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UNIVERSITY OF DELHI

B. Sc. (Program) Applied Life Sciences with Agrochemicals and Pest Management

(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

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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 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 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 program 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 B.Sc. program Applied Life Science 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 a degree in B.Sc. Applied Life Science intends to provide a skeleton ground which different aims and objectives of the program can be developed. Moreover, the framework is intended to allow periodic review; flexibility in program design and syllabi development, teaching-learning process as well as assessment of learning levels of the students. Additionally it enhances not only the theoretical knowledge but also the practical skills of the students. The program is so structured that a student of the course will have an advantage in making a better and informed career choice.

2. Learning Outcome-based Curriculum Framework

2.1 Nature and Extent of the Program

B.Sc. Applied Life Science is a three year degree program for the undergraduate students with Zoology as one of the important subject. The course is designed to provide quality education and skill to the students interested in safe and effective use of agrochemicals as well as management of pests. The course aims to provide students with core knowledge of subjects like Animal form and structure, Cell and cellular processes, Biochemistry and immunology, Molecular and developmental biology that are required for substantial understanding of biology and knowledge of how life works as a whole. The discipline centric subjects in the course are General entomology, Applied entomology and Integrated pest management where the students will not only be acquainted with morphology, anatomy and physiology of insects but will understand the role of insects as powerful competitors of man as they can cause enormous injury to crops and animals and can also act as vectors of many diseases. Knowledge about the different pest control measures, their principles and methodology will help in framing the appropriate management strategies. Skill enhancement in the papers of Biotechnological control of pests, Biological control, Insect toxicology, Quality control in Integrated Pest Management, Use of nuclear technology in agrochemical pest management will not only give them expertise in the applied courses but will enhance career opportunities for students in public and private sectors. The course addresses holistic approach to the applied life science with agrochemical and pest management by giving equal credits to botany and chemistry.

Zoology is an immensely important subject of Applied Life Science course as it concretize the fact that it includes study all types of animals with special focus on important insect pests and vectors of different diseases. The treatment and control of these pests by traditional and new methods like biological, nuclear, biotechnological and integrated etc. is studied for the betterment of our health, welfare and survival. With due deliberations and several rounds of discussions the provisions to lay the foundation and implementation of the Ethical committees in educational institutions are suggested. It is to maintain judicious use of animals/insects for experiments to test suitability and efficacy of different pest control methods so that the gaps between the ethical treatment of the animals and the scientific study on them go hand in hand .

2.2 Aim of Bachelor Degree Program

It's main aims are:

- To provide understanding of core concepts of animal form and function, cell and molecular biology, biochemistry, immunology and developmental biology of animals
- To provide a knowledge and understanding of general and applied entomology, agrochemicals and integrated pest management
- To provide experience in practical and analytical skill sets relevant to biological and biotechnological control of the pests, toxicology, integrated pest management
- To develop skills to maintain quality control in the formulation of pest management strategies under different social, economic and agronomic production regimes and to develop decision-making skills with use of new technology in agrochemicals and pest management.

3. Graduate Attributes in B.Sc. Program Applied Life Science

The attributes of applied life science graduate are:

Subject knowledge: Capable of demonstrating comprehensive knowledge in core and discipline centric subjects of applied zoology with respect to agrochemicals and pest management.

Logical thinker and problem solver: Ability to logically find solutions to the problems of agrochemical and pest management by experimentation, survey, data collection and analysis through traditional and modern methods.

Team work: Ability to understand principles and concepts of the subject, solve problems with reasoning, work in groups in the laboratories and participate in educational visits.

Leadership quality: Ability to identify, write, conduct and manage relevant and useful projects on different issues of bio control, biotechnological control and pest management taking care of ethical and safety guidelines.

Digitally literate: Capable of using computers for presentation, computational and statistical analysis using appropriate software.

