo (Brief account of dicot embryo development); Embryo endosperm relationship (General account).

Practical

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: *Zea mays*; Dicot: *Helianthus*.
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*.
5. Leaf: Dicot and Monocot (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).
7. Structure of anther (young and mature).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac (Permanent slides/photographs).

10. Pollination types and seed dispersal mechanisms (including appendages, aril,caruncle) Photographs/specimens).
11. Dissection of embryo/endosperm from developing seeds.
12. Calculation of percentage of germinated pollen in a given medium.

References

1. Bhojwani, S.S., Bhatnagar, S.P. , Dantu P. K. (2015). *Embryology of Angiosperms*, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd. (chapter 1 for unit 5;chapters 2, 3, 4, 6 and 7 for unit 6; chapters 8, 9 for unit 7; chapters 11, 12 and 15 for unit 8)
2. Dickison,W.C.(2000). *Integrated Plant anatomy*. Cambridge, U.K.: Academic press Inc. (chapter 2 for unit 1; chapter 3 for unit 2; chapter 4 for unit 3; chapters 2 and 8 for unit 4)
3. Fahn, A. (1982). *Plant anatomy.* Oxford, U.K.: Pergamon Press. (chapters 3 to 8 for unit 1; chapters 11 to 13 for unit 2; chapters 13, 14 for unit 3; chapters 10 to 13 for unit 4)
4. Mauseth, J.D. (1988). *Plant Anatomy.* San Francisco, California: The Benjamin/Cummings Publisher. (chapters 3 to 8 for unit 1; chapters 11 to 13 for unit 2; chapters 14, 15 for unit 3; chapter 10 for unit 4)

Additional Resources

1. Evert F. R., Eichhorn S. E. (2008). *Raven Biology of Plants*. 8th Edition. New York, W.H. Freeman and Company Publishers. (chapters 23 to 26 for units 1 to 4, Chapter 19 for units 5 to 8)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.

Weekly lesson plan

Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV

Week 7: Unit V
Week 8: Unit VI
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit VIII

Assessment Methods

Theory:The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher An assignment can be given in place of the presentation. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals:For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained are scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
I	Meristematic and permanent tissues: Simple (parenchyma, collenchyma, sclerenchyma) and complex tissues (xylem, phloem), Root and shoot apical meristems (describe theories in brief with special reference to Tunica Corpus and Korper-Kappe theory)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Organs: Structure of dicot and monocot root stem and leaf.	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

		experiments	
III	Secondary Growth: Vascular cambium: structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Adaptive and protective systems: Epidermis (trichomes and hair), cuticle, stomata: structure and type (Metcalf and Chalk Classification); General account of adaptations in xerophytes and hydrophytes (Examples may be cited from *Nerium, Opuntia*, *Hydrilla* and *Nymphaea*).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Introduction to Reproduction: Modes of reproduction in plants: vegetative options - natural and artificial; introduction and Significance of sexual reproduction.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Structural organization of flower: Organization of flower, Structure; Anther and Pollen (No developmental stage); Ovules: Structure and types; Embryo sac: Types special reference to *Polygonum* type.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization and triple fusion; Seed: Structure (Dicot and Monocot, No developmental stages) appendages and dispersal mechanisms.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VIII	Embryo and endosperm: Endosperm types (one example of each type), structure and functions; Dicot and Monocot embryo; Embryo endosperm relationship (General account).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Meristem, secondary growth, Vascular cambium, anther, embryo sac, pollination, double fertilization, endosperm, reproductive biology.

Plant Ecology and Taxonomy
(LSCC3)
Core Course - (CC) Credit:6

Course Objective (2-3)

To make students understand ecology and basic ecological concepts, interrelation between the living world and environment. Also to make them aware about identification, nomenclature and classification.

Course Learning Outcomes

After successful completion of the course the student shall have adequate knowledge about the basic principals of environment and taxonomy.

Unit 1

Introduction (1 lecture)
Inter-relation between the living world and environment

Unit 2

Ecological factors (11 lectures)
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance.

Unit 3

Plant communities (6 lectures)

Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)

Unit 4

Ecosystem (8 lectures)
Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

---

Unit 5

Phytogeography (4 lectures)
Principle biogeographical zones; Endemism (definition and types)

Unit 6
Introduction to plant taxonomy (1 lecture)
Identification, Classification, Nomenclature.

Unit 7
Identification (5 lectures)
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access

---

Unit 8
Taxonomic evidences from palynology, cytology, phytochemistry and molecular data. (6 lectures)

Unit 9
Taxonomic hierarchy (2 lectures) Ranks, categories and taxonomic groups

---

Unit 10
Botanical nomenclature (6 lectures)
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 11
Classification (6 lectures)
Types of classification-artificial, natural and phylogenetic.Bentham and Hooker (up to series), Engler and Prantl (up to series).

Unit 12
Biometrics, numerical taxonomy and cladistics (4 lectures)
Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

Practical

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer, hygrometer, rain gauge and lux meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.
1. 3 (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).
2. (b)Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants)
3. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed)
4. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law
5. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):Brassicaceae -*Brassica*,*Alyssum* / *Iberis*; Asteraceae -*Sonchus/Launaea*, *Vernonia/Ageratum*, *Eclipta/Tridax*; Solanaceae -*Solanumnigrum*, *Withania*; Lamiaceae -*Salvia*, *Ocimum*; Liliaceae - *Asphodelus / Lilium / Allium*.
6. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted on the herbarium sheet with appropriate label.)

References

1. Kotpal, R.L., Bali, N.P. (1978). *Concepts of Ecology*. Jullundur, Punjab, Vishal Publications, (Chapter 1 for Unit 1; Chapter 3,4,56, for Unit 2: Chapter 12,13 for Unit 3. Chapter 7,8 for Unit 4))
2. Sharma, P.D. (2010). *Ecology and Environment*. 8th edition Meerut, India: Rastogi Publications,..(Chapter 1 for Unit 1, Chapter 2,3,4 for Unit 2; Chapter 9,10 for Unit 3; Chapter 12,13 for Unit 4; Chapter 15 for Unit 5;
3. Simpson, M.G. (2006). *Plant Systematics*. San Diego, CA: Elsevier Academic Press, (Chapter 1, 16 for Unit 6. Chapter 15,17,18 for Unit 7; Chapters 9-12,14, 18-21 for Unit 8; Chapter 1,2 for Unit 9; Chapter 16 for Unit 10; Chapter 7,8 for Unit 11);
4. Singh, G. (2012). *Plant Systematics: Theory and Practice*. New Delhi :Oxford & IBH Pvt. Ltd., (Chapter 1 for Unit 6; Chapter 5 for Unit 7; Chapter 7 for Unit 8; Chapter 3 for Unit 9; Chapter 2 for Unit 10; Chapter 10 for Unit 11).

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and talk and chalk method. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking and evaluation

Teaching Learning Plan

Week 1: Unit I and II
Week 2: Unit II
Week 3: Unit II
Week 4: Unit III
Week 5: Unit III, IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit V
Week 9: Unit VI, VII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII, VIII
Week 13: Unit IX, X
Week 14: Unit XI
Week 15: Unit XII

Assessment Methods

Theory: The students are continuously evaluated based on a written assignment, class test and/or presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students. Each student in a class is given a different topic to prepare an Assignment/PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation. The Internal

Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained are scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.

Assessment method

Unit No	Coure learning Outcome	Teaching and Learning Activity	Assessment Task
I	Inter-relation between the living world and environment	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
II	Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
III	Plant communities, Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
IV	Ecosystem structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
V	Phytogeography, Principle biogeographical zones; Endemism	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VI	Introduction to plant taxonomy, Identification, Classification, Nomenclature.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
VII	Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

VIII	Taxonomic evidences from palynology, cytology, phytochemistry and moleculardata	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Taxonomic hierarchy, Ranks, categories and taxonomic groups	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X	Botanical nomenclature, Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit XI	Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (up to series).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit XII	Biometrics, numerical taxonomy and cladistics, Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Environment, Soil, Water, Plant communities, Succession, Ecosystem, Phytogeography, Endemism, Plant taxonomy, Taxonomic hierarchy, Botanical Nomenclature, Classification, Biometrics

Plant Physiology and Metabolism
(LSCC1)
Core Course - (CC) Credit:6

Course Objective (2-3)

The course aims at making students realize how plants function, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Learning Outcomes

The students are able to correlate morphology, anatomy, cell structure and biochemistry with plant functioning. The link between theory and practical syllabus is established, and the employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Unit 1

Plant-water relations (8 Lectures)
Importance of water, water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory.

Unit 2

Mineral nutrition (8 Lectures)
Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.

Unit 3

Translocation in phloem (6 lectures)
Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 4

Photosynthesis (10 Lectures)
Historical contribution of Julius von Sachs, Blackman, Emerson, Engelmann, Hill.Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II, reaction center, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration

---

Unit 5

Respiration (6 Lectures)
Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle,RQ.

Unit 6

Enzymes (4 Lectures)
Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.

Unit 7

Nitrogen metabolism (6 Lectures)
Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.

Unit 8

Plant growth regulators (6 Lectures)
Discovery, physiological roles of auxins, gibberellins, cytokinins and ethylene.

Unit 9

Plant response to light and temperature (6 Lectures)
Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account).
*NO STRUCTURES AND FORMULAE TO BE ASKED IN THE EXAM

Practical

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of the environmental factor light on transpiration by excised twig.
1. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
3. To Study Hill's reaction.
4. To study the activity of catalase and study the effect of pH and enzyme concentration.
5. To study the effect of light intensity on O2 evolution in photosynthesis.
6. Comparison of the rate of respiration in any two parts of a plant.

Demonstration experiments

1. Bolting.
2. Effect of auxins on rooting.
3. Suction due to transpiration.
4. Hydroponics (using a photograph).
5. To demonstrate the delay of senescence by cytokinins.
6. To study the phenomenon of seed germination (effect of light and darkness)

References

1. Bajracharya, D. (1999). *Experiments in Plant Physiology: A Laboratory Manual*. New Delhi, Delhi: Narosa Publishing House. (For Practicals)

2. Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism.* Singapore: Springer Nature, Singapore Pvt. Ltd. (Chapter 1 for Unit 1, Chapters 2 and 3 for Unit 2, Chapter 6 for Unit 3, Chapter 5 for Unit 4, Chapter 7 for Unit 5, Chapter 4 for Unit 6, Chapter 11 for Unit 7, Chapters 14 to 17, 19, and 27 for Unit 8, Chapters 13 and 25 for Unit 9)

3. Hopkins, W. G., Huner, N. P. A. (2009). *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd. (Chapters 1, 2 and 8 for Unit 1, Chapters 3 and 4 for Unit 2, Chapter 9 for Unit 3, Chapters 7 and 8 for Unit 4, Chapter 10 for Unit 5, Chapter 8 for Unit 6, Chapter 11 for Unit 7, Chapters 18 to 21, and 23 for Unit 8, Chapters 22 and 24 for Unit 9)

4. Kochhar, S.L., Gujral, S.K. (2017). *Plant Physiology: Theory and Applications.* New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd. (Chapters 1 to 6 for Unit 1, Chapter 7 for Unit 2, Chapter 13 for Unit 3, Chapter 9 for Unit 4, Chapter 10 for Unit 5, Chapter 8 for Unit 6, Chapter 11 for Unit 7, Chapter 15 for Unit 8, Chapter 14 for Unit 9)

Additional Resources:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). *Plant Physiology and Development* International 6th edition. New York, NY: Oxford University Press, Sinauer Associates. (Chapters 3 and 4 for Unit 1, Chapters 5 and 6 for Unit 2, Chapter 11 for Unit 3, Chapters 7 and 8 for Unit 4, Chapter 12 for Unit 5, Chapter 13 for Unit 7, Chapters 15, 18, 21 and 22 for Unit 8, Chapters 16 and 20 for Unit 9)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
Weekly Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit IV
Week 7: Unit IV
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VI
Week 13: Unit VII
Week 14: Unit VIII
Week 15: Unit IX

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher An assignment can be given in place of the presentation. The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Importance of water, water potential and its components, pathway of water movement,	Class room lectures and Practical	Hands on exercises, PPT,

	ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation, stomatal movements – only ion theory..	demonstration, experiments	assignments, tests
Unit II:	Essential elements, macro- and micronutrients, criteria of essentiality of elements, methods of studying mineral requirement (Hydroponics, Aeroponics), role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Historical contribution of Julius von Sachs, Blackman, Emerson, Engelmann, Hill. Arnon; photosynthetic pigments (chlorophyll a and b, xanthophyll, carotene); photosystem I and II, reaction centre, antenna molecules; electron transport and mechanism of ATP synthesis, C3 pathway; C4 and CAM plants (in brief, no pathways); photorespiration	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V	Glycolysis, anaerobic respiration, TCA cycle, oxidative phosphorylation, glyoxylate cycle, RQ.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI	Structure and properties, Km (no derivation), mechanism of enzyme catalysis and enzyme inhibition.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Biological nitrogen fixation - nodulation in detail, nitrate and ammonia assimilation, dinitrogenase, NR, NiR, transamination.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII	Discovery, physiological roles of auxins, gibberellins, cytokininsand ethylene.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX	Photoperiodism - discovery (SDP, LDP, day neutral plants); phytochrome (discovery and structure), red and far-red light response on photomorphogenesis (general account), florigen (brief account)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Movement of water, ascent of sap, transpiration, stomatal movements, mineral nutrients, active and passive transport, translocation, enzymes, photosynthesis, respiration, nitrogen metabolism, plant growth regulators, photoperiodism, photomorphogenesis.

Analytical Techniques in Plant Sciences
(LSDS3)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

To gain the knowledge on various techniques and instruments used for the study of plant biology

---

Course Learning Outcomes

Understanding of principles and use various methods, tools and techniques used in plant sciences such as light microscopy, confocal transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques

---

Unit 1

Imaging and related techniques (15 lectures)
Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; Use of fluorochromes: (a) Flow cytometry (FACS); (b) Applications of fluorescence microscopy: Chromosome banding, FISH, chromosome painting; Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 2

Cell fractionation (8 lectures)
Centrifugation: Differential and density gradient centrifugation, sucrose density gradient, $CaCl_2$ gradient, analytical centrifugation, ultracentrifugation, marker enzymes.

Unit 3

Radioisotopes (4 lectures)

Use in biological research, auto-radiography, pulse chase experiment.

Unit 4
Spectrophotometry (4 lectures)
Principle and its application in biological research.

Unit 5

Chromatography (8 lectures)
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ionexchange chromatography; Molecular sieve chromatography; Affinity chromatography.

Unit 6

Characterization of proteins and nucleic acids (6 lectures)
Mass spectrometry; X-ray diffraction; X-ray crystallography; Characterization of proteins and nucleic acids; Electrophoresis: AGE, PAGE, SDS-PAG

Practical

1. Study of Blotting techniques: Southern, Northern and Western, DNA fingerprinting, DNA sequencing, PCR through photographs.
2. Demonstration of ELISA.
3. To separate nitrogenous bases by paper chromatography.
4. To separate sugars by thin layer chromatography.
5. Isolation of chloroplasts by differential centrifugation.
6. To separate chloroplast pigments by column chromatography.
7. To estimate protein concentration through Lowry's methods.
8. To separate proteins using PAGE.
9. To separation DNA (marker) using AGE.
10. Study of different microscopic techniques using photographs/micrographs (freeze fracture, freeze etching, negative staining, positive staining, fluorescence and FISH).
11. Preparation of permanent slides (double staining).

References

1. Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA. (Chapter 1 for Unit 1;
2. 2. Iwasa,J, Marshall , W. (2016). Karps's Cell and Molecular Biology ; Concepts and experiments. New Jersey, U.S.A.: John Wiley & Sons. Chapter 18 for Unit 1,2,3,5,)

Teaching Learning Process

1) Lectures and seminars
2) Problem oriented learning
3) Individual seminar
4) Presentation and interpretation to other students
5) Discussion of published research articles on the selected topics
6) Practical will introduce the students to a range of tools and techniques of biotechnology

Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Instrumentation lab visit
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI

Assessment Methods

Assessment must encourage and reinforce learning. It will enable robust and fair judgments about student performance. It gives the opportunity demonstrate what they have learned.
It will be done through a academic standard procedures. Assessment will be by written class test, assignment, project work, viva for internal assessment and written theory and practical examination for university evaluation.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Unit II:	Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (RasMol, J mol).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Biological Databases, Sequence Alignment, Phylogenetics Analysis, Protein Structure prediction and analysis.

Bioinformatics
(LSDS4)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

A computer-based approach is now central to biological research. Bioinformatics operates at the intersection of biology and informatics and has a strong mathematical component. Training students in various aspects of Bioinformatics is the objective of this course.

Course Learning Outcomes

With a working knowledge of the practical and theoretical concepts of bioinformatics, you will be well qualified to progress onto advanced graduate study. The portfolio of skills developed on the programme is also suited to academic research or work within the bioinformatics industry as well as range of commercial settings.

Unit 1

Introduction to Bioinformatics (10 lectures)

Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.

Unit 2

Biological databases (10 lectures)

Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).

Unit 3

Data Generation and Data Retrieval (8 lectures)

Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA,

GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)

Unit 4

Basic concepts of Sequence alignment (8 lectures)
Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.

Unit 5

Phylogenetic analysis (8 lectures)
Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.

Unit 6

Applications of Bioinformatics (16 lectures)
Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Practical

1. Sequence retrieval (protein and gene) from NCBI.
2. Structure download (protein and DNA) from PDB.
3. Molecular file formats - FASTA, GenBank, Genpept, GCG, CLUSTAL, Swiss-Prot, FIR.
4. Molecular viewer by visualization software.
5. Translate a nucleotide sequence and select the correct reading frame of the polypeptide from the output sequences.
6. Predict the structure of protein from its amino acid sequence.
7. BLAST suite of tools for pairwise alignment.
8. Sequence homology and Gene annotation.
9. Construction of phylogenetic tree.
10. Generating phylogenetic tree using PHYLIP.
11. Gene prediction using GENSCAN and GLIMMER.

References

1. Ghosh, Z., Mallick, B. (2008). *Bioinformatics – Principles and Applications*, 1st edition. New Delhi, Delhi: Oxford University Press.(chapters 1-11 of Unit 1, chapters 1-7 0f Unit 2, chapters 1-5 0f Unit 3,chapters 1-7 of Unit 4, chapters 1-4 of Unit 5, chapters 1-8 of Unit 6.
2. Knight Regan (2017) *An Introduction to Bioinformatics,* Larsen & Keller Education, United States. (chapters 1-7 0f Unit 2, chapters 1-5 0f Unit 3).

3. Mount D.W.(2004). *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbour Laboratory Press, New York, USA. (chapters 1-5 0f Unit 3,chapters 1-7 of Unit 4, chapters 1-4 of Unit 5) .
4. Sharma, V, Munjal, A, Shankar A. (2018). *A Text Book of Bioinformatics*. Rastogi Publications, Meerut, India. (chapters 1-4 0f Unit 2, chapters 1-5 0f Unit 3,chapters 1-7 of Unit 4, chapters 1-4 of Unit 5, chapters 1-8 of Unit 6.)

Teaching Learning Process

Multimedia tutorials and hands on training over biological data using world wide web services.
Interactive classroom teaching of mathematical modelings and Computer programs.
Weekly Lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit I
Week 4: Unit II
Week 5: Unit II
Week 6: Unit III
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit V
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit VI
Week 14: Unit VI

Assessment Methods

Theoretical tests with the help of assignments, project works, presentations, and through practical examinations.
Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - Genomics, Transcriptomics, Proteomics, Metabolomics, Molecular Phylogeny, computer aided Drug Design (structure based and ligand based approaches), Systems Biology and Functional Biology. Applications and Limitations of bioinformatics.	Class room lectures and Practical demonstration, experiments , gene ration and analysis of data	Hands on exercises, PPT, assignments, tests,
Unit II:	Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG,	Class room lectures and Practical demonstration, experiments, gener	Hands on exercises, PPT, assignments, tests

	EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol).	ation and analysis of data	
Unit III:	Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit IV:	Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms. Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Scoring Matrices/ Amino acid substitution matrices (PAM and BLOSUM), and CLUSTALW.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit V:	Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests
Unit VI:	Functional genomics (genome-wide and high throughput approaches to gene and protein function), Protein structure prediction and analysis- Levels of protein structure. gene prediction methods and tools. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.	Class room lectures and Practical demonstration, experiments , generation and analysis of data	Hands on exercises, PPT, assignments, tests

Keywords

Biological Databases, Sequence Alignment, Phylogenetics Analysis, Protein Structure prediction and analysis.

Cell and Molecular Biology
(LSDS2)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

Cell biology study will help the students to gain knowledge on the activities in which the giant molecules and minuscule structures that inhabit the cellular world of life are engaged. This will provide inside into the organization of cell, its features and regulation at different levels. Through the study of biomolecules (i.e. protein, carbohydrate, lipid and nucleic acid) and cell organelles, they will be able to understand the various metabolic processes such as respiration, photosynthesis etc. which are important for life. It would help in gaining the knowledge of structure and functions of DNA and RNA

Course Learning Outcomes

This course will be able to demonstrate foundational knowledge in understanding of: The relationship between the properties of macromolecules, their cellular activities and biological responses Understanding of Cell metabolism, chemical composition, physiochemical and functional organization of organelle Contemporary approaches in modern cell and molecular biology.Understanding of nucleic acid, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.Processing and modification of RNA and translation process, function and regulation of expression.Applichation in biotechnology

Unit 1

Techniques in Biology (8 Lectures)
Principles of microscopy; Light Microscopy; Phase contrast microscopy; Fluorescence microscopy; Confocal microscopy; Sample Preparation for light microscopy; Electron microscopy (EM)- Scanning EM and Scanning Transmission EM (STEM); Sample Preparation for electron microscopy; X-ray diffraction analysis.

Unit 2

Cell as a unit of Life (2 Lectures)
The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components.

Unit 3

Cell Organelles (20 Lectures)
Mitochondria:- Structure, marker enzymes, composition; Semiautonomous nature; Symbiont hypothesis; Proteins synthesized within mitochondria; mitochondrial DNA. Chloroplast- Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA. ER, Golgi body & Lysosomes:-Structures and roles. Peroxisomes and Glyoxisomes:_Structures, composition, functions in animals and plants and biogenesis. Nucleus:- Nuclear Envelope- structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief)

Unit 4

Cell Membrane and Cell Wall (6 Lectures)
The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of the membranes; Selective permeability of the membranes; Cell wall.

Unit 5

Cell Cycle (6 Lectures)
Overview of Cell cycle, Mitosis and Meiosis; Molecular controls.

Unit 6

Genetic material (6 Lectures)
DNA: Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material. DNA replication (Prokaryotes and eukaryotes): bidirectional replication, semi—conservative, semi discontinuous RNA priming, 6 (theta) mode of replication, replication of linear, ds-DNA, replicating the 5 end of linear chromosome including replication enzymes.

Unit 7
Transcription (Prokaryotes and Eukaryotes) (6 Lectures) Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation (Prokaryotes and eukaryotes), genetic code.

Unit 8
Regulation of gene expression (6 Lectures) Prokaryotes:Lac operon and Tryptophan operon ; and in Eukaryotes.

Practical

1. To study prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs.
2. 2.Study of the photomicrographs or cell organdies
3. To study the structure of plant cell through temporary mounts.
4. To study the structure of animal cells by temporary mounts-squamous epithelial cell and nerve cell.
5. Preparation of temporary mounts of striated muscle fiber
6. To prepare temporary stained preparation of mitochondria from striated muscle cells /cheek epithelial cells using vital stain Janus green.
7. Study of mitosis and meiosis (temporary mounts and permanent slides).
8. Study the effect of temperature, organic solvent on semi permeable membrane.
9. Demonstration of dialysis of starch and simple sugar.
10. Study of plasmolysis and deplasmolysis on *Rhoeo* leaf.
11. .11. Measure the cell size (either length or breadth/diameter) by micrometry.
12. Study the structure of nuclear pore complex by photograph (from Gerald Karp) Study of special chromosomes (polytene&lampbrush) either by slides or photographs.
13. Study DNA packaging by micrographs.
14. Preparation of the karyotype and ideogram from given photograph of somatic metaphase chromosome.

References

1. Becker, W.M., Kleinsmith, L.J., Hardin. J., Bertoni, G. P. (2009). *The World of the Cell*, 7th edition. San Francisco, California: Pearson Benjamin Cummings Publishing. (Ch 4 for unit 2, Ch. 21, 22 for unit 7, Ch. 23 for unit 8).
2. Cooper, G.M., Hausman, R.E. (2009). *The Cell: A Molecular Approach*, 5th edition. Sunderland, Massachusetts: Sinauer Associates, MA. (Ch. 9-11 for unit 3, Ch. 13, 14 for unit 4, Ch. 16 for unit 5, Ch. 6 for unit 6, Ch. 7,8 for unit 7).
3. De Robertis, E.D.P., De Robertis, E.M.F. (2006). *Cell and Molecular Biology*, 8th edition. Philadelphia, Pennsylvania: Lippincott Williams and Wilkins. .(Ch3 for unit 1, Ch. 1 for unit 2, Ch. 8-13 for unit 3, Ch. 4 for unit 4, Ch. 14-16 for unit 5, Ch. 22 for unit 8).
4. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*, 6th Edition. New Jersey, U.S.: John Wiley & Sons. Inc.(Ch18 for unit 1, Ch. 1 for unit 2, Ch. 6,9,10,12 for unit 3, Ch. 8,11for unit 4, Ch. 14 for unit 5, Ch. 4, 7 for unit 6, Ch. 6 for unit 7, Ch. 6 for unit 8).

Teaching Learning Process

Visual media would be helpful. Botany Department, University of Delhi may be entrusted with preparation of good visual aids that would help students get a feel of the subject and they find the subject interesting. College teachers can form a group and work out these possibilities of visual aids that would enhance teaching learning process.
Weekly lesson Plan

Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit III
Week 5: Unit IV
Week 6: Unit IV
Week 7: Unit V
Week 8: Unit VI
Week 9: Unit VI
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VII
Week 13: Unit VII
Week 14: Unit VIII

Assessment Methods

Making drawings may be made a compulsory part of practical record books, We may ponder over making students involve in highlighting the salient features of the genera/ groups through digital media such as ppt and animations.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Principles of microscopy; Light Microscopy; Phase contrast microscopy; Fluorescence microscopy; Confocal microscopy; Sample Preparation for light microscopy; Electron microscopy (EM)- Scanning EM and Scanning Transmission EM (STEM); Sample Preparation for electron microscopy; X-ray diffraction analysis.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Mitochondria:- Structure, marker enzymes, composition; Semiautonomous nature; Symbiont hypothesis; Proteins synthesized within mitochondria; mitochondrial DNA. Chloroplast-Structure, marker enzymes, composition; semiautonomous nature,chloroplast DNA. ER, Golgi body & Lysosomes:-Structures and roles. Peroxisomes and Glyoxisomes: Structures, composition, functions in animals and plants and biogenesis. Nucleus:- Nuclear Envelope- structure of	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

	nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure		
Unit IV:	The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of the membranes; Selective permeability of the membranes; Cell wall.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V	Overview of Cell cycle, Mitosis and Meiosis; Molecular controls.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI	DNA: Miescher to Watson and Crick- historic perspective, Griffith's and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure,types of DNA, types of genetic material. DNA replication (Prokaryotes and eukaryotes): bidirectional replication, semi—conservative, semi discontinuous RNA priming, 6 (theta) mode of replication, replication of linear, ds-DNA, replicating the 5 end of linear chromosome including replication enzymes.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII	Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation (Prokaryotes and eukaryotes), genetic code.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII	Regulation of gene expression	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Microscopy,X-ray diffraction, eukaryotic cell, mitochondria, chloroplast, Golgi body, nucleus, chromatin, membrane protein, meiosis,ribosomes,DNA replication,transcription, gene expression

Economic Botany and Biotechnology
(LSDS1)
Discipline Specific Elective - (DSE) Credit:6

Course Objective (2-3)

To gain the knowledge on the economically important of plants, their life cycle, processing, plant part used, application of biotechnology for the production of plant resources and production of new varieties

Course Learning Outcomes

Understanding of morphology and processing and economic value of plant sources of cereals, legumes,spices, oil,rubber, timber and medicines

Unit 1

Origin of Cultivated Plants (4 lectures)
Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2

Cereals (4lectures)
Wheat -Origin, morphology, uses

Unit 3

Legumes (6 lectures)
General account with special reference to Gram and soybean

Unit 4

Spices (6 lectures)
General account with special reference to clove and black pepper(Botanical name, family, part used, morphology and uses)

Unit 5

Beverages (4 lectures)
Tea (morphology, processing, uses)

Unit 6

Oils and Fats (4lectures)
General description with special reference to groundnut

Unit 7
Fibre Yielding Plants (4lectures)
General description with special reference to Cotton (Botanical name, family, part used, morphology and uses)

Unit 8
Introduction to Plant Biotechnology (1 lecture)

Unit 9
Tissue Culture Technology (9 lectures)
Introduction; nutrient media; aseptic and culture conditions; developmental pathways: direct and indirect organogenesis and embryogenesis; single cell and protoplast culture.

Unit 10
Recombinant Technology (18 lectures)
Molecular techniques: Blotting techniques (Southern, Northern and Western); PCR; Molecular DNA markers (RAPD, RFLP, SNPs) and DNA fingerprinting in plants, Genetic Engineering Techniques: Gene cloning vectors (pUC 18, pBR322, BAC, YAC, Tiplasmid); construction of genomic and C-DNA libraries; screening for gene of interest by DNA probe hybridisation, complementation; Insertion of genes into plant tissues (Agrobacterium mediated, electroporation, micro-projectile bombardment); selection of recombinants by selectable marker and reporter genes (GUS, luciferase, GFP). Applications: Bt cotton, Roundup ready soybean, Golden rice, Flavr-Savr tomato, edible vaccines, industrial enzyme production, Bioreactors Applications: Micropropagation, androgenesis, gynogenesis, embryo and endosperm culture, secondary metabolite production, germplasm conservation.

Practical

1. Study of economically important plants: Wheat, Gram, Soybean, Black pepper, Clove Tea, Cotton, Groundnut through specimens, sections and micro chemical tests
2. Familiarization with basic equipment’s in tissue culture.
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

References

1. Kochhar, S.L. (2011). *Economic Botany in Tropics*. New Delhi, India: MacMillan & Co. (Chapter 1 for Unit 1; Chapter 3 for Unit 2; Chapter 5 for Unit 3; Chapter 9 for Unit 4; Chapter 11 for Unit 5; Chapter 6 for Unit 6; Chapter 2 for Unit 7);
2. Bhojwani, S.S., Razdan, M.K. (1996). *Plant Tissue Culture: Theory and Practice*. Amsterdam, Netherlands: Elsevier Science. (Chapter 3, 4, 5, 6,12 for Unit 9)
3. Glick, B.R., Pasternak, J.J. (2003). *Molecular Biotechnology- Principles and Applications*. Washington, U.S.: ASM Press. (Chapter 1 for Unit 8; Chapter 3 for Unit 10)
4. Gupta , R., Rajpal , T., (2012) Concise Notes on Biotechnology. Delhi: Mc Graw Hill Publication. (Chapter 1 for Unit 8; chapter 8 for Unit 9; chapter 4 for unit 10)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination

Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
Weekly lesson plan
Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VII
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IX
Week 13: Unit X
Week 14: Unit X
Week 15: Unit X

Assessment Methods

The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students. Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.

Unit No	**Course learning Outcome**	**Teaching and Learning Activity**	**Assessment Task**
Unit I:	Concept of centres of origin, their importance with reference to Vavilov's work.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Cereals : Wheat -Origin, morphology, uses	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Legumes, general account with special reference to Gram and soybean	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Spices ,general account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Beverages, Tea (morphology, processing, uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Oils and Fats, general description with special reference to groundnut	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VII:	General 4description with special reference to Cotton (Botanical name, family, part used,morphology and uses)	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Introduction to Plant Biotechnology	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Nutrient media; aseptic and culture conditions; developmental pathways: direct and indirect organogenesis and embryogenesis; single cell and protoplast culture.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit X:	Molecular techniques: Blotting techniques (Southern, Northern and Western); PCR; Molecular DNA markers (RAPD, RFLP, SNPs) and	Class room lectures and Practical demonstration, experiments	exercises, PPT, assignments, tests

	DNA fingerprinting in plants.Gene cloning vectors (pUC 18, pBR322, BAC, YAC, Ti plasmid); construction of genomic and C-DNA libraries; screening for gene of interest by DNA probe hybridisation, complementation; Insertion of genes into plant tissues (*Agrobacterium* mediated, electroporation, micro-projectile bombardment); selection of recombinants by selectable marker and reporter genes (GUS, luciferase, GFP). Applications: Bt cotton, Roundup ready soybean, Golden rice, Flavr-Savr tomato, edible vaccines, industrial enzyme production, Bioreactors Micropropagation, androgenesis, gynogenesis, embryo and endosperm culture, secondary metabolite production, germplasm conservation.		

Keywords

Rhizobium, *Azotobacter*, inoculum,cyanobacteria, nitrogen fixation, Azolla,VAM, mycorrhizae

Biofertilizers
(LSSE1)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To gain the knowledge on the following aspects

1. Eco-friendly fertilizers like Rhizobium, Azospirilium Azotobactor, cyanobacteria and mycorrhizae, their identification, growth multiplication
2. Organic farming and recycling of the organic waste

Course Learning Outcomes

The student would have a deep understanding of ecofriendly fertilizers. They will be able to understand the growth and multiplication conditions of useful microbes such as Rhizobium, cyanobacteria, mycorrhizae, Azotobactor etc, their role in mineral cycling and nutrition to plants. The can also think of the methods of decomposition of biodegradable waste and convert into the compost

Unit 1

General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. (4 lectures)

Unit 2

Azospirillum: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication. (8 lectures)

Unit 3

Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation. (4 lectures)

Unit 4

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants. (8 lectures)

Unit 5

Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application. (6 lectures)

Practical

1. Isolation of *Anabaena* from *Azolla* leaf
2. Study of Rhizobium from root nodules of leguminous plants by Gram staining method
3. Test for pH, No2, SO4, Cl and organic matter of different composts
4. Observation of mycorrhizae from roots
5. isolation of arbuscular mycorrhizal spores from rhizospheric soil
6. Spots, Specimen /photographs of earthworm, Azolla, arbuscules . vesicles
7. Biocontrol photographs -pheromons trap,Trichoderma,, Pseudomonas, , Neem etc, , Identification and application
8. Photographs of biocompost methods,
9. Projects on any topic mentioned in the syllabus, with Rhizobium technology, , AMF technology, Organicfarming, vermicomposting,, biocompost , *Azolla* culture

References

1. Kumaresan, V. (2005). *Biotechnology*. New Delhi, Delhi: Saras Publication. Chapter 39 for Unit 1, Chapter 38 for Unit 3, Chapter 57 for Unit 5)
2. Sathe, T.V. (2004). *Vermiculture and Organic Farming*. New Delhi, Delhi: Daya publishers. (Chapter 1 and 2 for Units 1, 2,3 and 5)
3. Subha Rao, N.S. (2000). *Soil Microbiology*. New Delhi, Delhi: Oxford & IBH Publishers. (Chapter 5 for Unit 2; Chapter 6 for Unit 3; Chapter 8 for Unit 1; Chapter 9 for Unit 4);

Additional Resources:

1. Vayas,S.C, Vayas, S., Modi, H.A. (1998). *Bio-fertilizers and organic Farming*. Nadiad, Gujarat: Akta Prakashan. (Chapters 2,3,4 for Unit 1; Chapter 18 for Unit 2; Chapter 19 for Unit 3; Chapter 20 for Unit 4; Chapter 4,5,6,12,13 for Unit 5)
2. Annonymous (2016) *Proceedings of Workshop on Biofertilizers*. New Delhi. Delhi: Zakir Husain Delhi College (Chapter1 to 9 for Unit 1 to 5)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded.
When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
strong>Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during

class hours. The students are asked to submit their record notebooks to the teacher/s for checking.
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Field visit
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit IV
Week 13: Unit V
Week 14: Unit V
Week 15: Unit V

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. The question paper is suitably modified for such students.
Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improves their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Practicals: For continuous evaluation two tests are conducted; one on the table work experiments for 10 marks, and the other on setups for 10 marks. The total marks obtained is scaled down to 10. Ten marks are allotted for record notebooks, and 5 marks for attendance. The Internal Assessment for practicals comprises 50 % of the total marks.
Assessment Task

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	General account about the microbes used as biofertilizer – Rhizobium – isolation,identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	*Azospirillum*: isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms.Azotobacter: classification, characteristics – crop response to Azotobacter inoculum, maintenance and mass multiplication.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Unit III:	Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Organic farming – Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Rhizobium, Azotobacter, inoculum, cyanobacteria, nitrigen fixation, Azolla,VAM, mycorrhizae

Ethnobotany
(LSSE3)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To have the knowledge of the plants used by the local communities, tribals, ethenic groups, their nutritive and medicinal value.

Course Learning Outcomes

Students would have an understanding of the treasure, value and usefulness of the natural products and their efficient use by the local communities as food and medicine and their conservation practices.

Unit 1

Ethnobotany (6Lectures)
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. Plants used by the tribals: a) Food plants, b) intoxicants and beverages and c) Resins and oils and miscellaneous uses.

Unit 2

Methodology of Ethnobotanical studies (6 lectures)
a) Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places.

Unit 3

Role of ethnobotany in modern Medicine (10 lectures) Medicoethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiracthaindica* b) *Ocimum sanctum* c) *Vitexnegundo* d) *Gloriosasuperba* e) *Tribulusterrestris* f) *Pongamiapinnata* g) *Cassia auriculata* h) *Indigoferatinctoria*.

Unit 4

Role of ethnobotany in modern medicine with special example of *Rauvolfiasepentina*, *Trichopuszeylanicus, 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 (8 lectures)
Ethnobotany as a tool to protect interests of ethnic groups.Sharing of wealth concept with few examples from India; Biopiracy.

Unit 6

Intellectual Property Rights and Traditional Knowledge.

Practical

1. Collection, identification and preparation of herbarium of three ethnobotanically important plants with appropriate references
2. Preparation of crude extract of ethnobotanically important plants with appropriate references (any method to be used)
3. Project work-documentation, literature survey, and collection of information on ethnobotanically useful plants from traditional healers)

References

1. Gupta , R., Rajpal , T., (2012) Concise R. (2011). *Plant Taxonomy past Present and Future* . New Delhi, Delhi: TERI Press (Chapter 7 for Unit 8)

3. Gupta , R., Rajpal, T. (2012) *Concise notes on Biotechnology*. New Delhi, Delhi: McGraw Hill Publication (chapter 14 for Unit 8)

3. Jain, S.K. (1995). *Manual of Ethnobotany.* Rajasthan: Scientific Publishers. (Chapter 1,2,3 for Unit 1; Chapter 4 for Unit 2; Chapter 9 for Unit 3; Chapter 14 for Unit 4 ; Chapter 16 for Unit 5)

Teaching Learning Process

To engage students and transform them into active learners the students are updated with latest books and review articles. The experiments included in the paper are performed individually or in group and are followed by group discussions and interjections
Weekly lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Local Field Visits
Week 6: Unit II
Week 7: Unit III
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Local Institute Visit
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

The students are assessed on the basis of oral presentations and regular class tests. Students are continuously assessed during practical class. Submission of class records is mandatory. This exercise develops scientific skill as well as methods of recording and presenting scientific data.

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	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. Plants used by the tribals: a) Food plants b) intoxicants and beverages c) Resins and oils and miscellaneous uses	Activity :Class room lectures and Practical demonstration, experiments	Assessment: Hands on exercises, PPT, assignments, tests
Unit II:	Methodology of Ethnobotanical studies- Field work, Herbarium, Ancient Literature, Archaeological findings, temples and sacred places	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Medicoethnobotanical sources in India;Significance of the following plants in ethno botanical practices (along with their habitat and morphology) a) *Azadiracthaindica* b) *Ocimum sanctum* c) *Vitex negundo* d) *Gloriosasuperba* e) *Tribulusterrestris* f) *Pongamiapinnata* g) *Cassia auriculata* h) *Indigoferatinctoria*.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Role of ethnobotany in modern medicine with special example of *Rauvolfiasepentina*, *Trichopuszeylanicus*, *Artemisia*, *Withania*. Role of ethnic groups in conservation of plant genetic resources. Endangered taxa and forest management (participatory forest management).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Ethnobotany and legal aspects (8 lectures). Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. Biopiracy.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Intellectual Property Rights and Traditional Knowledge.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Tribals, minor forest products, beverages, Resins, sacred groves, ethnobotanical practices, *Azadiractha indica*, *Ocimum sanctum*, *Vitex negundo*,*Gloriosa superba*, *Indigofera, tinctoria*. ethnomedicimes, conservation, Traditional Knowledge.

Intellectual Property Right
(LSSE6)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To have knowledge of roles regulations, laws and processes of patents, copyright trademarks and concepts of traditional knowledge and protection of plant varieties.

Course Learning Outcomes

Students would have deep understanding of patents copyrights, their importance. They can think about the importance of traditional knowledge, bio-prospecting, biopiracy. They would gain the knowledge of farmers rights and the importance on indigenous plant varieties, concept of novelty and biotechnological inventions

Unit 1

Introduction to intellectual property right (IPR) (2 lectures)
Concept and kinds.Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).

Unit 2

Patents (3 Lectures)
Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents.Infringement.

Unit 3

Copyrights (3 Lectures)
Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement

Unit 4

Trademarks (3 Lectures)

Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name

---

Unit 5

Geographical Indications (3 Lectures)
Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position

---

Unit 6

Protection of Traditional Knowledge (4 Lectures)
Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio- Prospecting and Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.

Unit 7
Industrial Designs (2 Lectures) Objectives, Rights, Assignments, Infringements, Defences of Design Infringement

---

Unit 8
Protection of Plant Varieties (2 Lectures)
Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues farmers, Breeders and Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit 9
Information Technology Related Intellectual Property Rights (4 Lectures)
Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection

---

Unit 10
Biotechnology and Intellectual Property Rights (4 Lectures): Patenting Biotech Inventions

---

Practical

1. Patent search
2. Trademark search
3. copyright infringement (Plagiarism checkby Urkundand other available software,
4. Geographical Indicators

5. food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese,
6. handlooms (Kota Doria, Banarasi Sari, Muga Silk, Kanchipuram),
7. Industry (Mysore agarbatti, Feni Goa, ChampagneFrance).
8. Natural resources- Makrana marbles Two example of each category Biopiracy- neem, turmeric
9. Industrial designs- Jewelry design, chair design, car design, Bottle design, Aircraft design,
10. IPR e diary

References

1. Gupta, R. (2011). *Plant Taxonomy past Present and Future*. New Delhi, Delhi: TERI Press (Chapter 7 for Unit 6)

2. Gupta, R., Rajpal, T. (2012). *Concise Notes on Biotechnology*. New Delhi,Delhi: Mc Graw Hill Publication (chapter 14 for Unit 1)

3. Acharya, N.K.(2001). *Text Book on Intellectual Property Rights: (Copyright, Trademark, Patent Design, Geographical Indications, Protection of New Plant Varieties & Farmers Rights and Protection of Biodiversity*. New Delhi S.P Gogia HUF) (chapters 1 to 8 for Units 1 to 9)

Teaching Learning Process

Theory: The theory topics are covered in lectures with the help of PowerPoint presentations and the chalkboard. Students are encouraged to ask questions. The reading list has been suitably upgraded. When the entire syllabus is completed, a few lectures are devoted to discuss the previous years' question papers, thus preparing the students for the examination.
Practicals: Every practical session begins with detailed instructions, followed by students conducting the experiment/s. When all the students have collected the data, the observations are discussed. Any deviation from the expected trend in results is explained. The students are encouraged to graphically represent the data and record the experiment during class hours.
Weekly lesson plan
Week 1: Unit I
Week 2: Unit II
Week 3: Unit III
Week 4: Unit IV
Week 5: Unit V
Week 6: Unit VI
Week 7: Unit VI
Week 8: Unit VII
Week 9: Unit VIII
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit VIII
Week 13: Unit IX
Week 14: Unit IX

Week 15: Unit X

Assessment Methods

Theory: The students are continuously evaluated based on a class test and the presentation given by each student. The answer scripts of the test are returned to the students and the test paper is discussed at length. Students who are absent for the test are allowed to appear for the test at a later date; the question paper is suitably modified for such students Each student in a class is given a different topic to prepare a PowerPoint presentation. All the remaining students listen to the presentation of each student, and peer students are also encouraged to ask questions. Presentations by students improve their reasoning and communication skills. The presentations of students are evaluated by the teacher based on the content, effectiveness of the presentation, whether any new information has been added, and lastly on the answers given by students to the questions posed by the teacher. An assignment can be given in place of the presentation.
The Internal Assessment has a break-up as 10 marks for the test, 10 marks for the presentation/ assignment and 5 marks for the attendance, and comprises 25 % of the total marks.
Assessment method

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Concept and kinds. Economic importance. IPR in India and world: Genesis and scope, some important examples.IPR and WTO (TRIPS, WIPO).	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Objectives, Rights, Patent Act 1970 and its amendments. Procedure of obtaining patents, Working of patents.Infringement.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Copyrights (3 Lectures) Introduction, Works protected under copyright law, Rights, Transfer of Copyright, Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Objectives, Types, Rights, Protection of goodwill, Infringement, Passing off, Defences, Domain name	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Geographical Indications (3 Lectures) Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and	Class room lectures and Practical demonstration,	Hands on exercises, PPT, assignments, tests

	Bio-Piracy, Alternative ways, Protectability, needfor a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library.	experiments	
Unit VII:	Industrial Designs (2 Lectures) Objectives, Rights, Assignments, Infringements, Defences of Design Infringement	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VIII:	Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues farmers, Breeders and Researchers.National gene bank, Benefit sharing.Protection of Plant Varieties and Farmers' Rights Act, 2001.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IX:	Information Technology Related Intellectual Property Rights Computer Software and Intellectual Property, Database and Data Protection, Protection of Semi-conductor chips, Domain Name Protection	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
	Biotechnology and Intellectual Property Rights. Patenting Biotech Inventions	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Patents, IPR, Copyrights,trademarks, geographical indicators, traditional knowledge, industrial design, plant varieties, novelty, biotechnology.

Medicinal Botany
(LSSE2)
Skill-Enhancement Elective Course - (SEC) Credit:4

Course Objective (2-3)

To introduce students to complementary and alternative medicine and provide them an opportunity
To explore uses of plants as medicine ranging from traditional indigenous approach for treating ailments to modern pharmaceuticals
To inculcate awareness about the rich diversity of medicinal plants in India.

Course Learning Outcomes

Knowledge Skills
· An appreciation of the contribution of medicinal plants to traditional and modern medicine and the importance of holistic mode of treatment of the Indian traditional systems of medicine.
· To develop an understanding of the constraints in promotion and marketing of medicinal plants.
Professional and Practical Skills
· Transforming the knowledge into skills for promotion of traditional medicines.
· Developing entrepreneurship skills to establish value addition products, botanical extracts and isolation of bioactive compounds.

Unit 1

Scope and importance of medicinal plants in the traditional systems of medicine and modern medicine.Importance of preventive and holistic healing in the Indian traditional systems of medicine.Ayurveda: History, origin, fundamental doctrine and concepts of Panchamahabhutas, Saptadhatus andTridoshasin relation to health and disease.

Unit 2

Therapeutic and pharmaceutical uses of important plants used in the Ayurveda system of medicine. Concept of Rasayanadrugs. Siddha Origin, concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine.Unani: History, concept of Umoor-e-Tabiya(Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine

Unit 3

Nutraceuticals and polyherbalformulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.Role of AYUSH, NMPB and AIIA in thepromotion of medicinal plants.

Unit 4

Adulteration of herbal drugs.Evaluation and Standardization of crude drugs.Fundamentals of Pharmacognosy.Organoleptic,microscopicand phytochemical evaluation of plant drugs.

Unit 5

Conservation of Endangered and Endemic Medicinal plants.Red Data List Criteria. In situ Conservation: Biosphere Reserves, National Parks, Sacred Groves. Ex-situ conservation:Botanic Gardens, National Gene Banks, Plant cell, tissue, and Organ culture, Cryopreservation. Role of NBPGR, CIMAP, JNTBGRI and RRL

Unit 6

General aspects of cultivation and propagation of medicinal plants. WHO Guidelines of Good Agricultural and Cultivation Practices (GACP). Objectives of the Nursery,classification and important components ofnursery.Greenhouse technology.Propagation through cuttings, layering, grafting and budding.

Practical

1. Identification and medicinal value of locally available medicinal plants in the field.
2. Study of organoleptic, macroscopic and microscopic parameters of any two plant drugs. Sections and powder microscopic evaluation.
3. Isolation of bioactive compounds in the lab and phytochemical analysis of the crude extract of various parts of medicinal plants.
4. Study of ingredients and medicinal uses of common polyherbal formulations used in the traditional systems of medicine.
5. Project Report based onvisit to PharmaceuticalIndustries and/or Institutes.
6. E-presentations : Traditional Systems of Medicine, Contribution of medicinal plants toalternative and modern medicine, Conservation strategies of medicinal plants,Nutraceuticals, Rasayana drugs, Medicinal plants and non-communicable diseases, Cultivation, marketing and utilisation of medicinal plants.
7. Laboratory Records

References

1. Chaudhry, B. (2019). *A Handbook of Common Medicinal Plants Used in Ayurveda.* Kojo Press, New Delhi. (For Units 1-3).

2. Purohit, Vyas (2008). *Medicinal Plant Cultivation : A Scientific Approach*, 2nd edition. Jodhpur, Rajasthan: Agrobios. (Chapter 1 for Unit 1; Chapter-6 for Unit 6, Chapter 12 for Unit 5).
3. S.B. Gokhale, C.K. Kokate (2009). *Practical Pharmacognosy*. Pune, Maharashtra: Nirali Prakashan. (For Unit 4).
4. Trivedi, P.C. (2006). *Medicinal Plants Traditional Knowledge*. New Delhi, Delhi: I.K. International Publishing House Pvt. Ltd. (Chapter 1 for Unit 4; Chapter 2 and 11 for Unit 3)

Additional Resources:
1. Trivedi, P.C. (2009). *Medicinal Plants. Utilisation and Conservation*. Jaipur, Rajasthan: Aavishkar Publishers. (Chapter 1 and 19 for Unit 5; Chapter 20 for Unit 3).
2. Evans, W. (2009*). Trease and Evans's Pharmacognosy*, 16th edition. Edinburg, London, Philadelphia, Pennsylvania: Saunders Ltd. (Chapter 1, 42-44 for Unit 4).
3. Ayush.gov.in (Ministry of AYUSH) (for Unit 1 and 2).

Teaching Learning Process

To encourage innovation, to link theoretical knowledge with practical training and application of knowledge to find practical solutions to the challenges encountered in the field of traditional medicine. To hold regular and structured workshops, seminars, field trips, collaboration with Research institutions, Industry and other Government Organizations, in order to facilitate peer learning and skill enhancement. To complement classroom teaching with discussions, presentations, quizzes, interpretation of results, short projects, writing project reports and field exposure.
Weekly lesson Plan
Week 1: Unit I
Week 2: Unit I
Week 3: Unit II
Week 4: Unit II
Week 5: Unit III
Week 6: Unit III
Week 7: Field visit
Week 8: Unit IV
Week 9: Unit IV
Week 10: Mid semester Exam
Week 11: Mid Semester Break
Week 12: Unit V
Week 13: Unit V
Week 14: Unit VI
Week 15: Unit VI

Assessment Methods

Continuous Evaluation
(Project/ E-presentation:10 marks, Lab Records :
Attendance in Practicals
Practical Examination:

Unit No	Course learning Outcome	Teaching and Learning Activity	Assessment Task
Unit I:	Scope and importance of medicinal plants in the traditional systems of medicine and modern medicine.Importance of preventive and holistic healing in theIndian traditional systems of medicine.Ayurveda: History, origin, fundamental doctrine and concepts of Panchamahabhutas, Saptadhatus andTridoshasin relation to health and disease.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit II:	Therapeutic and pharmaceutical uses of important plants used in the Ayurveda system of medicine. Concept of Rasayanadrugs. Siddha : Origin, concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine.Unani : History, concept of Umoor-e-Tabiya (Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit III:	Nutraceuticals and polyherbalformulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.Role of AYUSH, NMPB and AIIA in thepromotion of medicinal plants.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit IV:	Adulteration of herbal drugs. Evaluation and Standardization of crude drugs. Fundamentals of Pharmacognosy. Organoleptic,microscopicand phytochemical evaluation of plant drugs.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit V:	Conservation of Endangered and Endemic Medicinal plants. Red Data List Criteria. In-situ Conservation: Biosphere Reserves, National Parks, Sacred Groves. Ex-situ conservation: Botanic Gardens, National Gene Banks, Plant cell, tissue, and Organ culture, Cryopreservation. Role of NBPGR, CIMAP, JNTBGRI and RRL.	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests
Unit VI:	General aspects of cultivation and propagation of medicinal plants. WHO Guidelines of Good Agricultural and Cultivation Practices (GACP). Objectives of the Nursery,classification and important components ofnursery. Greenhouse technology. Propagation through cuttings, layering, grafting and budding	Class room lectures and Practical demonstration, experiments	Hands on exercises, PPT, assignments, tests

Keywords

Medicinal plants, Ayurveda, Siddha, Unani, Holistic healing, Phytochemicals, Pharmacognosy, Polyherbals, Conservation, Propagation, Nursery and Gardening

---

ACKNOWLEDGEMENTS

This work would not have been possible without the help by the Undergraduate Curriculum Committee, who time to time provided the academic as well as technical guidance during the revision of the courses.

I am especially indebted to Professor K. S. Rao, Head, Department of Botany, University of Delhi, who worked actively to provide me with the academic time to pursue the goal of course revision.

I am grateful to all of those with whom I have had the pleasure to work. Each of the conveners and members of working groups and other teachers have provided me extensive personal and professional guidance in the improvement of the contents of the syllabi of Botany programmes. I would especially like to thank Dr. Anuradha Sharma, Hindu College, Dr Vijay Kumar, Shivaji College and Atika Chandra, Maitryie College, who have greatly contributed in the preparation of the course revision groups and preparation of the framework and writing substantial part of the course outcome. Besides that I especially thank the following members who have been more important to me in the pursuit of this project by working as convenors and working members for the revision of the courses of Botany programmes

1. Dr Sadhna Babbar, Swami Shraddhanand College
2. Dr Madhu Bajaj, Miranda House
3. Dr Suman Kumra, Hindu College
4. Dr Sujata Sinha, Deen Dayal Upaddhyay College
5. Dr Renu Kathpalia Kiromal College
6. Dr Kuldeep K. Koul, Hindu College
7. Dr Janaki Subramanyan, Miranda House
8. Dr Roshni Rajamohan, Deshbandhu College
9. Dr Kalyani Krishnan, Sri Venkateshwara College
10. Dr Rajni Gupta, Kirorimal College
11. Dr Meenam Bhatia, Daulat Ram College
12. Dr Neeru Bhandari, Dyal Singh College
13. Dr Vijaya Rani Rajpal, Hansraj College
14. Dr Dharmendra Mallick, Deshbandhu College
15. Dr Surinder Kaur, SGTB Khalsa College
16. Dr Inderdeep Kaur, SGTB Khalsa College
17. Dr Bharti Chaudhry, Ramjas College
18. Dr Rashni Mathur, Sri Aurobindo College
19. Dr D. Monika Ram, Hindu College
20. Dr S N Tripathi, Deen Dayal Upaddhyay College
21. Dr Anjana Sagar, SGTB Khalsa College

22. Dr Suman Sharma, Ramjas College
23. Dr Archana Singh, Hansraj College
24. Dr Kumar Shantanu, Deshbandhu College
25. Dr Anand Sonkar, Hansraj College
26. Dr Bhupender Giri, Swami Shraddhanand College
27. Dr Priyanka Pandey (nee) Kapoor, Gargi College
28. Dr Shukla Saluja, Sri Venkateshwara College
29. Aparna Nautiyal, Deshbandhu College, University of Delhi
30. Jasleen Kaur Kalia, Dyal Singh College
31. Dr Varnika Bhatia Deen Dayal Upaddhyay College
32. Dr Monika Koul, Hansraj College
33. Dr Sudesh Bhardwaj, Kalindi College
34. Dr Saloni Bahari, Miranda House
35. Dr Mohammad Wahid Anisari, Zakir Husain Delhi College
36. Dr Savindra Chatwal, Zakr Husain Delhi College
37. Dr Smita Tripathi, Shivaji College
38. Dr Somdatta Sinha, Miranda House
39. Dr Savita Singh, Hindu College

Prem L Uniyal
(Professor and Coordinator,
Botany Programmes)

दिल्ली विश्वविद्यालय

UNIVERSITY OF DELHI

B. Sc. (Program) Life Sciences

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges, Non Collegiate Women's Education Board and School of Open Learning

Table of Content

Page No.

Preamble

The objective of any Program at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its Programs in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under-Graduate Programs.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the Program of their choice. The Under-Graduate Programs will prepare the students for both, academia and employability.

Each Program vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The Programs also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each Program prepares students for sustainability and life-long learning.

The University of Delhi hopes the LOCF approach of the program B.Sc. (Prog.) Life Sciences will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

1. Introduction

The learning outcomes-based curriculum framework for B. Sc. (Program) Life Sciences is structured to offer a broad outline within which a holistic biology program could be developed. The course is advanced with respect to the students' aspirations and the ever changing learning environment. The courses within zoology have been reconsidered to include current innovations and laboratory techniques to skill the students. The revised structure is expected to upgrade the understanding levels of students and to maintain the requisite standard of Life Sciences/Biology Programs across the country. Efforts have been made to incorporate use of MOOCs to assist learning-teaching processes among stakeholders. This structure allows the review of the learning outcomes, qualification descriptors, and course-level learning outcomes periodically. Further, it offers innovation and flexibility in designing the syllabi and methods to be adopted facilitating learning assessment. Prime objective is to enhance the subject knowledge, encouraging the students to be critical thinkers and have a problem-solving approach. Overall, this modified course has been concerted to upgrade skills related to biological science giving the students' a competitive edge in securing a career in industry, academia, pharmaceutical research, and as an entrepreneur.

2. Learning Outcome

2.1 Nature and Extent of B.Sc. Program (Life Sciences)

Zoology is a comprehensive subject encompassing both classical and modern biology. The scope of zoology as a subject is wide-ranging but the students of Life Sciences are provided with a flavour of the major areas of zoology in the form of Discipline Core Courses: Diversity of Non-chordates and Chordates; Comparative Anatomy and Development Biology of Vertebrates; Physiology and Biochemistry, Genetics and Evolutionary Biology. Diversity of Non-chordates and Chordates deals with the classification and adaptive diversity of animals from diverse phyla; Comparative Anatomy of Vertebrates deals with structural comparisons among all vertebrates. Physiology gives us knowledge about the functions of all the parts and systems of the body. It is also of central importance in medicine and related health science. Biochemistry deals with the study of biomolecules; their structures and functions in the living organisms. Genetics deals with the molecular structure and function of genes, and gene behaviour in context of a cell or organism; while evolutionary biology discuss the evolutionary processes that gave rise to biodiversity on earth.

In the fifth and sixth semester the students can opt for one Discipline Specific Elective per semester from: Reproductive Biology, Wild Life Conservation and Management, Biotechnology, Immunology, Applied Zoology or Dissertation. Further, the curriculum also includes applied topics like Apiculture, Aquarium Fish Keeping, Medical Diagnostics, Public Health and Hygiene, Sericulture and Environment Audit, etc., that are designed for developing skills of the students with an aim to explore employment opportunities. It also includes visits to industries, fields or commercial culture units to get in-depth knowledge of the subject.

2.2 Aims of the Bachelor's Degree Program in Life Sciences

Zoology is one of the most fundamental branch of biology to be studied at undergraduate level. It is required to learn and understand about animal diversity and to appreciate their variability in relation to their morphology, anatomy and behaviour. The course will also provide an opportunity to learn and understand about evolution. Students will be able to appreciate evolutionary parameters using various bioinformatics and computational tools used in modern sciences. The course further enhances understanding of classical genetics to comprehend distribution of various traits among populations, their inheritance, ethnicity and students can correlate these aspects with contemporary and modern subjects like genomics, metagenomics and genome editing tools. Skills gained in practical and theory will be helpful in designing holistic public health strategies for social welfare. Studying zoology as a part of life science course, further enhance knowledge of applied subjects to hone students' skills to build a career and become an entrepreneur in the field of aquatic biology, sericulture, apiculture etc. After completion of this course, students could contribute as policy makers in wild life conservation, and environment protection.

3. Characteristic Attributes of a Graduate in Life Sciences

Some of the characteristic attributes of a B.Sc. (Program) graduate who has pursued Zoology as part of Life Science discipline may include the following.

Disciplinary knowledge*:* Capable of demonstrating (i) comprehensive basic knowledge of major concepts, theoretical principles and experimental findings in zoology and its different sub-fields including biodiversity, physiology, biochemistry, biotechnology, genetics, evolutionary biology, and immunology and some of the other applied areas of study such as wildlife conservation and management, apiculture, sericulture, aquatic biology, etc. (ii) interdisciplinary knowledge of allied biological sciences, environmental science and chemical science; (iii) learning of the various techniques and computational softwares used for analysis of animal's forms and functions.

Effective communicator*:*Ability to grasp the complex zoological information effectively and efficiently.

Logical thinking and reasoning*:*Develop the capability to seek solutions logically, resolving them by experimentation and processing the data either manually or through software.

Team spirit*:*Trained to be interdisciplinary and possess the ability to work effectively in a heterogeneous team.

Leadership quality: Ability to recognise and mobilise relevant resources which are essential for a project, and to manage the project in a responsible way by following ethical scientific conduct and bio-safety protocols.

Ethical awareness: Avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, as well as appreciate the environmental and sustainability issues.

4. Qualification Descriptors

The qualification descriptors for a Bachelor's Degree Program in Life sciences may include the following:

Demonstrate logical and consistent understanding of the broad concepts in zoology and its applications in related interdisciplinary subjects.

Inculcate in-depth knowledge to help students pursue varied types of professions in research and development, academia, government, public sector service and even entrepreneurship sector.

Use wide-range knowledge, logical thinking and skills for evaluating problems and issues related to animals.

Enhance one's own learning desires, employing broad range of research and development work, and professional materials.

Apply one's subject knowledge and skills to innovate and address complicated problems with evidence-based well-defined elucidations.

Demonstrate subject-related skills relevant to zoology-related jobs and employment opportunities.

5. Program Learning Outcomes

Students enrolled in B.Sc. (Program) Life Sciences will study and acquire complete knowledge of disciplinary and allied biological sciences. At the end of graduation, they would have expertise which will provide them competitive advantage in pursuing higher studies from India and abroad or seek jobs in academia, research or industries.

Students should be able to identify, classify and differentiate in types of chordates and non-chordates based on their morphological, anatomical and systemic organization. This will create a curiosity and awareness among them to explore the animal diversity and take up wildlife photography or wildlife exploration as a career option. The procedural knowledge about identifying and classifying animals will help students professional advantages in teaching, research and taxonomist jobs in various Government organizations, such as Zoological Survey of India or National Sanctuaries.

Acquired practical skills in biochemistry and biotechnology can be used in pursuing career as a scientist in pharmaceutical industry in India or abroad.

Students will be gaining basic experimental skills in genetics, biotechnology, qualitative and quantitative microscopy, and also enzymology that will give them an edge to pursue higher studies.

The skill enhancement courses will hone skills in rearing fish, bees and silk moth for generating self-employment.

Students can acquire expertise to join clinical and research laboratories for diagnostic assays, haematology, histopathology, staining procedures etc.

They will be able to examine and assess some basic physiological functions and interpret physiological charts.

5.1 Course-Level Learning Outcomes of B.Sc. (Program) Life Science

Detailed course-learning outcomes of B.Sc. (Program) Life Sciences are described in following sections.

Discipline Core Course I: Animal Diversity (Semester I)

The course would provide an insight about different life forms on Earth, and appreciate the diversity of animal life. The course makes the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature. Choosing this course will help students to have the following learning outcomes:

- Understand the importance of taxonomy and structural organization of animals from Protista to Mammalia to appreciate the diversity of non-chordates and chordates living in varied habitats.
- Meticulously analyze the complexity and characteristic features of non-chordates and chordates by familiarizaion with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the evolutionary history and relationships of different non-chordates and chordates through functional and structural affinities.
- Realize the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- Appreciate the diverse habitats, including marine, freshwater and terrestrial.
- Understand similarities and differences in life functions among various chordates.

Discipline Core Course II: Comparative Anatomy and Developmental - Biology of Vertebrates (Semester II)

This course conveys the knowledge base for appreciating the vertebrate anatomy. Students will learn to critically analyze and evaluate the structure and functions of vertebrate systems comparatively.

Students will develop the necessary skill to draw a connection between anatomical changes, the differences between homologous and analogous structures, adaptation to habitat and the pattern of evolutionary diversification of the vertebrates.

Students will value the contribution of comparative anatomy to the society by learning how the adaptations of vertebrate structures like wings of birds, gills in fishes and mammalian eye help the engineers to mimic the design and develop various devices including wings of aircraft, optics, countercurrent exchange etc.

The importance of comparative vertebrate anatomy to discern human biology will be emphasized. By learning about the organization, functions, strength and weaknesses of various life systems, students' can critically think how the evolution has shaped these traits in human body.

The core course 'Comparative Anatomy of Vertebrates' aims at providing the following critical learning outcomes.

- Critically think and analyse the significance of morphological traits that vertebrates possess and understand the position of humans in evolutionary history.
- Understand the events that lead to formation of a multicellular organism from a single fertilized egg, the zygote. The students acquire basic knowledge of the cellular processes of development and the molecular mechanisms underlying these.
- Able to describe the general patterns and sequential developmental stages during embryogenesis. The students understand how the developmental processes lead to establishment of body plan of multicellular organisms.
- Discuss the general mechanisms involved in morphogenesis and explain how different cells and tissues interact in a coordinated way to form various tissues and organs.
- Learn the importance of latest techniques like stem cell therapy, *in vitro* fertilization and amniocentesis etc. to be applied for human welfare.
- Become aware of teratogens responsible for the rise of congenital abnormalities globally.
- Comprehend the concept of gene activation, determination, induction, differentiation, morphogenesis, intercellular communication, cell movements and cell death.

Discipline Core Course III: Physiology and Biochemistry (Semester III)

Thisparticular cours of zoology is aimed on building knowledge of basic physiological principles as well as introducing latest concepts in line with the research developments in physiological sciences.

The students will have a clear knowledge of basic fundamentals as well as understanding of advanced concepts in human physiology and biochemical processes. They will learn about an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body; for example, cardiovascular and respiratory systems to meet the oxygen demand of the body. They can develop a strong foundation that will help them to acquire skills and knowledge to pursue advanced degree courses and research institutes..

The core course 'Physiology and Biochemistry' aims at providing the following critical learning outcomes.

- Comprehend and analyze problem based questions.
- Develop investigative, communicative, analytical and personal skills with respect to the subject.Recognize and explain how all physiological systems work in unison to maintain homeostasis in the body and feedback loops control the same.
- Synthesize ideas to make connection between knowledge of physiology and real world situations, including healthy life style decisions and homeostatic imbalances i.e. how physiological mechanisms adapt in response to various external and internal stimuli in order to maintain health.
- Know the role of regulatory systems *viz.* endocrine and nervous systems and their amalgamation in maintaining various physiological processes.
- Understand the concepts of biochemistry and interaction of biomolecules with each other to bring about life processes.
- Appreciate the role of enzymes in metabolic pathways.
- Learn control of enzyme activity, its mechanism of action and how a drug might inhibit the enzyme.

- Develop practical learning skills; like qualitative estimation of carbohydrates, chromatography and interpretation of results.

Discipline Core Course IV: Genetics and Evolutionary Biology (Semester V)

This course aims to provide an overview of genetics; starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutation. The course will help in building sound fundamental knowledge of the principles of genetics to be used as a stepping stone for higher studies and research in this field.

The course has been designed with an aim that knowledge of the principles of inheritance is essential for a deeper understanding of the varied branches of the biological sciences like microbiology, evolutionary biology, genomics and metagenomics.Analysis of pedigree will lead to development of analytical skills and critical thinking enabling the students to present the conclusion of their findings in a scientific manner. Field studies can be conducted and case histories of families can be collected. This will not only help the students in hypothesis formulating and testing but will also teach them an essential skill of data collection. Students can prepare reports and present their findings in posters or oral presentations. This will help them to upgrade their data presentation and communication skills.

Knowledge of the mechanisms of mutations and the causative agents will lead to an increase in awareness of the students about the harmful impact of various chemicals and drugs being used in day to day life. These students will, in turn, make people aware of the impact of indiscriminate use of such compounds. Students can work to find out the effects of indiscriminate use of various chemicals, drugs or insecticides in nature by studying their effects on various bacterial species in soil and water samples collected from different industrial or polluted areas. This will help to enhance the organizational and experimental skills of the students.

This course emphasizes on the development of evolutionary thought by dealing in general with the process and pattern of biological evolution. It aims at providing the following critical learning outcomes.

- Development of problem solving and high order analytical skills by attempting numerical problems as well as performing simulation studies of various evolutionary forces in action.
- Application of knowledge gained on populations in real time, while studying speciation, behaviour and susceptibility to diseases.
- Utlization of knowledge gained from study of variations, genetic drift to ensure that conservation efforts for small threatened populations are focused in right direction.
- Predict the practical implication of various evolutionary forces acting on the human population in the field of human health, agriculture and wildlife conservation.
- Be interested towards the field of bioinformatics and coding used in programming language by using various software.

Discipline Specific Elective Zoology

Discipline Specific Elective-1: Reproductive Biology

This course is meant for making the students learn about the various aspects of reproductive biology in humans. Students are also made aware of new technologies in assisted reproduction as well as contraceptive methods. It aims at providing the following critical learning outcomes.

- In-depth understanding of morphology, anatomy and histology of male and female reproductive organs.
- Knowledge of the different processes in reproduction starting from germ cell formation to fertilization and consequent pregnancy, parturition and lactation.
- Comparison of estrous and menstrual cycles and their hormonal regulation.
- Comprehension of the interplay of various hormones in the functioning and regulation of the male and female reproductive systems.
- Knowledge of the diagnosis and management of infertility, including latest methods, technologies and infrastructure in assisted reproduction.
- Practical understanding of modern methods in contraception and their use in family planning strategies.
- Ability to translate this understanding into development of products; like non-hormonal contraceptives, contributing to drug discovery programs as well as neonatal and maternal health programs, working with family planning teams to understand the needs and preferences of individuals belonging to lower socioeconomic groups.

Discipline Specific Elective-2: Wild Life Conservation and Management

The discipline specific paper on, Wildlife Conservation and Management‘ is designed to acquaint students with varied aspects of wildlife conservation, including its importance, major threats, management of their habitats and populations. This course will motivate students to pursue career in the field of wildlife conservation and management.

It aims at providing the following critical learning outcomes.

- Awareness about the importance of wildlife in general, and its conservation and management, in particular.
- Comprehend the application of the principles of ecology and animal behaviour to formulate strategies for the management of wildlife populations and their habitats.
- Understand the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.
- Understand the key factors for loss of wildlife and important strategies for their *in-situ* and *ex-situ* conservation.
- Understand the techniques for estimation, remote sensing and global position tracking for wildlife.
- Awareness about the wildlife diseases and the quarantine policies.
- Knowledge about the protected area networks in India, ecotourism, ecology of perturbation and climax persistence.
- Perform critical thinking, literature review; scientific writing as well as presentations; and participation in citizen science initiatives with reference to wildlife.

Discipline Specific Elective-3: Immunology

This course is designed to enable understanding the molecular and cellular basis of the development and function of the immune system and identification of its biological, clinical and therapeutic implications. This course aims at providing the following critical learning outcomes.

- Describe the basic mechanisms, distinctions and functional interplay of innate and adaptive immunity,

- Define the cellular/molecular pathways of humoral/cell-mediated adaptive responses including the role of major histocompatibility complex.
- Explain the cellular and molecular aspects of lymphocyte activation, homeostasis, differentiation and memory.
- Understand the molecular basis of complex, humoral (cytokines, complement) and cellular processes involved in inflammation and immunity, in states of health and disease.
- Describe basic and state-of-the-art experimental methods and technologies.
- Integrate knowledge of each subsystem to see their contribution to the functioning of higher-level systems in health and disease including basis of vaccination, autoimmunity, immunodeficiency, hypersensitivity and tolerance.

Discipline Specific Elective-4: Animal Biotechnology

Biotechnology is the advanced branch of biological sciences which mostly deals with technological application on biological systems. This course is designed to equip the students with basic tools of biotechnology, so that they can use it in future research. It aims at providing the following critical learning outcomes.

- Basic techniques of biotechnology; like DNA isolation, PCR, transformation, restriction, digestion etc.
- Make a strategy to manipulate genetic structure of an organism for the improvement in any trait or its well-being based on the techniqueslearned during this course.
- Understand better the ethical and social issues raised regarding GMOs.
- Use the knowledge for designing a project for research and execute it.

Discipline Specific Elective-5: Applied Zoology

This particular course deals with the applied fields of zoology and emphasizes on the role of biological principles in medicine, economic zoology, agriculture, poultry, etc. It aims at providing the following critical learning outcomes.

- Understand the concept of host, definitive host, intermediate host, parasitism, symbiosis, commensalism, reservoir, zoonosis.
- Know about epidemiology of diseases;*i.e*., transmission, prevention and control of diseases Understand pathogenicity of Protozoanand parasitic helminths.
- Learn about the concept of pest and pest status.
- Understand the difference between various types of pests and extent of damage caused by them.
- Gain knowledge about important pests of crops, fruits, vegetables, stored grains and insects of medical importance.
- Analysis of varied types of control measures for management of pest populations and list suitable control measures, specific for every pest.
- Preservation and artificial insemination in cattle; Induction of early puberty and synchronization of estrus in cattle.
- General idea about poultry farming.

Skill Enhancement Courses

Skill Enhancement Course-1: Apiculture

The course will make the student aware about the significance of beekeeping as an economically viable industry. It will help the students to understand the biology and behaviour of bees. The course would clarify the techniques of honey bee rearing, optimisation of techniques based on climate and the geographical regions, and various measures to be taken to maximize the benefits. It would also help the students to develop entrepreneurial skills required for self-employment in beekeeping sector. Students are expected to learn following.

- Learn about the various species of honey bees in India, their social organisation and importance.
- Be aware about the opportunities and employment in apiculture – in public, private and government sector.
- Gain thorough knowledge about the techniques involved in bee keeping and honey production.
- Know about various products obtained from beekeeping sector and their importance.
- Develop entrepreneurial skills necessary for self-employment in beekeeping sector.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Skill Enhancement Course-2: Aquarium Fish Keeping

The main aim of Skill Enhancement Course in Aquarium Fish Keeping is to impart basic knowledge of ornamental fish Industry and inculcate its scope as an avenue for career development in Entrepreneurship or as an Aquariculturist as well as to promote skill capacity building of students by teaching the techniques of aquarium constructions, feed formulation and preparation, transportation, maintenance and management of the system. At the end of this course students are expected to demonstrate following skills.

- Know about different kinds of fishes, their compatibility in aquarium.
- Recognize the role of aquarium in commercial, decorative and scientific studies.
- Development of personal skill - maintenance of aquarium.
- Understand the basic needs of an aquarium, *i.e.* dechlorinated water, reflector, filters, scavenger, aquatic plants etc.
- Know how to set an aquarium and make it cost-effective.
- Development of skill after visiting any farm and know about the preparation of fish feed.

Skill Enhancement Course-3: Medical Diagnostics

This paper is aimed to provide students a unique opportunity to study how doctors or clinicians diagnose a disease, prevent and conduct optimal treatment regimens. Students will learn about multiple diagnostic tools, techniques and technologies used in medical practices. The emphasis is on how to select an appropriate diagnostic technique, methods and technologies to conduct analyses to understand the results and their implications in patient diagnoses. The course essentially aims to impart training to students in:

- Gain knowledge about various infectious, non-infectious and lifestyle diseases, tumors and their diagnosis
- Understand the use of histology and biochemistry of clinical diagnostics and learn about the molecular diagnostic tools and their relation to precision medicine.

• Develop skills in various types of tests and staining procedure involved in hematology, clinical biochemistry and the basics of instrument handling.
• Learn the scientific approaches/techniques used in the clinical laboratories to investigate various diseases.
• Acquire knowledge about common imaging technologies and their utility in the clinic to diagnose a specific disease.

Skill Enhancement Course-4: Public Health and Hygiene
This course is multidisciplinary in nature which can be opted by students from all science courses. Starting from the basic concepts of Environmental science, it gives a deep insight into the factors causing environmental degradation and its outcome in form of increasing number of diseases leading to deterioration of public health.
The paper has the following learning outcomes.