Good orator and communicator: Ability to speak and present the subject knowledge in simple lucid way to the audience at different forums. The student should be able to express effectively at various awareness programmes for the farmers so that the knowledge of the insects, bio-control methods and integrated pest management is disseminated to the beneficiary.

Life-long learner: Capable of maintaining interest in the subject with the quest for new trends to keep student updated through different resource materials.

4. Qualification Descriptors

- The qualification descriptors for a Bachelor's Degree in Applied Life Science with agrochemical and pest management may include the following:
- Demonstrate understanding of the broad concepts in Applied Zoology with agrochemicals and pest management. Thorough practical and technical knowledge that produces experts for contributing in research and development, teaching, government and public sector services.
- Use broad knowledge base, rational thinking and technical skills for insect culture and evaluating problems of agrochemicals and pest management.
- Collection and analysis of data on different types of insect pests, damages caused and control measures undertaken, obtained from various sources using appropriate research methodologies for problem solving and formulating pest management strategies.
- Effective communication of the investigations and surveys undertaken in a variety of contexts related to agrochemicals and pest management, using the major concepts, principles and techniques of the subject(s).
- Prolific reading to fulfil the quest for more information of recent and advanced knowledge through broad range of research and professional inputs.
- Demonstrate subject-related skills that are relevant to applied zoology related jobs and employment opportunities.

5. Program Learning Outcome:

On successful completion of this course a student will be able to:

- Understand the basics of animal structure and function and have a good knowledge of entomology.
- Reflect on the importance of agriculture sector in Indian economy, agricultural intensification and the development of the need for integrated approaches to crop protection.
- Characterize the major components of pest management strategies and compare their relative merits for different pests and crops.
- Critically reflect on use of newer technology, emerging trends, advances and developments in applied zoology.

- Apply a range of sampling techniques for data collection and analyses, interpret results and writing report on the outcome.
- Demonstrate professional attitude and identify the ethical issues related to the different technical experiments in the laboratory and its application in the agriculture fields, promote eco-friendly methods and sustainable development.

6. Course Structure

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

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

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**

Details of Courses

Core Courses –Botany

1. Biology of life forms: Plants
2. Agricultural Botany and Weed science
3. Fundamentals of Plant Systematics and Ecology
4. Developmental Biology: Plants

Core Courses: Zoology

1. Animal: Form, Structure and Function
2. Cell and cellular Processes
3. Biochemistry and Immunology
4. Molecular biology and Development biology

Core Courses-Chemistry

1. Inorganic chemistry
2. Organic Chemistry -1
3. Organic Chemistry-2
4. Physical chemistry

Discipline Specific Electives-Botany (Any two)

1. Genetics and Plant Biotechnology
2. Plants regulators and Economic Botany
3. Dissertation

Discipline Specific Electives: Zoology (Any two)

1. General Entomology
2. Applied Entomology
3. Integrated Pest Management
4. Dissertation

Discipline Specific Electives-Chemistry (Any two)

1. Soils And Fertilizers
2. Herbicides
3. Fungicides
4. Dissertation

Ability Enhancement Compulsory Courses

1. English Communication
2. Environmental Science

Skill Enhancement Courses (Any four)

Botany

1. Medicinal Plants and IPR (Intellectual Property Rights)
2. Plants Quarantine
3. Plant health diagnostics and Management
4. Plants regulators and Economic Botany

Zoology

1. Biotechnological control of Pest
2. Biological Control
3. Insect Toxicology
4. Quality control in IPM
5. Use of nuclear technology for agro-pest management

Chemistry

1. Conventional Insecticides
2. Biological Insecticides
3. Pesticide Formulations
4. Analytical Techniques involved in Pesticide Analysis

Scheme of B.Sc. Programme (Applied Life Sciences with Agro-chemicals and Pest Management)