- Familiarisation with various aspects of environmental risks and hazards.
- Be sensitized about the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and modes of prevention.
- Learn about the nuclear and chemical disasters and their after effects through cases studies.
- Know about the various waste management technologies and their utility.
- Learn about diagnosis of various diseases and methods to prevent them.
- Be sensitized enough to understand the importance of conservation of nature for betterment of human race and all living beings.

Skill Enhancement Course-5: Sericulture
The course will make the students aware about the significance of sericulture as the profit-making enterprise. It will help the students to understand the biology of silkworms and its nutritional requirement to secrete quality silk. The course would clarify the techniques of silkworm rearing, reeling of silk and various measures to be taken to maximize the benefits. It would also help the students to know about various uses of silk and develop entrepreneurial skills required for self-employment in sericulture and silk production sector. Some of the learning outcomes are as follows.

- Learn about the history of sericulture and silk route.
- Recognize various species of silk moths in India, and exotic and indigenous races.
- Be aware about the opportunities and employment in sericulture industry – in public, private and government sector.
- Gain thorough knowledge about the techniques involved in silkworm rearing and silk reeling.
- Develop entrepreneurial skills necessary for self-employment in mulberry and seed production and be apprised about practicing sericulture as a profit-making enterprise.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Skill Enhancement Course-6: Environmental Audit
The students will be able to develop the appropriate documentation for an environmental impact statement and respond appropriately to an environment audit or Environmental Management System (EMS). It will provide students with information in order to obtain competencies for

environmental auditing. Further apprise them on the environmental commitments that an industry has and how it can be monitored and audited. It will help them understand the potential environmental impacts that are described in Environmental Impact Assessments (EIA)

- how industry controls their environmental impacts through EMS?
- how environmental management systems are audited?
- how waste is generated and controlled?
- other environmental management initiatives such as product life cycle analysis and sustainability Programs
- To develop ability to plan, execute and document the environmental audit.
- To develop entrepreneurial skills

6. Teaching-Learning Processes

Life Sciences as a program has been structured to impart all-inclusive knowledge of animal sciences (both disciplinary allied biological subjects) and to provide a competitive advantage to students in academia, research and development and industrial jobs. Information will be shared between teacher and students through two-way communication and students learning will be enabled by using multimedia, quiz-based platform, smart class-based teaching, simulation and animation videos. Advancement of practical skills is a significant aspect of teaching and learning process. Hence, interactive lectures, computer-aided methods for displaying virtual dissection, seminars, presentations, field trip or project-based learning, as well as *in-silico* experiments will be implemented to facilitate learning process. Students would be encouraged to access e-learning resources like SWAYAM, MOOC, CourseSra, MIT OpenCourseWare etc. to make them self-learners and facilitate them to understand the concepts. The above mentioned research-based tools and approaches will enhance problem solving, peer reviewing, and inculcate team work spirit.

Assessment Methods

Assessment will be flexible and designed depending upon the requirement of course being taught. Students will be continuously assessed for their learning and corrective measures would be taken to enhance their learning outcome periodically. Students will be assessed from time to time through class tests to judge their grasp on the topics taught in the classroom. Regular projects, assignments and presentations will be given to students to inculcate analytical skills, confidence and competencies among them. Their presentations will be assessed based on the content, novelty through plagiarism check and response to queries raised by peers.

(a) Students will typically undergo two forms of assessment to fulfil the underlined points of learning outcome. Formative assessment is an important part of learning assessment. Continuous assessment will be made through problem solving exercises, practical assignments, closed and open book class tests and *viva-voce* etc. to assess the retention abilities of our students.

(b) Summative assessment: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained

by each student comparatively. Hence, towards the end of semester, written tests, presentations and practical are carried out as per university guidelines.

Students will be assessed on basis of their performance in theory as well as practical.
Theory – 100 marks
End semester exam- 75 marks
Internal Assessment- 25 marks (Assignment-10; Mid-term test-10; Attendance-5)

Practical - 50 marks
End semester exam25 marks
Continuous Evaluation- 25 (Records - 10, Project/*viva*- 5, Attendance-5, Total number of practical performed- 5)

6. Structure of B.Sc. (Program) Life Sciences with Zoology

	DISCIPLINE| CORE COURSE DSC (12)	**Ability Enhancement Compulsory Courses AECC (2)**	**Skill Enhancement Courses SEC (4)**	**Discipline Specific Elective DSE (4)**
I	DSC 1- Zoology I: Animal Diversity DSC 2 – Paper I DSC 3- Paper I	English/Hindi/MIL Communication/Environmental Science		
II	DSC 1- Zoology II: Comparative Anatomy and Developmental Biology of Vertebrates DSC 2 – Paper II DSC 3- Paper II	English/Hindi/MIL Communication/Environmental Science		
III	DSC I- Zoology III: Physiologyand Biochemistry DSC 2 – Paper III DSC 3- Paper III		SEC-I	
IV	DSC 1- Zoology IV: Genetics and Evolutionary Biology DSC 2 – Paper IV DSC 3- Paper IV		SEC-II	
V			SEC-III	DSE-Zoology Paper I DSE-Discipline 2-Paper I DSE- Discipline 3-Paper I
VI			SEC-IV	DSE-Zoology Paper II DSE-Discipline 2-Paper II DSE- Discipline 3-Paper II

Discipline Core Courses: Zoology
1. Animal Diversity
2. Comparative Anatomy and Developmental Biology of Vertebrates
3. Physiology and Biochemistry
4. Genetics and Evolutionary Biology

Discipline Specific Electives: Zoology (Any two)
1. Reproductive Biology
2. Wild Life Conservation and Management
3. Animal Biotechnology
4. Immunology
5. Applied Zoology
6. Dissertation

Skill Enhancement Courses: Zoology
1. Apiculture
2. Aquarium Fish Keeping
3. Medical Diagnostics
4. Public Health and Hygiene
5. Sericulture
6. Environmental Audit

6.1 Course Credit

Semester	Course Opted	Course Name	Credits
I	Ability Enhancement Compulsory Course-I	English/Hindi/MIL Communication/ Environmental Science	4
	Discipline Core Course-I	Animal Diversity	4
	Discipline Core Course-I Practical		2
	Discipline Core Course-I Botany		4
	Discipline Core Course-I Botany Practical		2
	Discipline Core Course-I Chemistry		4
	Discipline Core Course-I Chemistry Practical		2
II	Ability Enhancement Compulsory Course-II	English/Hindi/MIL Communication/ Environmental Science	4
	Discipline Core Course-II	Comparative Anatomy of Vertebrates	4
	Discipline Core Course-II Practical		2
	Discipline Core Course-II Botany		4
	Discipline Core Course-II Botany Practical		2
	Discipline Core Course-II Chemistry		4
	Discipline Core Course-II Chemistry Practical		2
III	Discipline Core Course-III	Physiology and Biochemistry	4
	Discipline Core Course-III Practical		2
	Discipline Core Course-III Botany		4
	Discipline Core Course-III Botany Practical		2
	Discipline Core Course-III Chemistry		4
	Discipline Core Course-III Chemistry Practical		2
	Skill Enhancement Course-I	SEC-1	2
	Discipline Core Course-IV	Genetics and Evolutionary Biology	4
	Discipline Core Course- IV Practical		2
	Discipline Core Course-IV Botany		4

17.1

Semester	Course Opted	Course Name	Credits
IV	Discipline Core Course-IV Botany Practical		2
	Discipline Core Course-IV Chemistry		4
	Discipline Core Course-IV Chemistry Practical		2
	Skill Enhancement Course-II	SEC-II	2
V	Discipline Specific Elective -1 Zoology	DSE-1 Zoology	4
	Discipline Specific Elective -1 Zoology Practical		2
	Discipline Specific Elective -1 Botany	DSE-1 Botany	4
	Discipline Specific Elective- 1 Botany Practical		2
	Discipline Specific Elective -1 Chemistry	DSE-1 Chemistry	4
	Discipline Specific Elective- 1 Chemistry Practical		2
	Skill Enhancement Course-III	SEC-III	2
VI	Discipline Specific Elective -2 Zoology	DSE-2 Zoology	4
	Discipline Specific Elective -2 Zoology Practical		2
	Discipline Specific Elective -2 Botany	DSE-2 Botany	4
	Discipline Specific Elective- 2 Botany Practical		2
	Discipline Specific Elective -2 Chemistry	DSE-2 Chemistry	4
	Discipline Specific Elective- 2 Chemistry Practical		2
	Skill Enhancement Course-IV	SEC-IV	2

17.2

Theory+Practical	Theory+Practical	
I. Core Centre **(12 papers)** 04 courses from each of the 03 disciplines of choice	12X4=48	12X4=48
Core course Practical/ Tutorial* **(12 Practical/ Tutorial*)** 04 courses from each of the 03 disciplines of choice	12X2=24	12X2=24
II. Elective Course (6 Papers) Two papers from each discipline of choice Including paper of interdisciplinary nature.	6X4=24	6X5=30
Elective Course Practical/ tutorials* **(6 Practical/ Tutorial*)** Two papers from each discipline of choice Including paper of interdisciplinary nature.	6X2=12	6X1=6
III. Ability Enhancement Course		
1. Ability Enhancement Compulsory (2 Papers of 2 credits each) **Environment Science** **English/ MIL Communication**	2X2=4	2X2=4
2. Ability Enhancement Elective (Skill Based) (4 papers of 2 credits each)	4X2=8	4X2=8
	Total credit=120	**Total credit=120**

- **Optional Dissertation orproject work in place of one Discipline elective paper(6 credits) in 6th Semester**

17.3

7. Courses for B.Sc. (Prog.) Life Sciences

LS Core I: Animal Diversity

Course Learning Objective:

The main purpose of introducing this course is to teach the students the Morpho-taxonomy, and evolutionary relationships among and between non-chordates and chordates along with creating awareness and concern towards importance of animal diversity for human survival and its socio-economic significance. In addition to this, the course is aimed at nurturing skills of conducting scientific inquiry and experimentation in the field of animal diversity to acquire knowledge of fundamental concepts and theories of animal diversity.

Course Learning Outcome:

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

- Learn Morpho-taxonomy and structural organization of non-chordate and chordate groups.
- Acquire knowledge of diversity of non-chordate and chordate groups.
- Learn evolutionary relationships and phylogeny of non-chordates and chordates through functional and structural similarities.
- Understand the economic importance of non-chordates and chordates and their significance in the ecosystem.
- Promote shared learning through practical classes, class room presentations and projects.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit 1: Protista 3 hrs

General Characteristics and Classification up to classes; Locomotory Organelles and locomotion in Protozoa.

(Chapter1-3: Barnes)

Unit 2: Porifera 3 hrs

General characteristics and Classification up to classes; Canal system in *Sycon*

(Chapter 5: Barnes)

Unit 3: Cnidaria 3 hrs

General characteristics and Classification up to classes; Polymorphism in Hydrozoa

(Chapter7: Barnes)

Unit 4: Platyhelminthes 3 hrs

General characteristics and Classification up to classes; Life cycle of *Taeniasolium* and its parasitic adaptations

(Chapter10: Barnes)

Unit 5: Nemathelminthes 4 hrs

General characteristics and Classification up to classes; Life cycle of *Ascarislumbricoides* and its parasitic adaptations

(Chapter11: Barnes)

Unit 6: Annelida 3 hrs
General characteristics and Classification up to classes; Metamerism in Annelida
(Chapter13: Barnes)

Unit7: Arthropoda 7 hrs
General characteristics and Classification up to classes; Vision in Arthropoda, Metamorphosis in Insects.
(Chapter16 and 21: Barnes)

Unit8: Mollusca 3 hrs
General characteristics and Classification up to classes; Torsion and detorsion in Gastropoda; Pearl Formation.
(Chapter12: Barnes)

Unit 10: Echinodermata 3 hrs
General characteristics and Classification up to classes; Water-vascular system in Asteroidea.
(Chapter28: Barnes)

Note: *Classification to be followed from "Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Leaning, India."*

Unit 11: Protochordata 3 hrs
General characteristics and Classification of Protochordata, Retrogressive metamorphosis
(Chapter29: Barnes)

Unit 12: Agnatha 3 hrs
General characteristics and outline classification of cyclostomes up to classes
(Chapter 4: Young)

Unit 13: Pisces 3 hrs
General characteristics and Classification up to order. Migration, Osmoregulation and Parental care in fishes
(Chapter 5: Young)

Unit 14: Amphibia 4 hrs
General characteristics and classification up to order; Parental care in Amphibians
(Chapter 11 and 12: Young)

Unit 15: Reptilia 4 hrs
General characteristics and classification up to order; Biting mechanism in snakes
(Chapter 10 and 14: Young)

Unit 16: Aves 6 hrs
General characteristics and classification up to order; Flight adaptations and Migration in birds.
(Chapter 15, 16 and 17: Young)

Unit 16: Mammals 4 hrs

General characteristics and classification up to orders; Origin of mammals.

(Chapter 18: Young)

Practical [Credits: 2]

1. Study of following specimens:

Amoeba, Euglena, Paramecium, Sycon, Hyalonema, Euplectella, Obelia, Physalia, Aurelia, Tubipora, Metridium, Taeniasolium, Male and female *Ascaris lumbricoides, Aphrodite, Nereis, Heteronereis, Chaetopterus, Pheretima, Hirudinaria, Palaemon, Cancer, Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Chiton, Dentalium, Pila, Unio, Sepia, Octopus, Pentaceros, Ophiothrix, Echinus, Cucumaria, Antedon, Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo, Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Chamaeleon, Draco, Vipera, Naja, Crocodylus*, Any three common birds from different orders, Bat, *Funambulus, Loris*.

2. Study of following permanent slides:
   - T.S. and L.S. of *Sycon*.
   - Study of larval stages of *Taenia solium*
3. Key for Identification of poisonous and non-poisonous snakes
4. A visit to Biodiversity parks and Zoological Museum
5. Study of Digestive, Reproductive and Nervous system of Cockroach.
6. Study of Urinogenital and Nervous system of Rat.

Teaching and Learning Process:

Information and concepts about morphology, anatomy and physiology of animals will be imparted not only through classroom lectures to inculcate a conceptual base among the students about the subject but also through observations in nature and through real animals/preserved specimens/models which will create interest among students and enhance their understanding. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of animal biology would be created to not only ensure effective learning and understanding of the concepts, but also inculcate confidence in the students. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

- Continuous Evaluation: To keep a check on progress of student's learning in order to find out their weak areas so that appropriate remedial measures can be taken timely.
- Class Tests: Taking regular class tests will provide information on knowledge of the students.
- Presentations, Projects and Assignments: Regular Presentations, assignment and projects will instil independent thinking among the students.

- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

Keywords:

Protista, Porifera, Cnidaria, Annelida, Arthropoda, Classification, Echinodermata, Mollusca, Structural organization, Protochordata, Chordata, Cyclostomata, Pisces, Tetrapoda, Amphibia, Reptilia, Aves, Mammalia.

Recommended Books:

- Barnes, R.D. (2006) *Invertebrate Zoology*. VII Edition, Cengage Learning, India.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002) *The Invertebrates: A New Synthesis*. III Edition, Blackwell Science
- Young, J. Z. (2004) *The Life of Vertebrates*. III Edition. Oxford university press.

Suggested Readings:

- Barrington, E.J.W. (2012) *Invertebrate Structure and Functions*. II Edition, EWP Publishers
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003) *Invertebrate Zoology: A Functional Evolutionary Approach*. VII Edition, Cengage Learning, India
- Pechenik, J. A. (2015) *Biology of the Invertebrates*. VII Edition, McGraw-Hill Education
- Pough H. *Vertebrate Life*, VIII Edition, Pearson International

Online tools and Web Resources:

- https://swayam.gov.in/courses/animal-diversity
- https://swayam.gov.in/courses/zoology
- https://epgp.inflibnet.ac.in/ahl.php?csrn
- http://vle.du.ac.in/course/view.php? id

LS Core II: Comparative Anatomy and Developmental Biology of Vertebrates

Course Learning Objective:

The course offers a complete understanding about anatomy of vertebrate animals. It educates the students regarding derivatives of integuments, skeletal system and visceral arches, anatomy of digestive system and associated glands, different respiratory organs, urinogenital organs, components of nervous system and receptors in vertebrates. Thorough understanding of essential and evolutionary aspects of comparative anatomy will be developed through pictorial presentation of different anatomical details. The course will also provide a glimpse of scope and historical background of developmental biology to the students, impart knowledge regarding basic concepts of differentiation, morphogenesis and pattern formation and insight into IVF, stem cells and cloning. Detailed understanding of essential events of developmental biology will be imparted through proper explanation of gametogenesis, and stages of embryonic development and foetal formation.

Course Learning Outcome:

Upon completion of this course, students should be able to:

- Know about the levels of organization among different groups of vertebrates.
- Understand that different organs and organ systems integrate with each other to impart proper regulation of a particular function.
- Understand how the various organs evolved during the course of evolution through succession.
- Know the evolution of different concepts in developmental biology.
- Be able to understand the process of gamete formation from stem cell population to mature ova and sperm.
- Be able to comprehend the sequence of steps leading to the formation of gametes and development of embryo..
- Learn the mechanisms underpinning cellular diversity and specificity in animals.
- Study the methods and tools related to developmental biology which help to understand different processes of embryogenesis.

Content:

Theory (Credits: 4) **60 hrs**

Unit 1: Integumentary System

Structure and function of integument, Derivatives of integument glands. 5hrs

Chapter 5: Weichert

Unit 2: Skeletal System 4 hrs

Overview of skeleton Briefaccount of jaw suspensorium and visceral arches

Chapter 6, 8: Weichert

Unit 3: Digestive System 3 hrs

Brief account of alimentary canal and digestive glands

Chapter 9: Weichert

Unit 4: Respiratory System 4 hrs
Brief account of gills, lungs, air sacs and swim bladder
Chapter 8: Weichert

Unit 5: Circulatory System 3 hrs
Evolution of heart and aortic arches
Chapter 12: Weichert

Unit 6: Urinogenital System 4 hrs
Succession of kidney, Evolution of urinogenital ducts
Chapter 10: Weichert

Unit 7: Nervous System 3 hrs
Comparative account of brain
Chapter 13: Weichert

Unit 8: Sense Organs 4 hrs
Types of receptors, Visual receptors in man
Chapter 15: Weichert

Unit 9: Scope and History of Developmental Biology 5 hrs
Concepts of Epigenesis, Preformation, Specification, Determination, Differentiation, Morphogenesis, Embryonic induction
Chapter 1 and 3: Gilbert

Unit 10: Early Embryonic Development 12 hrs
Gametogenesis: Spermatogenesis and Oogenesis in mammals; Fertilization: External (amphibians), Internal (mammals), blocking mechanisms to Polyspermy; Types and Patterns of cleavage; Types of morphogenetic movements; Early development of frog and human (up to formation of gastrula); Fate maps, Fate of germ layers
Chapter 3, 4, 5, 6, 7, 10: Balinsky; Chapter 8, 9 and 17: Gilbert

Unit 11: Late Embryonic Development 7 hrs
Metamorphic events in life cycle of frogand its hormonal regulation.
Implantation of embryo in human; Formation, types and functions of placenta in mammals.
Chapter 11 and 18: Balinsky; Chapter 16: Gilbert

Unit 12: Applied Aspects of Developmental Biology 6 hrs
Stem cells, Cloning, IVF
Chapter 3: Gilbert

Practical(Credits: 2)

1. Osteology:

a) Disarticulated skeleton of fowl and rabbit

b) Carapace and plastron of turtle/tortoise
c) Mammalian skulls: one herbivorous and one carnivorous animal.

2. Frog - Study of developmental stages - whole mounts and sections through permanent slides - cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages.
3. Study of the different types of placenta- histological sections through permanent slides or photomicrograph.
4. Temporary mount of sperm (frog/rat) *(To be approved by Animal Ethical Committee of the college)
5. Study visit to a IVF centre and submission of report.

Teaching and Learning Processes:

Information and concepts about morphology, anatomy and development of animals will be imparted through classroom lectures assisted with online tools and power point presentations. Hands-on exposure would be provided to the students leading to more comprehensive learning. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of animal biology would be created to not only ensure effective learning and understanding of the concepts, but also inculcate confidence in the students. Curriculum-related assignments would improve the reading, writing and abstracting skills; and enhance the critical thinking of the students.

Assessment Methods:

The learners/ students can be assessed in many different ways- such as: MCQs/Quizzes, Assignments, Projects, Paper presentations, Class tests and Continuous evaluation

Keywords:

Integument, Viscera, Gills, Bladder, Aortic, Urinogenital, Gametogenesis, Fertilization, Polyspermy, Fate map, Placenta, Metamorphosis, Stem cell, Cloning, IVF.

Recommended Books:

- Weichert C.K and William Presch (1970). *Elements of Chordate Anatomy*. Tata McGraw Hills
- Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate Structure*. John Wiley and Sons
- Wolpert, L & Tickle, C (2011) *Principles of Developmental Biology (4th edition)*. Oxford University Press, ISBN: 9780198792918
- Carlson, Bruce M (1996). *Patten's Foundations of Embryology*, McGraw Hill, Inc. ISBN: 9780070634275

Suggested Readings:

- Kent, G.C. and Carr R.K.(2000)*Comparative Anatomy of the Vertebrates.* IX Edition. The McGraw-Hill Companies
- Kardong, K.V.(2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IV Edition. McGraw-Hill Higher Education

- Gilbert, SF (2014) *Developmental Biology.* X Edition. Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.ISBN : 9780878939787
- Balinsky, B.I. (2008). *An Introduction to Embryology*. International Thomson Computer Press.

Online Tools and Web Resources:

- KSU | Faculty Web - Vertebrate Anatomy
- https://www.biodiversitylibrary.org/item/114889#page/23/mode/1up
- https://www.hhmi.org/biointeractive/human-embryonic-development
- http://worms.zoology.wisc.edu/embryology_main
- https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm

LS Core III: Physiology and Biochemistry

Course Learning Objective:

The study of physiology is the study of the internal working of organisms; how organs and systems within the body work, communicate and integrate their efforts to make conditions favourable for survival. The study of biochemistry explains how inanimate constituents of living organisms *i.e.* the biomolecules interact to maintain and perpetuate life. The paper Physiology and Biochemistry for B.Sc. (Prog) Life Science Semester- III, is a course of central importance as these two have important implications in our daily life. The students after their school have an elementary knowledge with respect to structure, function and metabolism in human body. Many concepts have earlier been presented as isolated topics with little association to context and/or application. The present course aims to expand their knowledge with respect to functioning of various organ systems such as muscular, nervous, digestive, circulatory, respiratory, excretory, reproductive and endocrine in humans. The biochemistry portion is designed in a way to help the student understand fundamental metabolic pathways and their coordinated regulation in the body.

Course Learning Outcome:

Upon completion of the course, students would be able to:

- Have an increased knowledge of human physiology and be able to appreciate its functions.
- Understand the functions of major physiological systems in body.
- Recognise and identify principal tissue structures.
- Have understanding of the metabolic pathways of carbohydrates, proteins and fats; and appreciate how the cells harness energy.
- Understand the importance of enzymes, mechanism of working and kinetics.
- Relate how biochemical systems interact to yield integrated physiological responses.
- Understand the principles and approach to experimental design.
- Perform, analyse and interpret basic experiments and observations in physiology and biochemistry.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Nerve and Muscle 8 hrs

Structure of a neuron, Resting membrane potential, Graded potential, Origin of action potential and its propagation in myelinated and non-myelinated nerve fibres, Ultrastructure of skeletal muscle, Molecular and chemical basis of muscle contraction

(Chapters 10,12: Tortora; Chapters 5, 6 and 9: Vander)

Unit 2:

Digestion 5 hrs

Physiology of digestion in the alimentary canal; Absorption of carbohydrates, proteins, lipids

(Chapters 24: Tortora; Chapters 15: Vander)

Unit 3:

Respiration 5 hrs

Pulmonary ventilation, Respiratory volumes and capacities, Transport of Oxygen and carbon dioxide in blood

(Chapters 23: Tortora; Chapters 13: Vander)

Unit 4:Excretion 5 hrs

Structure of nephron, Mechanism of Urine formation, Counter-current Mechanism

(Chapters 26: Tortora; Chapters 14: Vander)

Unit 5: Cardiovascular system 5 hrs

Structure of Heart, Origin and conduction of the cardiac impulse, Cardiac cycle

(Chapters 20: Tortora; Chapters 12: Vander)

Unit 6: Reproduction and Endocrine Glands 7 hrs

Physiology of male reproduction: hormonal control of spermatogenesis; Physiology of female reproduction: hormonal control of menstrual cycle. Structure and function of pituitary, thyroid, Parathyroid, pancreas and adrenal gland.

(Chapters 18 and 28: Tortora; Chapters 11 and 17: Vander)

Unit 7:Carbohydrate Metabolism 9 hrs

Basic structure and physiological significance of Monosaccharides, Disaccharides, Homo and Heteropolysaccharides. Glycolysis (Preparatory and Payoff phases, regulation, fates of pyruvate), Kreb's Cycle (formation of Acetyl CoA, reactions of cycle, regulation), Pentose phosphate pathway (Oxidative and Non-oxidative Phases), Gluconeogenesis (Bypass reactions, regulation and reciprocal coordination of glycolysis and gluconeogenesis, Glycogen Metabolism (Glycogenolysis, Glycogenesis and its coordinated regulation), Review of Electron Transport Chain (Basics of electron transfer reactions, Universal Electron Acceptors without detailed structures, electron flow through complexes, Chemiosmotic theory, basics of ATP synthesis)

(Chapters 11,14,16,17,18,20,21: Stryer; Chapters 7,14,15,16 and19: Lehninger)

Unit 8: Lipid Metabolism 5 hrs

Basic structure and physiological significance of fatty acids, structure and significance of storage and structural lipids. Biosynthesis (FAS and synthesis reactions, regulation) and β oxidation of palmitic acid (activation of fatty acids and oxidation with bioenergetics, regulation)

(Chapters 12 and 22: Stryer; Chapters 10,17and 21: Lehninger)

Unit 9:Protein metabolism 5 hrs

Structure, classification and properties of amino acids, basics of protein structure; Transamination, Deamination, Glutamine formation, Glucose alanine cycle and Urea Cycle

(Chapters 3 and 23: Stryer; Chapters 3,4 and 18: Lehninger)

Unit10:Enzymes 6 hrs

Introduction (basics of classification, properties and functions), Mechanism of action (understanding of basic concepts, Induced Fit Theory), Enzyme Kinetics (Michaelis Menten

equation for single enzyme single substrate reactions, Line Weaver Burke Plot), Inhibition and Regulation (types of Inhibition, allosteric enzymes, covalently regulated enzymes)
(Chapters 8 and 10: Stryer; Chapter 6: Lehninger)

Practical [Credits: 2]

1. Preparation of hemin and hemochromogen crystals.
2. Study of permanent histological sections of mammalian pituitary, thyroid, pancreas, adrenal gland.
3. Study of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage.
4. Qualitative tests to identify functional groups of carbohydrates in given solutions (Glucose, Fructose, Sucrose, Lactose)
5. Estimation of total protein in given solutions by Lowry's method.
6. Study of activity of salivary amylase under optimum conditions.

Teaching and Learning Process:

Teaching-Learning process will include delivery of lectures using boards, multimedia presentations on course contents, showing 3D molecular structure and system tutorial/videos, giving online quizzes etc.

Assessment Methods:

The students can be assessed by MCQs/Quizzes, Assignments, Projects, Oral presentations, Class tests and Continuous evaluationby biweekly topic based 'Pre-class assignment'.

Keywords:

Digestion, Absorption, Metabolism, Excretion, Respiration, Reproduction, Nerve, Muscle, Heart, Endocrine glands, Carbohydrates, Lipids, Proteins, Enzymes

Recommended Books:

- Tortora, - G.J. and Derrickson, B.H. (2009) *Principles of Anatomy and Physiology,* XII Edition, John Wiley & Sons, Inc.
- Widmaier, E.P., Raff, H. and Strang, K.T. (2008) *Vander 's Human Physiology*, XI Edition., McGraw Hill
- Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006) *Biochemistry*. VI Edition. W.H Freeman and Co.
- Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). *Principles of Biochemistry*. IV Edition. W.H. Freeman and Co.

Suggested Readings:

- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009). *Harper's Illustrated Biochemistry.* XXVIII Edition. Lange Medical Books/Mc Graw3Hill.
- Guyton, A.C. and Hall, J.E. (2011). *Textbook of Medical Physiology,* XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company

Online Tools and Web Resources:

- https://swayam.gov.in/courses/5371-jan-2019-animal-physiology
- https://swayam.gov.in/course/3712-animal-physiology
- https://swayam.gov.in/courses/5366-jan-2019-biochemistry
- https://swayam.gov.in/course/1405-biochemistry
- https://swayam.gov.in/courses/5638-biochemistry
- https://vle.du.ac.in
- https://library.palmer.edu/physiology/PhysioWeb
- http://med.wikidot.com/biochemistry-online-links

LS Core IV: Genetics and Evolutionary Biology

Course Learning Objective:

The focus of first half of this course is to familiarize students with basic principles of genetics and its application in understanding of real-life hereditary conditions. The second half of the course aims at imparting fundamental understanding of evolutionary processes and how it works in context of populations.

Learning Outcome:

Students would be able to understand the fundamentals of Mendelian inheritance and its exceptions. They would be able to appreciate various other gene interactions like co-dominance, incomplete dominance, lethal alleles and pleiotropy. Further, students would be able to describe the concepts of linkage and crossing over and their usage in constructing gene maps.

- Help students understand the basic principles of pedigree analysis and will be able to construct and analyse pedigree related problems for inherited traits.
- Students would gain knowledge on chromosomal and genetic mutation.
- Students would be able to describe the chromosomal sex-determination mechanisms and dosage compensation.
- Students would be able to understand the major events in history of life and major theories of evolution.
- Students would be able to appreciate the contribution of fossil studies in evolution and the phylogeny of horse.
- Students would be able to calculate the gene and allele frequency using Hardy-Weinberg law and analyse population genetics problems. T
- Students would understand the fundamental concepts of natural selection, speciation, mass extinction and macro-evolution.

Course Content:

Theory(Credit 4) 60 hrs

Unit 1: Mendelian Genetics and its Extension 10hrs

Mendel's work on transmission of traits, principles of inheritance, chromosome theory of inheritance, incomplete dominance and co-dominance, multiple alleles, lethal alleles, epistasis, pleiotropy, polygenic inheritance, sex linked inheritance, extra-chromosomal inheritance

Chapter-3, 4, 9, 23: Klug & Cummings

Unit 2: Linkage, Crossing Over and Chromosomal Mapping 6hrs

Linkage and crossing over, recombination frequency as a measure of linkage intensity, two factor and three factor crosses, interference and coincidence, somatic cell genetics - an alternative approach to gene mapping

Chapter-5: Klug & Cummings; Chapter-7: Pierce

Unit 3: Mutations 5hrs

Chromosomal mutations (classification, types and examples), gene mutations (types and classification)
Chapter-8, 1: 5 Klug & Cummings

Unit 4: Sex Determination 2hrs
Chromosomal mechanisms, dosage compensation
Chapter-7: Klug & Cummings

Unit 5: History of Life and Introduction to Evolutionary Theories 5hrs
Major events in history of life, Lamarckism, Darwinism, Neo-Darwinism
Chapter-22: Campbell

Unit 6: Direct Evidences of Evolution 4hrs
Types of fossils, incompleteness of fossil record, dating of fossils, phylogeny of horse
Chapter-4: Futuyama

Unit 7: Population Genetics and Processes of Evolutionary Change 12hrs
Hardy-Weinberg law (statement, derivation and applications), evolutionary forces upsetting H-W equilibrium (concepts only), organic variations, isolating mechanisms, natural selection and its types, artificial selection
Chapter-25: Klug & Cummings

Unit 8: Species Concept 6hrs
Biological species concept (advantages and limitations), modes of speciation
Chapter-24: Campbell; Chapter-24: Strickberger

Unit 9: Macro-evolution 5hrs
Macro-evolutionary principles (example: Darwin's Finches)
Chapter-21: Futuyama

Unit 10: Extinction 5hrs
Mass extinction (causes, names of five major extinctions, K-T extinction in detail), role of extinction in evolution
Chapter-23: Ridley

Practical [Credits: 2]

1. Study of Mendelian inheritance and gene interactions (non-Mendelian inheritance) using suitable examples (chi-square analysis).
2. Study of linkage, recombination, gene mapping using data.
3. Study of human karyotypes (normal and abnormal).
4. Study of homology and analogy from suitable specimens/pictures.
5. Pedigree analysis of some human inherited traits.
6. Study and verification of Hardy-Weinberg Law by Chi-square analysis.
7. Visit to natural history museum and submission of report.

Teaching-Learning Process:

The whole course envisages a lot of student-teacher interactions. The real-life relevance of both genetics and evolution makes it necessary that the teaching-learning strategies should involve discussions among students, guided by the teacher. There is ample opportunity for students to analyse genetic and evolutionary data, and develop skills in various simulation exercises. Visit to a natural history museum could be suitably integrated with the course content.

Assessment Methods:

Following assessment methods are suggested:

- Summative assessment comprising of written tests and *viva-voce*.
- Formative assessment with exercises involving genetic data analyses, evolutionary processes' simulations, and linkage mapping.
- Written report on the learning of museum visit.

Keywords:

Mendelian inheritance, Multiple alleles, Penetrance, Epistasis, Pleiotropy, Gene, Chromosomal mapping, Recombination, Interference, Mutations, Mutagens, chromosomal aberrations, Sex determination, Dosage compensation, Nuclear inheritance, Mitochondrial inheritance, Polygenic inheritance, Complementation, Transposons, Ty elements, Ac-Ds elements.

Recommended Books:

- Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons In.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*. X Edition. Benjamin Cumming
- Pierce B. A. (2012). *Genetics-A Conceptual Approach.* IV Edition. W. H. Freeman and Company

Suggested Readings:

- Russell, P. J. (2009). *Genetics- A Molecular Approach.*III Edition. Benjamin Cummings
- Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. *Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co.
- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4922-genetics-and-genomics
- https://swayam.gov.in/course/96-genetics
- https://www.coursera.org/learn/genetics-evolution
- https://onlinelearning.hms.harvard.edu/hmx/courses/hmx-genetics/
- https://learn.genetics.utah.edu/

LS DSE-1: Reproductive Biology

Course Learning Objective:

The foremost aim of a living being on this planet is to reproduce so that their species can flourish. Reproductive system is an intricate physiological system of the body and has been extensively studied in mammals. Understanding its intriguing working and regulation would be useful to address the effect of modern day's stressful life on infertility issues both in males and females. The design of the course is to understand the anatomy and functional histology of male and female reproductive systems, their cycles and regulations. The syllabi design is intended to impart the basic knowledge of male and female reproductive systems with close reference to human being.

Course Learning Outcome:

Upon completion of the course, students would be able to:

- Understand the functioning of male and female reproductive systems particularly in humans.
- Know about modern contraceptive devices.
- Get knowledge about assisted reproductive technologies to face the challenges of growing incidence of infertility.

Course Content

Theory [Credits:4] 60 hrs

Unit 1:Reproductive Endocrinology 10 hrs

Hypothalamo–hypophyseal–gonadal axis, gonadal and glycoprotein hormones; Steroidogenesis; Mechanism of action of gonadotropins and gonadal (steroids) hormones; Regulation of gonadotropin and gonadal (steroids) hormone secretion in male and female.

(Chapters 1, 2, 4 and 6: Jones, R.E. and Lopez, K.H.; Chapters 1, 2, 3, 4, 5, 6 and 7: Johnson, M.H. and Everitt, B.J.)

Unit2: Male reproduction 10hrs

Functional anatomy of male reproductive system in human; Testis (histological details): Testicular cells functions, Spermatogenesis and its regulation: Epididymal maturation of sperms; Sperm transportation in male tract.

(Chapter 4: Jones, R.E. and Lopez, K.H.; *Chapters 3 and 8: Johnson, M.H. and Everitt, B.J.)*

Unit 3: Female reproduction 30hrs

Functional anatomy of female reproductive system in human; Structure and functions of ovary (histological details): folliculogenesis, ovulation, Corpus luteum formation and regression; Reproductive cycles and their regulation, changes in the female tract; Ovum transport in the fallopian tubes; Activation of Sperm and its transport in the female tract, fertilization; Mechanism of implantation; Hormonal regulation of gestation, Maternal recognition of pregnancy; Gestational adaptations; pregnancy diagnosis; foeto-placental Unit; Mechanism of parturition and its hormonal regulation; Lactation and its regulation.

(Chapters 2, 3, 9, 10, 11, and 12: Jones, R.E. and Lopez, K.H.; Chapters 4, 8-13: Johnson, M.H. and Everitt, B.J.)

Unit4: Reproductive Health 10hrs

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: Sperm banks, frozen embryos, in vitro fertilization, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST; Modern contraceptive methods.

(Chapters 14 and 16: Jones, R.E. and Lopez, K.H.; Chapter 14: Johnson, M.H. and Everitt, B.J.)

Practical [Credits: 2]

1. Visit to animal house facility/animal husbandry centres to study the set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Study of estrous cycle by vaginal smear technique.
3. Principle and procedures of surgeries with respect to reproductive system (Orchidectomy, ovariectomy, vasectomy, tubectomy, hysterectomy).
4. Study the effect of cryptorchidism on sperm count and sperm motility in rats.
5. Histological study of male and female reproductive systems using microscopic slides/photomicrographs: Testes, ovary, epididymis, vas deferens, prostate gland, seminal vesicle, uterus (secretory and proliferative).
6. Study the effect of testosterone/estrogen on male/female accessory reproductive organs using hormone replacement therapy.
7. Study of modern contraceptive devices.
8. Mini projects involving survey, data collection, statistical analysis and submission of project report on reproductive health in a small human community.

Teaching and Learning Process:

Teaching-Learning process will include delivery of lectures using boards, multimedia presentations on course contents, showing 3D molecular structure and system tutorial/videos, giving online quizzes etc. Survey-based short project assignments and visit to the research institutes will clarify the concepts and enhance student's learning.

Assessment Methods:

The students can be assessed by MCQs/Quizzes, Assignments, Projects, Oral presentations, Class tests and Continuous evaluation by biweekly topic based 'Pre-class assignment'.

Keywords:

Testis, ovary, spermatogenesis, steroidogenesis, folliculogenesis, fertilization, pregnancy, gestation, lactation

Recommended Books:

- Austin, C.R. and Short, R.V. *Reproduction in Mammals*. Cambridge University Press.
- Degroot, L.J. and Jameson, J.L. (eds). *Endocrinology*. W.B. Saunders and Company.

Suggested Readings:

- Barrel et al., *Ganong's review of Medical Physiology.* 25th Edition. A Lange Medical Book.
- Knobil, E. et al. (eds). *The Physiology of Reproduction*. Raven Press Ltd.