Semester	Course Opted	Course Name	Credits
I	**Ability Enhancement Compulsory Courses-I**	Environmental Science/ English Communication	**2**
	Core course Botany –I		**4**
	Core Course Botany I Practical		**2**
	Core course Zoology- I		**4**
	Core Course Zoology- I Practical		**2**
	Core course Chemistry- I		**4**
	Core Course Chemistry- I Practical		**2**
II	**Ability Enhancement Compulsory Courses-II**	Environmental Science/ English Communication	**2**
	Core course Botany –II		**4**
	Core Course Botany II Practical		**2**
	Core course Zoology-II		**4**
	Core Course Zoology- II Practical		**2**
	Core course Chemistry- II		**4**
	Core Course Chemistry- II Practical		**2**
III	**Core course Botany –III**		**4**
	Core Course Botany III Practical		**2**
	Core course Zoology-III		**4**
	Core Course Zoology- III Practical		**2**
	Core course Chemistry- III		**4**
	Core Course Chemistry- III Practical		**2**
	Skill Enhancement Course_I		**2**
IV	**Core course Botany –IV**		**4**
	Core Course Botany IV Practical		**2**
	Core course Zoology-IV		**4**
	Core Course Zoology- IV Practical		**2**
	Core course Chemistry- IV		**4**
	Core Course Chemistry- IV Practical		**2**
	Skill Enhancement Course_II		**2**
V	**Discipline Specific Elective Botany –I**		**4**
	Discipline Specific Elective Botany-I Practical		**2**
	Discipline Specific Elective Zoology –I		**4**
	Discipline Specific Elective Zoology –I Practical		**2**
	Discipline Specific Elective Chemistry –I		**4**
	Discipline Specific Elective Chemistry –I Practical		**2**
	Skill Enhancement Course_III		**2**
VI	**Discipline Specific Elective Botany –II**		**4**
	Discipline Specific Elective Botany-II Practical		**2**

	Discipline Specific Elective Zoology –II		**4**
	Discipline Specific Elective Zoology –II Practical		**2**
	Discipline Specific Elective Chemistry –II		**4**
	Discipline Specific Elective Chemistry –II Practical		**2**
	Skill Enhancement Course_IV		**2**
	Total		**120**

7. Course–Level Learning Outcome:

Core course-I Animal Form, Structure and Function

- Understand systematics, taxonomy and structural organization of Kingdom Animalia.
- Understand various characteristic features of different classes and orders under both Non-chordates and Chordates.
- Understand and correlate with morphological and anatomical aspects in various classes under Kingdom Animalia.
- Understand the functioning of various physiological systems within the human body and correlate with the interaction of various organ systems, which eventually results in the overall normal functioning of the body.
- Enhance collaborative learning with better analytical ability and communication skills through practical sessions, teamwork, group discussions, assignments, and projects.

Core course-II Cell and Cellular Processes

- Define the cell, and understands the cellular-level organization of diverse tissue of the body.
- Gain knowledge and skill in identifying various cell structures and their vital components.
- A preliminary knowledge of various techniques involved in fixation, staining and procedures used to visualize the cell and its components.
- Learn classical laboratory techniques like handling microscopic materials and use of simple and compound microscopes.
- Be knowledgeable in proper procedures and regulations in handling and disposal of biological and chemical waste

Core course-III Biochemistry and Immunology

- Understand the concepts of biochemistry and how biomolecules interact with each other to bring about life processes.
- Appreciate the role of enzymes in metabolic pathways.
- Learn how enzyme activity is controlled, 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.
- Understand different components of the Immune system, different defense mechanisms and how they work and provide immunity.
- Learn about the structures and functions of different classes of Antibodies.
- Develop the knowledge about Monoclonal antibodies and their applications.
- Learn how the highly regulated Immune system behaves when the balance is disturbed.
- To appreciate the immune system and its various components to protect the host from pathogen with a special emphasis on AIDS, Vaccines and transplantation.