- Hatcher, R.A. et al. *The Essentials of Contraceptive Technology*.
- Jones, R.E., and Lopez, K.H. (2014) *Human Reproductive Biology.* IV Edition. Elsevier Publication.
- Franklyn F. Bolander. *Molecular Endocrinology*. III Edition, Academic Press, USA

LS DSE 2: Wildlife Conservation and Management

Course Learning Objective:

The Discipline Specific Paper on Wildlife Conservation and Management is designed to acquaint students with varied aspects of wildlife conservation, including its importance, major threats, management of their habitats and populations. The emphasis will be on developing interest and invoking a sense of responsibility among students towards wildlife conservation. The course also explores different techniques, perspectives, and approaches to both identify and achieve wildlife management goals. This course will motivate students to pursue career in the field of wildlife conservation and management.

Course Learning Outcome:

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

- Become aware about the importance of wildlife in general, and its conservation and management in particular.
- Comprehend the application of the principles of ecology and animal behaviour to formulate strategies for the management of wildlife populations and their habitats.
- Understand the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.
- Know the key factors for loss of wildlife and important strategies for their *in situ* and *ex situ* conservation.
- Recognize the techniques for estimation, remote sensing and Global Position Tracking for wildlife.
- Gain knowledge about the wildlife diseases and the quarantine policies.
- Know about the Protected Area Networks in India, Ecotourism, Ecology of perturbation and Climax persistence.
- Perform critical thinking, literature review; scientific writing as well as presentations; and participation in citizen science initiatives with reference to wildlife.

Course Content:

Theory [Credits: 4] 60hrs

Unit1: Introduction to Wildlife 6hrs

Values of wildlife - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies: WCS, CBD, Agenda 21

(Chapter 1, 2, 3 and 10: Singh; Chapter 1 and 3: Saha and Mazumdar)

Unit2: Evaluation and Management of Wildlife 10hrs

Habitat analysis: a) Physical parameters: Topography, Geology, Soil and water; b) Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

(Chapter 2, 11 & 12: Sutherland; Chapter 6: Singh; Chapter 6: Saha and Mazumdar)

Unit 3: Management of Habitats 10hrs

Setting back succession: Grazing logging; Mechanical treatment; Advancing the successional

process: Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats.
(Chapter 11 & 12: Sutherland; Chapter 6: Singh)

Unit4: Population Estimation 12hrs
Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, and Hair identification; Pug marks and Census methods
(Chapter 2 & 4: Sutherland; Chapter 8 and 9: Singh; Chapter 6: Saha and Mazumdar)

Unit5: 8hrs
Management Planning of Wildlife in Protected Areas; Estimation of carrying capacity; Human-wildlife conflict; Eco tourism / wild life tourism in forests; Climax communities: characteristics and theories; Ecology of perturbance.
(Chapter 9: Sutherland; Chapter 1: Woodroff; Chapters 8 and 11: Singh; Chapter 9: Saha and Mazumdar)

Unit6: 6hrs
Management of Excess Population, Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and Mouth Disease, *Mycobacterium* TB, Bovine and Avian Flu
(Chapters 6, 7 and 11: Saha and Mazumdar)

Unit:7 8hrs
Protected Areas, National parks and sanctuaries; Biosphere reserves; Conservation and Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India and Management challenges in Tiger reserve.
(Chapters 11 and 12: Singh; Chapters 3 and 9: Saha and Mazumdar)

Practical[Credits: 2]

1. Identification of mammalian fauna, avian fauna, herpeto-fauna through direct and indirect evidences seen on a field trip to a wildlife conservation site.
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
3. Familiarization and study of animal evidences in the field: Identification of animals through pug marks, hoof marks, scats, nests and antlers.
4. Demonstration of different field techniques for flora and fauna: PCQM.
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
6. Identification of big cats: Lion, tiger, panther, cheetah, leopard and jaguar.
7. A report based on a visit to National Park/Wildlife Sanctuary/Biodiversity Park or any other wildlife conservation site.

Teaching and Learning Process:

The case study approach with real-life examples from the field will give a better understanding of the subject and its applications. The traditional chalk and talk method will be supplemented with LCD projection system and use of visualizer for theory classes. Projection of videos or short movies available on the subject will enhance the understanding of the subject. Digital collection of pictures of pugmarks, hoof marks, bird's nests, wild fauna and flora will facilitate observation of their characteristic features with ease. Group discussions, book reviews, paper presentations, videos, animations, are some methods that can be employed for effective teaching. Project based reports, assignments and E-posters can also form an important part of learning regime. Field-based research projects will develop interest in the subject and motivate students to peruse research as a career in future. Laboratory visits to renowned institutions like WII, Dehradun and Field visits to various conservation sites like Jim Corbett National Park, Aravali Biodiversity Park and National Zoological Park will provide students a practical or hands on knowledge of the subject. Students should participate in citizen science initiatives related to wildlife such as bird counts and uploading of the data on E-bird.org.

Assessment Methods:

Students will be assessed using the following methods:

- Formative/ Continuous assessment: This will be done through problem solving exercises, oral and written examinations, closed-book and open book tests, practical assignment laboratory reports, observation of practical skills, individual project reports, seminar presentation, viva voce interviews, computerized adaptive testing, literature surveys and evaluations, outputs from collaborative work etc. to assess the retention abilities of students.
- Summative assessment: Semester-end written and practical examinations will be an indicator of student's learning throughout the semester and analyses comprehensive knowledge gained by the students.

Keywords:

Wildlife, Conservation, Management, Population, Habitat, Succession, Climax, Quarantine, Tiger Project, National Park, Wildlife Sanctuaries, Biodiversity Reserves, Wildlife Diseases, Protected Areas

Recommended Books:

- Saha, G.K. and Mazumdar, S. (2017) *Wildlife Biology: An Indian Perspective*. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313
- Sinclair, A.R.E.,Fryxell, J.M. and Caughley, G. (2006) *Wildlife Ecology, Conservation and Management*. Wiley-Blackwell, Oxford, UK.
- Singh, S.K. (2005) *Text Book of Wildlife Management*. IBDC, Lucknow.

Suggested Readings:

- Hudson, P.J., Rizzoli, A., Grenfell, B.T. Heestrbeek, H. and Dobson, A.P. (2002) *The Ecology of Wildlife Diseases*. Oxford University Press, Oxford.
- Banerjee, K. (2002) *Biodiversity Conservation in Managed and Protected Areas*. Agrobios, India.
- Sharma, B.D. (1999) *Indian Wildlife Resources Ecology and Development*. Daya Publishing House, Delhi.

- Primack, R.B. (1998). *Essentials of Conservation Biology*. Sinauer Associates, Inc. Sunderland, MA.
- Hossetti, B. B. (1997). *Concepts in Wildlife Management*. Daya Publishing House, Delhi.

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4687-july-2018-wildlife-conservation
- https://swayam.gov.in/courses/5364-jan-2019-wild-life-ecology
- https://papaco.org/mooc-on-species-conservation/
- https://www.iucn.org/theme/protected-areas/our-work/capacity-development/moocs
- https://www.zsl.org/united-for-wildlife-free-conservation-courses
- https://wildlife.org/next-generation/career-development/online-courses/
- https://www.openlearning.com/umtmooc/courses/wildlife-management

LS DSE 3:Animal Biotechnology

Course Learning Objective:

Biotechnology is the advanced branch of biological sciences which mostly deals with technologies that use living organisms or their components to produce products for specific use. The present paper attempts to give a wholesome idea of biotechnology at a basic level. It provides a tool kit in the form of a number of various techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine. It makes one aware of the scope of this field which encompasses almost every field of science like engineering, research, commercialization and academics. It equips students with basic techniques of biotechnology which are a must for everyone interested in pursuing a career in biotechnology. This paper also attempts to illustrate the role of biotechnology by giving very common examples as to how to use these tools to solve a specific problem in either of medicine, agriculture or food technology.

Course Learning Outcome:

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

- Use or demonstrate the basic techniques of biotechnology; like DNA isolation, PCR, transformation, restriction, digestion etc.
- Devise a strategy to manipulate genetic structure of an organism for the improvement in any trait or its well-being based on the techniques.
- Understand the ethical and social issues raised regarding GMOs.
- Apply the knowledge for designing a proposal for research project.

Course Content:

Theory [Credits: 4] **60 hrs**

Unit1**:** Concept and Scope of Biotechnology 4 hrs
(Chapter 1: Glick & Pasternak)

Unit2**:** Molecular Techniques in Gene manipulation 28 hrs
Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics); Restriction enzymes: Overview., Nomenclature, detailed study of Type II; DNA modification enzymes: Alkaline phosphatase, Terminal transferase, Reverse transcriptase, T4 DNA kinase, ligases CRISPR Cas-9 (as genome editing tool); Transformation techniques; Calcium chloride and electroporation method; Construction of genomic and cDNA libraries and screening by colony and plaque hybridization; cDNA library screening by immunological methods; Southern, Northern and Western blotting; DNA sequencing: Sanger and NGS (illumine) methods; Polymerase Chain Reaction (RT-PCR, real time PCR), and DNA microarray
(Chapter 3 and 4: Glick & Pasternak)

Unit3: Genetically Modified Organisms 18 hrs

Production of cloned and transgenic animals: Nuclear Transplantation (cloning of dolly as an example), Retroviral Method, DNA microinjection. Applications of transgenic animals: Production of pharmaceuticals, Production of transgenic plants: *Agrobacteriurn* mediated transformation. Applications of transgenic plants: insect resistant plants, and edible vaccines and golden rice as examples.

(Chapter 21: Glick & Pasternak; Chapter 24: Watson)

Unit4: Applications of Biotechnology 10 hrs

Meta-genomics: an introduction, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anaemia) Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

(Chapter 9: Glick & Pasternak; Chapter 23: Watson; Chapter 26: Primrose and Twyman)

Practical [Credits: 2]

1. Genomic DNA isolation from *E. coli*
2. Plasmid DNA isolation (pUC 18/19) from *E. coli*
3. Restriction digestion of lambda DNA with *Eco*RI and *Hind*III (Demonstration).
4. Construction of circular and linear restriction map from the data provided.
5. Preparation of competent cells and their transformation by $CaCl_2$ method. Calculation of transformation efficiency from the data/plate provided.
6. To study following techniques through photographs:
7. Southern Blotting (Demonstration)
8. Western Blotting
9. DNA Sequencing (Sanger's Method).
10. PCR (demonstrations).
11. DNA fingerprinting and case studies (photographs only to study crime, or paternity cases).
12. Project report on Animal Cell Culture/visit to a biotechnology laboratory or industry

Teaching and Learning Process:

Students will be taught using traditional chalk and talk method blended with e-learning tools. Paper presentations and reports by students on recent Biotechnology developments will enhance their learning. Quizzes on Biotechnology, Projects-based discussions, Hands-on experiments, Practical demonstrations and Visit to nearby Biotechnology laboratories, pharmaceutical industries and companies will help them learn about modern advancements.

Assessment Methods:

- **Theory component** would be assessed by written examination, and internal assessment based on performance in tests, class presentations and Group discussion and attendance,
- **Practical Component** would be assessed by Practical examination at the end of term which would include continuous evaluation of student, project report, *viva-voce* and Practical records.

Keywords:

Biotechnology, rDNAtechnology, GeneticallyModifiedOrganisms (GMOs), Transformation, Cloningvectors, Restriction endonucleases, PCR, DNA microarrays, DNA Sequencing, Gene Therapy

Recommended Books:

- Glick, B.R. and Pasternak, J.J. (2009) *Molecular Biotechnology - Principles and Applications of Recombinant DNA*. IV Edition, ASM press, Washington, USA.
- Primrose S. B. and Twyman R.M. (2006) *Principles of Gene Manipulation and Genomics.* VII Edition. Blackwell publishing
- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007) *Recombinant DNA- Genes and Genomes- A Short Course*. III Edition, Freeman and Co., N.Y., USA.

Suggested Readings:

- Brown, T.A. (1998) *Molecular Biology Labfax II: Gene Cloning and DNA Analysis*. II Edition, Academic Press, California, USA.
- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009) *An Introduction to Genetic Analysis.* IX Edition. Freeman and Co., N.Y., USA.
- Snustad, D.P. and Simmons, M.J. (2009) *Principles of Genetics.* V Edition, John Wiley and Sons Inc.

Online Tools and Web Resources:

- http://illl.du.ac.in/
- https://www.coursera.org/learn/genes
- Swayam (MHRD) Portal

LS DSE 4: Immunology

Course Learning Objective:

Immunology is a broad discipline that encompasses specialties as diverse as biochemistry, clinical biology, medicine, ecology and evolutionary biology. Basic knowledge of Immunology can be applied to understand and treat a wide range of diseases and infections. This branch has expanded into newer avenues of prophylaxis and immunotherapy thus providing new therapeutic approaches to immunodeficiency diseases, cancer therapy and autoimmune disorders. The comprehensive topics are broken down into simple and easy-to-remember steps to facilitate fruitful learning.

Course Learning Outcome:

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

- Study hematopoiesis to know the concepts of stem cells and their differentiation into progenitor stem cells and adult lineages.
- Learn the concepts of innate and acquired immunity.
- Understand adaptive immune responses and sequential phases-antigen recognition by lymphocytes, their proliferation, differentiation into effector and memory cells and elimination of pathogens.
- Learn about major histocompatibility complex and their role in transplantation immunity and autoimmunity
- Gain knowledge about the Complement system and how they interact and activate a catalytic cascade to remove immunogens.
- Study the role of various cytokines involved in cell to cell communication in the removal of pathogens**.**
- Understand the advent of hypersensitivities due to inappropriate innate and adaptive immune responses.
- Know the basic immunological aspects to comprehend the newer strategies in vaccine design, and efforts to treat autoimmunity, hypersensitivity and immunodeficiency.

Course Content:

Theory [Credits: 4] 60 hrs

Unit1: Overview of the Immune System 10hrs

Historical perspective, early theories of immunology, clonal selection theory. Innate immunity: defensive barriers of innate immunity, cell types and molecules involved in innate immunity.
Adaptive immune system: attributes of acquired immunity, Humoral and cellular mediated immunity, active and passive immunity, primary and secondary cellular response, cells and molecules involved in adaptive immunity.
(Chapter 1: Kuby)

Unit2: Cells and Organs of the Immune System 8hrs

Hematopoiesis, Cells of immune system, primary and secondary lymphoid organs.
Chapter 1 and 2: Kuby

Unit 3:Antigens 8hrs

Antigens and immunogens, antigenicity and immunogenicity, Factors affecting immunogenicity, Antigenic determinants (B and T cell epitopes), Conceptof antigen recognition by B and T-cells, Adjuvants and haptens.

Chapter 4: Kuby

Unit4: Immunoglobulins 10hrs

Structure, different classes and function of antibodies, Antigenic determinants on immunoglobulins, Antigen-antibody interactions as tools for research and diagnosis (precipitation reaction, agglutination, immunofluorescence and ELISA), Polyclonal sera, Hybridoma technology for monoclonal antibodies in therapeutics and diagnosis.

Chapter 4 and 6: Kuby

Unit 5: Major Histocompatibility Complex (MHC I and II) 6hrs

Structure and functions of MHC

Chapter 8: Kuby

Unit6: Complement System 4hrs

Components, alternate and classical pathway, biological consequences of complement activation.

Chapter 7: Kuby

Unit7: Cytokines 4hrs

Basic properties and functions of cytokines.

Chapter 12: Kuby

Unit8: Immune System in Health and Diseases 7hrs

Hypersensitivity:Gell and Coombs' classification; Briefly discuss the concepts of Autoimmunity, Immune dysfunctions and Immunodeficiency.

Chapter 9: Kuby

Unit9: Vaccines 3hrs

General introduction and types of vaccines

Chapter 18: Kuby

Practical [Credits: 2]

1. Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/photographs.
3. Preparation of stained blood film to study various types of blood cells.
4. Oüchterlony's double immuno-diffusion method.
5. ABO blood group determination.
7. Demonstration of ELISA and Immunoelectrophoresis.

Assessment Methods:

Examinations shall be conducted at the end of each semester as per the Academic Calendar notified by the University of Delhi. Quizzes, Internal assessment, Assignments, Projects, Presentations and group discussions, Regularity and discipline.

Keywords:

Hematopoiesis, Innate immunity, Adaptive Immunity, BCR, TCR, Antigens, Immunogens, Antigen-antibody interactions, Immunoglobulins, MHC, Complement, Cytokines, hypersensitivity, vaccines

Teaching and Learning Processes:

This course is designed to will help understand the basics of immunology- how it develops, functions and sometimes malfunctions, thereby causing disease. Though not targeted exclusively towards medical students, this course provides an insight to students of Life Sciences a peek into the world of our own defense mechanisms and how our body fights against the innumerable pathogens that surround us. The course, thus aims to build-in the concepts of immunology keeping in mind the other areas of courses like biochemistry, cell and molecular biology, genetics, evolution etc. The topics were carefully chosen to acquaint the students to all aspects of immune system without overwhelming them with too much details and research on a particular topic, thus maintaining the balance for a holistic teaching–learning process.

Recommended Books:

- Kindt, T.J.,Goldsby, R. A. and Osborne B.A. (2007) *Kuby Immunology.* W.H.Freeman and Co, New York.
- Murphy, K., Travers, P.,and Walport, M. (2008) *Janeway'sImmunobiology.*Garland Science, Taylor and Francis Group, LLC

Suggested Readings:

- David, M., Jonathan, B., David, R. B. and Ivan R. (2006) *Immunology.*VII Edition, Mosby, Elsevier Publication.
- Abbas, K. Abul and Lechtman H. Andrew (2003) *Cellular and Molecular Immunology.* V Edition. Saunders Publication.

Online Tools and Web Resources:

- MOOCs courses available at Swayam portal, https://swayam.gov.in/courses/public
- Coursera, https://www.coursera.org/courses?query=immunology

LS DSE 5: Applied Zoology

Course Learning Objective:

Applied zoology paper aims to enable the students to learn different practical beneficial of zoology. It explores the students to the biology of human parasites, their transmission and method to control them. An insight into Agricultural Pests and medically important insect vector is provided and methods to manage them. The beneficial aspects and management of Diary Technology, Poultry Farming and Aquaculture is to be explored.

Course Learning Outcome:

After completing this Course, the students will be able to contribute towards resolving serious issues pertaining to:

- Medical Zoology: Parasitology, Protozoology, Helminthology, and Entomology (especially with respect to increase in requirement for expert resource persons for containing the alarming rise in mosquito-borne diseases; Dengue and Chikungunya in Delhi)
- Animal Husbandry
- Poultry farming
- Fish farming

And, after thorough practical training skills pertaining to the commercial aspects of these studies, the students would emerge as successful entrepreneurs and establish their research enterprise and later, generate employment as well

Content:

Theory [Credits: 4] 60 hrs

Unit:1 Introduction to Applied Zoology 5-hrs

Review of the fundamental concepts and applied aspects pertaining to different parasites (spirochaetes, rickettsiae, protozoa, helminths), insect carriers and vectors studied in the previous semesters.Terminology and concepts related to Host-Parasite relationship: Host, Definitive host, Intermediate Host, Carrier, Vector, Parasitism, Symbiosis, Commensalism, Reservoir, Zoonosis (with special emphasis on Rabies)

Unit:2 Epidemiology of Diseases 5-hrs

Transmission, Prevention and control of diseases: Tuberculosis, Typhoid

Unit:3 Parasitology 10-hrs

Rickettsiae and Spirochaetes: Brief account of *Rickettsia prowazekii*, *Borreliarecurrentis* and *Treponemapallidum;* Protozoa: Life history and pathogenicity of *Entamoebahistolytica*, *Plasmodium vivax* and *Trypanosomagambiense;*Helminths: Life history and pathogenicity of *Ancylostomaduodenale* and *Wuchereriabancrofti*

Unit: 4 Agricultural and Medical Entomology 15-hrs

Biology of the following pests of agricultural importance: *Helicoverpaarmigera*, *Pyrillaperpusilla*and *Papiliodemoleus*; Study of damage caused by them, and measures to manage/ control them.

Biology of the following pests of medical importance: *Pediculus humanus capitis*, *Pediculus humanus corporis*, *Anopheles*, *Aedes*, *Culex* and *Xenopsylla cheopis.* Study of damage caused by them, and measures to manage/ control them

Unit:5 Animal Husbandry and Poultry Farming 15-hrs

Study, significance and commercial prospects of the Artificial Reproductive Techniques (ART) with special emphasis on Artificial insemination in cattle, Induction of early puberty and synchronization of estrus in cattle. Study, significance and commercial prospects of Dairy technology; Principles of poultry breeding, Management of breeding stock, Processing and preservation of eggs

Unit: 6 Aquaculture and Fish Technology 10-hrs

Study, significance and commercial prospects of Aquarium and Fish keeping; Genetic improvements in aquaculture industry; Induced breeding and transportation of fish seed

Practical [Credits: 2]

1. Study of *Plasmodium vivax, Entamoeba histolytica, Trypanosoma gambiense, Ancylostoma duodenale*and *Wuchereria bancrofti* and their life stages through permanent slides/photomicrographs or specimens.
2. Study of arthropod vectors associated with human diseases: *Pediculus, Culex, Anopheles, Aedes* and *Xenopsylla.*
3. Study of insect damage to different plant parts/stored grains through damagedproducts/photographs. Submission of items/products damaged by insects.
4. Identifying feature and economic importance of *Helicoverpa (Heliothis) armigera, Papilio demoleus, Pyrilla perpusilla, Callosobruchus chinensis, Sitophilus oryzae* and *Tribolium castaneum*
5. Visit to poultry farm or animal breeding centre. Submission of Field visit report.
6. Maintenance of freshwater aquarium.

Teaching and Learning Process:

Teaching-learning methods for Applied Zoology paper will include the conventional 'chalk and talk method' which can be supplemented by using technologically advanced methods, such as use of LCD projectors to showcase videos, films and power-point presentations. The classroom teaching will be inclusive and provide ample opportunities and challenging environment for honing the soft skills of the students by way of interactive discussions, etc.

Seminars, discussions, field visits, and projects should be organized on a regular basis where the students are given an opportunity to apply the concepts learnt in the classroom. Emphasis should mainly be on putting the classroom teaching to practice in their day-to-day life for the overall progress of the society, at large.

Assessment Methods:

The scheme for the assessment of the students should broadly address two main components: Formative and Summative.

Formative assessment (Continuous Evaluation) can be made on the basis of periodic tests, presentations, assignments, attendance, etc. whereas the Summative assessment would be done at

the end of the semester or term of the course, where some weightage of the Formative assessment should also be incorporated.

Keywords:

Medical Zoology, Parasitology, Economic Entomology, Medical Entomology, Agricultural Entomology, Insect Pests, Animal Husbandry, Artificial insemination in cattle, Dairy technology, Poultry farming, Aquaculture, Fish farming

Recommend Books:

- Park, K. (2007). Preventive and Social Medicine. XVI Edition. B.B Publishers.
- Arora, D.R. and Arora, B. (2001). Medical Parasitology. H Edition. CBS Publications and Distributors.
- Metcalf, C.L. and W.L. Flint (1962). Destructive and Useful insects: their habits and control. Mc-Graw Hill publishers, 1087 p. (4^{th} Ed. Revised by R.L. Metcalf)
- Atwal, A.S. (1986). Agricultural Pests of India and South East Asia, Kalyani Publishers.
- Hafez, E. S. E. (1962). Reproduction in Farm Animals. Lea & Fabiger Publisher
- Dunham R.A. (2004). Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI publications, U.K.

Suggested Readings:

- Pedigo, L.P. (2002). Entomology and Pest Management, Prentice Hall.
- Dennis, H. (2009). Agricultural Entomology. Timber Press (OR).

LS SEC 1: Apiculture

Course Learning Objective:

The course will make the student aware about the significance of beekeeping as the economically viable industry. It will help the students to understand the biology and behaviour of bees. The course would clarify the techniques of honey bee rearing, optimization of techniques based on climate and the geographical regions, and various measures to be taken to maximize the benefits. It would also help the students to develop entrepreneurial skills required for self-employment in beekeeping sector.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the various species of honey bees in India, their social organization and importance.
- Be aware about the opportunities and employment in apiculture – in public, private and government sector.
- Gain thorough knowledge about the techniques involved in bee keeping and honey production.
- Know about various products obtained from beekeeping sector and their importance.
- Develop entrepreneurial skills necessary for self-employment in beekeeping sector.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 2] 30 hrs

Unit1: Biology of Bees 4 hrs

History, Classification and Biology of Honey Bees Different species of honey bees -*Apisdorsata, Apisceranaindica, Apisflorea, Apismellifera, Melipona*sp.Social Organization of Bee Colony, Behavioural patterns (Bee dance, swarming)

(Chapter 1, 2 and 3: Singh, S.; Chapter 2, 3 and 5: Mishra, R.C.)

Unit 2: Rearing of Bees 14 hrs

Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth; Bee Pasturage; Selection of Bee Species for Apiculture –*Apisceranaindica, Apismellifera;* Bee Keeping Equipment Methods of Extraction of Honey (Indigenous and Modern)& processing; Apiary management – Honey flow period and Lean period

(Chapter 4, 5, 6 and 7: Singh, S.; Chapter 4, 8 and 9: Mishra, R.C.)

Unit 3: Diseases and Enemies 5 hrs

Bee Diseases, control and preventive measures; Enemies of bees and their control

(Chapter 10: Singh, S.; Chapter 10: Mishra, R.C

Chapter 6: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)

Unit 4: Bee Economy 3 hrs

Products of Apiculture Industry (Honey, Bees Wax, Propolis, Royal jelly, Pollen etc.) & their uses; Modern Methods in employing artificial Beehives for cross pollination in horticultural gardens
(Chapter 11: Singh, S.; Chapter 11 and 12: Mishra, R.C.
Chapter 9: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)

Unit 5: Entrepreneurship in Apiculture 4 hrs
Bee Keeping Industries – Recent Efforts, Employment opportunities, Economics in small scale and large-scale beekeeping, Scope for women entrepreneurs in beekeeping sector
(Chapter 10: https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf
Entrepreneurial Potential of Small-scale Beekeeping in Rural India: A Case in Kanyakumari district, Tamil Nadu. M. Esakkimuthu& VLV. Kameswari, Tropical Agricultural Research, (2017) 28: 411)

Practical [Credits: 2]

1. Study of the life history of honey bee, *Apisceranaindica* and *Apismellifera* from specimen/ photographs - Egg, larva, pupa, adult (queen, drone, worker)
2. Study of natural bee hive and identification of queen cells, drone cells and brood
3. Study of morphological structures of honey bee through permanent slides/ photographs – mouth part, antenna, wings, legs (antenna cleaner, mid leg, pollen basket), sting apparatus.
4. Permanent/temporary mount of antenna cleaner, mid leg and pollen basket OR mount of pollen grains from flowers
5. Study of artificial hive (Langstroth/Newton), its various parts and beekeeping equipment.
6. Analysis of honey – purity, biochemical analysis (Any two constituents)
7. Visit to an apiary/honey processing unit/institute and submission of a report.
8. Study of bee pasturage –
   - Visit to fields/gardens/orchards for studying the bee activity (role in pollination and nectar collection).
   - Making of herbarium of nectar and pollen yielding flowering plants
9. Submission of a few products obtained from apiculture industry.

Teaching and Learning Process:

Information and concepts about benefits of honey bees in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of bees in nature and study of rearing technology will be assisted through visits to various apiculture institutes which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make student's learning more dynamic. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of bee biology will be promoted to not only ensure effective learning and understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of bees and their rearing methods. Collection of plants and bee products will also help students to know the

benefits of apiculture. Visit to various apiculture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

Various measures adopted will be as follows.

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones in which evaluation is held.
- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.
- Regular Presentations: Presentations by the students on a topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries.
- *Viva-voce: Viva-voce* is a critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:

Apiculture, Bee, Bee hive, Beekeeping, Bees' wax, Brood, Comb sheets, Drones, Entrepreneurship, Honey, Langstroth's hive, Newton's hive, Propolis, Queen bee, Royal jelly

Recommended Books:

- Singh S. (1962) *Beekeeping in India*, Indian Council of Agricultural Research, New Delhi.
- Mishra, R. C. (1995). *Honeybees and their management in India.* Indian Council of Agricultural Research, New Delhi.

Suggested Readings:

- Prost, P. J. (1962). *Apiculture*. Oxford and IBH, New Delhi.
- Rahman, A. (2017) *Beekeeping in India.* Indian Council of Agricultural Research, New Delhi
- Gupta, J. K. (2016). *Apiculture,* Indian Council of Agricultural Research, New Delhi

Online Tools and Web Resources:

- Master Beekeeping (https://www.ecornell.com/certificates/beekeeping/master-beekeeping/)
- Beekeeping (https://nios.ac.in/media/documents/nsqf/beekeeping%20theory.pdf)
- Swayam (MHRD) Portal: Vocational Beekeeping (https://swayam.gov.in/courses/5844-vocational-beekeeping

LS SEC 2: Aquarium Fish Keeping

Course Learning Objective:

The course will impart basic knowledge of ornamental fish Industry and inculcate its scope as an avenue for career development in Entrepreneurship or as an Aquariculturist. It will provide a clear understanding on the basics of habits and biology of aquarium fishes so as to facilitate taking up ornamental fish keeping even at a household level. The skill capacity building of students will be promoted by teaching the techniques of aquarium constructions, feed formulation and preparation, transportation, maintenance and management of the system. The students will have first hands-on experience by exposure to technology, production, functioning or operation of an institution through visits to public aquariums in the markets, ornamental fish farms, hatcheries, and fish feed production plant as study tours or field visits.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Acquire knowledge about different kinds of fishes, their compatibility in aquarium.
- Become aware of Aquarium as commercial, decorative and of scientific studies.
- Develop personal skills on maintenance of aquarium.
- Know about the basic needs to set up an aquarium, *i.e*., dechlorinated water, reflector, filters, scavenger, aquatic plants etc. and the ways to make it cost-effective.

Course Content:

Theory [Credits: 2] 30 hrs

Unit1: Introduction to Aquarium Fish Keeping 2 hrs

The potential scope of Aquarium Fish Industry as a Cottage Industry; Exotic and Endemic species of Aquarium Fishes

(Chapter 50 and 54: Pandey and Shukla)

Unit 2: Biology of Aquarium Fishes 6 hrs

Study of different species of Aquarium fishes and biology (Breeding, Feeding economic importance etc) of exotic and endemic fish. Common characters and sexual dimorphism of Fresh water and Marine Aquarium fishes such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish.

(*Chapter 3: Dawes)*

Unit 3: Food and feeding of Aquarium fishes 8 hrs

Use of live fish feed organisms (Advantages and Disadvantages of live food), Use of formulated feeds, Types of formulated feed, Formulation and preparation of feed, Advantages and disadvantages of formulated feed

(Chapter 50: Pandey and Shukla)

Unit 4: Fish Transportation 8 hrs

Live fish transport (Capture and Pre-transport Maintenance, Capture and Handling techniques); Fish packing and transport (Closed and open transport system, Preparation for packaging, Procedure for packaging, Precautions, Post transport maintenance) General Handling techniques *(Chapter 13, Jhingran)*

Unit 5: Maintenance of Aquarium 6 hrs

General Aquarium maintenance - budget for setting up an Aquarium Fish Farm as a Cottage Industry.
(Chapter 2: Dawes)

Practical [Credits: 2]

1. Study of different species of Aquarium fishes and biology (Breeding, Feeding economic importance etc) of exotic and endemic fish.
2. Study of Sexual Dimorphism of Fresh water and Marine Aquarium Fish(Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish, Butterfly fish)
3. Type, composition and formulation of fish feed (using Pearson Square Methods)
4. Construction and maintenance of Glass Aquarium and Filter System Using Indigenous Locally available materials.
5. Monitoring of aquarium water quality (Temperature, pH, Dissolved Oxygen, Carbon dioxide, Ammonical N-Load) through titrimetry methods.
6. To write a project proposal for setting up a small aquarium fish keeping as a cottage industry to a funding agency for self-employment of youths or for helping poor farmers; after visiting any farm/enterprise.

Teaching and Learning Process:

Teaching Learning must include the videos, surveys, presentation to show the significance of the course - its commercial, scientific and aesthetic prospects. Learning must inculcate in students with the visit of any farm or lab. Practical exercise with the set- up of an aquarium and its maintenance; and hands-on training for the formation of feeds will develop skill among students. Students should be assigned for subject related surveys, presentation, reports so that they can be rewarded on this basis.

Assessment Methods:

The students can be assessed by MCQs/Quizzes, Assignments, Projects, Oral presentations, Problem-solving exercises, Class tests and Continuous evaluation by biweekly topic based 'Pre-class assignment', Observation of practical skills and *Viva-voce*

Keywords:

Ornamental fishes, Cottage industry, Endemic fish, Feed formulation, Transportation techniques.

Recommended Books:

- Dawes, J. A. (1984) *TheFreshwater Aquarium*, Roberts RoyeeLtd.London.
- Gunther, A. (1980) *AnIntroduction to the Study of Fishes*. A and C. Black Edinburgh.

Suggested Readings:

- Jhingran, V.G.(1982) *Fish and Fisheries in India*. Hindustan publ.Corp, India.
- Pandey, K and J.P. Shukla (2013) *Fish and Fisheries*. Rastogi publication

LS SEC 3: Medical Diagnostics

Course Learning Objective:

Medical diagnostics paper is aimed to provide students a unique opportunity to study how doctors or clinicians come to a conclusion regarding disease prediction, prevention, diagnosis, and optimal treatment regimens. Students will learn about multiple diagnostic tools, techniques and technologies use in medical practices. The emphasis is on how to select an appropriate diagnostic technique, methods and technologies to conduct analyses to understand the results and their implications in patient diagnosis. The medical diagnostic paper is primarily focused on, clinical chemistry, hematology, diagnostic microbiology, histopathology, molecular diagnostics and diagnostic medical imaging.

Course Learning Outcome:

After completing this course, the students should be able to:

- Gain knowledge about various infectious, non-infectious and lifestyle diseases, tumors and their diagnosis.
- Understand the use of histology and biochemistry of clinical diagnostics and learn about the molecular diagnostic tools and their relation to precision medicine.
- Develop their skills in various types of tests and staining procedure involved in hematology, clinical biochemistry and will know the basics of instrument handling.
- Learn scientific approaches/techniques used in the clinical laboratories to investigate various diseases and will be skilled to work in research laboratories.
- Gain knowledge about common imaging technologies and their utility in the clinic to diagnose a specific disease.

Course Content:

Theory [Credits: 2] 30 hrs

Unit 1: Introduction to Medical Diagnostics and its Importance 2 hrs
(Chapter: 4 K. Park, 2013

Unit 2: Medical Diagnostics of Body Fluids 10 hrs
Blood composition, Blood bank, Transfusion of blood, RBC, WBC and platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.), Analysis of urine, sputum, faeces and semen(sperm count)
(Chapter 9a, 9b, 9c, 12, 19, 20, 21: Prakash, G.

Unit 3: Medical Diagnostics of Non-infectious Diseases 10 hrs
Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Diagnosis and detection of types of tumors (Benign/Malignant) and metastasis, FNAC.
(Chapter 16, 22a: Prakash, G.; *(Chapter: 6 K. Park, 2013)*

Unit 4: Diagnostics Microbiology 5 hrs
Methods to diagnose and isolate infectious agents of diseases like Tuberculosis, Hepatitis and AIDS.

(Chapter: 5 K. Park, 2013)

Unit 5:Diagnostic Medical Imaging 3 hrs
Principle of Medical imaging techniques like X-Ray of Bone fracture, PET, MRI and CT Scan
(Chapter 24: Prakash, G.

Practical [Credits: 2]

1. ABO blood group typing.
2. Estimation of haemoglobin content using Sahli's haemoglobinometer.
3. Analysis of urine for abnormal constituents.
4. Total leucocytes count from blood.
5. Measurement of blood pressure under normal and stress condition.
6. Estimation of blood glucose/ cholesterol by kit.
7. Determination of bleeding time/clotting time
8. Detecting defects of colour vision by Ishihara Charts.
9. Interpretation of ECG.
10. Medical Imaging techniques: X-Ray of bone fracture, MRI, CT scan.

Teaching and Learning Process:

Different instructing strategies shall be adopted including: Lectures, interactive lectures, classroom discussions and practical based on a theory paper by analyzing body fluids, tissues, blood typing, chemical analyses, cell counts of human body etc. Use of digital technologies will enable students to get a better understanding of the concepts. Hands-on experience, including diagnostic analysis in the diagnostic laboratory and student presentations will provide supplement to conventional text books. Field studies will include visits to diagnostic laboratory or a visit to a hospital having diagnostic facilities.

Assessment Methods:

- Closed-book tests to evaluate the students' knowledge and understanding of material covered in the class.
- Internal evaluation based on the experiment performed during the internal examination or class tests conducted by the internal examiners.
- Dimension of comprehension and capacity to respond to inquiries as a piece of *viva-voce*.
- Involvement in class and group discussions of individual research and contribution to fruitful discussions.
- Assignments based on the text prescribed in the syllabus.
- Power Point presentation on any aspect of medical diagnostics.
- Hospital visit/medical institute visit.
- Project work (Students should execute one project of their choice or teacher may assign the project. Project report should be scanned for plagiarism through freely available software and a soft copy of the report should be mandatory).

Keywords:
Diagnostic methods, Infectious and Non-Infectious Diseases, Imaging Techniques

Recommended Books:
- Park, K. (2007), *Preventive and Social Medicine*, B.B. Publishers
- Godkar P.B. and Godkar D.P. *Textbook of Medical Laboratory Technology*, II Edition, Bhalani Publishing House
- Prakash, G. (2012), Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Co. Ltd.

Suggested Readings:
- Cheesbrough M., *A Laboratory Manual for Rural Tropical Hospitals, A Basis ForTraining Courses*
- Guyton A.C. and Hall J.E. *Textbook of Medical Physiology*, Saunders
- Robbins and Cortan, *Pathologic Basis of Disease*, VIII Edition, Saunders

Online Tools and Web Resources:
- https://www.skillstat.com/tools/ecg-simulator
- https://www.youtube.com/watch?v=ZoGfQM5JCnI
- https://www.youtube.com/watch?v=Qbnz4_qed9Q&t=276s
- https://www.youtube.com/watch?v=djAxjtN_7VE
- https://www.youtube.com/watch?v=9SUHgtREWQc&t=188s
- https://www.youtube.com/watch?v=fHUzVqoDnts

LS SEC 4: Public Health and Hygiene

Course Learning Objective:

This course is multidisciplinary in nature which can be opted by students from all science courses. Starting from the basic concepts of Environmental science, it gives a deep insight into the factors causing environmental degradation and its outcome in form of increasing number of diseases leading to deterioration of public health.

Course Learning Outcome:

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

- Get familiarised with various aspects of environmental risks and hazards.
- Sensitize about the climate change due to human activities.
- Be aware about the various impacts of environmental degradation on human health through case studies and modes of prevention.
- Learn about the nuclear and chemical disasters and their aftereffects through cases studies.
- Know about the various waste management technologies and their utility.
- Learn about diagnosis of various diseases and methods to prevent them.
- Be sensitized enough to understand the importance of conservation of nature for betterment of human race and all living beings.

Theory [Credits: 2] 30 hrs

Unit 1: Introduction to Public health and Hygiene 7hrs

Significance of Public health and Hygiene, Nutrition and health, Classification of foods, Major nutritional Deficiency diseases- Protein Energy Malnutrition (Kwashiorkor and Marasmus), Vitamin deficiency disorders, Iron deficiency disorders, Iodine deficiency disorders

Chapter 1 and 2: Park K.

Unit 2: Environment and Health hazards 6 hrs

Environmental degradation, Environmental Pollution – Air, water, soil and noise; Associated health hazards

Chapter 12: Park K.

Unit 3: Communicable Diseases 6hrs

Different types of communicable diseases and their control measures – Tuberculosis, Measles, Dengue, Leprosy

Chapter 5: Park K.

Unit 4: Life Style Related Non-Communicable Diseases 6hrs

Different types of Life style related non-communicable diseases - Hypertension, Coronary Heart diseases, Stroke, Diabetes mellitus, Obesity and Mental ill-health - their causes and prevention through dietary and lifestyle modifications

Chapter 6: Park K

Unit 5: Social Health Problems 5hrs

Smoking, alcoholism, drug dependence and Acquired Immuno-Deficiency Syndrome (AIDS) - their causes, treatment and prevention.

Chapter 11: Park K

Practical [Credits: 2]

1. Estimation of blood glucose level
2. Study of household pests following with reference to public health.
3. Testing potability of water for human consumption by MPN method
4. To determine the content of different pollutants in soil/water samples.
5. Calculate the BMI of students and analyse the results with suitable statistical tools.
6. Measure the blood pressure using sphygmomanometer.
7. Data collection, case studies or interviews of the individuals suffering from diseases; and Submission of report.

Teaching and Learning Process:

Different instructing strategies shall be adopted including: Lectures, interactive lectures, classroom discussions and practical based on a theory paper by analyzing blood glucose, water samples, soil samples, etc. Use of digital technologies will enable students to get a better understanding of the concepts. Hands-on experience, including diagnostics and student presentations will provide supplement to conventional text books. Field studies will include visits to laboratories for case studies or conducting interview of certain patients.

Assessment Methods:

- Closed-book tests to evaluate the students' knowledge and understanding of material covered in the class.
- Internal evaluation based on the experiment performed during the internal examination or class tests conducted by the internal examiners.
- Dimension of comprehension and capacity to respond to inquiries as a piece of *viva-voce*.
- Involvement in class and group discussions.
- Assignments and Power Point presentation.
- Project work (Students should execute one project of their choice or teacher may assign the project. Project report should be scanned for plagiarism through freely available software and a soft copy of the report should be mandatory).

Keywords:

Health, Hygiene, Deficiency disorders, Communicable diseases, Non-communicable diseases, Pollution, Smoking, Drug dependency, Hypertension

Recommended Books:

- Park, K. (2017), *Preventive and Social Medicine*, B.B. Publishers
- Brownson, R. C., Baker, E.A., Leet T.L., and Follespie K.N. (2003) *Evidence based Public Health*, Oxford University Press.

Suggested Readings:

- Guyton A.C. and Hall J.E. *Textbook of Medical Physiology*, Saunders
- Robbins and Cortan, *Pathologic basis of Disease*, VIII Edition, Saunders
- Engelkirk P.G. and Duben-Engelkirk J. (2015) *Burton's Microbiology for the Health Sciences*, 10th Edn. Wolters Kluwer Health.

Online Tools and Web Resources:

- https://swayam.gov.in/nd1_noc19_ee66/preview
- https://swayam.gov.in/nd1_noc19_ge24/preview
- https://swayam.gov.in/nd1_noc19_mg50/preview
- https://www.coursera.org/lecture/screening/case-1-hypertension-bfOLx
- https://www.coursera.org/lecture/sustainable-agriculture/water-quality-and-regulations-4uCE2
- https://www.eawag.ch/en/department/sandec/e-learning/moocs/

LS SEC 5: Sericulture

Course Learning Objective:

The course will make the student aware about the significance of sericulture as the profit-making enterprise. It will help the students to understand the biology of silkworms and its nutritional requirement to secrete quality silk. The course would clarify the techniques of silkworm rearing, reeling of silk and various measures to be taken to maximize the benefits. It would also help the students to know about various uses of silk and develop entrepreneurial skills required for self-employment in sericulture and silk production sector.

Course Learning Outcome:

Upon completion of the course, students should be able to:

- Learn about the history of sericulture and silk route.
- Recognize various species of silk moths in India, and Exotic and indigenous races.
- Be aware about the opportunities and employment in sericulture industry – in public, private and government sector.
- Gain thorough knowledge about the techniques involved in silkworm rearing and silk reeling.
- Develop entrepreneurial skills necessary for self-employment in mulberry and seed production and be apprised about practicing sericulture as a profit-making enterprise.
- Enhance collaborative learning and communication skills through practical sessions, team work, group discussions, assignments and projects.

Course Content:

Theory [Credits: 2] 30 hrs

Unit 1: Introduction 4 hrs

Sericulture: Definition, history and present status; Silk route; Types of silkworms, Distribution and Races; Exotic and indigenous; Mulberry sericulture; Non-mulberry Sericulture, Eri, Muga, Tasar

(Chapter 3, Section 3.1: Manual on Sericulture
http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

Unit 2: Biology of Silkworm 3 hrs

Life cycle of *Bombyxmori;* Structure of silk gland and secretion of silk; Composition and properties of silk

(Chapter 3, Section 3.1: Manual on Sericulture
http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

Unit 3: Rearing of Silkworms 14 hrs

Selection of mulberry variety and establishment of mulberry gardenRearing house and rearing appliancesDisinfectants: Formalin, bleaching powder, RKOSilkworm rearing technology: Early age and Late age rearing. Types of mountages.Harvesting and storage of cocoons.Post-harvest technology – Silk reeling, Dyeing and Weaving, Ahimsa silk

(Chapter 3, Section 3.3, 3.4, 3.5 and 3.6: Manual on Sericulture
http://agritech.tnau.ac.in/sericulture/seri_silkworm4_lateage%20rearing.html)

Unit 4: Pests and Diseases 4 hrs

Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial; Control and prevention of pests and diseases

(Chapter 4, Section 3.1: Manual on Sericulture
http://silks.csb.gov.in/coochbehar/wp-content/themes/common_district/coochbehar/dpm-frame2.html
http://agritech.tnau.ac.in/sericulture/disese%20mgt_silkworm.html)

Unit 5: Silk Industry and Its Importance 2 hrs

Silk usage and application in Textile and non-textile industry

(Sericulture:http://csb.gov.in/silk-sericulture/sericulture/
http://egyankosh.ac.in/bitstream/123456789/9070/1/Unit-1.pdf)

Unit 6: Entrepreneurship in Sericulture3 hrs

Prospectus of Sericulture in India: Sericulture industry in different states, Employment opportunities in mulberry and non-mulberry sericulturesector, Economics in small scale and large-scale silk worm rearing, Scope for women entrepreneurs in sericulture sector,

(http://csb.gov.in/services/training/entrepreneurship/
http://ministryoftextiles.gov.in/sites/default/files/note-on-sericulture-English-Jan2019.pdf
http://www.researchjournal.co.in/upload/assignments/5_188-190.pdf)

Practical [Credits: 2]

1. Study of the life cycle of different species of silk moths - *Bombyxmori, Philosamiaricini, Anthereapaphia/Anthereamylitta, Anthereaassama*and silk secreted by them.
2. Study of the sexual dimorphism in caterpillar, pupae and adults of *Bombyxmori.*
3. Study of the structure of silk gland of mulberry silk worms.
4. Study of rearing house and different appliances used in rearing of mulberry silk worms.
5. Study of the different disinfectants used in silkworm rearing houses.
6. Study of different types of mountages from specimen/photographs.
7. Analysis of silk fibre quality – Visual examination, thickness, purity.
8. Study of the parasites and predators of silk worms and their control - Uzi fly, Dermestid beetle, Vertebrates.
9. Study of silkworm diseases and their control – Pebrine, Flacherie, Grasserie, Muscardine.
10. Submission of a report on visit to 'Sericulture Institute'/ 'Various Sericulture Centres in India'.

Teaching and Learning Process:

Information and concepts about benefits of silkworms in human life and how these benefits can be reaped, will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through observations of silkworms in nature and study of rearing technology will be assisted through visits to various sericulture institutes which will create interest, enhance their understanding and inculcate entrepreneurial skills among students to set up SMEs. Blended learning including chalk-n-talk method and e-learning will be encouraged to make student's learning more dynamic. Inquiry-based collaborative learning environment through presentations, debates, group discussions, and roundtables on the various aspects of silkworm biology will be promoted to not only ensure effective learning and

understanding of the concepts, but also to inculcate confidence in the students. Field-based project activities and hands-on exposure have been added to make students aware about handling of worms and their rearing methods. Visit to various sericulture institutes will clarify their concepts about the bees and their rearing technology.

Assessment Methods:

Various measures adopted will be as follows.

- Class Tests: Regular class tests will judge the grasp of the topics by the students. It includes practice sessions as well as the ones in which evaluation is held.
- Projects and Assignments: Individual/group projects will inculcate independent thinking as well as the team work skills among the students. Assessment on the participation of each student, analytical skills and project outcome will be held.
- Regular Presentations: Presentations by the students on a topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries.
- *Viva-voce: Viva-voce* is a critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. Assessment of students through final exams analyses comprehensive knowledge gained by each student comparatively.

Keywords:

Cocoon, Disinfectant, Eri, Flacherie, Grasserie, Moriculture, Mountages, Muga, Mulberry, Muscardine, Pebrine, Rearing, Reeling, Sericulture, Silk moth, Tassar, Textile, Uzi fly, Weaving

Recommended Books:

- Manual on Sericulture (1976); Food and Agriculture Organisation, Rome
- Ullal, S.R. and NarasimhannaM.N. (1987) *Handbook of Practical Sericulture*; 3rd Edition, CSB, Bangalore

Suggested Readings:

- Yonemura, M. and Rama Rao, N. (1951) *A Handbook of Sericulture*. I. Rearing of silk-worms. Government Branch Press, Mysore.
- Ananthanarayanan, S. K. (2008). *Silkworm Rearing*. Daya Publishing House
- Aruga, H. (1994). *Principles of Sericulture*. CRC Press
- Sathe, T. V. and Jadhav, A. (2002) *Sericulture and Pest Management*. Daya Publishing House
- Yup-Lian, L. (1991) *Silkworm Diseases*. Food and Agricultural Organization.

Online Tools and Web Resources:

- Silkworm crop protection (https://swayam.gov.in/courses/152-silkworm-crop-protection)
- Sericulture (http://csb.gov.in/silk-sericulture/sericulture/)

- http://csb.gov.in/publications/videos/
- http://www.fao.org/3/x2099e/x2099e02.htm

LS SEC 6: Environmental Audit

Course Learning Objective:

An environmental audit as defined a systematic, documented verification process of objectively obtaining and evaluating audit evidence to determine whether specified environmental activities, events, conditions, management systems, or information about these matters conform with audit criteria, and communicating the results of this process. The International Chamber of Commerce defines environmental auditing as, "a management tool comprising a systematic documented, periodic and objective evaluation of how well environmental organization, management and equipment are performing with the aim of contributing to safeguarding the environment by facilitating management control of environmental practices and assessing

- To provide comprehension by the students on ethical principles of audit profession;
- To provide the understanding by the students of general chronology of audit, audit strategy, audit program and audit procedures;
- To provide the definition of the internal control system, control activity, to provide on how the financial reporting assertions are related to internal controls, and how the effectiveness of internal controls is assessed;
- To provide the view on audit risk assessment, its calculation and importance for audit strategy;
- To present to the students examples of analytical procedures and other types of substantive procedures performed on audit;
- To introduce the types of audit reports.

Course Learning Outcome:

On completion, students will be able to develop the appropriate documentation for an environmental impact statement and respond appropriately to an environment audit or environmental management system.

- To provide students with information in order to obtain competencies for environmental auditing
- how the environmental commitments by industry can be monitored and audited
- how potential environmental impacts are described in Environmental Impact Assessments (EIA)
- how industry controls their environmental impacts through Environmental Management Systems (EMS)
- how environmental management systems are audited
- how waste is generated and controlled
- other environmental management initiatives such as product life cycle analysis and sustainability Programs
- To develop ability to plan, execute and document the environmental audit.
- To develop entrepreneurial skills

Course Content:

Theory (Credits: 2) **30 hrs**

Unit 1: Understanding Pollution 10 hrs

Definition; pollution, Air Pollution: Air pollutants-Sources, primary and secondary pollutants and particulate matter, HAPs (hazardous air pollutants), Indoor pollution- different sources. Water Pollution: Sources- direct and indirect, impact of pollution on water bodies groundwater pollution – sources and effects. Wastes: Source, characteristics, types, and fate of solid wastes. Metal pollution: Metals in soil, food and water, elementary idea on metal pollution. Noise Pollution: General features, sources, noise classification, effects of sound pollution. Radiation Pollution: Man-made radiation, radiation hazards, nuclear accidents. Pesticide Pollution: Definition; sources, categories, pesticides in water and effects; elementary idea on IPM. Soil Pollution: Sources, types, effects of soil pollution
(Chapter 1, 2, 3, 4: Liu, Zhang, Liu; Chapter 9: Vasudevan)

Unit 2: Protection of Environment 7 hrs
International concerns and efforts for environmental protection; role of United Nations; Stockholm summit; priority issues; Rio Summit: Sustainable Development; Earth day; Environment day; ecotourism
(Chapter 9: Vasudevan; Chapter 1: Barrow; CPCB Report)

Unit 3: Environmental Audit 13 hrs
Introduction: Definition; types of auditing, Features of Effective Auditing, Program planning and organization of Auditing Program, Pre visit data collection, Auditing Protocol, Onsite Audit; Data Sampling; Inspection and Evaluation and Presentation, Audit Report; Action plan, Management of Audit, Benefits of Environmental Audit, Environmental Audit Program in India.
Case Study: Any one industries case study from following:- Construction, Metal Processing, Pharmaceutical, Electrical, Electronic, Fertilizer, Pesticide, any regional Industry.
(Chapter 1, 13, 14, 15, 16, 17, 18, 19 and 20: Srivastava)

Teaching and Learning Process:

The students will be able given information and concepts about benefits of environmental audits in Industries and recognise environmental impacts resulting from industrial activity. They will be taught how to how critically review an environmental management system. They will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject. Learning through case studies will be assisted through visits to industries which will create interest, enhance their understanding to prepare and perform a simple environmental audit and inculcate entrepreneurial skills among students.

Assessment Methods:

The assessment of students' achievement in immunology will be aligned with the course/program learning outcomes.

- Continuous evaluation of learning by formative and diagnostic evaluation should be followed at the University.
- Efforts should be made to measure cognitive as well as applied learning.
- Project work, quiz, problem solving exercise, classroom assessment methods, closed-book and open-book tests, problem-solving exercises, practical assignment, laboratory reports, seminar presentation, viva voce interviews, computerized adaptive testing, literature surveys and summative evaluations by end-semester examination *etc.* constitute the different components of the overall assessment.

- More over, students should be provided with feedback on their work with the aim of improving their academic performance.

Keywords:

Pollutants, Environment Protection and Management, Auditing, Environmental Audit Program.

Recommended Books:

- Environmental science by S. C. Santra, New Central Book Agency London, Third Edition, 2015. Humphrey N, Hadley M (2000)
- Environmental Auditing, Palladian Law Publishing Ltd, Cambridge, Isle of Wight. Hunt D, Johnson C (1995)

Suggested Readings:

- Environmental Management Systems, McGraw Hill, London. International Chamber of Commerce (1989), Environmental Auditing, June 1989, ICC Publication No 468, International Chamber of Commerce (ICC), Paris. International Chamber of Commerce (1991), ICC Guide to Effective Environmental Auditing. ICC Publication No 483, International Chamber of Commerce (ICC), Paris Smets H (1988) The cost of accidental pollution.

Online Tools and Web Resources:

- E-content on e-PG Pathshala portal of Government of Indiahttps://epgp.inflibnet.ac.in
- www.gpcb.gov.in
- www.cpcb.nic.in
- www.nptel.ac.in

Acknowledgements

Department of Zoology, University of Delhi duly acknowledges the contributors and reviewers in revising the B.Sc. (Program) Life Sciences syllabus in LOCF.

List of Contributors and Reviewers

Course Type	Course Name	Contributors Name	Reviewers Name
CC-I	Animal Diversity	C. L Jonwal P.P. Saini Shivani Tyagi	C. L Jonwal P.P. Saini Shivani Tyagi
CC-II	Comp Anatomy and Developmental Biology	Sanjukta Das Monica Misra Satish Ganta	Sanjukta Das Monica Misra Satish Ganta
CC-III	Physiology and Biochemistry	Rigzin Anju Jain Vatsala Dwivedi	Rigzin Anju Jain Vatsala Dwivedi
CC-IV	Genetics and Evolution	Chitra Bhasin Anshu Arora Anand Divya Gnaneshwari	Chitra Bhasin Anshu Arora Anand Divya Gnaneshwari
DSE-I	Animal Biotech	Rekha Kumari Neetu Kukreja Gauri Mishra	Rekha Kumari Neetu Kukreja Gauri Mishra
DSE-II	Applied Zoology	Anupam Varshney Satish Ganta Meena Yadav	Anupam Varshney Satish Ganta Meena Yadav
DSE-III	Aquatic Biology	Om Prakash Vandana Rani R. Moses	Om Prakash Vandana Rani R. Moses
DSE-IV	Immunology	Sadhna Gupta Soma M. Ghorai Dinesh Gautam	Sadhna Gupta Soma M. Ghorai Dinesh Gautam
DSE-V	Insect Vector and Disease	Jeepinder J. Kaur Anupam Varshney Sunita Yadav	Jeepinder J. Kaur Anupam Varshney Sunita Yadav
DSE-VI	Reproductive Biology	Smita Bhatia Brototi Roy Sunil Kumar	Smita Bhatia Brototi Roy Sunil Kumar
SEC-I	Apiculture	Rita Rath Sarita Kumar	Rita Rath Sarita Kumar
SEC-II	Aquarium Fish Keeping	Luni Om Prakash R. Moses	Luni Om Prakash R. Moses
SEC-III	Medical Diagnostics	Sunil Kayesth Neetu Bhattacharya Shilpa Bharti	Sunil Kayesth Neetu Bhattacharya Shilpa Bharti

Course Type	Course Name	Contributors Name	Reviewers Name
SEC-IV	Public Health and Hygiene	Anita Verma	Anita Verma
SEC-V	Sericulture	Sarita Kumar Rita Rath	Sarita Kumar Rita Rath
SEC-VI	Environmental Audit	Anita K Verma	Anita K Verma

B.SC. LIFE SCIENCE

CHEMISTRY COURSES OFFERED UNDER B.Sc. Life Science PROGRAMME (CBCS)

CORE COURSES (six credits each) – Each course has 4 Periods/week for Theory, 4 Periods/week for Practical			
SEMESTER	**COURSE CATEGORY**	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
I	CORE	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	T=4 P=2
II	CORE	Chemical Energetics, Equilibria and Functional Group Organic Chemistry-I	T=4 P=2
III	CORE	Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II	T=4 P=2
IV	CORE	Chemistry of s- and p-Block Elements, States of Matter and Chemical Kinetics	T=4 P=2

DISCIPLINE SPECIFIC ELECTIVE (DSE) (SIX credits each) **Two courses (**Chemistry of d-block elements, Quantum Chemistry and Spectroscopy and any one from the rest) **are offered in Semester V/VI**		
COURSE CATEGORY	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
CHEMISTRY DSE-1	Applications of Computers in Chemistry	T=4 P=2
CHEMISTRY DSE-2	Analytical Methods in Chemistry	T=4 P=2
CHEMISTRY DSE-3	Molecular Modelling & Drug Design	T=4 P=2
CHEMISTRY DSE-4	Novel Inorganic Solids	T=4 P=2
CHEMISTRY DSE-5	Polymer Chemistry	T=4 P=2
CHEMISTRY DSE-6	Research Methodology for Chemistry	T=4 P=2
CHEMISTRY DSE-7	Green Chemistry	T=4 P=2
CHEMISTRY DSE-8	Industrial Chemicals & Environment	T=4 P=2
CHEMISTRY DSE-9	Inorganic Materials of Industrial Importance	T=4 P=2
CHEMISTRY DSE-10	Instrumental Methods of Chemical Analysis	T=4 P=2
CHEMISTRY DSE-11	Chemistry of d-block elements, Quantum Chemistry and Spectroscopy (compulsory)	T=4 P=2
CHEMISTRY DSE-12	Organometallics, Bioinorganic chemistry, Polynuclear hydrocarbons and UV, IR Spectroscopy	T=4 P=2
CHEMISTRY DSE-13	Molecules of Life	T=4 P=2
CHEMISTRY DSE-14	Nanoscale Materials and their Applications	T=4 P=2
CHEMISTRY DSE-15	Dissertation	6

Skill Enhancement Courses (SEC) (four credits each) Any four courses from the following to be offered in Semester III/IV/V/VI		
COURSE CATEGORY	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
CHEMISTRY SEC-1	IT Skills for Chemists	T=4 P=2
CHEMISTRY SEC-2	Basic Analytical Chemistry	T=4 P=2
CHEMISTRY SEC-3	Chemical Technology & Society	T=4 P=2
CHEMISTRY SEC-4	Cheminformatics	T=4 P=2
CHEMISTRY SEC-5	Business Skills for Chemists	T=4 P=2
CHEMISTRY SEC-6	Intellectual Property Rights	T=4 P=2
CHEMISTRY SEC-7	Analytical Clinical Biochemistry	T=4 P=2
CHEMISTRY SEC-8	Green Methods in Chemistry	T=4 P=2
CHEMISTRY SEC-9	Pharmaceutical Chemistry	T=4 P=2
CHEMISTRY SEC-10	Chemistry of Cosmetics & Perfumes	T=4 P=2
CHEMISTRY SEC-11	Pesticide Chemistry	T=4 P=2
CHEMISTRY SEC-12	Fuel Chemistry	T=4 P=2

Student has to study 4 core papers in chemistry in semesters I, II, III & IV.

Student has to study 4 Skill Enhancement Courses (SEC), which can be chosen from Chemistry/Botany/Zoology. (At least ONE SEC of each discipline)

Student has to study 2 Discipline Specific Elective papers from Chemistry in semester V & VI.

Note: Wherever there is a practical there will be no tutorial and vice-versa. The size of the group for chemistry practical papers is recommended to be maximum of 15 to 20 students.

SEMESTER –I

Course Code: CHEMISTRY – Core Paper-1
Course Title: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons

Total Credits: 06 **(Credits: Theory-04, Practical-02)**
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It provides basic knowledge about ionic, covalent and metallic bonding and explains that chemical bonding is best regarded as a continuum between the three cases. It discusses the Periodicity in properties with reference to the *s* and *p* block, which is necessary in understanding their group chemistry. The course is also infused with the recapitulation of fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts, the classes of alkanes, alkenes, alkynes and aromatic hydrocarbons are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Learning Outcomes:

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

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization energy and electron affinity of elements.
- Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
- Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reaction mechanisms including free radical substitution, electrophilic addition and electrophilic aromatic substitution.

Section A: Inorganic Chemistry (Lectures:30)

Unit 1:

Atomic Structure

Review of: Bohr's theory and its limitations, Heisenberg uncertainty principle, Dual behaviour of matter and radiation, De-Broglie's relation, Hydrogen atom spectra, need of a new approach to atomic structure. What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom, radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation), radial and angular nodes and their significance, radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals.

Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of s, p and d atomic orbitals, nodal planes, discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, electronic configurations of the atoms, stability of half-filled and completely filled orbitals, concept of exchange energy, relative energies of atomic orbitals, anomalous electronic configurations.

(Lectures: 14)

Unit 2:

Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, statement of Born-Landé equation for calculation of lattice energy (no derivation), Born-Haber cycle and its applications, covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules. Ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR (H_2O, NH_3, PCl_5, SF_6, ClF_3, SF_4) and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+.

(Lectures: 16)

Section B: Organic Chemistry (Lectures:30)

Unit 3:

Fundamentals of Organic Chemistry

Electronic displacements: Inductive effect, electromeric effect, resonance, hyperconjugation. Cleavage of bonds: homolysis and heterolysis. Reaction intermediates: carbocations, carbanions and free radicals. Electrophiles and nucleophiles, Aromaticity: benzenoids and Hückel's rule.

(Lectures: 08)

Unit 4:

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane, interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations, concept of chirality (upto two carbon atoms). configuration: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; *cis* - *trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z nomenclature (for upto two C=C systems).

(Lectures: 10)

Unit 5:

Aliphatic Hydrocarbons

Functional group approach for the following reactions: preparations, physical property & chemical reactions to be studied with mechanism in context to their structure.

Alkanes:

Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, Grignard reagent.

Reactions: Free radical substitution: Halogenation.

Alkenes:

Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction).

Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes:

Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides and acidity of alkynes, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$. Hydration to form carbonyl compounds

(Lectures: 12)

Practical:

(Credits: 2, Laboratory periods: 60)

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of oxalic acid by titrating it with $KMnO_4$.

2. Estimation of Mohr's salt by titrating it with $KMnO_4$.

3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B: Organic Chemistry

1. Purification of organic compound by crystallisation (from water and alcohol) and distillation.

2. Criteria of purity: Determination of M.P./B.P.

3. Separation of mixtures by chromatography: Measure the Rf value in each case (combination of two compounds to be given)

a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by radial/ascending paper chromatography.

b) Identify and separate the sugars present in the given mixture by radial/ascending paper chromatography.

References:

Theory:

1. Lee., J. D. **A new Concise Inorganic Chemistry**, Pearson Education.
2. Huheey, J.E.; Keiter, E.; Keiter, R. (2009),**Inorganic Chemistry: Principles of Structure and Reactivity**, Pearson Publication.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A.(2010),**Shriver and Atkin's Inorganic Chemistry**, Oxford
4. Sykes, P.(2005), **A Guide Book to Mechanism in Organic Chemistry**, Orient Longman.
5. Eliel, E. L. (2000), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
6. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C.(1989),**Vogel's Textbook of Quantitative Chemical Analysis,** 5th Edn.**,** John Wiley and Sons Inc,.
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012),**Vogel's Textbook ofPractical Organic Chemistry**, Pearson.
3. Mann, F.G.; Saunders, B.C.(2009),**Practical Organic Chemistry**, Pearson Education.

Teaching Learning Process:

- Lectures in class rooms
- Peer assisted learning.
- Hands-on learning using 3-D models, videos, presentations, seminars
- Technology driven learning.
- Industry visits

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords

Atomic structures, Quantum numbers, Lattice energy, Electronic effects, Stereochemistry, Chemistry of aliphatic hydrocarbons.

SEMESTER-II

Course Code: CHEMISTRY –Core Paper-2
Course Title: Chemical Energetics, Equilibria and Functional Group Organic Chemistry-I

Total Credits: 06 **(Credits: Theory-04, Practical-02)**
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The objective of this paper is to develop basic understanding of the chemical energetics, laws of thermodynamics, chemical and ionic equilibrium. It provides basic understanding of the behaviour of electrolytes and their solutions. It acquaints the students with the functional group approach to study organic chemistry. To establish applications of this concept structure, methods of preparation and reactions for the following classes of compounds: Aromatic hydrocarbons, alkyl and aryl halides, alcohols, phenols and ethers, aldehydes and ketones are described. This course helps the students to relate the structure of an organic compound to its physical and chemical properties.

Learning Outcomes:

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

- Understand the laws of thermodynamics, thermochemistry and equilibria.
- Understand concept of pH and its effect on the various physical and chemical properties of the compounds.
- Use the concepts learnt to predict feasibility of chemical reactions and to study the behaviour of reactions in equilibrium.
- Understand the fundamentals of functional group chemistry through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
- Use concepts learnt to understand stereochemistry of a reaction and predict the reaction outcome
- Design newer synthetic routes for various organic compounds.

Section A: Physical Chemistry (Lectures:30)

Unit 1:

Chemical Energetics

Review of thermodynamics and the laws of thermodynamics, important principles and definitions of thermochemistry, concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, variation of enthalpy of a reaction with temperature – Kirchhoff's equation., statement of third law of thermodynamics and calculation of absolute entropies of substances.

(Lectures: 8)

Unit 2:

Chemical Equilibrium

Free energy change in a chemical reaction, Thermodynamic derivation of the law of chemical equilibrium, distinction between G and Go, Le Chatelier's principle, relationships between Kp, Kc and Kx for reactions involving ideal gases.

.

(Lectures: 8)

Unit 3:

Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, Ostwald's dilution law, ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect, salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions, Henderson-Hasselbach equation.Solubility and solubility product of sparingly soluble salts – applications of solubility product principle

(Lectures: 14)

Section B: Organic Chemistry (Lectures: 30)

Unit 4:

Aromatic Hydrocarbons

Structure and aromatic character of benzene.

Preparation**:** methods of preparation of benzene from phenol, benzoic acid, acetylene and benzene sulphonic acid.

Reactions**:** electrophilic substitution reactions in benzene citing examples of nitration, halogenation, sulphonation and Friedel-Craft's alkylation and acylation with emphasis on carbocationic rearrangement, side chain oxidation of alkyl benzenes.

(Lectures: 5)

Unit 5:

Alkyl and Aryl Halides

A) Alkyl halides (upto 5 carbons):

Structure of haloalkanes and their classification as 1º, 2º & 3º.

Preparation: starting from alcohols (1º, 2º & 3º) and alkenes with mechanisms.

Reactions: Nucleophilic substitution reactions with mechanism and their types (S_N1, S_N2 and S_Ni), competition with elimination reactions (elimination vs substitution), nucleophilic substitution reactions with

specific examples from: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation and Williamson's ether synthesis.

B) Haloarenes:

Structure and resonance

Preparation: Methods of preparation of chloro, bromo & iodobenzene from benzene (electrophilic substitution), from phenols (nucleophilic substitution reaction) and from aniline (Sandmeyer and Gattermann reactions).

Reaction: Nucleophilic aromatic substitution by OH group (Bimolecular Displacement Mechanism), Effect of nitro substituent on reactivity of haloarenes, Reaction with strong bases $NaNH_2/NH_3$ (elimination-addition mechanism involving benzyne intermediate), relative reactivity and strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(Lectures:11)

Unit 6:

Alcohols, Phenols, Ethers, Aldehydes and Ketones (Aliphatic and Aromatic)

A) Alcohols (upto 5 Carbon):

Structure and classification of alcohols as 1º, 2º & 3º.

Preparation: Methods of preparation of 1º, 2º & 3º by using Grignard reagent, ester hydrolysis and reduction of aldehydes, ketones, carboxylic acids and esters.

Reactions: Acidic character of alcohols and reaction with sodium, with HX (Lucas Test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic $K_2Cr_2O_7$ and conc. HNO_3), Oppeneauer Oxidation.

B) Diols (upto 6 Carbons): Oxidation and Pinacol-Pinacolone rearrangement.

C) Phenols: acidity of phenols and factors affecting their acidity.

Preparation: Methods of preparation from cumene, diazonium salts and benzene sulphonic acid.

Reactions: Directive influence of OH group and Electrophilic substitution reactions, viz. nitration, halogenation, sulphonation, Reimer-Tiemann reaction, Gattermann–Koch reaction, Houben-Hoesch condensation, reaction due to OH group: Schotten-Baumann reaction

D) Ethers (Aliphatic & Aromatic):

Williamson's ether synthesis, Cleavage of ethers with HI

E) Aldehydes and ketones (Aliphatic and Aromatic):

Preparation: from acid chlorides and from nitriles.

Reactions: Nucleophilic addition, nucleophilic addition – elimination reaction including reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test, Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemmensen reduction, Wolff Kishner reduction, Meerwein-Pondorff Verley reduction.

(Lectures:14)

Practical:

(Credits: 2, Laboratory periods: 60)

Section A: Physical Chemistry

Energetics:

1. Determination of heat capacity of calorimeter.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
4. Determination of enthalpy of hydration of copper sulphate.

Ionic equilibria:

1. Preparation of buffer solutions: (i) Sodium acetate-acetic acid or (ii) Ammonium chloride-ammonium acetate. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

Preparations: (Mechanism of various reactions involved to be discussed)

(Recrystallization, determination of melting point and calculation of quantitative yields to be done in all cases)

1. Bromination of phenol/aniline
2. Benzoylation of amines/phenols
3. Oxime of aldehydes and ketones
4. 2,4-dinitrophenylhydrazone of aldehydes and ketones
5. Semicarbazone of aldehydes and ketones

References:

Theory:

1. Castellan, G. W. (2004),**Physical Chemistry**, Narosa.
2. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**,Vol 1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L.(2015), **A Textbook of Physical Chemistry**, Vol 2, 6th Edition,McGraw Hill Education.
4. B.R.Puri, L.R.Sharma, M.S.Pathania, (2017),**Principles of Physical Chemistry**, Vishal Publishing Co.
5. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

7. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.

Practical:

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015),**Senior Practical Physical Chemistry**, R. Chand & Co.
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012),**Vogel's Textbook ofPractical Organic Chemistry**, Pearson.
3. Mann, F.G.; Saunders, B.C. (2009),**Practical Organic Chemistry**, Pearson Education.

Additional Resources:

1. Mahan, B. H.(2013),**University Chemistry**, Narosa.
2. Barrow, G.M. (2006). **Physical Chemistry**, 5th Edition,McGraw Hill.

Teaching Learning Process:

- The teaching learning process will involve the blended learning technique along with traditional chalk and black board method wherever required.
- Certain topics like stereochemistry of nucleophilic substitution, elimination reactions and their underlying stereochemistry, where traditional chalk and talk method may not be able to convey the concept, are especially taught through audio-visual aids.
- Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics.

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Chemical energetics, Feasibility of reaction, Hydrocarbons, Haloalkanes and haloarenes, Alcohols, Phenols and Ethers, Aldehydes and Ketones.

SEMESTER –III

Course Code: CHEMISTRY –Core Paper-3
Course Title: Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II

Total Credits: 06 **(Credits: Theory-04, Practical-02)**
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The students will learn about ideal and non-ideal solutions, Raoult's law, partially miscible and immiscible solutions and their applications. The student will also learn about equilibrium between phases with

emphasis on one component and simple eutectic systems. In electrochemical cells the students will learn about electrolytic and galvanic cells, measurement of conductance and its applications, measurement of emf and its applications.The topics of carbohydrates, amino acids, peptides and proteins are introduced through some specific examples. A relationship between structure, reactivity and biological properties of biomolecules is established through the study of these representative biomolecules.

Learning Outcomes:

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

- Explain the concepts of different types of binary solutions-miscible, partially miscible and immiscible along with their applications.
- Explain the thermodynamic aspects of equilibria between phases and draw phase diagrams of simple one component and two component systems.
- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand different types of galvanic cells, their Nernst equations, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses.
- Design newer synthetic routes for various organic compounds.

Section A: Physical Chemistry (Lectures:30)

Unit 1:

Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law- non-ideal solutions. Vapour pressure, composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions, Lever rule, Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids: principle of steam distillation, Nernst distribution law and its applications, solvent extraction.

(Lectures: 6)

Unit 2:

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium, Gibbs phase rule and its thermodynamic derivation, derivation of Clausius- Clapeyron equation and its importance in phase equilibria, phase diagrams of one component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

(Lectures: 6)

Unit 3:

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions, transference number and its experimental determination using Hittorf and moving boundary methods, Ionic mobility, applications of conductance measurements: determination of degree of ionization of weak electrolytes, solubility and solubility

products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

(Lectures: 8)

Unit 4:

Electrochemistry

Reversible and irreversible cells, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes, standard electrode potential, electrochemical series. thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data, concentration cells with transference and without transference, liquid junction potential and salt bridge, pH determination using hydrogen electrode and quinhydrone electrode, Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

(Lectures: 10)

Section B: Organic Chemistry (Lectures:30)

Unit 5:

Functional group approach for the following reactions: Preparations, physical & chemical properties to be studied in context to their structure with mechanism.

A) Carboxylic acids and their derivatives (aliphatic and aromatic)

Preparation: Acidic and alkaline hydrolysis of esters.

Reactions: Hell-Volhard Zelinsky reaction, acidity of carboxylic acids, effect of substitution on acid strength.

Carboxylic acid derivatives (aliphatic):

Preparation: Acid chlorides, anhydrides, esters and amides from acids and their interconversion, Claisen condensation.

Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky reaction, Perkin condensation.

B) Amines (aliphatic & aromatic) and Diazonium Salts

Amines

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Hofmann vs Saytzeff elimination, carbylamine test, Hinsberg test, reaction with HNO_2, Schotten-Baumann reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation, basicity of amines.

Diazonium salt

Preparation: from aromatic amines

Reactions: conversion to benzene, phenol and dyes.

(Lectures: 13)

Unit 6:

Amino Acids, Peptides and Proteins

Zwitterion, isoelectric point and electrophoresis

Preparation of amino acids: Strecker synthesis and using Gabriel's phthalimide synthesis.

Reactions of amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of primary structure of peptides by degradation Edmann degradation (N- terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C- activating groups and Merrifield solid-phase synthesis.

(Lectures: 9)

B) Carbohydrates

Classification, and general properties, glucose and fructose (open chain and cyclic structure), determination of configuration of monosaccharides, absolute configuration of glucose and fructose, mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

(Lectures:8)

Practical:

(Credits: 2, Laboratory periods: 60)

Section A: Physical Chemistry

Phase Equilibria

1. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
2. Determination of critical solution temperature and composition of phenol water system and study the effect of impurities on it.

Conductance

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:

a) Strong acid vs strong base

b) Weak acid vs strong base.

Potentiometry

Perform the potentiometric titrations of (i) Strong acid vs strong base and (ii) Weak acid vs strong base.

Section B: Organic Chemistry

Systematic qualitative analysis of organic compounds possessing monofunctional groups (Alcohols, Phenols, Carbonyl, -COOH). (Including Derivative Preparation).