Core course- IV Molecular Biology and Developmental Biology

- Understand the basic structure and types of nucleic acids - DNA and RNA;
- Learn the salient features of the genetic code,

- Compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes,
- Elucidate the molecular machinery and mechanism of information transfer processes –transcription (formation of RNA from DNA) and translation (formation of proteins from RNA) - in prokaryotes and eukaryotes.
- Understand the general principles of transcription regulation in prokaryotes by exploring the structure and function of lactose and tryptophan metabolism operons.
- Identify components of gene expression regulation in eukaryotes.
- Explain the process of gametogenesis – spermatogenesis and oogenesis.
- Describe the fertilization process and mechanisms to block polyspermy.
- Define fate maps; explain its significance of methods of constructing.
- Detail the early development of frog and chick embryo and identify its stages.
- Enlist different types of placenta, its structure and significance.

DSE-1 General Entomology

- Identify and classify insects upto orders
- Understand methods of collection and preservation of insects and their rearing in the laboratory
- Describe the morphology of head, thorax and abdomen of an insect
- Explain the structure of various body appendages
- Describe the anatomy and physiology of various organ systems in insects
- Explain the concept of metamorphosis and its hormonal control
- Understand the phenomenon of parthenogenetic development in insects

DSE-II Applied Entomology

- 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.

DSE-III Integrated Pest Management

- Create the awareness about adverse effects of insecticides on the environment and need for environment friendly approach for management of insect pests.
- Students will gain knowledge about the concepts and tools of pest management.
- Understand the planning of agricultural ecosystem, tolerance of pest damage, timing of different pest control tactics to manage the pest population effectively.
- Learn about the use of different pest control techniques in a harmonious manner.
- Understand the role of IPM in sustainable agriculture as the future of modern plant protection and pest control strategy.

SEC-I Biotechnological control of pests

- Learn Recombination techniques, GIT, Bioremediation

- Gain knowledge about transgenic plants (Bt cotton) and animals.
- Understand SDS –PAGE
- Learn the computer programs to predict and forecast pest attack

SEC-II Biological control of crop pest

- Understand principles of biological control and gain knowledge on Biological control agents
- Mass production of biological control agents
- Demonstrate release of bio-control agents in the fields and their evaluation.
- Understand and learn Quarantine and its regulations.

SEC-III Insect toxicology

- Demonstrate fundamental knowledge and understanding of the principles of insecticide toxicity, and its evaluation for insect pest control.
- Explain pest resistance to insecticides and its management, and best practices for safe use of toxic insecticides as well as treatments for insecticide poisoning.
- Practical skills of management of pests in public buildings like termite proofing, rodent control, etc.

SEC-IV Quality control in IPM

- Explain basic concepts of quality control attributes, mass rearing and maintenance of biological control agents.
- Understand quality control criteria of bio-control agents' viz. sex-ratio, emergence, fecundity, longevity, parasitism, pupal and adult body size
- Identify quality control measures in relation to locomotor behavior and bio-efficacy of egg-parasitism

SEC-V Use of Nuclear Technology for Agro-Pest Management

- Demonstrate the knowledge of radiation, types of irradiators and radiation dosimetry in relation to safety and security
- Uses of radiation technology for production of insect host as well as natural enemies
- Skill for uses of Sterile Insect Technology (SIT) in pest management

8. Teaching Learning Process:

Learning material will be presented through a series of lectures, mainly designed to introduce principles and concepts. Lectures will be supported by power point presentations, charts, videos and open education resources and practical laboratory training as well as case studies requiring analysis and evaluation by students. Students will undertake different projects where they will understand handling and culture of insects of interest. They will be provided mathematical and computational training by data base studies related to LC50, EIL, ETL, probit analysis, etc. To foster more interest in the students various educational trips will be conducted. Students will also be encouraged to access e-learning resources like MOOCS, SWAYAM, Coursera, etc.