References:

Theory:

1. Castellan, G.W. (2004),**Physical Chemistry**, Narosa.
2. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**,Vol 1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L. (2013),**A Textbook of Physical Chemistry**,Vol 3, 3rd Edition, McGraw Hill Education.
4. B.R.Puri, L.R.Sharma, M.S.Pathania, (2017),**Principles of Physical Chemistry**, Vishal Publishing Co.
5. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Practical:

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015),**Senior Practical Physical Chemistry**, R. Chand & Co.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Raoult's law, Lever rule, azeotropes, critical solution temperature, transference number, EMF, Carboxylic acids and derivatives, Amines and diazonium salts, Polynuclear and heterocyclic compounds

SEMESTER-IV

Course Code: CHEMISTRY –Core Paper-4
Course Title: Chemistry of s- and p-Block Elements, States of Matter and Chemical Kinetics

Total Credits: 06 **(Credits: Theory-04, Practical-02)**
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The objective of this paper is to provide basic understanding of the fundamental principles of metallurgy through study of the methods of extraction of metals, recovery of the by-products during extraction, applications of metals, alloy behaviour and their manufacturing processes. The course illustrates the diversity and fascination of inorganic chemistry through the study of properties and utilities of s- and p-block elements and their compounds. The students will learn about the properties of ideal and real gases and deviation from ideal behaviour, properties of liquid, types of solids with details about crystal structure. The student will also learn about the reaction rate, order, activation energy and theories of reaction rates.

Learning Outcomes:

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

- Understand the chemistry and applications of s- and p-block elements.
- Derive ideal gas law from kinetic theory of gases and explain why the real gases deviate from ideal behaviour.
- Explain Maxwell-Boltzmann distribution, critical constants and viscosity of gases.
- Explain the properties of liquids especially surface tension and viscosity.
- Explain symmetry elements, crystal structure specially NaCl, KCl and CsCl
- Define rate of reactions and the factors that affect the rates of reaction.
- Understand the concept of rate laws e.g., order, molecularity, half-life and their determination
- Learn about various theories of reaction rates and how these account for experimental observations.

Section A: Inorganic Chemistry (Lectures:30)

Unit 1:

General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

Hydrometallurgy with reference to cyanide process for silver and gold, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, van Arkel-De Boer process, Mond's process and Zone Refining.

(Lectures: 4)

Unit 2:

s- and p- block elements

Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Muliken, and Allred-Rochow scales). Allotropy in C, S, and P. Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group. ,compounds of s- and p-block elements , diborane and concept of multicentre bonding. Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial and environmental chemistry. Hydrides of nitrogen (NH_3, N_2H_4, N_3H, NH_2OH) Oxoacids of P, S and Cl, Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2.

(Lectures: 26)

Section B: Physical Chemistry (Lectures:30)

Unit 3:

Kinetic Theory of Gases

Postulates of kinetic theory of gases and derivation of the kinetic gas equation, deviation of real gases from ideal behaviour, compressibility factor, causes of deviation, van der Waals equation of state for real gases. Boyle temperature (derivation not required), critical phenomena, critical constants and their calculation from van der Waals equation, Andrews isotherms of CO_2, Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions, most probable, average and root mean square velocities (no derivation), collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules, viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(Lectures: 10)

Unit 4:

Liquids

Surface tension and its determination using stalagmometer, Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer, effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

(Lectures: 3)

Unit 5:

Solids

Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of crystallography - law of constancy of interfacial angles.

Law of rational indices, Miller indices. X–ray diffraction by crystals, Bragg's law, structures of NaCl, KCl and CsCl (qualitative treatment only), defects in crystals.Glasses and liquid crystals.

(Lectures: 6)

Unit 6:

Chemical Kinetics

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants), half–life of a reaction, general methods for determination of order of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Theories of reaction rates: Collision theory and activated complex theory of bi-molecular reactions. Comparison of the two theories (qualitative treatment only)

(Lectures: 11)

Practical:

(Credits: 2, Laboratory periods: 60)

Section A: Inorganic Chemistry

Semi-micro qualitative analysis of mixtures using H_2S or any other scheme- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations: NH_4^+, Pb^{2+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+

Anions: CO_3^{2-}, S^{2-} , SO_3^- , NO_2^- , CH_3COO^-, Cl^-, Br^-, I^-, NO_3^-,SO_4^{2-} , PO_4^{3-} , BO_3^{3-} , $C_2O_4^{2-}$, F^-.

(Spot tests should be carried out wherever feasible)

Section B: Physical Chemistry

1. Surface tension measurement (use of organic solvents excluded):

Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

2. Viscosity measurement (use of organic solvents excluded):

   a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.
   b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

3. Chemical Kinetics

   Study the kinetics of the following reactions by integrated rate method:

   a) Acid hydrolysis of methyl acetate with hydrochloric acid.
   b) Compare the strength of HCl and H_2SO_4 by studying the kinetics of hydrolysis methyl acetate.

References:

Theory:

1. Lee., J. D. **A new Concise Inorganic Chemistry**, Pearson Education.

2. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010),**Shriver and Atkin's Inorganic Chemistry**, Oxford.
3. Miessler, G. L.; Tarr, D.A.(2014), **Inorganic Chemistry**, Pearson.
4. Castellan, G. W.(2004),**Physical Chemistry**, Narosa.
5. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
6. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.
7. B.R.Puri, L.R.Sharma, M.S.Pathania, (2017),**Principles of Physical Chemistry,** Vishal Publishing Co.

Practical:

1. Svehla, G. (1996),**Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
2. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015),**Senior Practical Physical Chemistry**, R. Chand & Co.

Teaching Learning Process:

- Through chalk and board method.
- Revising and asking questions from students at the end of class
- Motivating students to do some activity related to the topic
- Power point presentation
- Correlating the topic with real life cases.
- Quiz contest among students on important topic.

Assessment Methods:

1. Graded assignments
2. Conventional class tests
3. Class seminars by students on course topics with a view to strengthening the content through width and depth
4. Quizzes
5. End semester university examination.

Keywords:

Metallurgy, Periodicity, Anomalous behaviour, Ellingham diagrams, Hydrometallurgy, Allotropy, Diagonal relationship, Multicentre bonding, Ideal/real gases, Surface tension, Viscosity, Crystal systems, Rate Law, Rate constant

CHEMISTRY DISCIPLINE ELECTIVE COURSES (DSE)

Chemistry of d block elements, Quantum Chemistry and Spectroscopy is compulsory. Choose any one more.

Course Code: CHEMISTRY –DSE-1
Course Title: Applications of Computers in Chemistry

Total Credits: 06 (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory- 60, Practicals-60)

Objectives:

The aim of this paper is to make the students learn the working of computer and its applications in chemistry via programming language, QBASIC and use of software as a tool to understand chemistry, and solve chemistry based problems.

Learning Outcomes:

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

- Have knowledge of most commonly used commands and library functions used in QBASIC programming.
- Develop algorithm to solve problems and write corresponding programs in BASIC for performing calculations involved in laboratory experiments and research work.
- Use various spreadsheet software to perform theoretical calculations and plot graphs

Unit 1:

Basic Computer system (in brief)

Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, Octal and Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String constants and variables. Operating Systems (DOS, WINDOWS, and Linux); Software languages: Low level and High Level languages (Machine language, Assembly language; QBASIC, FORTRAN and C++); Compiled versus interpreted languages. Debugging Software Products (Office, chemsketch, scilab, matlab, and hyperchem), internet application

(Lectures: 5)

Unit 2:

Use of Programming Language for solving problems in Chemistry

Computer Programming Language- QBASIC, (for solving some of the basic and complicated chemistry problems). QB4 version of QBASIC can be used.

Programming Language – QBASIC; arithmetic expressions, hierarchy of operations, inbuilt functions. Syntax and use of the following QBASIC commands: INPUT and PRINT; GOTO, If, ELSEIF, THEN and END IF ; FOR and NEXT; Library Functions (ABS, ASC, CHR$, EXP,INT, LOG, RND, SQR,TAB and trigonometric Functions), DIM, READ, DATA, REM, RESTORE, DEF FNR, GOSUB, RETURN, SCREEN, VIEW, WINDOW, LINE, CIRCLE, LOCATE, PSET

Simple programs using above mentioned commands.

Solution of quadratic equation, polynomial equations (formula, iteration, Newton – Raphson methods, binary bisection and Regula Falsi); Numerical differential, Numerical integration (Trapezoidal and Simpson's rule), Simultaneous equations, Matrix addition and multiplication, Statistical analysis.

QBASIC programs for Chemistry problems - Example: plotting van der Waals Isotherms (Simple Problem, available in general text books) and observe whether van der Waal gas equation is valid at temperatures lower than critical temperature where we require to solve a cubic equation and calculation of area under the curves (Complicated Problem, not available in general text books).

(Lectures: 40)

Unit 3:

Use of Software Products

Computer Software like Scilab, Excel, LibreOffice and Calc , to solve some of the plotting or calculation problems, Handling of experimental data

(Lectures: 15)

Practical:

(Credits: 2, Laboratory periods: 60)

Computer programs using QBASIC based on numerical methods

1. Roots of equations: (e.g. volume of gas using van der Waals equation and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/ enthalpy change from heat capacity data).
4. Probability distributions (gas kinetic theory) and mean values.
5. Mean, standard deviation and Least square curve fitting method for linear equation.
6. Matrix operations: addition, multiplication and transpose
7. Graphic programs related to Chemistry problems. e.g. van der Waals isotherm, Compressibility versus pressure curves, Maxwell distribution curves, concentration-time graph, pH metric titration curve, conductometric titration curves, Lambert Beer's law graph, s, p, d orbital shapes, radial distribution curves, particle in one dimensional box.

Use of Software Products

1. Computer Software like Scilab and Excel, etc for data handling and manipulation.

2. Simple exercises using molecular visualization software.

3. Open source chemistry software to draw structures.

References:

Theory:

1. McQuarrie, D. A.(2008), **Mathematics for Physical Chemistry,** University Science Books.
2. Mortimer, R.(2005), **Mathematics for Physical Chemistry**,3rd Edition, Elsevier.
3. Steiner, E.(1996),**The Chemical Maths Book,** Oxford University Press.
4. Yates, P. (2007),**Chemical Calculations**, CRC Press.
5. Harris, D. C. (2007),**Quantitative Chemical Analysis**,6th Edition, Freeman, Chapters 3-5.

Practical:

1. Levie, R.D.(2001),**How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge University Press.
2. Noggle, J. H.(1985), **Physical Chemistry on a Microcomputer**, Little Brown & Co.
3. Venit, S.M.(1996),**Programming in BASIC: Problem solving with structure and style**, Jaico Publishing House.

Teaching Learning Process:

Conventional methods of teaching i.e. lectures, PPTs, Complete demonstrations of computer systems in chemistry using QBASIC -a DOS based language. Using DOSBOX emulator for different operating systems and running QB45 in it can solve this problem. Another version that runs on WINDOWS is QB64. This is compatible with most of the QBASIC commands.

Assessment Methods:

- The students to be assigned projects based on chemistry problems done in class or in practical classes and use BASIC program to solve it. The projects to be a part of internal assessment.
- Presentation
- Test
- Semester end examination

Keywords:

Hardware, software, programming language, ASCII, BCD, QBASIC, Library commands, mathematical operators, QBASIC commands.

Course Code: CHEMISTRY –DSE-2
Course Title: Analytical Methods in Chemistry
Total Credits: 06 (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory- 60, Practicals-60)

Objectives:

The objective of this course is to make student aware of the concept of sampling, Accuracy, Precision, Statistical test data-F, Q and t test. The course exposes students to the laws of spectroscopy and selection rules governing the possible transitions in the different regions of the electromagnetic spectra. Thermal and electroanalytical methods of analysis are also dealt with. Students are exposed to important separation methods like solvent extraction and chromatography. The practicals expose students to latest instrumentation and they learn to detect analytes in a mixture.

Learning Outcomes:

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

- Perform experiment with accuracy and precision.
- Develop methods of analysis for different samples independently.
- Test contaminated water samples.
- Understand basic principle of instrument like Flame Photometer, UV-vis spectrophotometer.
- Learn separation of analytes by chromatography.
- Apply knowledge of geometrical isomers and keto-enol tautomers to analysis.
- Determine composition of soil.
- Estimate macronutrients using Flame photometry.

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 of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

(Lectures: 5)

Unit 2:

Optical methods of analysis

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Transmittance. Absorbance and Beer-Lambert law

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs). Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal, Techniques for the quantitative estimation of trace level of metal ions from water samples.

(Lectures: 25)

Unit 3:

Thermal methods of analysis:

Theory of thermogravimetry (TG) and basic principle of instrumentation of thermal analyser. Techniques for quantitative estimation of Ca and Mg from their mixture.

(Lectures: 5)

Unit 4:

Electroanalytical methods

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations.Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

(Lectures:10)

Unit 5:

Separation techniques

Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation, Technique of extraction: batch, continuous and counter current extractions, Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

Chromatography: Classification, principle and efficiency of the technique, Mechanism of separation: adsorption, partition & ion-exchange, Development of chromatograms: frontal, elution and displacement methods.

(Lectures:15)

Practical:

(Credits: 2, Laboratory periods: 60)

1. Separation of mixtures by paper chromatography and reporting the R_f values:
   (i) Co^{2+} and Ni^{2+}.
   (ii) Amino acids present in the given mixture.
2. Solvent Extractions

(i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+} DMG complex in chloroform, and determine its concentration by spectrophotometry.

3. Analysis of soil:

(i) Determination of pH of soil.
(ii) Total soluble salt
(iii) Estimation of calcium and magnesium
(iv) Qualitative detection of nitrate and phosphate

4. Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
(ii) Separation of amino acids from organic acids by ion exchange chromatography.

5. Spectrophotometry

(i) Verification of Lambert-Beer's law and determination of concentration of a coloured species ($CuSO_4$, $KMnO_4$, $CoCl_2$, $CoSO_4$)
(ii) Determination of concentration of coloured species via following methods;
1. Graphical method, (b) Epsilon method, (c) Ratio method, (iv) Standard addition method

References:

Theory:

1. Willard, H.H.(1988),**Instrumental Methods of Analysis**, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D.(2004),**Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C.(2007),**Quantitative Chemical Analysis**,6th Edition, Freeman.
4. Khopkar, S.M. (2008), **Basic Concepts of Analytical Chemistry,** New Age International Publisher.
5. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis,** Thomson Asia Pvt. Ltd.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C.(1989),**Vogel's Textbook of Quantitative Chemical Analysis**,John Wiley and Sons.

Teaching Learning Process:

- Teaching through audio-visual aids.
- Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Assessment Methods:

- Presentations by individual student/ small group of students
- Class tests at periodic intervals.
- Written assignment(s)
- Objective type chemical quizzes based on contents of the paper.
- End semester university theory and practical examination.

Keywords:

Separation techniques, Solvent extraction, Ion-exchange, Optical methods, Flame Atomic Absorption and Emission Spectrometry, indeterminate errors, statistical test of data; F, Q and t tests. TGA.

Course Code: CHEMISTRY –DSE-3
Course Title: Molecular Modelling and Drug Design
Total Credits: 06 (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory- 60, Practicals-60)

Objectives:

Objective of this course is to make students learn the theoretical background of principles of computational techniques in molecular modelling, evaluation and applications of different methods for various molecular systems, energy minimization techniques, analysis of Mulliken Charge & ESP Plots and elementary idea of drug design.

Learning Outcomes:

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

- Understand theoretical background of computational techniques and selective application to various molecular systems.
- Learn Energy minimization methods through use of different force fields.
- Learn ESP Plots by suitable soft wares, electron rich and electron deficient sites,
- Compare computational and experimental results and explain deviations.
- Carry out Molecular dynamics (MD) and Monte Carlo (MC) simulations on several molecules and polymers.
- Learn QSAR properties and their role in molecular modelling, cheminformatics and drug discovery.
- Perform Optimization of geometry parameters of a molecule (such as shape, bond length and bond angle) through use of software like Chem Sketch and Argus Lab in interesting hands-on exercises.

Unit 1:

Introduction: Overview of Classical and Quantum Mechanical Methods (Ab initio, Semi-empirical, Molecular Mechanics, Molecular Dynamics and Monte Carlo) General considerations.

Coordinate systems: Cartesian and Internal Coordinates, Bond lengths, bond angles and torsion angles, Writing Z -matrix (ex: methane, ethane, ethene, ethyne, water, H_2O_2 .

(Lectures: 8)

Unit 2:

Potential Energy Surfaces: Intrinsic Reaction Coordinates, Stationary points, Equilibrium points – Local and Global minima, concept of transition state with examples: Ethane, propane, butane, cyclohexane. Meaning of rigid and relaxed PES.

Applications of computational chemistry to determine reaction mechanisms.

Energy Minimization and Transition State Search: Geometry optimization, Methods of energy minimization: Multivariate Grid Search, Steepest Descent Method, Newton-Raphson method and Hessian matrix.

(Lectures: 12)

Unit 3:

Molecular Mechanics: Force Fields, Non-bonded interactions (van der Waals and electrostatic), how to handle torsions of flexible molecules, van der Waals interactions using Lennard-Jones potential, hydrogen bonding interactions, electrostatic term, Parameterization. Applications of MM, disadvantages, Software, Different variants of MM: MM1, MM2, MM3, MM4, MM+, AMBER, BIO+, OPLS.GUI.

(Lectures: 10)

Unit 4:

Molecular Dynamics: Radial distribution functions for solids, liquids and gases, intermolecular Potentials (Hard sphere, finite square well and Lennard-Jones potential), concept of periodic box, ensembles (microcanonical, canonical, isothermal – isobaric), Ergodic hypothesis. Integration of Newton's equations (Leapfrog and Verlet Algorithms), Rescaling, Simulation of Pure water – Radial distribution curves and interpretation, TIP & TIP3P, Typical MD simulation

Brief introduction to Langevin and Brownian dynamics

Monte Carlo Method: Metropolis algorithm.

(Lectures: 10)

Unit 5:

Huckel MO with examples: ethane, propenyl, cyclopropenyl systems, Properties calculated – energy, charges, dipole moments, bond order, electronic energies, resonance energies, Oxidation and reduction (cationic and anionic species of above systems)

Extension to Extended Huckel theory and PPP methods

***Ab-initio* methods:** Writing the Hamiltonian of a system, Brief recap of H – atom solution, Units in quantum mechanical calculations, Born-Oppenheimer approximation (recap), Antisymmetry principle, Slater determinants, Coulomb and Exchange integrals,

Examples of He atom and hydrogen molecule, Hartree-Fock method

Basis sets, Basis functions, STOs and GTOs, diffuse and polarization functions. Minimal basis sets

Advantages of ab initio calculations, Koopman's theorem, Brief idea of Density Functional Theory

(Lectures: 12)

Unit 6:

Semi-empirical methods: Brief idea of CNDO, INDO, MINDO/3, MNDO, AM1, PM3 methods. Other file formats – PDB. Visualization of orbitals – HOMO, LUMO, ESP maps.

QSAR: Structure-activity relationships. Properties in QSAR (Partial atomic charges, polarizabilities, volume and surface area, log P, lipophilicity and Hammet equation and applications, hydration energies, refractivity). Biological activities (LD50, IC50, ED50.)

(Lectures: 8)

Practical:

(Credits: 2, Laboratory periods: 60)

1. Plotting a 3D graph depicting a saddle point in a spreadsheet software.

2. Determine the enthalpy of isomerization of cis and trans 2-butene.

3. Determine the heat of hydrogenation of ethylene.

4. Compare the optimized C-C bond lengths and Wiberg bond orders in ethane, ethene, ethyne and benzene using PM3. Is there any relationship between the bond lengths and bond orders? Visualize the highest occupied and lowest unoccupied molecular orbitals of ethane, ethene, ethyne, benzene and pyridine.

5. Perform a conformational analysis of butane.

6. Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine by comparison of their Mulliken charges and ESP maps.

7. Compare the gas phase basicities of the methylamines by comparing the enthalpies of the following reactions:

$BH^+ + NH_3 \rightarrow B + NH_4^+$

where B = CH_3NH_2, $(CH_3)_2NH$, $(CH_3)_3N$

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. Compare the optimized bond angles H_2O, H_2S, H_2Se using PM3.

10. Compare the HAH bond angles for the second row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory.

11. (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).

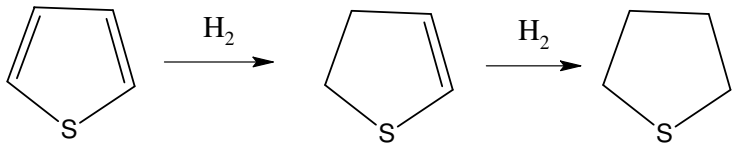
12. Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.

13. Plot the electrostatic potential mapped on electron density for benzene and use it to predict the type of stacking in the crystal structure of benzene dimer.

14. Predict the aromaticity of thiophene with respect to benzene by comparing the enthalpies of the following reactions:

(a) Hydrogenation of benzene to 1,3-cyclohexadiene and then 1,3-cyclohexadiene to cyclohexene.

(b)



15. Docking of Sulfonamide-type D-Glu inhibitor into MurD active site using Argus lab.

Note: Software: Argus Lab (www.planaria-software.com).

References:

Theory:

1. Lewars, E. (2003), **Computational Chemistry**, Kluwer academic Publisher.
2. Cramer, C.J.(2004),**Essentials of Computational Chemistry**, John Wiley & Sons.
3. Hinchcliffe, A. (1996),**Modelling Molecular Structures**, John Wiley & Sons.
4. Leach, A.R.(2001),**Molecular Modelling**, Prentice-Hall.

Practical:

1. Lewars, E. G. (2011),**Computational Chemistry**, Springer (India) Pvt. Ltd. Chapter 1 & 2.
2. Engel, T.; Reid, P.(2012),**Physical Chemistry**, Prentice-Hall. Chapter 26.

Teaching Learning Process:

Conventional methods of teaching i.e. lectures, PPTs, Hands on practice of molecule centric problems with maximum characterization parameters and recently designed lead drug molecules

Assessment Methods:

- Assignment based on Theoretical designing of small molecules of drug prospective
- Presentation on fundamentals of drug designing and molecular modelling
- Test
- Semester end examination

Keywords:

Molecular modelling, Quantum Mechanical Method, Cartesian Coordinates, Molecular Dynamics, Force Field, Software of Computational Chemistry.

Course Code: CHEMISTRY –DSE-4
Course Title: Novel Inorganic Solids
Total Credits: 06 **(Credits: Theory-04, Practicals-02)**
(Total Lectures: Theory- 60, Practicals-60)

Objectives:

Solid-state chemistry also referred as material chemistry currently has emerged with great focus on novel inorganic solids. It has found enormous applications in both industrial and research arenas and has helped to shape modern day recyclable adsorbents and catalysts. Novel inorganic-organic hybrid nanocomposites have received a lot of attention because of their abundance and cost-effective nature they can be utilized as catalysts, as a nano reactor to host reactants for synthesis and for the controlled release of biomolecules. Materials such as semiconductors, metals, composites, nanomaterials, carbon or high-tech ceramics make life easier in this era and are great sources of industrial growth and technological changes. Therefore, its exposure to the undergraduates with science backgrounds can groom them for future researches.

Learning Outcomes:

By the end of the course, the student will be able to:

- Understand the mechanism of solid-state synthesis.
- Explain about the different characterization techniques and their principle.
- Understand the concept of nanomaterials, their synthesis and properties.
- Explain the mechanism of growth of self-assembled nanostructures.
- Appreciate the existence of bioinorganic nanomaterials.
- Explain the importance of composites, conducting polymers and their applications.
- Understand the usage of solid materials in various instruments, batteries, etc. which would help them to appreciate the real life importance of these materials

Unit 1:

Basic introduction to solid-state chemistry: Semiconductors, different types of semiconductors and their applications.

Synthesis of inorganic solids: Conventional heat and beat method, Co-precipitation method, Sol-gel method, Hydrothermal method, Chemical vapor deposition (CVD), Ion-exchange and Intercalation method.

(Lectures: 10)

Unit 2:

Characterization techniques of inorganic solids: Powder X-ray Diffraction, UV-visible spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Fourier-Transform Infrared (FTIR) spectroscopy, Brunauer–Emmett–Teller (BET) surface area analyser, Dynamic Light Scattering (DLS)

(Lectures: 10)

Unit 3:

Cationic, anionic and mixed solid electrolytes and their applications. Inorganic pigments – coloured, white and black pigments.

One-dimensional metals, molecular magnets, inorganic liquid crystals.

(Lectures: 10)

Unit 4:

Nanomaterials: Overview of nanostructures and nanomaterials, classification, preparation and optical properties of gold and silver metallic nanoparticles, concept of surface plasmon resonance, carbon nanotubes, inorganic nanowires, Bioinorganic nanomaterials, DNA and its nanomaterials, natural and artificial nanomaterials, self-assembled nanostructures, control of nanoarchitecture, one dimensional control.

(Lectures: 10)

Unit 5:

Composite materials: Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, bio-nanocomposites, environmental effects on composites, applications of composites.

(Lectures: 10)

Unit 6:

Speciality polymers: Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene, polyanilineand polypyrrole, applications of conducting polymers, ion-exchange resins and their applications.

Ceramic & Refractory: Introduction, classification, properties, manufacturing and applications of ceramics, refractory and superalloys as examples.

(Lectures: 10)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Practical: Novel Inorganic Solids

1. Synthesis of silver nanoparticles by chemical methods and characterization using UV-visible spectrophotometer.

2. Synthesis of silver nanoparticles by green approach methods and characterization using UV-visible spectrophotometer.

3. Preparation of polyaniline and its characterization using UV-visible spectrophotometer.

4. Synthesis of metal sulphide nanoparticles (MnS, CdS, ZnS, CuS, NiO) and characterization using UV-visible spectrophotometer.

5. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.

6. Synthesis of inorganic pigments ($PbCrO_4$, $ZnCrO_4$, Prussian Blue, Malachite).

7. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.

8. Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using zeolite.

References:

Theory:

1. West, A. R. (2014), **Solid State Chemistry and Its Application**, Wiley.
2. Smart, L. E.; Moore, E. A., (2012),**Solid State Chemistry: An Introduction** CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997),**New Direction in Solid State Chemistry**, Cambridge University Press.
4. Poole Jr.; Charles P.; Owens, Frank J. (2003), **Introduction to Nanotechnology**, John Wiley and Sons.

Practicals:

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; **Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory**,J. Chem. Educ. 2015, 92, 339–344.
2. MacDiarmid, G.; Chiang, J.C.; Richter, A.F.; Somasiri, N.L.D.(1987), **Polyaniline: Synthesis and Characterization of the Emeraldine Oxidation State by Elemental Analysis**, L. Alcaeer (ed.), Conducting Polymers, 105-120, D. Reidel Publishing.
3. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981),**Hexagonal Tungsten Trioxide and Its Intercalation Chemistry**, Solid State Ionics, 5, 1981, 355-358.
4. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; **Synthesis of ZnO Nanoparticles by Precipitation Method**, Orient J Chem 2015, 31(2).

Teaching Learning Process:

Blackboard, Power point presentations, Assignments, Field Trips to Industry, Different working models ICT enabled classes, Interactive sessions, Debate, recent literature using internet and research articles.

Assessment Methods:

Students' evaluation will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Solid State Chemistry, Nanomaterials, Solid electrolyte, Inorganic Pigments, Self-assembled, Composite Materials, Instrumentation, Polymers.

Course Code: CHEMISTRY –DSE-5
Course Title: Polymer Chemistry
Total Credits: 06 **(Credits: Theory-04, Practical-02)**
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The primary objective of this paper is to help the student to know about the synthesis, properties and applications of polymers.

Learning Outcomes:

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

- Know about history of polymeric materials and their classification
- Learn about different mechanisms of polymerization and polymerization techniques
- Evaluate kinetic chain length of polymers based on their mechanism
- Differentiate between polymers and copolymers
- Learn about different methods of finding out average molecular weight of polymers
- Differentiate between glass transition temperature (Tg) and crystalline melting point (Tm)
- Determine Tg and Tm
- Know about solid and solution properties of polymers
- Learn properties and applications of various useful polymers in our daily life.

This paper will give glimpse of polymer industry to the student and help them to choose their career in the field of polymer chemistry.

Unit 1:

Introduction and history of polymeric materials:

History of polymeric materials, Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers

Functionality and its importance:

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization Bifunctional systems, Poly-functional systems

(Lectures: 12)

Unit 2:

Kinetics of Polymerization

Mechanism of step growth polymerization, kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic), Mechanism and kinetics of copolymerization, polymerization techniques

(Lectures: 8)

Unit 3:

Glass transition temperature (Tg) and determination of Tg, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).

Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

Nature and structure of polymers-Structure Property relationships

(Lectures: 14)

Unit 4:

Determination of molecular weight of polymers (M_n, M_w, etc.) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index

Polymer Solution

Criteria for polymer solubility and Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy and free energy change of mixing of polymers solutions.

Polymer Degradation

Thermal, oxidative, hydrolytic and photodegradation

(Lectures: 16)

Unit 5:

Properties of Polymers

(Physical, thermal, Flow & Mechanical Properties) Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novolac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers: polyacetylene, polyaniline, poly(p-phenylene sulphide, polypyrrole, polythiophene

(Lectures: 10)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab: Polymer chemistry

Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA)/MethylAcrylate (MA).

2. Preparation of nylon 6,6

3. Redox polymerization of acrylamide

4. Precipitation polymerization of acrylonitrile

5. Preparation of urea-formaldehyde resin

6. Preparations of novalac resin/resold resin.

7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight of polyvinyl propylidene in water by viscometry:

2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of head-to-head monomer linkages in the polymer.

3. Determination of molecular weight by end group analysis of polymethacrylic acid.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method

2. IR studies of polymers

3. DSC (Differential Scanning Calorimetry) analysis of polymers

4. TG-DTA (Thermo-Gravimetery-Differential Thermal Analaysis) of polymers

Suggested Additional Experiment:

1. Purification of monomer.
2. Emulsion polymerization of a monomer.

References:

Theory:

1. Carraher,C. E. Jr. (2013), **Seymour's Polymer Chemistry**, Marcel Dekker, Inc.
2. Odian, G. (2004), **Principles of Polymerization**, John Wiley.
3. Billmeyer, F.W. (1984),**Text Book of Polymer Science**, John Wiley.
4. Ghosh, P. (2001),**Polymer Science & Technology**, Tata Mcgraw-Hill.
5. Lenz, R.W. (1967),**Organic Chemistry of Synthetic High Polymers**, Intersecience (Wiley).

Practical:

1. Allcock, H.R.; ; Lampe, F. W.; Mark, J. E. (2003),**Contemporary Polymer Chemistry**, Prentice-Hall.
2. Fried, J.R. (2003), **Polymer Science and Technology**, Prentice-Hall.
3. Munk, P.; Aminabhavi, T. M. (2002), **Introduction to Macromolecular Science,** John Wiley & Sons.
4. Sperling, L.H.(2005),**Introduction to Physical Polymer Science**, John Wiley & Sons.

Teaching-Learning Process:

- Teaching learning process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Bonding, Texture, Polymerization, Degradation, Polymer solution, Crystallization, Properties, Applications.

Course Code: CHEMISTRY –DSE-6
Course Title: Research Methodology For Chemistry
Total Credits: 06 (Credits: Theory-05, Tutorial-01)
(Total Lectures: Theory- 75, Tutorial-15)

Objectives:

The objective of this paper is to formulate the research problems and connect the research outcomes to the society. Student should be able to assess the local resources and opportunities in public domains. It further helps in gaining the knowledge of safety and ethical handlings of chemicals in lab and households.

Learning Outcomes:

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

- Learn how to identify research problems.
- Evaluate local resources and need for addressing the research problem
- Find out local solution.
- Know how to communicate the research findings.

Unit 1:

Literature Survey

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information. Open source Lead lectures. Open source chemistry designing sources, Essentials of Problem formulation and communication with society.

(Lectures: 20)

Unit 2:

Methods of Scientific Research and Writing Scientific Papers

Reporting practical and project work. Idea about public funding agencies of research, Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism. Assessment of locally available resources.

(Lectures: 20)

Unit 3:

Chemical Safety and Ethical Handling of Chemicals

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric level. Safe storage and disposal of waste chemicals. Recovery, recycling and reuse of laboratory chemicals. Procedure for laboratory disposal of explosives. Identification, verification and segregation of laboratory waste.Disposal of chemicals in the sanitary sewer system.Incineration and transportation of hazardous chemicals.

(Lectures: 12)

Unit 4:

Data Analysis

The Investigative Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments.

Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis.

Biostatistics: brief introduction and data handling.

(Lectures: 13)

Exposure of chemistry software

Chemistry Students must be given exposure to applications of molecular modelling softwares e.g. Hyperchem, Schrodinger etc. Hands on experiments of docking.

(Lectures: 10)

References:

Theory:

1. Dean, J.R.; Jones, A.M.; Holmes, D;, Reed, R.; Jones, A.Weyers, J. (2011),**Practical skills in chemistry**, Prentice-Hall.
2. Hibbert, D.B.; Gooding, J.J. (2006),**Data analysis for chemistry**, Oxford University Press.
3. Topping, J.(1984),**Errors of observation and their treatment,** Chapman Hall, London.
4. Levie, R. de.(2001),**How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge University Press.
5. Le, C.T.; Eberly,L.E. (2016),**Introductory Biostatistics**, Wiley.

Additional References:

1. **Chemical safety matters IUPAC – IPCS**, Cambridge University Press, 1992.
2. **OSU safety manual** 1.01.

Teaching Learning Process

Lecture with conventional teaching aids, presentations, invited talks on thrusting areas, group discussions, literature survey and lab visit.

Assessment Methods

- Internal assessment through assignments and class test.
- Writing review on identified research problem
- Poster presentation
- End semester university examination

Keywords

Review of research papers, writing research papers, citation, and Laboratory safety.

Course Code: CHEMISTRY –DSE-7
Course Title: Green Chemistry
Total Credits: 06 (Credits: Theory-04, Practical-02)
(Total Lectures: Theory- 60, Practical-60)

Objectives:

Today's society is moving towards becoming more and more environmentally conscious. There is rising concern of environmental pollution, depleting resources,climate change, ozone depletion, heaps and heaps of landfills piling up, legislation which is getting stringent with strict environmental laws,,rising cost of waste deposits and so on. We are faced with a challenge to work towards sustainable practices.Green chemistry has arisen from these concerns.It is not a new branch of chemistry but the way chemistry should be practiced.

Innovations and applications of green chemistry in education has helped companies not only gain environmental benefits but at the same time achieve economic and societal goals also. This is possible because these undergraduate students are ultimate scientific community of tomorrow.

Learning Outcomes:

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

- Understand the twelve principles of green chemistry and will build the basic understanding of toxicity,hazard and risk of chemical substances.
- Understand stoichiometric calculations and relate them to green chemistry metrics.They will learn about atom economy and how it is different from percentage yield.
- Learn to design safer chemical ,products and processes that are less toxic,than current alternatives. Hence,they will understand the meaning of inherently safer design for accident prevention and the principle "what you don't have can't harm you"
- Understand benefits of use of catalyst and bio catalyst ,use of renewable feed stock which helps in energy efficiency and protection of the environment, renewable energy sources, importance led reactions in various green solvents.
- Appreciate the use of green chemistry in problem solving skills, critical thinking and valuable skills to innovate and find out solution to environmental problems. Thus the students are able to realise that chemistry can be used to solve rather than cause environmental problems.
- Green chemistry is a way to boost profits, increase productivity and ensure sustainability with absolute zero waste. Success stories and real world cases also motivate them to practice green chemistry.These days customers are demanding to know about a product: Is it green? Does it contribute to global warming? Was it made from non depletable resources? Students have many career opportunities as " green" is the path to success.

Unit 1:

Introduction to Green Chemistry

What is Green Chemistry? Some important environmental laws, pollution prevention Act of 1990, emergence of green chemistry, Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

(Lectures:5)

Unit 2:

Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry and their explanation with examples

Special emphasis on the following:

- Prevention of Waste/ by products; maximum incorporation of the materials used in the process into the final products , Environmental impact factor, waste or pollution prevention hierarchy
- Green metrics to assess greenness of a reaction, e.g. Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
- Prevention/ minimization of hazardous/ toxic products reducing toxicity
- Risk = (function) hazard x exposure
- Designing safer chemicals with minimum toxicity yet has the ability to perform the desired functions
- Green solvents: super critical fluids with special reference to carbon dioxide, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, solvents obtained from renewable resources and how to compare greenness of solvents
- Energy requirements for reactions – alternative sources of energy: use of microwaves , ultrasonic energy and photochemical energy

- Selection of starting materials; should be renewable rather than depleting, Illustrate with few examples such as biodiesel and polymers from renewable resources (such as green plastic)
- Avoidance of unnecessary derivatization – careful use of blocking/protecting groups
- Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- Design for degradation: A product should not persist after the commercial function is over e.g. soaps and detergents, pesticides and polymers
- Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.
- Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

(Lectures:25)

Unit 3:

Examples of Green Synthesis/ Reactions

- Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).
- Green Reagents: Non-phosgene Isocyanate Synthesis, Selective Methylation using dimethylcarbonate.
- Microwave assisted solvent free synthesis of copper phthalocyanine
- Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid and Decarboxylation reaction
- Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

(Lectures:10)

Unit 4:

Real world case studies based on the Presidential green chemistry awards of EPA

- Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
- A new generation of environmentally advanced wood preservatives: Getting the chromium and Arsenic out of pressure treated wood.
- An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.
- Healthier Fats and oils by Green Chemistry: Enzymatic Inter esterification for production of No Trans-Fats and Oils.
- Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting.
- Using a naturally occurring protein to stimulate plant growth, improve crop quality, increase yields, and suppress disease.

(Lectures:10)

Unit 5:

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimcry and green chemistry, Biomimetic, Multifunctional Reagents; mechanochemical and solvent free synthesis of inorganic complexes; co crystal controlled solid state synthesis (C^2S^3); Green chemistry in sustainable development.

(Lectures:10)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab- Green chemistry

Characterization by m. pt., U.V.-Visible spectroscopy, IR spectroscopy, and any other specific method should be done (wherever applicable).

Safer starting materials

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.

Using renewable resources

2. Preparation of biodiesel from waste cooking oiland characterization (TLC, pH, Solubility, Combustion Test, Density, Viscosity, Gel Formation at Low Temperature and IR can be provided).

Use of enzymes as catalysts

3. Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

Alternative green solvents

4. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.
5. Mechanochemical solvent free, solid–solid synthesis of azomethine using p- toluidine and o-vanillin/p-vanillin (various other combinations of primary amine and aldehyde can also be tried).

Alternative sources of energy

6. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).
7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reducing waste

8. Designing and conducting an experiment by utilizing the products and by products obtained in above preparations which become waste otherwise if not used. This is done by critical thinking and literature survey.