9. Assessment Methods:

The assessment of students' achievement in B.Sc. Applied Life Sciences will be aligned with the course/programme learning outcomes. Assessment may be designed as per the requirement of the course. However, continuous evaluation can be achieved by following the pattern of formative and summative evaluation. Efforts should be made to improve the rational and applied thinking of the student which can be achieved through project work, quiz, problem solving exercises, classroom assessment methods, closed-book and open-book tests, problem-solving exercises, practical assignments, laboratory reports, seminar presentation; *viva voce* interviews, computerized adaptive testing, literature surveys, etc. As currently in practice, the summative evaluations could be by end-semester examination both in theory and practical papers as per the university guidelines. The currently followed assessment pattern may also be adapted-

Theory-100 marks

- End Semester exam- 75 marks
- Internal Assessment- 25 marks (Assignment-10, Test-10, Attendance-5)

Practical-50 marks

- Exam-25 marks
- Continuous Evaluation-25 marks (Records-10, Viva/Project-5, Attendance-5, Total no. of practical units performed-5).

10. Courses for Program BSc. Applied Life Science

ALS Core Course-I: Animal: Form, Structure and Function

Course Learning Objective:

Biology of Animal is designed for applied life science undergraduates to inculcate a deep appreciation, interest, and knowledge about the various life forms under the Kingdom Animalia. The course will familiarize the students with systemic classification based on evolutionary relationship, structural-functional affinities, morphological and anatomical diversities in different animal taxa, along with the principles and basic facts of Animal Physiology. The emphasis will be on mammalian physiology, focusing on various organ-systems; however, cellular and molecular mechanisms will be also discussed in order to present a current view of physiological principles. The laboratory component of the course is designed to reinforce the topics discussed in lecture, as well as to familiarize students with the diversity of life forms under kingdom Animalia and also with some of the laboratory techniques and equipment used in the acquisition of physiological data.

Course Learning Outcome:

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

- Understand systematics, taxonomy and structural organization of kingdom Animalia.
- Comprehend various characteristic features of different classes and orders categorized under both Non-chordates and Chordates.
- Study the morphological and anatomical features of various animals belonging to various classes under kingdom Animalia.
- Learn the functioning of various physiological systems within the human body.
- Appreciate the interaction of various organ systems, which eventually results in the overall normal functioning of the body.
- Enhance collaborative learning with better analytical ability and communication skills through practical sessions, teamwork, group discussions, assignments, and projects.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Introduction 3 hrs

General characteristics and outline classification of different animal groups (up to classes for non-chordates and up to orders for chordates)

(Chapter- 3, 7, 8, 10, 12, 13, 16, 15, 17-20, 28: Barnes; Chapter- 2, 3, 4, 5, 6, 7, 12, 14, 17, 18, 19, 20: Young)

Unit 2: Acoelomates 6 hrs

Locomotion and reproduction in Protista; Canal system in Porifera; Polymorphism in Cnidarians; Parasitic adaptations in Platyhelminthes.

(Chapter 2,3, 5,7, 10: Barnes)

Unit 3: Schizocoelomates 4 hrs

Metamerism in Annelida; Vision in Arthropods; Pearl formation in Molluscs.

(Chapter 13, 16, 12: Barnes)

Unit 4: Enterocoelomates 7 hrs

Water vascular system in Echinodermata; Osmoregulation in Fishes; Respiration in Amphibians; Terrestrial Adaptation in Reptiles; Flight adaptations in Birds; Integument in Mammals

(Chapter 28: Barnes; Chapter 5,11,13,15, 18: Young)

Unit 5: Tissues and Glands 6 hrs

Different types of tissues in man - Epithelial, Connective, Muscular and Nervous; Types of Glands

(Chapter 4: Tortora)

Unit 6: Muscular Physiology 6 hrs

Ultra structure of skeletal muscle, Molecular mechanism of muscular contraction

(Chapter 11: Tortora)

Unit 7: Physiology of Digestion 6 hrs

Digestion and Absorption of carbohydrate, fat and protein in GI tract

(Chapter 24: Tortora)

Unit 8: Respiration & Renal physiology 8 hrs

Respiratory Pigments, Transport of oxygen & carbon dioxide in blood. Functional anatomy of kidney, counter-current mechanism

(Chapter 23, 26: Tortora)

Unit 9: Circulatory System 6 hrs

Components of Blood and lymph, Structure and function of heart, Conduction of Heart beat.

(Chapter19, 20: Tortora)

Unit 10: Endocrine system 8 hrs

Endocrine glands and their hormones.

(Chapter 18: Tortora)

Practical [Credits: 2]

1. Non-Chordata:

(a) Study of following specimens:

Euglena, Noctiluca, Paramecium, Sycon, Euplectella, Auralia, Physalia, Tubipora, Metridium, Fasciola, Taenia, Ascaris, Nereis, Leech, Peripatus, Limulus, Hermitcrab, Millipede, Centipede, Scorpion, Chiton, Dentalium, Octopus, Asterias, and Antedon

(b) Study of Permanent Slides: T.S. and L.S. of *Sycon*; Medusa of *Obelia*, T. S. of arm of Starfish.

2. Chordata

(a) Study of following specimens:

Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Icthyophis/ Uraeotyphlus, Salamandra, Rhacophorus, Draco, Naja, Viper, model of Archaeopteryx, any three common birds (Crow, duck, Owl), Squirrel and Bat.

(b) Study of Permanent slides/ Photographs: Placoid and Cycloid scales, Nerve cells, Striated muscle.

3. Preparation of haemin and hemochromogen crystals.
4. Estimation of haemoglobin using Haemoglobinometer.
5. Study of histological slides- Examination of sections of mammalian skin, oesophagus, ileum, rectum, liver, pancreas, trachea, lung, kidney, pituitary, adrenal, thyroid, ovary, testis.

Teaching and Learning Process:

In order to attain the best understanding of concepts and acquiring of skills, teaching-learning process includes various strategies. Interactive classroom lectures will impart a conceptual based understanding and learning of the subject. Practical exercises complement the theory syllabus in order to attain a better understanding of theoretical concepts. This includes drawing and labelling the various specimens, to attain a better understanding about the organisms. Studying specimen organisms *i.e.* incorporating museum specimens during the practical teaching process will ensure linking of the theoretical concepts and facts with the specimen. This also allows for an informal communication with student groups, paving way for active participation of students. This will be further complemented by use of computers and projectors to show photographs/diagrams/animations. Utilising the advance and effcetive methods and technologies such as models, computer assisted learning by powerpoint slides, videos, photographs and diagrams will enhance their learning. Giving students opportunity for peer teaching and collaborative learning by means of Presentation, group discussions, debates etc. will further increase their confidence as well as provide clarity in concepts, by stimulating the thinking process. Students will be encouraged to take up projects which provide them an opportunity to explore the resources. Use of e-learning resources for self study; SWAYAM, Coursera, EdX; will assist learning process. Helping students learn in some fun ways to memorise by the use of mnemonics; especially when students need to memorise pathways such as one involved in blood coagulation; will provide an effective learning platform. Feedbacks and suggestions, involving specific inputs on various teaching methods adopted, would help to a great extent in devising effective strategy for teaching and learning.

Assessment Methods:

Students will be assessed by the following ways:

- Continuous assessment during entire semester along with the Summative assessment by the semester-end evaluations.
- Power point or black-board presentation on related topics by students thereby, increasing presentation skills and knowledge of students.
- Assignments and projects on related topics; improving writing skills and academic performance of the students.
- Regular class tests for concept clarity.
- *Viva –voice* for ensuring the basic understanding and concept building.