Some representative examples:

- Use of nanoparticles as catalyst for a reaction
- Benzoin converted into Benzil and Benzil into Benzilic acid by a green method
- Use of azomethine for complex formation
- Rearrangement reaction from Benzopinacol to Benzopinacolone
- Conversion of byproduct of biodiesel to a useful product
- Students should be taught to do spot tests for qualitative inorganic analysis for cations and anions, and qualitative organic analysis for preliminary test and functional group analysis.

References:

Theory:

1. Anastas, P.T.; Warner, J.C.(1998), **Green Chemistry, Theory and Practice,** Oxford University Press.

2. Lancaster, M.(2016),**Green Chemistry An Introductory Text.**2nd Edition, RSC Publishing.
3. Cann , M. C.; Umile, T.P. (2008), **Real world cases in Green chemistry** Vol 11, American chemical Society,Washington.
4. Matlack, A.S.(2001),**Introduction to Green Chemistry,** Marcel Dekker.
5. Alhuwalia, V. K.; Kidwai, M.R.(2005),**New Trends in Green chemistry**, Anamalaya Publishers.

Practical:

1. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment.** American Chemical Society, Washington DC.
2. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K.(2013), **Green Chemistry Experiments: A monograph,** I.K. International Publishing House Pvt Ltd. New Delhi.
3. Pavia,D.L.; Lamponam, G.H.; Kriz, G.S.W. B.(2006),**Introduction to organic Laboratory Technique-A Microscale approach**,4th Edition, Brrooks-Cole Laboratory Series for Organic chemistry.
4. Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated. Indu Tucker Sidhwani et al. University of Delhi, Journal of Undergraduate Research and Innovation, Volume 1, Issue 1,February 2015, ISSN: 2395-2334.
5. Sidhwani, Tucker I.; Chowdhury, S. Greener alternatives to Qualitative Analysis for Cations without H_2S and other sulfur containing compounds, J. Chem. Educ. 2008, 85, 1099.
6. Sidhwani, Tucker I.; Chowdhury, S. et al., DU Journal of Undergraduate Research and Innovation2016, Volume 2, Issue 2, 70-79.
7. Dhingra, S., ;Angrish, C. Qualitative organic analysis: An efficient, safer, and economical approach to preliminary tests and functional group analysis. *Journal of Chemical Education*, 2011, *88*(5), 649-651.

Teaching Learning Process:

- Conventional chalk and board teaching
- Power point presentations
- Interactive sessions
- Literature survey and critical thinking to design to improve a traditional reaction and problem solving
- Visit to a green chemistry lab
- Some motivating short movies in green chemistry especially in bio mimicry

Assessment Methods:

- Presentation by students
- Class Test
- Written Assignment
- End Semester University Theory and Practical Exams

Keywords:

Green chemistry, Twelveprinciples of green chemistry, Atom economy, Waste minimization, Green metric, Green solvents, Solvent free, Catalyst, Bio-catalyst, Renewable energy sources, Hazardous, Renewable feedstock ,Ionic liquids, Supercritical fluids ,Inherent safer design, Green synthesis, Co-crystal controlled solid state synthesis, Sustainable development, Presidential green chemistry awards.

Course Code: CHEMISTRY –DSE-8
Course Title: Industrial Chemicals and Environment
Total Credits: 06 (Credits: Theory-04, Practical-02)
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The objective of this course is to make students aware about the concepts of different gases and their industrial production, uses, storage and hazards. Manufacturing, applications, analysis and hazards of the Inorganic Chemicals, Preparation of Ultra-Pure metals for semiconducting technology, Air and Water pollution, control measures for Air and Water Pollutants, Catalyst and Biocatalyst, Energy and Environment.

Learning Outcomes:

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

- The different toxic gases and their toxicity hazards
- Safe design systems for large scale production of industrial gases.
- Manufacturing processes, handling and storage of inorganic chemicals.
- Hazardous effects of the inorganic chemicals on human beings and vegetation.
- The requirement of ultra-pure metals for the semiconducting technologies
- Composition of air, various air pollutants, effects and control measures of air pollutants.
- Different sources of water, water quality parameters, impacts of water pollution, water treatment.
- Different industrial effluents and their treatment methods.
- Different sources of energy.
- Generation of nuclear waste and its disposal.
- Use of biocatalyst in chemical industries.

Unit 1:

Industrial Gases: Large scale production, uses storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, and sulphur dioxide.

(Lectures: 6)

Unit 2:

Inorganic Chemicals: Manufacture, applications, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potassium dichromate and potassium permanganate

(Lectures: 10)

Unit 3:

Industrial Metallurgy: Preparation of ultrapure metals for semiconductor technology.

(Lectures: 4)

Unit 4:

Environment and its segments:

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere,chemical and photochemical reactions in atmosphere.

Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Major sources of air pollution, Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul smelling gases, methods of estimation of CO, NO_x, SO_x and control procedures, Effects of air pollution on living organisms and vegetation

Greenhouse effect and Global warming, Environmental effects of ozone, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, Air pollution control, Settling Chambers, Venturi Scrubbers, Cyclones, Electrostatic Precipitators (ESPs).

(Lectures:15)

Unit 5:

Water Pollution:

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological cycle and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro fertilizer.

Sludge disposal. Industrial waste management, incineration of waste.

Water treatment and purification (reverse osmosis, electro dialysis, ion exchange).

Water quality parameters for wastewater, industrial water and domestic water.

(Lectures:15)

Unit 6:

Energy & Environment: Sources of energy: Coal, petrol and natural gas. Nuclear fusion / fission, solar, hydrogen, geothermal, tidal and hydel.

Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis: Introduction to biocatalysis: Importance in green chemistry and chemical industry.

(Lectures: 10)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab: Industrial Chemicals & Environment

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD).
3. Determination of Biological Oxygen Demand (BOD).
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
7. Measurement of dissolved CO_2
8. Determination of hexavalent Chromium Cr(VI) concentration in tannery wastes/waste water sample using UV-Vis spectrophotometry technique.
9. Preparation of borax/ boric acid

References:

Theory

1. Manahan, S.E. (2017),**Environmental Chemistry**, CRC Press
2. Buchel, K.H.; Moretto, H.H.; Woditsch, P.(2003),**Industrial Inorganic Chemistry**, Wiley-VCH.
3. De, A.K.(2012), **Environmental Chemistry,** New Age International Pvt., Ltd.
4. Khopkar, S.M.(2010), **Environmental Pollution Analysis**, New Age International Publisher.

Practical

1. Vowles, P.D.; Connell, D.W. (1980),**Experiments in Environmental Chemistry: A Laboratory Manual**, Vol.4, Pergamon Series in Environmental Science.
2. Gopalan, R.; Anand, A.; Sugumar R.W. (2008),**A Laboratory Manual for Environmental Chemistry**, I. K. International.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Visit to chemical industries to get information about the technologies, methods to check pollutants and its treatment.
- ICT enabled classes.
- Power point presentations.
- Interactive sessions.
- To get recent information through the internet.

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Air pollution,Biocatalysis, Environment,Green chemistry, Industrial gases, Inorganic chemicals, Metals, Ultrapure metals,Sources of energy,Water pollution.

Course Code: CHEMISTRY –DSE-9
Course Title: Inorganic Materials of Industrial Importance
Total Credits: 06 (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory- 60, Practicals-60)

Objectives:

The course introduces learners to the diverse roles of inorganic materials in the industry. It gives an insight into how these raw materials are converted into products used in day to day life. Students learn about silicates, fertilizers, surface coatings, batteries, engineering materials for mechanical construction as well as the emerging area of nano-sized materials. The course helps develop the interest of students in the frontier areas of inorganic and material chemistry.

Learning Outcomes:

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

- Learn the composition and applications of the different kinds of glass.
- Understand glazing of ceramics and the factors affecting their porosity.
- Give the composition of cement and discuss the mechanism of setting of cement.
- Explain the suitability of fertilizers for different kinds of crops and soil.
- Explain the process of formulation of paints and the basic principle behind the protection offered by the surface coatings.
- Explain the principle, working and applications of different batteries.
- List and explain the properties of engineering materials for mechanical construction used in day to day life.
- Explain the synthesis and properties of nano-dimensional materials, various semiconductor and superconductor oxides.

Unit 1:

Silicate Industries

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Ceramics: Brief introduction to types of ceramics. glazing of ceramics.

Cement: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.

(Lectures: 10)

Unit 2:

Fertilizers:

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime, potassium chloride and potassium nitrate.

(Lectures: 10)

Unit 3:

Surface Coatings:

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC)and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing.

Contemporary surface coating methods like physical vapor deposition, chemical vapor deposition, galvanising, carburizing, sherardising, boriding, nitriding and cementation.

(Lectures: 18)

Unit 4:

Batteries:

Primary and secondary batteries, characteristics of an Ideal Battery, principle, working, applications and comparison of the following batteries: Pb- acid battery, Li-metal batteries, Li-ion batteries, Li-polymer batteries, solid state electrolyte batteries, fuel cells, solar cells and polymer cells.

(Lectures: 8)

Unit 5:

Engineering materials for mechanical construction:

Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, superalloys, thermoplastics, thermosets and composite materials.

(Lectures: 8)

Unit 6:

Nano dimensional materials

Introduction to zero, one and two-dimensional nanomaterial: Synthesis, properties and applications of fullerenes, carbon nanotubes, carbon fibres, semiconducting and superconducting oxides.

(Lectures: 6)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab: Inorganic materials of industrial importance

1. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.

2. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.

3. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.

4. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration).

5. Analysis of (Cu, Ni) in alloy or synthetic samples (Multiple methods involving Complexometry, Gravimetry and Spectrophotometry).

6. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, Complexometry and Potentiometry).

7. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.

8. Synthesis of silver nanoparticles by green and chemical approach methods and its characterization using UV-visible spectrophotometer.

References:

Theory:

1. West, A. R. (2014),**Solid State Chemistry and Its Application**, Wiley
2. Smart, L. E.; Moore, E. A. (2012),**Solid State Chemistry An Introduction**, CRC Press Taylor & Francis.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A.(2010),**Shriver and Atkins Inorganic Chemistry**, W. H. Freeman and Company.
4. Kent, J. A. (ed**)** (1997),**Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
5. Poole Jr.; Charles P.; Owens, Frank J.(2003), **Introduction to Nanotechnology**, John Wiley and Sons.

Practical:

1. Svehla, G.(1996),**Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
2. Banewicz, J. J.; Kenner, C.T. **Determination of Calcium and Magnesium in Limestones and Dolomites**, Anal. Chem., 1952, 24 (7), 1186–1187.
3. Ghorbani, H. R.; Mehr, F.P.; Pazoki, H.; Rahmani B. M. **Synthesis of ZnO Nanoparticles by Precipitation Method.** Orient J Chem 2015;31(2).
4. Orbaek, W.; McHale, M.M.; Barron, A.R. **Synthesis and characterization of silver nanoparticles for an undergraduate laboratory**, J. Chem. Educ. 2015, 92, 339–344.

Additional Resources:

1. Kingery, W. D.; Bowen H. K.; Uhlmann, D. R. (1976),**Introduction to Ceramics**, Wiley Publishers, New Delhi.
2. Gopalan, R. Venkappayya, D.; Nagarajan, S. (2004),**Engineering Chemistry**, Vikas Publications.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods:

Assessment will be done based on regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Silicates, Ceramics, Cement, Fertilizers, Surface Coatings, Batteries, Engineering materials for mechanical construction**,** Nano dimensional materials.

Course Code: CHEMISTRY –DSE-10
Course Title: Instrumental Methods of Chemical Analysis
Total Credits: 06 (Credits: Theory-04, Practical-02)
(Total Lectures: Theory- 60, Practical-60)

Objectives:

This course aims to provide knowledge on various spectroscopic techniques for chemical analysis along with the basic principles of instrumentation.

Learning Outcomes:

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

- Handle analytical data
- Understand basic components of IR, FTIR, UV-Visible and Mass spectrometer.
- Interpret of IR, FTIR, UV-visible spectra and their applications.
- Understand the use of single and double beam instruments.
- Learn separations techniques like Chromatography.
- Learn elemental analysis, NMR spectroscopy, Electroanalytical Methods, Radiochemical Methods, X-ray analysis and electron spectroscopy.

Unit 1:

Introduction to analytical methods of data analysis

Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiations.

(Lectures: 4)

Unit 2:

Molecular spectroscopy

Infrared spectroscopy: Interaction of radiations with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier-Transform Infrared (FTIR) spectroscopy.

Applications: Issues of quality assurance and quality control, special problems for portable instrumentation and rapid detection.

(Lectures: 8)

Unit 3:

UV-Visible/ Near IR Spectroscopy

Emission, absorption, fluorescence and photoacoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and double beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoacoustic, fluorescent tags).

(Lectures: 8)

Unit 4:

Separation techniques

Chromatography: Gas chromatography, liquid chromatography, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis. Immunoassays and DNA techniques.

(Lectures: 8)

Unit 5:

Mass spectroscopy

Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, detection and interpretation.

(Lectures: 8)

Unit 6:

Elemental analysis

Mass spectrometry (electrical discharges).
Atomic spectroscopy**:** Atomic absorption, atomic emission, and atomic fluorescence. Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), wavelength separation and resolution (dependence on technique), detection of radiation (simultaneous/scanning, signal noise), interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

(Lectures: 8)

NMR spectroscopy: Principle, Instrumentation, Factors affecting chemical shift, Spin-coupling, Applications.

(Lectures: 4)

Electroanalytical Methods: Potentiometry & Voltammetry.**(Lectures: 4)**

Radiochemical Methods.**(Lectures: 4)**

X-ray analysis and electron spectroscopy (surface analysis). **(Lectures: 4)**

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab: Instrumental methods of chemical analysis

At least 10 experiments to be performed.

1. Determination of the isoelectric pH of a protein.
2. Titration curve of an amino acid.
3. Determination of the void volume of a gel filtration column.
4. Determination of a mixture of cobalt and nickel (UV-visible spectroscopy).
5. Study of electronic transitions in organic molecules (i.e., acetone in water).
6. IR absorption spectra (study of aldehydes and ketones).
7. Determination of calcium, iron, and copper in food by atomic absorption spectroscopy.
8. Quantitative analysis of mixtures by gas chromatography (i.e., chloroform and carbon tetrachloride).
9. Separation of carbohydrates by HPLC.
10. Determination of caffeine in beverages by HPLC.
11. Potentiometric titration of a chloride-iodide mixture.
12. Cyclic voltammetry of the ferrocyanide/ferricyanide couple.
13. Use of nuclear magnetic resonance instrument and to analyse the spectra of methanol and ethanol
14. Use of fluorescence to do “presumptive tests” to identify blood or other body fluids.
15. Use of “presumptive tests” for anthrax or cocaine.
16. Collection, preservation, and control of blood evidence being used for DNA testing.
17. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome).
18. Use of sequencing for the analysis of mitochondrial DNA.
19. Laboratory analysis to confirm anthrax or cocaine.
20. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives.
21. Detection of illegal drugs or steroids in athletes.
22. Detection of pollutants or illegal dumping.
23. Fibre analysis.

References:

Theory:

1. Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F.A. Jr.(2004), **Instrumental methods of analysis**, 7th edition, CBS Publishers.
2. Christian, G.D.(2004),**Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Skoog, D.A.; Holler, F. J.; Crouch, S.(2006),**Principles of Instrumental Analysis**,Thomson Brooks/Cole.
4. Banwell, C.N. (2006),**Fundamentals of Molecular Spectroscopy**,Tata McGraw-Hill Education

Practical:

1. Skoog, D. A.; Holler, F. J.; Crouch, S.(2006),**Principles of Instrumental Analysis**, Cengage Learning.
2. Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F.A. Jr.(2004), **Instrumental methods of analysis**, 7th edition, CBS Publishers.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and group discussions
- Power point presentation on important topics.

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Analytical methods of data analysis, Infrared spectroscopy, UV-Visible spectroscopy, Chromatographic techniques, Mass spectra, Elemental analysis methods, NMR spectroscopy, Electroanalytical methods, Radiochemical methods, X-ray analysis, Electronic spectroscopy.

Course Code: CHEMISTRY –DSE-11
Course Title: Chemistry of d-Block Elements, Quantum Chemistry and Spectroscopy

Total Credits: 06 **(Credits: Theory-04, Practical-02)**
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The objective of this course is to introduce the students to d and f block elements and highlights the concept of horizontal similarity in a period and stresses on their unique properties. It familiarizes them with coordination compounds which find manifold applications in diverse fields. This course also disseminates the concepts and methodology of quantum mechanics, its applications to spectroscopy and establishes relation between structure determination and spectra.

Learning Outcomes:

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

- Understand chemistry of d and f block elements, Latimer diagrams, properties of coordination compounds and VBT and CFT for bonding in coordination compounds
- Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions.
- Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra.
- Explain Lambert-Beer's law, quantum efficiency and photochemical processes.

Section A: Inorganic Chemistry (Lectures:30)

Unit 1:

Transition Elements (3d series)

General properties of elements of 3d series with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties and ability to form complexes. A brief introduction to Latimer diagrams (Mn, Fe and Cu) and their use to identify oxidizing, reducing species and species which disproportionate. Calculation of skip step potentials.

Lanthanoids and actinoids: Electronic configurations, oxidation states displayed. A very brief discussion of colour and magnetic properties. Lanthanoid contraction(causes and consequences), separation of lanthanoids by ion exchange method.

(Lectures: 10)

Unit 2:

Coordination Chemistry

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

(Lectures: 6)

Unit 3:

Bonding in coordination compounds

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes of Cr, Fe, Co and Ni. Drawbacks of VBT.

Crystal Field Theory

Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields. Crystal field stabilization energy (CFSE), concept of pairing energy. Factors affecting the magnitude of Δ. Spectrochemical series. Splitting of d orbitals in tetrahedral symmetry. Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry. Jahn-Teller distortion, square planar coordination.

(Lectures: 14)

Section B: Physical Chemistry (Lectures:30)

Unit 4:

Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators.

Free particle. Particle in a 1-D box (complete solution), quantization, normalization of wave functions, concept of zero-point energy.

Rotational Motion: Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels.

Vibrational Motion: Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels.

(Lectures: 12)

Unit 5:

Spectroscopy

Spectroscopy and its importance in chemistry. Wave-particle duality. Link between spectroscopy and quantum chemistry. Electromagnetic radiation and its interaction with matter.

Types of spectroscopy. Difference between atomic and molecular spectra. Born- Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components.

Microwave (pure rotational) spectra of diatomic molecules. Selection rules. Structural information derived from rotational spectroscopy.

IR Spectroscopy: Selection rules, IR spectra of diatomic molecules. Structural information derived from vibrational spectra. Vibrations of polyatomic molecules. Group frequencies. Effect of hydrogen bonding (inter- and intramolecular) and substitution on vibrational frequencies.

Electronic Spectroscopy: Electronic excited states. Free electron model and its application to electronic spectra of polyenes. Colour and constitution, chromophores, auxochromes, bathochromic and hypsochromic shifts.

(Lectures: 12)

Unit 6:

Photochemistry

Laws of photochemistry. Lambert-Beer's law. Fluorescence and phosphorescence. Quantum efficiency and reasons for high and low quantum yields. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions. Photoelectric cells.

(Lectures: 6)

Practical:

(Credits: 2, Laboratory periods: 60)

Section A: Inorganic Chemistry

1. Estimation of the amount of nickel present in a given solution as bis - (dimethylglyoximato) nickel(II) or aluminium as oxinate in a given solution gravimetrically.

2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.

3. Estimation of total hardness of a given sample of water by complexometric titration.

4. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} - phenanthroline complex in solution by Job's method.

Section B: Physical Chemistry

UV/Visible spectroscopy

1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).

2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$

3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colorimetry

1. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$/$CoSO_4$ in a solution of unknown concentration

Chemical Kinetics; Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method: Saponification of ethyl acetate.

References:

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A.(2010),**Shriver and Atkins Inorganic Chemistry**, W. H. Freeman and Company.
2. Miessler, G. L.; Fischer P.J.; Tarr, D.A.(2014),**Inorganic Chemistry**, Pearson.
3. Huheey, J.E.; Keiter, E.A., Keiter; R.L., Medhi, O.K. (2009),**Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
4. Pfennig, B. W.(2015), **Principles of Inorganic Chemistry.** John Wiley & Sons.
5. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.4, 5th Edition, McGraw Hill Education.
6. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.

7. B.R.Puri, L.R.Sharma, M.S.Pathania, (2017),**Principles of Physical Chemistry**, Vishal Publishing Co.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C.(1989),**Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Marr, G.; Rockett, B.W. (1972),**Practical Inorganic Chemistry**, Van Nostrand Reinhold.
3. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015),**Senior Practical Physical Chemistry**, R. Chand & Co.

Additional Resources:

1. Castellan, G. W.(2004),**Physical Chemistry**, Narosa.
2. Petrucci, R. H.(1989),**General Chemistry: Principles and Applications**, Macmillan Publishing Co.

Teaching Learning Process:

- Lectures to introduce a topic and give its details.
- Discussions so that the student can internalize the concepts.
- Problem solving to make the student understand the working and application of the concepts.

Assessment Methods:

- Graded assignments
- Conventional class tests
- Class seminars by students on course topics with a view to strengthening the content through width and depth
- Quizzes
- End semester university examination.

Keywords:

d-block elements, Actinoids, Lanthinoids, VBT, Crystal field theory, Splitting of d levels, Coordination compounds, Quantisation, Selection rules, Schrodinger equation, Operator, Spectrum, Quantum efficiency, Fluorescence.

Course Code: CHEMISTRY –DSE-12
Course Title: Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons and UV, IR Spectroscopy

Total Credits: 06 **(Credits: Theory-04, Practical-02)**
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The purpose of the course is to introduce students to some important 3d metals and their compounds which they are likely to come across. Students learn about organometallic compounds and bioinorganic chemistry which are currently frontier areas of chemistry providing an interface between organic chemistry, inorganic Chemistry and biology.The functional group approach to organic chemistry

introduced in the previous courses is reinforced through the study of the chemistry of carboxylic acids and their derivatives, Amines and diazonium salts, active methylene compounds. The students will also be introduced to the chemistry and applications of polynuclear hydrocarbons and heterocyclic compounds.The learners are introduced to spectroscopy, an important analytical tool which allows identification of organic compounds by correlating their spectra to structure.

Learning Outcomes:

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

- Understand the chemistry and applications of 3d elements including their oxidation states and important properties of the familiar compounds potassium dichromate, potassium permanganate and potassium ferrocyanide
- Use IR data to explain the extent of back bonding in carbonyl complexes
- Get a general idea of toxicity of metal ions through the study of Hg^{2+} and Cd^{2+} in the physiological system
- Understand the fundamentals of functional group chemistry, polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
- Gain insight into the basic fundamental principles of IR and UV-Vis spectroscopic techniques.
- Use basic theoretical principles underlying UV-visible and IR spectroscopy as a tool for functional group identification in organic molecules.

Section A: Inorganic Chemistry (Lectures:30)

Unit 1:

Chemistry of 3d metals

General discussion of 3d metals. Oxidation states displayed by Cr, Fe, Co, Ni and Cu.

A study of the following compounds (including preparation and important properties):

$K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$.

(Lectures: 6)

Unit 2:

Organometallic Compounds

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structure and bonding of methyl lithium and Zeise's salt. Structure and physical properties of ferrocene. 18-electron rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

(Lectures: 12)

Unit 3:

Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Brief introduction to oxygen transport and storage (haemoglobin-myoglobin system). Brief introduction about toxicity of metal ions ($Hg^{2+}$and Cd^{2+}).

(Lectures: 12)

Section B: Organic Chemistry (Lectures:30)

Unit 4:

Polynuclear and heteronuclear aromatic compounds:

Structure elucidation of naphthalene, preparation and properties of naphthalene and anthracene.

Preparation and Properties of the following compounds with reference to electrophilic and nucleophilic substitution: furan, pyrrole, thiophene, and pyridine.

(Lectures: 13)

Unit 5:

Active methylene compounds

Preparation: Claisen ester condensation, Keto-enol tautomerism.

Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having up to 6 carbons).

(Lectures: 5)

Unit 6:

UV-Visible and infrared spectroscopy and their application to simple organic molecules.

Electromagnetic radiations and their properties; double bond equivalence and hydrogen deficiency.

UV-Visible spectroscopy (electronic spectroscopy): General electronic transitions, λ_{max} &ε_{max}, chromophores & auxochromes, bathochromic & hypsochromic shifts. Application of Woodward rules for calculation of λ_{max} for the following systems: conjugated dienes - alicyclic, homoannular and heteroannular; α,β-unsaturated aldehydes and ketones, charge transfer complex.

Infrared (IR) Spectroscopy: Infrared radiation and types of molecular vibrations, significance of functional group & fingerprint region. IR spectra of alkanes, alkenes, aromatic hydrocarbons (effect of conjugation and resonance on IR absorptions), simple alcohols (inter and intramolecular hydrogen bonding and IR absorptions), phenol, carbonyl compounds, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

(Lectures: 12)

Practical:

(Credits: 2, Laboratory periods: 60)

Section A: Inorganic Chemistry

1. Separation of mixtures of two ions by paper chromatography and measurement of R_f value in each case:

(Fe^{3+}, Al^{3+} and Cr^{3+}) or (Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+})

2.Preparation of any two of the following complexes and measurement of their conductivity:

(i) tetraamminecopper (II) sulphate (ii) potassium trioxalatoferrate (III) trihydrate.

Compare the conductance of the complexes with that of M/1000 solution of NaCl, $MgCl_2$ and $LiCl_3$.

Section B: Organic Chemistry

1. Detection of extra elements

2. Systematic qualitative analysis of organic compounds possessing monofunctional groups: amide, amines, halo-hydrocarbons and carbohydrates (Including Derivative preparation)

3. Identification of simple organic compounds containing the above functional groups by IR spectroscopy through examination of spectra (spectra to be provided).

References:

Theory:

1. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009),**Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
2. Lee., J. D. **A new Concise Inorganic Chemistry**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**,John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010),**Shriver and Atkins Inorganic Chemistry**, 5th Edn, W. H. Freeman and Company, 41 Madison Avenue, New York, NY.
5. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.

Practical:

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A.(2005),**College Practical Chemistry**, University Press (India) Ltd.
2. Ahluwalia, V.K.; Dhingra, S.(2004),**Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Vogel, A.I.(1972),**Textbook of Practical Organic Chemistry**, Prentice Hall.
4. Svehla, G. (1996),**Vogel's Qualitative Inorganic Analysis**, Prentice Hall.

Additional Resources:

1. Cotton, F. A.; Wilkinson, G.; Gaus, P.L. (1995), **Basic Inorganic Chemistry**, 3rd Edition, John Wiley.
2. Sharpe, A.G.(2005), **Inorganic Chemistry**, Pearson Education.
3. Greenwood, N.N.; Earnshaw, A.(1997), **Chemistry of the Elements,** Elsevier.
4. Silverstein, R.M.; Bassler, G.C.; Morrill, T.C. (1991),**Spectroscopic Identification of Organic Compounds**, John Wiley & Sons.

5. Dyer, J.R.(1978),**Applications of Absorption Spectroscopy of Organic Compounds**, Prentice Hall.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

3d metals; Organometallic Chemistry; Metal Carbonyl; Ferrocene; 18-electron rule; Synergic bonding; Bioinorganic chemistry; Sodium potassium pump; Haemoglobin-myoglobin system; Biomolecules, UV-visible spectroscopy; IR spectroscopy; Charge transfer spectra.

Course Code: CHEMISTRY –DSE-13
Course Title: Molecules of Life
Total Credits: 06 **(Credits: Theory-04, Practical-02)**
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The objective of this course is to deliver information about biochemically significant features of the chemistry of carbohydrates, proteins, enzymes, nucleic acids and lipids, using suitable examples. This includes classification, reaction chemistry and biological importance of these biomolecules. This course extends the knowledge gained from synthetic organic chemistry to chemistry of biomolecules. Key emphasis is placed on understanding the structural principles that govern reactivity/physical /biological properties of biomolecules as opposed to learning structural detail.

Learning Outcomes:

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

- Learn and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses.
- Gain an insight into mechanism of enzyme action and inhibition.
- Understand the basic principles of drug-receptor interaction and SAR.
- Understand biological processes like replication, transcription and translation.
- Demonstrate an understanding of metabolic pathways, their inter-relationship, regulation and energy production from biochemical processes.

Unit 1:

Carbohydrates

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of configuration of glucose (Fischer proof), cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

(Lectures: 10)

Unit 2:

Amino Acids, Peptides and Proteins

Classification of amino acids and biological uses of amino Acids, peptides and proteins. Zwitterion structure, isoelectric point and correlation to acidity and basicity of amino acids. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (up to dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis, Overview of primary, secondary, tertiary and quaternary structure of proteins, denaturation of proteins.

(Lectures: 12)

Unit 3:

Enzymes and correlation with drug action

Classification of enzymes and their uses(mention Ribozymes). Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, specificity of enzyme action(including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (Competitive and non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure – activity relationships of drug molecules, binding role of –OH group,-NH_2 group, double bond and aromatic ring.

(Lectures: 10)

Unit 4:

Nucleic Acids

Components of Nucleic acids: Adenine, guanine, thymine,cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA(types of RNA),difference between DNA and RNA, genetic code, biological roles of DNA and RNA: replication, transcription and translation.

(Lectures: 10)

Unit 5:

Lipids

Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega-3&6 fatty acids, trans fats, hydrogenation, hydrolysis, acid value, saponification value, iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

(Lectures: 8)

Unit 6:

Concept of Energy in Biosystems

Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of carbohydrate- glycolysis, fermentation and Krebs cycle. Overview of catabolic pathways of fats and proteins. Interrelationships in the metabolic pathways of proteins, fats and carbohydrates.

(Lectures: 10)

Practical:

(Credits: 2, Laboratory periods: 60)

1. Separation of amino acids by paper chromatography
2. Study of titration curve of glycine and determination of its isoelectric point.
3. Estimation of proteins by Lowry's method
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Qualitative tests for carbohydrates- Molisch test Barfoed's reagent test, rapid furfural test,Tollen's test and Fehling solution test(Only these tests are to be done in class)
9. Qualitative tests for proteins
10. Extraction of DNA from onion/cauliflower

References:

Theory:

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Berg, J. M.; Tymoczko, J. L.; Stryer, L.(2002),**Biochemistry**, W. H. Freeman.

Practical:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012),**Vogel's Textbook ofPractical Organic Chemistry**, Pearson.
2. **Manual of Biochemistry Workshop**, 2012, Department of Chemistry, University of Delhi.

Teaching Learning Process:

- The teaching learning process will involve the traditional chalk and black board method. Along with pedagogy of flipped classroom
- Certain topics like mechanism of enzyme action and enzyme inhibition, transcription and translation etc. where traditional chalk and talk method may not be able to convey the concept, are taught through audio-visual aids.
- Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics, peer assessment, designing games based on specific topics etc.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Assessment Methods:

- Graded assignments
- Conventional class tests
- Class seminars by students on course topics with a view to strengthening the content through width and depth
- Quizzes
- End semester university examination.

Keywords:

Biomolecules, Enzymes, Mechanism of enzyme action and inhibition, SAR, Drug Receptor Theory, Energy concept in biological system, Catabolic pathways and their inter-relationship.

Course Code: CHEMISTRY –DSE-14
Course Title: Nanoscale Materials and Their Applications
Total Credits: 06 (Credits: Theory-04, Practical-02)
(Total Lectures: Theory- 60, Practical-60)

Objectives:

The aim of this course is to introduce materials at nanoscale, their preparation, characterization and applications.

Learning Outcomes:

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

- Understand the concept of nanodimensions.
- Know the various methods of preparation of nanomaterials.
- Know the different characterization techniques used for the analysis of nanomaterials and understand the basic principle behind these techniques.

- Understand the optical and conducting properties of nanostructures.
- Appreciate the real life applications of nanomaterials.

Unit 1:

Introduction to nanodimensions

0D, 1D, 2D nanomaterials, Quantum Dots,Nanoparticles, Nanostructures (nanowires, thin films, nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), Size Effects in nano systems, Quantum confinement and its consequences, Semiconductors.Band structure and band gap.

(Lectures: 10)

Unit 2:

Preparation of nanomaterials

Top down and Bottom up approach, Photolithography. Ball milling.Vacuum deposition.Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Thermal decomposition, Chemical reduction, Sol-Gel synthesis, Hydrothermal synthesis, Spray pyrolysis,Electrochemical deposition, Pulsed Laser deposition.

(Lectures:8)

Unit 3:

Characterization techniques *(Basic working principles and interpretation of experimental data using these techniques need to be covered)*

UV-visible spectroscopy, X-ray diffraction (Powder and Single Crystal), Raman Spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Energy Dispersive X-ray Spectroscopy (EDX), X-ray Photoelectron Spectroscopy (XPS), Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), Dynamic light scattering (DLS), Brunauer-Emmett-Teller (BET) Surface area measurement and Thermogravimetric analysis (TG).

(Lectures:14)

Unit 4:

Optical Properties

Surface plasmon resonance, Excitons in direct and indirect band gap semiconductor nanocrystals. Radiative processes: General absorption, emission and luminescence (fluorescence and photoluminescence). **(Lectures:8)**

Unit 5:

Conducting properties

Carrier transport in nanostructures.Tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **(Lectures:6)**

Unit 6:

Applications

Nanomaterials as Catalysts, semiconductor nanomaterials as photocatalysts, nanocomposites as catalysts.

Carbon nanostructures as catalytic nanoreactors, metal and metal oxides confined inside carbon nanostructures, Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).

(Lectures:14)

References:

1. West, A. R.(2014),**Solid State Chemistry and Its Application**, Wiley
2. Smart, L. E.; Moore, E. A.(2012),**Solid State Chemistry An Introduction**, CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J.(1997),**New Direction in Solid State Chemistry**, Cambridge University Press.
4. Poole, Jr.; Charles P.; Owens, Frank J.;(2003), **Introduction to Nanotechnology**, John Wiley and Sons.
5. Chattopadhyay, K.K.; Banerjee, A. N.(2009),**Introduction to Nanoscience and Technology**, PHI.

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab: Nanoscale materials and their applications

At least 04 experiments from the following:

1. Synthesis of metal nanoparticles by chemical reduction method.

2. Synthesis of semiconductor nanoparticles.

3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.

4. XRD pattern of nanomaterials and estimation of particle size. (Students can be provided with XRD patterns of known materials and asked to interpret the data.)

5. To study the effect of size on color of nanomaterials.

6. To prepare composite of CNTs with other materials.

7. Growth of quantum dots by thermal evaporation.

8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.

9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.

Teaching Learning Process:

Lectures, ICT enabled presentations and group discussions will be part of teaching learning process.

Assessment Methods:

Internal assessment will be through assignments, projects, presentation and class test. End semester examination will be for theory and practical.

Keywords:

Nanomaterials, Preparation, Characterization, Applications.

Course Code: CHEMISTRY –DSE-15
Course Title: Dissertation
Total Credits: 06

Objectives:

The Objective is to enable student to identify a problem in the field of chemistry and to carry out literature survey, design an experiment, perform experiment, analyse data and write a report.

Learning Outcomes:

By the end of the dissertation, the students will be able to;

- Do survey, study and cite published literature on a particular area of interest.
- Correlate the experimental observations with theoretical understanding.
- Interpret results, write a report and submit to the supervisor.
- Use laboratory resources judiciously.
- Work in a team under the supervision of a teacher.
- Develop scientific writing skills.

Content:

Unit 1: Identification of research problem

Unit 2: Survey of literature

Unit 3: Formulation of hypothesis, experimental design and methodology

Unit 4: Analysis of data and interpretation of results

Unit 5: Discussion and conclusion

Unit 6: Writing a project report

Assessment Methods:

The assessment will be through evaluation of the dissertation, presentation and viva voce involving external and internal examiners.

SKILL-ENHANCEMENT COURSES (SEC)

Course Code: CHEMISTRY –SEC-1
Course Title: IT Skills For Chemists
Total Credits: 04 **(Credits: Theory-02, Practical-02)**
(Total Lectures: Theory- 30, Practical-60)

Objectives:

The objective of this course is to introduce the students to fundamental mathematical techniques and basic computer skills that will help them in solving chemistry problems. It aims to make the students understand the concept of uncertainty and error in experimental data. It acquaints the students with different software for data tabulation, calculation, graph plotting, data analysis and document preparation.

Learning Outcomes:

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

- Become familiar with the use of computers
- Use software for tabulating data, plotting graphs and charts, carry out statistical analysis of the data.
- Solve chemistry problems and simulate graphs.
- Prepare documents that will incorporate chemical structure, chemical equations, mathematical expressions from chemistry.

Unit 1:

Mathematics

Fundamentals, mathematical functions, polynomial expressions, logarithms, the exponential function, units of a measurement, interconversion of units, constants and variables, equation of a straight line, plotting graphs.

Uncertainty in experimental techniques: Displaying uncertainties, measurements in chemistry, decimal places, significant figures, combining quantities.

Uncertainty in measurement: types of uncertainties, combining uncertainties. Statistical treatment. Mean, standard deviation, relative error. Data reduction and the propagation of errors. Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression).

Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation in different forms). Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary –bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).

Differential calculus: The tangent line and the derivative of a function, numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).

Numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).

(Lectures: 10)

Unit 2:

Introductory writing activities: Introduction to word processor and structure drawing (ChemSketch) software. Incorporating chemical structures, chemical equations, expressions from chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg's law, van der Waals equation, etc.) into word processing documents.

(Lectures: 4)

Unit 3:

Handling numeric data: Spreadsheet software (Excel/ LibreOffice Calc), creating a spreadsheet, entering and formatting information, basic functions and formulae, creating charts, tables and graphs Incorporating tables and graphs into word processing documents. Simple calculations, plotting graphs using a spreadsheet (Planck's distribution law, radial distribution curves for hydrogenic orbitals, gas kinetic theory- Maxwell-Boltzmann distribution curves as function of temperature and molecular weight), spectral data, pressure-volume curves of van der Waals gas (van der Waals isotherms), data from phase equilibria studies. Graphical solution of equations

(Lectures: 6)

Unit 4:

Numeric modelling: Simulation of pH metric titration curves. Excel functions LINEST and Least Squares. Numerical curve fitting, linear regression (rate constants from concentration- time data, molar extinction coefficients from absorbance data), numerical differentiation (e.g. handling data from potentiometric and pH metric titrations, pKa of weak acid), integration (e.g. entropy/enthalpy change from heat capacity data)

(Lectures: 6)

Unit 5:

Statistical analysis: Gaussian distribution and Errors in measurements and their effect on data sets. Descriptive statistics using Excel. Statistical significance testing: The t test. The F test. Presentation graphics.