Keywords:

Protista, Metazoa, Cnidaria, Annelida, Arthropoda, Acoelomates, Schizocoelomates, Enterocoelomates, Canal system, Polymorphism, Metamerism, Pearl, Deuterostomia, Echinodermata, Insecta, Mollusca, Structural organization, Protochoradata, Chordata, Cyclostomata, Pisces, Tetrapoda, Amphibia, Reptilia, Aves, Mammalia, Osmoregulation, Integument, Tissues, Glands, Muscles, Digestion, Respiration, Excretion, Heart, Blood, Hormones.

Recommended Books:

- Barnes, R.D. (2006) Invertebrate Zoology. VII Edition, Cengage Learning, India.
- Young, J. Z. (2004) The Life of Vertebrates. III Edition. Oxford University Press.
- Tortora, G.J. and Grabowski, S. (2001) Principles of Anatomy and Physiology. Harper Publishers.
- Campbell & Reece (2005). Biology. Pearson Education, (Singapore) Pvt. Ltd.
- Vander A, Sherman J. and Luciano D. (2014) Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills.

Note: Chapter number may vary with edition.

Suggested Readings:

- Ganong WF (2019) Review of Medical Physiology. 26th Edition, Mc Graw-Hill.
- Guyton, A.C & Hall, J.E, (2006) Text book of Medical Physiology. XI Edition, Hercourt Asian PTE Ltd/W.B. Saunders Company.
- Barrington, E.J.W. (2012) Invertebrate Structure and Functions. II Edition, EWP Publishers.
- Ruppert, Fox and Barnes (2006) Invertebrate Zoology. A functional Evolutionary Approach. VII Edition, Thomson Books/Cole.
- Pechenik, J. A. (2015) Biology of the Invertebrates. VII Edition, McGraw-Hill Education.
- Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
- Verma, P.S. A Manual of Practical Zoology: Invertebrates. S. Chand & Company.
- Verma, P.S A Manual of Practical Zoology: Vertebrates. S. Chand & Company.
- Lal, S.S. Practical Zoology. Volume 1, 2 & 3. Rastogi Publications.

Online Tools and Web Resources:

- Swayam (MHRD) Portal
    - Animal Diversity (https://swayam.gov.in/courses/5686-animal-diversity)
    - Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology)
- ePG Pathshala (MHRD) Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35
- https://opentextbc.ca/biology2eopenstax/chapter/chordates/
- https://students.ga.desire2learn.com/d2l/lor/viewer/viewFile.d2lfile/1798/12815/animals_print.html

ALS Core Course-II: Cell and Cellular Processes

Course Learning Objective:

The objective of the course is to help the students to learn and develop an understanding of a cell as a basic unit of life. This course is designed to enable them to understand the functions of cellular organelles and how a cell carries out and regulates cellular functions.

Course Learning Outcome:

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

- Understand fundamental principles of cell biology.
- Explain structure and functions of cell organelles involved in diverse cellular processes.
- Appreciate how cells grow, divide, survive, die and regulate these important processes.
- Learn the process of cell signalling and its role in cellular functions.
- Have an insight of how defects in functioning of cell organelles and regulation of cellular processes can develop into diseases. Learn the advances made in the field of cell biology and their applications.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Techniques in Biology 8 hrs

Principles of microscopy; Light Microscopy; Compound microscopy; Electron microscopy (EM); Scanning EM and Scanning Transmission EM (STEM)

(Chapter 1: Cooper; Chapter 18: Karp)

Unit 2: Cell as a Unit of Life 7 hrs

The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components

(Chapter 1: Cooper; Chapter 7: Campbell)

Unit 3: Cell Organelles 25 hrs

Mitochondria: Structure, marker enzymes, composition; Mitochondrial biogenesis; Semiautonomous nature; Symbiont hypothesis; Mitochondrial DNA; Chloroplast: Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA; ER, Golgi Body & Lysosomes: Structures and roles. Signal peptide hypothesis, N-linked glycosylation, Role of Golgi in O linked glycosylation. Cell secretion, Lysosome formation; Peroxisomes and Glyoxisomes: Structures, composition, functions in animals and plants and biogenesis; Nucleus: Nuclear Envelope- structure of nuclear pore complex; chromatin; DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure.