(Lectures: 4)

Practical:

(Credits: 2, Laboratory periods: 60)

1. Potting graphs using a spreadsheet

   i. Planck's distribution law

   ii. Radial distribution curves for hydrogenic orbitals,

   iii. Maxwell-Boltzmann distribution curves as function of temperature and molecular weight

iv. van der Waals isotherms

v. Data from phase equilibria studies

2. Calculations using spreadsheet

vi. Rate constants from concentration- time data

vii. Molar extinction coefficients from absorbance data

viii. Numerical differentiation (e.g. handling data from potentiometric and pH metric titrations)

ix. pKa of weak acid

3. Preparing a word processing document having tables, chemical structures and chemical equations

References:

1. McQuarrie, D.A. (2008), **Mathematics for Physical Chemistry** University Science Books.
2. Steiner, E.(2008),**The Chemical Maths Book** Oxford University Press.
3. Yates, P.(2007),**Chemical calculations**, CRC Press.
4. Harris,D.C.(2007),**Quantitative Chemical Analysis**. Freeman, Chapters 3-5.
5. Levie, R. de. (2001), **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press.
6. Venit, S.M. (1996),**Programming in BASIC: Problem solving with structure and style**. Jaico Publishing House.

Teaching Learning Process:

This course has major components of hands on exercises. The teaching learning process will require conventional teaching along with hands on exercise on computers.

Assessment Methods:

Assessment on solving chemistry related problems using spreadsheet.
Presentation on documentation preparation on any chemistry topic involving tables and graphs
Semester end practical and theory examination

Keywords:

Uncertainty in measurements, roots of quadratic and polynomial equations, Newton Raphson's method, binary bisection, numerical integration, trapezoidal rule, Simpson's rule, differential calculus, least square curve fitting method, Spreadsheet, charts, tables, graphs, LINEST, t-test, F-test.

Course Code: CHEMISTRY –SEC-2
Course Title: Basic Analytical Chemistry
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives:

The objective of this course is to make students aware about the importance and the concepts of chemical analysis of water and soil,using separation techniques like chromatography and instrumentation techniques like flame photometry and spectrophotometry.

Learning Outcomes:

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

- Handle analytical data
- Determine composition and pH of soil, which can be useful in agriculture
- Do quantitative analysis of metal ions in water
- Separate mixtures using separation techniques
- Estimate macro nutrients using Flame photometry

Unit 1:

Introduction

Introduction to analytical chemistry and its interdisciplinary nature, Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Significant figures. Presentation of experimental data and results.

(Lectures: 6)

Unit 2:

Analysis of soil

Composition of soil, concept of pH and its measurement, complexometric titrations, chelation, chelating agents, use of indicators.

(Lectures: 8)

Unit 3:

Analysis of water:

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

(Lectures:8)

Unit 4:

Chromatography

Definition and general introduction on principles of chromatography. Paper chromatography, thin layer chromatography, Column chromatography and ion-exchange chromatography.

(Lectures: 8)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab-Basic analytical chemistry

1. Determination of pH of soil samples.
2. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.
3. Determination of pH, acidity and alkalinity of a water sample.
4. Determination of dissolved oxygen (DO) of a water sample.
5. Paper chromatographic separation of mixture of metal ion (Ni^{2+} and Co^{2+}).
6. To study the use of phenolphthalein in trap cases.
7. To analyze arson accelerants.
8. To carry out analysis of gasoline.
9. Estimation of macro-nutrients: Potassium, calcium and magnesium in soil samples by flame photometry.
10. Spectrophotometric determination of Iron in vitamin / dietary tablets.
11. Spectrophotometric identification and determination of caffeine and benzoic acid in soft drink.
12. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

References:

1. Christian, G.D. (2004),**Analytical Chemistry**, John Wiley & Sons.
2. Harris, D. C. (2007),**Exploring Chemical Analysis**, W.H. Freeman and Co.
3. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005),**Principles of Instrumental Analysis**, Thomson Asia Pvt. Ltd.
4. Svehla, G. (1996),**Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
5. Mendham, J.; Denney, R.C.; Barnes, J.D.; Thomas, M.J.K. (2007), **Vogel's Quantitative Chemical Analysis**,6thEdition, Prentice Hall.

Teaching Learning Process:

- Conventional chalk and board teaching,

- Class room interactions and group discussions
- Lab demonstrations and experiments after completion of theory part
- ICT enabled classes

Assessment Methods:

Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Analytical chemistry, Sampling, Accuracy, Precision, Significant figures, Soil analysis, Analysis of water, Chromatography, Ion exchange chromatography, Flame photometry.

Course Code: CHEMISTRY –SEC-3
Course Title: Chemical Technology and Society
Total Credits: 04 **(Credits: Theory-04)**
(Total Lectures: Theory- 60)

Objectives:

This course will help students to connect chemical technology for societal benefits. It would fulfil the gap between academia and industries.

Learning Outcomes:

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

- Understand the use of basic chemistry to chemical engineering
- Learn and use various chemical technology used in industries
- Develop scientific solutions for societal needs

Chemical Technology

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry. Introduction to clean technology.

Society

Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants).

Sources of energy

Coal, petrol and natural gas. Nuclear fusion / fission, solar, hydrogen, geothermal, tidal and hydel.

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties)

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novolac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide), polypyrrole, polythiophene].

Natural Polymers

Structure, properties and applications of shellac, lignin, starch, nucleic acids and proteins.

Basics of drug synthesis

Application of genetic engineering

References:

1. Hill, J.W.; McCreary, T.W.; Kolb, D.K. (2013),**Chemistry for changing times**, Pearson.

Teaching Learning Process:

- Lectures using teaching aid (chalk/power point/videos)
- Group discussion
- Presentations
- Advise to students to prepare a report on technological applications
- Visit to nearby industries
- Invite people of industries for interaction with students

Assessment Methods:

- Graded assignments
- Conventional class tests
- Class seminars by students on course topics with a view to strengthening the content through width and depth
- Quizzes
- End semester university examination.

Keywords:

Chemical Technology; Society; Energy; Polymer; Pollutants.

Course Code: CHEMISTRY –SEC-4
Course Title: Chemoinformatics
Total Credits: 04 (Credits: Theory-02, Practicals-02)
(Total Lectures: Theory- 30, Practicals-60)

Objectives:

The aim of the course is to introduce the students to computational drug design through structure-activity relationship, QSAR and combinatorial chemistry. The students will learn about the target analysis, virtual screening for lead discovery, structure based and ligand based design method and the use of computational techniques, library preparation and data handling.

Learning Outcomes:

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

- Have a comprehensive understanding of drug discovery process and techniques including structure-activity relationship, quantitative structure activity relationship and the use of chemoinformatics in this, including molecular modelling and docking studies.
- Appreciate role of modern computation techniques in the drug discovery process and perform their own modelling studies.

Unit 1:

Introduction to Chemoinformatics: History and evolution of chemoinformatics, Use of chemoinformatics, Prospects of chemoinformatics, Molecular modelling and structure elucidation.

(Lectures: 2)

Unit 2:

Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

(Lectures: 2)

Unit 3:

Searching chemical structures: Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

(Lectures: 6)

Unit 4:

Applications: Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modeling Toxicity.

(Lectures: 6)

Unit 5:

Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design

(Lectures: 6)

Unit 6:

Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand-Based and Structure Based Drug design; Application of Chemoinformatics in Drug Design.

(Lectures: 8)

Practical:

(Credits: 2, Laboratory periods: 60)

1. Overview of Rational Drug Design, Ligands and Targets

2. In silico representation of chemical information

   i. CIF IUCr Crystallographic Information Framework
   ii. CML Chemical Markup Language
   iii. SMILES -- Simplified Molecular Input Line Entry Specification
   iv. InChi -- IUPAC International Chemical Identifier
   v. Other representations

3. Chemical Databases and Data Mining

   i. Cambridge Structural Database CCDC CSD
   ii. Crystallographic Open Database COD
   iii. Protein Data Bank PDB Ligand Explorer
   iv. Chemspider
   v. Other Data Bases

4. Molecular Drawing and Interactive Visualization

   i. ChemDraw
   ii. MarvinSketch
   iii. ORTEP
   iv. Chimera, RasMol, PyMol

5. Computer-Aided Drug Design Tools

   i. Molecular Modeling Tools
   ii. Structural Homology Modeling Tools
   iii. Docking Tools and Screening Tools
   iv. Other tools

6. Building a Ligand

i. Building ab initio
ii. Building from similar ligands
iii. Building with a known macromolecular target
iv. Building without a known macromolecular target
v. Computational assessment of activity and toxicity and drugability.

References:

1. Leach, A. R.; Gillet, V. J. (2007), **An introduction to Chemoinformatics**, Springer.
2. Gasteiger, J.; Engel, T. (2003), **Chemoinformatics: A text-book**. Wiley-VCH.
3. Gupta, S. P. (2011),**QSAR & Molecular Modeling**. Anamaya Pub.
4. Gasteiger, J. **Handbook of cheminformatics: from data to knowledge in 4 volumes,** Wiley.

Additional Resources:

1. Jürgen,B.(2004),**Chemoinformatics Concepts, Methods, and Tools for Drug Discovery**, Springer

Teaching Learning Process:

The course aims to introduce students to different cheminformatics methods and its use in drug research through practicals. It is a rather new discipline of science. It concerns with the applications of computer to solving the chemistry problems related to drug designing and drug discovery.

The course will give emphasis on active learning in students through a combination of lectures, tutorials and practical sessions. The underlying principles will be explained in lectures and the practicals will establish the understanding of these principles through applications to drug research.

Assessment Methods:

- Formative assessment supporting student learning in Cheminformatics practicals
- Summative assessment
- Review of a case study
- Exercise based on SAR and QSAR-Report
- Practical exam of five hours

Keywords:

Cheminformatics, Virtual Chemical Library, Virtual Screening, SAR-QSAR, Drug Design lead discovery.

Course Code: CHEMISTRY –SEC-5
Course Title: Business Skills for Chemists
Total Credits: 04 **(Credits: Theory-04)**
(Total Lecture: Theory-60)

Objectives:

The objective of this course is to enhance the business and entrepreneurial skills of undergraduate chemistry students and improve their employment prospects. The course will orient the students to understand the Industry linkage with chemistry, challenges and business opportunities. It will expose the students to the concepts of intellectual property rights, patents and commercialisation of innovations.

Learning Outcomes:

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

1. Learn basics skills of of business and project management.
2. Understand the process of product development and business planning that includes environmental compliancy.
3. Learn the process by which technical innovations are conceived and converted into successful business ventures.
4. Understand the intellectual property rights and patents which drive business viability and commercialization of innovation.
5. Relate to the importance of chemistry in daily life, along with the employment and business opportunities. They will effectively use the skills to contribute towards the well-being of the society and derive commercial value.

Unit 1:

Chemistry in industry

Current challenges and opportunities for the chemistry based industries.

Role of chemistry in India and global economies.

Chemistry based products in the market.

(Lectures: 10)

Unit 2:

Business Basics

Key business concepts, Business plans, Market need, Project management, Routes to market, Concept of entrepreneurship

(Lectures: 12)

Unit 3:

Project Management

Different stages of a project:

- Ideation
- Bench work
- Pilot trial
- Production
- Promotion/ Marketing

(Lectures: 10)

Unit 4:

Commercial Realisation and Case Studies

- Commercialisation
- Case study of Successful business ideas in chemistry
- Case study of Innovations in chemistry
- Financial aspects of business with case studies

(Lectures: 10)

Unit 5:

Intellectual Property Rights

Introduction to IPR & Patents

(Lectures: 6)

Unit 6:

Environmental Hazards

Industries involving hazardous chemicals. Importance of development of cost-effective alternative technology. Environmental ethics.

(Lectures: 12)

Students can be taken for industrial visits for practical knowledge and experience.
Group of 4-5 students may be asked to prepare business plan based on some innovative ideas and submit as a project / presentation discussing its complete execution.

References:

1. www.rsc.org
2. Nwaeke, L.I.(2002),**Business Concepts and Perspectives,** Springfield Publishers.
3. Silva, T. D. (2013),**Essential Management Skills for Pharmacy and Business Managers,** CRC Press.

Teaching Learning Process:

- Class room teaching board method or power point presentations
- Class room interactions and group discussions
- Through videos and online sources
- Visit to chemical industries for real understanding of whole process

Assessment Methods:

- Written examination and class tests
- Oral presentation of project proposal along with written assignment.

Keywords:

Business skills, Chemical industry, Entrepreneurship, Project management, Intellectual property rights, Environmental ethics.

Course Code: CHEMISTRY –SEC-6
Course Title: Intellectual Property Rights
Total Credits: 04 **(Total Lectures: Theory-60)**

Objectives:

The course aims to give insights into the basics of the Intellectual Property (IP) and in its wider purview it encompasses intricacies relating to IP. This course is designed to introduce a learning platform to those who may be involved in the making and creation of various forms of IP, besides the effective management of IPR of other creators. The course may also provide cursory understanding of the overall IP ecosystem in the country.

Learning Outcomes:

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

- Learn theoretical concepts of evolution of Intellectual Property Laws, and to differentiate between the different kinds of IP.
- Know the existing legal framework relating to IP in India.
- Comprehend the value of IP and its importance in their respective domains.
- This course may motivate the students to make their career in multifaceted field of intellectual property rights.

Unit 1:

Introduction

Basic concept of Intellectual Property, Rationale behind Intellectual Property, Justifications for protection of IP, IPR and Economic Development, Major International Instruments relating to the protection of IP. The World Intellectual Property Organization (WIPO), WTO and TRIPS Agreement.

(Lectures: 8)

Unit 2:

Copyright and Related rights

Introduction to copyright and its relevance, subject matter and conditions of protection, ownership and term of copyright, rights under copyright law, infringement of copyright and remedies, exceptions to infringement/ public rights.

(Lectures: 10)

Unit 3:

Patents

Introduction, Criteria for obtaining patents, Patentable subject matter, Non patentable inventions, Procedure for registration, Term of patent and Rights of patentee, Patent Cooperation Treaty & International registration, Basic concept of Compulsory license and Government use of patent,

Infringement of patents and remedies, Software patents and importance for India, Utility model & patent, Trade secrets and know-how agreement, Traditional Knowledge and efforts of Indian Govt. for its protection.

(Lectures: 15)

Unit 4:

Trade Marks

Meaning of mark and Trademark, Categories of Trademark: Service Mark, Certification Mark, Collective Mark, Well known Mark and Non-conventional Mark, Criteria for registrability of trademark: Distinctiveness & non- deceptiveness, A good Trade Mark & its functions, Procedure for registration and Term of protection, Grounds for refusal of trademark registration, Assignment and licensing of marks (Character merchandising), Infringement and Passing Off, Salient Features of Indian Trade Mark Act,1999.

(Lectures: 8)

Unit 5:

Designs, GI and Plant Varieties Protection

Designs**:** Meaning of design protection**,** Concept of original design**,** Registration &Term of protection**,** Copyright in Designs.

Geographical Indication: Meaning of GI, Difference between GI and Trade Marks, Registration of GI, Term & implications of registration, Concept of Authorized user, Homonymous GI

Plant Variety Protection and Farmer's Right: Meaning, Criteria of protection, Procedure for registration, effect of registration and term of Protection, Benefit Sharing and Farmer's rights

(Lectures: 12)

Unit 6:

Enforcement and Protection

Enforcement of Intellectual Property Rights: Counterfeiting and Piracy, Understanding Enforcement of IP and Enforcing IPRs, Enforcement under TRIPS Agreement, Role of Customs and Police in IPR Protection

(Lectures: 7)

Practical:

No Practical as such. However, students may be asked to prepare a project on different topics of IPR and present them before the class.

References:

1. Pandey, N.; Dhami, K. (2014),**Intellectual Property Rights**, PHI Learning Pvt. Ltd.
2. Acharya, N.K.(2001),**Text Book of Intellectual Property Rights**, Asia Law House.

3. Ganguli, P. (2001),**Intellectual Property Rights: unleashing the knowledge economy**. Tata McGraw Hill.

Additional Resources:

1. https://www.wipo.int
2. Ahuja, V.K.(2017),**Law Relating to Intellectual Property Rights**, Lexis Nexis.
3. Wadehra, B.L. (2000),**Law Relating to Patents, Trade Marks, Copyright, Designs &Geographical Indications**. Universal law Publishing Pvt. Ltd..
4. Journal of Intellectual Property Rights (JIPR); NISCAIR(CSIR).

Teaching Learning Process:

This course must be taught through lecture in class and by invited talks of experts. The students must visit the nearby intellectual property office or some law firm to have an idea of the way the work is being done there.

Assessment Methods:

The course is designed to be completed in 60 periods. The internal assessment shall be 25% (Class Test 10%, Assignment/project presentation 10% and attendance 5%) and the semester exam at the end of semester shall be 75%.

Keywords:

Intellectual Property, IP Laws, Patents, Copyright, Trademark, WIPO.

Course Code: CHEMISTRY –SEC-7
Course Title: Analytical Clinical Biochemistry
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives:

The objective of this course is to deliver information about biochemically significant features of the proteins, enzymes, nucleic acids and lipids, using suitable examples. This includes classification, properties and biological importance of biomolecules. The course provides an overview of drug receptor interaction and Structure Activity Relation (SAR) studies. It will introduce the students to the concept of genetic code and concept of heredity. Key emphasis is placed on understanding the basic principles that govern the biological functions of biomolecules.

Learning Outcomes:

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

- Understand and establish how the structure of biomolecules determines their reactivity and biological uses.
- Understand the basic principles of drug-receptor interaction and structure activity relation (SAR).
- Gain an insight into concept of heredity through biological processes like replication, transcription and translation.

- Demonstrate an understanding of the biochemistry of diseases.
- Understand the application of chemistry in biological systems.

Unit 1:

Metabolism

Biological importance of carbohydrates and proteins, Introduction to metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, outline of catabolic pathways of fats, proteins and carbohydrate-glycolysis, alcoholic and lactic acid fgermentation, Krebs cycle.

(Lectures: 4)

Unit 2:

Enzymes

Nomenclature, classification, Characterisation, Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (Including stereospecificity), Enzyme inhibitors and their importance, Introduction to biocatalysis: Importance in —green chemistry and chemical industry. Drug action-receptor theory. Structure – activity relationships of drug molecules, binding role of –OH group, $-NH_2$ group, double bond and aromatic ring.

(Lectures: 8)

Unit 3:

Lipids

Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Liposomes and their biological functions and underlying applications, Lipoproteins. Properties, functions and biochemical functions of steroid hormones and peptide hormones

(Lectures: 6)

Unit 4:

Nucleic Acids

Components of nucleic acids: adenine, guanine, thymine and cytosine (structure only), other components of nucleic acids, nucleosides and nucleotides (numbering), structure of DNA (Watson-Crick model) and RNA (types of RNA), genetic code, biological roles of DNA and RNA: replication, transcription and translation.

(Lectures: 6)

Unit 5:

Biochemistry of disease

A diagnostic approach by blood/ urine analysis, Blood: composition and functions of blood, blood coagulation. Blood collection and preservation of samples, Anaemia, Urine: Collection and preservation of samples. Formation of urine. Composition and estimation of constituents of normal and pathological

urine. Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.

(Lectures: 6)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab: Analytical clinical biochemistry

1. Proteins-Qualitative tests
2. Lipids – qualitative Tests.
3. Determination of the iodine number of oil.
4. Determination of the saponification number of oil.
5. Determination of acid value of fats and oils.
6. Determination of cholesterol using Liebermann- Burchard reaction.
7. Estimation of DNA by diphenylamine reaction
8. Determination of amount of protein using Lowry's method.
9. Determination of enzyme activity

References:

Theory:

1. Devlin, T.M. (2010),**Textbook of Biochemistry with Clinical Correlation**, Wiley.
2. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2002),**Biochemistry**, W. H. Freeman.
3. Satyanarayana, U.; Chakrapani, U. (2017), **Fundamentals of Biochemistry**, Books and Allied (P) Ltd.
4. Lehninger, A.L; Nelson, D.L; Cox, M.M. (2009),**Principles of Biochemistry**, W. H. Freeman.
5. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Practical:

1. Dean, J.R.; Jones, A.M.; Holmes, D;, Reed, R.; Jones, A.Weyers, J. (2011),**Practical skills in chemistry**, Prentice-Hall.
2. Wilson, K.; Walker, J. (2000),**Principles and techniques of practical biochemistry,**Cambridge University Press.
3. Gowenlock. A.H. (1988),**Varley's Practical Clinical Biochemistry**, CRC Press.

Teaching Learning Process:

- The teaching learning process will involve the traditional chalk and black board method.
- Certain topics like Mechanism of enzyme action, drug receptor theory, transcription and translation, SAR etc. where traditional chalk and talk method may not be able to convey the concept, are taught through audio-visual aids.

- Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Metabolism, Enzymes, Mechanism of enzyme action and Inhibition, Structure activity relation (SAR), Drug Receptor Theory, Biocatalysis, Lipids and their biological functions, Nucleic acids and concept of heredity, Biochemistry of diseases.

Course Code: CHEMISTRY –SEC-8
Course Title: Green Methods in Chemistry
Total Credits: 04 (Credits: Theory-02, Practicals-02)
(Total Lectures: Theory- 30, Practicals-60)

Objectives:

- To inspire the students about the chemistry which is good for human health and environment.
- To evaluate suitable technologies for the remediation of hazardous substances.
- To make students aware of how chemical processes can be designed, developed and run in a sustainable way.
- To acquire the knowledge of the twelve principles of green chemistry and how to apply in green synthesis.
- To make students aware about the benefits of using green chemistry.
- To have the idea of Biocatalytic Process—Conversion of Biomass into chemicals.

Learning Outcomes:

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

- Get idea of toxicology, environmental law, energy and the environment
- Think to design and develop materials and processes that reduce the use and generation of hazardous substances in industry.
- Think of chemical methods for recovering metals from used electronics materials.
- Get ideas of innovative approaches to environmental and societal challenges.
- Know how chemicals can have an adverse/potentially damaging effect on human and vegetation.
- Critically analyse the existing traditional chemical pathways and processes and creatively think about bringing environmentally benign reformations in these protocols.
- Convert biomass into valuable chemicals through green technologies.

Unit 1:

Introduction

- Definition of green chemistry and how it is different from conventional chemistry and environmental chemistry.
- Need of green chemistry
- Importance of green chemistry in- daily life, Industries and solving human health problems (four examples each).
- A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards).**(Lectures:8)**

Unit 2:

Twelve Principles of Green Chemistry

The twelve principles of the Green Chemistry with their explanations

Special emphasis on the following:

- Prevention of waste / byproducts, pollution prevention hierarchy.
- Green metrics to assess greenness of a reaction: environmental impact factor, atom economy and calculation of atom economy.
- Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, *so*lvent less reactions, solvents obtained from renewable sources.
- Catalysis and green chemistry- comparison of heterogeneous and homogeneous catalysis, bio-catalysis, asymmetric catalysis and photocatalysis.
- Green energy and sustainability.
- Real-time analysis for pollution prevention.
- Prevention of chemical accidents, designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

(Lectures:14)

Unit 3:

The following Real-world Cases in green chemistry should be discussed:
Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
Designing of environmentally safe marine antifoulant.
Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

(Lectures:8

)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab- Green methods in chemistry

Characterization by m. pt.; U.V.-Visible spectroscopy, IR spectroscopy, and any other specific method should be done (wherever applicable).

1. Preparation and characterization of nanoparticles of gold using tea leaves/ silver nanoparticles using plant extracts.
2. Preparation and characterization of biodiesel from vegetable oil preferably waste cooking oil.
3. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.
4. Mechanochemical solvent free, solid-solid synthesis of azomethine using p-toluidine and o-vanillin (various other combinations of primary amine and aldehyde can also be tried).
5. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).
6. Designing and conducting an experiment by utilizing the products and by-products obtained in above preparations which become waste otherwise if not used. This is done by critical thinking and literature survey.

Some representative examples:

7. Use of nanoparticles as catalyst for a reaction.
8. Use of azomethine for complex formation.
9. Conversion of byproduct of biodiesel to a useful product.

References:

Theory:

1. Anastas, P.T.; Warner, J.C.(1998), **Green Chemistry, Theory and Practice,** Oxford University Press.
2. Lancaster, M.(2016),**Green Chemistry An Introductory Text.**2nd Edition, RSC Publishing.
3. Cann , M. C.; Umile, T.P. (2008), **Real world cases in Green chemistry** Vol 11, American chemical Society,Washington.
4. Matlack, A.S.(2001),**Introduction to Green Chemistry,** Marcel Dekker.
5. Ryan, M.A.; Tinnesand, M. (2002), **Introduction to Green Chemistry** (Ed), American Chemical Society, Washington DC.

Practical:

1. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment.** American Chemical Society, Washington DC.
2. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K.(2013), **Green Chemistry Experiments: A monograph,** I.K. International Publishing House Pvt Ltd. New Delhi.
3. Pavia,D.L.; Lamponam, G.H.; Kriz, G.S.W. B.(2006),**Introduction to organic Laboratory Technique-A Microscale approach**,4th Edition, Brrooks-Cole Laboratory Series for Organic chemistry.
4. Sharma R. K., Sharma, C., & Sidhwani, I.T. Solventless and one-pot synthesis of Cu(II) phthalocyanine complex: a green chemistry experiment. Journal of Chemical Education, 2010, 88(1), 86-88.
5. Sharma, R. K., Gulati, S., & Mehta, S. Preparation of gold nanoparticles using tea: a green chemistry experiment. Journal of Chemical Education, 2012, 89(10), 1316-1318.
6. Wealth from waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated “A social Awareness Project” Indu Tucker Sidhwani, Geeta Saini, Sushmita Chowdhury, Dimple Garg, Malovika, Nidhi Garg, Delhi University Journal of Undergraduate Research and Innovation, Vol 1, Issue 1, Feb 2015. ISSN: 2395-2334.

Teaching Learning Process:

- ICT enabled classes
- Power point presentations
- visit to pharmaceutical industry
- Through videos classes
- Interactive classes

Assessment Methods:

- Graded assignments
- Conventional class tests

- Class seminars by students on course topics with a view to strengthening the content through width and depth
- Quizzes
- End semester university examination.

Keywords:

Green Chemistry, Twelve principles, Sustainable chemistry, Green energy, Marine antifoulant, Non toxic pigments.

Course Code: CHEMISTRY –SEC-9
Course Title: Pharmaceutical Chemistry
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives:

The objective of this paper is to develop basic understanding of drugs discovery, design, development and their side effects. The course will cover synthesis of major drug classes including-analgesics, antipyretics, anti- inflammatory agents, antibacterial and antifungal agents, antiviral agents, central nervous system agents and drugs for HIV--AIDS. An overview of fermentation process and production of certain dietary supplements and certain common antibiotics will be discussed.

Learning Outcomes:

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

- Gain insight into retro-synthesis approach in relation to drug design and drug discovery.
- Learn synthetic pathways of major drug classes.
- Understand the fermentation process and production of ethanol, citric acids, antibiotics and some classes of vitamins.

Unit 1:

Introduction

Drug discovery, design and development: Sources of drugs: biological, marine, minerals and plant tissue culture, physio-chemical aspects (optical, geometric and bioisosterism) of drug molecules and biological action, drug receptor interaction, basic retro-synthetic approach for development of drug. Cause of side effect of drugs like ibuprofen, cetirizine, thalidomide. Difference between drug and poison.

(Lectures: 7)

Unit 2:

Drugs and Pharmaceuticals

Study of pharmaceutical aids like talc, diatomite, kaolin, bentomite, gelatin and natural colours

Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol,

Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), central nervous system agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

(Lectures:15)

Unit 3:

Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

(Lectures: 8)

Practical:

(Credits: 2, Laboratory periods: 60)

Chemistry Lab: Pharmaceutical chemistry

1. Preparation of aspirin and its analysis.
2. Preparation of paracetamol and its analysis.
3. Preparation of sulphacetamide of sulphonamide and its analysis.
4. Determination of alcohol contents in liquid drugs/galenical.
5. Determination of ascorbic acid in vitamin C tablets by iodometric or coulometric titrations.
6. Synthesis of ibuprofen.
7. Analysis of commercial vitamin C tablets by iodometric and coulometric titrimetry.

References:

Theory:

1. Patrick, G. (2017), **Introduction to Medicinal Chemistry**, Oxford University Press.
2. Singh H.; Kapoor V.K. (1996), **Medicinal and Pharmaceutical Chemistry**, Vallabh Prakashan.
3. Foye, W.O.; Lemke, T. L.; William, D.A. (1995),**Principles of Medicinal Chemistry**, B.I. Waverly Pvt. Ltd.

Practical:

1. Kjonaas, R.A.; Williams, P.E.; Counce, D.A.; Crawley, L.R. **Synthesis of Ibuprofen**. J. Chem. Educ., 2011, 88 (6), pp 825–828 DOI: 10.1021/ed100892p.
2. Marsh, D.G.; Jacobs, D.L.; Veening, H. **Analysis of commercial vitamin C tablets by iodometric and coulometric titrimetry**. J. Chem. Educ., 1973, 50 (9), p 626. DOI: 10.1021/ed050p626

Teaching Learning Process:

The teaching learning process will involve the traditional chalk and black board method. Certain topics like retro-synthetic approach and fermentation processes are taught through audio-visual aids. Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics.

Assessment Methods:

Assessmentwill be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords:

Retro-synthesis, Drug discovery, Design and synthesis, Side effects, Fermentation.

Course Code: CHEMISTRY –SEC-10
Course Title: Chemistry of Cosmetics and Perfumes
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives:

Cosmetic plays an important role in our everyday lives as they make an individual's appearance more attractive and boost one's self-esteem and confidence. Keeping in view the tremendous potential which the cosmetic industry has today around the globe, this course will be useful for introducing students of Chemistry honours to the world of cosmetic chemistry. This has been designed to impart the theoretical and practical knowledge on basic principles of cosmetic chemistry, manufacture, formulation of various cosmetic products.

Learning outcomes:

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

- Learn basic of cosmetics, various cosmetic formulation, ingredients and their roles in cosmetic products.
- Learn the use of safe, economic and body-friendly cosmetics
- Prepare new innovative formulations.

Unit 1:

Cosmetics- Definition, History, Classification, Ingredients, Nomenclature, Regulations.

(Lectures: 4)

Unit 2:

Face Preparation: Structure of skin, Face powder, Compact powder, Talcum powder.

(Lectures: 6)

Unit 3:

Skin Preparation: Face cream, vanishing cream, cold cream, suntan cream, lather shaving cream

(Lectures: 5)

Unit 4:

Hair preparation: Structure of hair, classification of hair, Hair dye- classification – temporary, semi-permanent, demi permanent, permanent, formulation, hair sprays, shampoo- types of shampoo, conditioners

(Lectures: 6)

Unit 5:

Colored preparation: Nail preparation Structure of nail, Nail lacquers, Nail polish remover Lipsticks

(Lectures: 4)

Unit 6:

Personal hygiene products: Antiperspirants and deodorants, oral hygiene products, flavours and essential oils

(Lectures: 5)

Practical:

(Credits: 02, Laboratory periods: 60)

Preparation of:

1. Talcum powder.
2. Shampoo.
3. Enamels.
4. Face cream.
5. Nail polish and nail polish remover.
6. Hand wash
7. Hand sanitizer
8. Body lotion
9. Soap
10. Tooth powder
11. Tooth paste

References:

1. Barel, A.O.; Paye, M.; Maibach, H.I.(2014), **Handbook of Cosmetic Science and Technology,** CRC Press.
2. Garud, A.; Sharma, P.K.; Garud, N. (2012),**Text Book of Cosmetics**, Pragati Prakashan.
3. Gupta, P.K.; Gupta, S.K.(2011),**Pharmaceutics and Cosmetics**, Pragati Prakashan
4. Butler, H. (2000),**Poucher's Perfumes, Cosmetic and Soap**, Springer
5. Kumari, R.(2018),**Chemistry of Cosmetics**, Prestige Publisher.

Additional Resources:

1. Flick,E.W.(1990), **Cosmetic and toiletry formulations,** Noyes Publications / William Andrew Publishing.
2. Natural Ingredients for Cosmetics; EU Survey 2005
3. Formulation Guide for cosmetics; The Nisshin OilliO Group, Ltd.
4. Functional Ingredients & Formulated Products for Cosmetics & Pharmaceuticals; NOF Corporation

Teaching Learning Process:

- Conventional chalk and board teaching with power point presentation, you tube videos. and presentations from students on relevant topics.
- Theory coupled with preparation of cosmetic products in lab.

Assessment Methods:

Internal assessment through assignments and class test. End semester written and practical examination.

Keywords:

Cosmetic Products, Ingredients, Formulations, Raw materials, Lab. preparation, Ideal characteristics

---

Course Code: CHEMISTRY –SEC-11
Course Title: Pesticide Chemistry
Total Credits: 04 **(Credits: Theory-02, Practical-02)**
(Total Lectures: Theory- 30, Practical-60)

Objectives:

Pesticide plays an important role in controlling quantity as well quality of the economic crops by protecting them from the various pests. They are used for prevention of much spoilage of stored foods and also used for prevention of certain diseases, which conserves health and has saved the lives of millions of people and domestic animals.Keeping the importance of pesticides in mind this course is aimed to introduce synthesis and application of pesticides.

Learning Outcomes:

Students will be able to learn about the basic role of pesticide in everyday life, various ingredients and their role in controlling the pest. Students can also educate the farmers/gardeners to choose the appropriate pesticides for their crop production.

Unit 1:

Introduction: Classification, synthesis, structure activity relationship (SAR), mode of action, uses and adverse effects of representative pesticides in the following classes: Organochlorines (DDT, Gammaxene); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and Carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

(Lectures:12)

Unit 2:

Botanical insecticides [No structure elucidation or synthesis is required for the following compounds:]Alkaloids(Nicotine); Pyrethrum (natural and synthetic pyrethroids); Azadirachtin; Rotenone and Limonene.

(Lectures:8)

Unit 3:

Pesticide formulations: Wettable powders, Surfactants, Emulsifiable concentrates, Aerosols, Dust and Granules, Controlled Release Formulations.

(Lectures:6)

Unit 4:

New Tools in Biological Pest Control: Repellants, Chemosterilants, Antifeedants, Sex attractants.

(Lectures:4)

Practical:

(Credits: 2, Laboratory periods: 60)

1. To carryout market survey of potent pesticides with details as follows:

   a) Name of pesticide b) Chemical name, class and structure of pesticide c) Type of formulation available and Manufacturer's name d) Useful information on label of packaging regarding: Toxicity, LD_{50} ("Lethal Dose, 50%"), Side effects and Antidotes.

2. To carryout market survey of potent botanical pesticides with details as follows:

   a) Botanical name and family; b) Chemical name (active ingredient) and structure of active ingredient; c) Type of formulation available and Manufacturer's name; d) Useful information on label of packaging regarding: Toxicity, LD_{50} ("Lethal Dose, 50%"), Side effects and Antidotes.

3. Preparation of simple Organochlorine pesticides.
4. To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.
5. To calculate active ingredient in given sample of pesticide formulations as per BIS specifications.
6. Preparation of Neem based botanical pesticides.

References:

1. Perry, A.S.; Yamamoto, I.; Ishaaya, I.; Perry, R.Y.(1998),**Insecticides in Agriculture and Environment**, Springer-Verlag Berlin Heidelberg.
2. Kuhr, R.J. ; Derough, H.W.(1976),**Carbamate Insecticides: Chemistry, Biochemistry and Toxicology**, CRC Press,USA.

Teaching Learning Process:

Conventional chalk and board teaching with power point presentation, you tube videos and presentations from students on relevant topics.

Assessment Methods:

Internal assessment through assignments and class test. End semester written and practical examination.

Keywords:

Structure Activity Relationship (SAR), Organochlorines, Organophosphates, Carbamates, Quinones, Anilides, Botanical, Alkaloids, Pyrethrum, Azadirachtin, Rotenone, Limonene, Pesticide formulations, Repellants, Chemosterilants, Antifeedants, Sex attractants, Controlled release pesticide formulation.

Course Code: CHEMISTRY –SEC-12
Course Title: Fuel Chemistry
Total Credits: 04 **(Credits: Theory-02, Practical-02)**
(Total Lectures: Theory- 30, Practical-60)

Objectives:

The course aims to provide students with a basic scientific and technical understanding of the production, behaviour and handling of hydrocarbon fuels and lubricants, including emerging alternative & renewable fuels. This will enable them to be industry ready to contribute effectively in the field of petroleum chemistry and technology.

Learning Outcomes:

- The course covers both conventional petroleum-based fuels, and alternative & renewable fuels, including gaseous fuels.
- The students will learn the chemistry that underpins petroleum fuel technology, will understand the refining processes used to produce fuels and lubricants and will know how differences in chemical composition affect properties of fuels and their usage in different applications.
- The course will also cover origin of petroleum, crude oil, composition, different refining processes employed industrially to obtain different fractions of petroleum. Further, course will cover various alternative and renewable fuels like Biofuels (Different generations), Gaseous Fuels (e.g. CNG, LNG, CBG, Hydrogen etc.).
- The course will also cover fuel product specifications, various test methods used to qualify different types of fuels as well characterization methods.
- Review of energy scenario (Global & India), Energy sources (renewable and non-renewable). Types of Crude Oils, Composition and Properties. Crude oil assay

Unit 1:

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.Determination of calorific value by Bomb calorimeter and Junker's calorimeter.

(Lectures:4)

Unit 2:

Coal: Analysis of coal, Proximate and ultimate Analysis, Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydrogasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

(Lectures:7)

Unit 3:

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications.

(Lectures:4)

Unit 4:

Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking),

Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels.

(Lectures:6)

Unit 5:

Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

(Lectures:4)

Unit 6:

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semi-solid lubricants, synthetic lubricants.

Properties of lubricants (viscosity index, cloud point, pore point and and aniline Point) and their determination.

(Lectures:5)

Practical:

(Credits: 2, Laboratory periods: 60)

1. Test Methods for Petroleum products
2. To prepare biodiesel from vegetable oil
3. Calorific value of a fuel
4. Characterization of different petroleum products using UV and IR
5. To determine pore point and cloud point of fuel
6. To determine the viscosity of biodiesel ay various temperature using biodiesel.
7. To determine free fatty acid content in given sample.
8. To determine the density of the given fuel sample.

Reference:

Stocchi, E.(1990),**Industrial Chemistry**, Vol -I, Ellis Horwood Ltd. UK.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Lectures by Industry Experts
- Visit to Industry

Assessment Methods:

- Written exams-both objective and subjective questions.
- Dissertation work on a given topic - Preparation of literature report followed by presentation.
- Internal Assessment.
- End semester university examination for theory and practical.

Keywords:

Energy; Fuels; Petroleum; Biofuels; Synthetic Lubricants