(Chapter 10, 11 and 12: Cooper)

Unit 4: Cell Membrane and Cell Wall 10 hrs

The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Selective permeability of the membranes; Cell wall.

(Chapter 14 and 15: Cooper)

Unit 5: Cell Cycle 10 hrs

Interphase, Mitosis and Meiosis; Role of Cell division; Overview of Cell cycle; Molecular controls

(Chapter 16 and 17: Cooper)

Practical [Credit: 2]

- To learn use of microscope and principles of fixation and staining.
- Study of the photomicrographs of cell organelles; nuclear pore complex (photograph)
- To study the structure of plant cell through temporary mounts.
- To study the structure of animal cells by temporary mounts - Buccal epithelial cell and nerve cell.
- To prepare temporary stained preparation of mitochondria from striated muscle cells/cheek
- Epithelial cells using vital stain Janus Green B.
- To prepare temporary stained squash from root tips of *Allium cepa* and to study the various stages of mitosis.
- Demonstration of dialysis of starch and simple sugar.
- Study of plasmolysis and deplasmolysis on *Rhoeo* leaf.

Teaching and Learning Process:

The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student. A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this. Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions in the beginning to judge the student's pre-knowledge and post-lab questions on completion of experiment to evaluate the grasp. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

The assessment of students' achievement in Course on Cell and Cellular Processes will be aligned with the course learning outcomes.

- Continuous evaluation of learning by formative and diagnostic evaluation.
- 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., will constitute the different components of the overall assessment.

Keywords:

Cell organelles, cell membrane, cell junctions, endomembrane system, cytoskeleton, mitosis, meiosis, cell signaling.

Recommended Books:

- Cooper, G.M., Hausman, R.E. (2009) The Cell: A Molecular Approach. V Edition, ASM Press and Sinauer Associates.
- Becker, Kleinsmith, and Hardin (2009) The World of the Cell. VIII Edition, Benjamin Cummings Publishing, San Francisco.
- Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition, John Wiley & Sons Inc.

Suggested Readings:

- De Robertis, E.D.P. and De Robertis, E.M.F. (2009) The Cell and Molecular Biology. Lippincott Williams & Wilkins. Philadelphia.
- Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Robert Keith and Watson James. (2008) Molecular Biology of the Cell. V Edition, Garland publishing Inc., New York and London.

Online Tools and Web Resources:

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://www.khanacademy.org/science/biology

ALS Core Course-III: Biochemistry and Immunology

Course Learning Objective:

The aim of the course is to comprehend the fundamental principles of chemistry that govern complex biological systems. The program is designed to enable a student acquire sound knowledge of biochemistry and its practicable applicability. The new and updated syllabus is based on a basic and applied approach to ensure that students develop problem solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics. The course also emphasizes on the working of the immune system in normal health and how it fights the disease and may sometimes contributes to disease. As the immune system is incredibly complex, the course is hence 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.

Course Learning Outcome:

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

- Understand the concepts of biochemistry and how biomolecules interact with each other to bring about life processes.
- Appreciate the role of enzymes in metabolic pathways.
- Learn how enzyme activity is controlled, 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.
- Understand different components of the immune system, different defense mechanisms and their working to provide immunity.
- Learn about the structure and functions of different classes of antibodies.
- Develop knowledge about Monoclonal antibodies and their applications.
- Learn the behavior of highly regulated immune system when the balance is disturbed.
- To appreciate the immune system and its various components to protect the host from pathogen with a special emphasis on AIDS, Vaccines and transplantation.

Course Content:

Theory [Credit: 4] 60 hrs

Unit 1: Biomolecules 12 hrs

Carbohydrates: Functional significance of mono-, di- and polysaccharides; Lipids: functional significance of fatty acids, triglycerides, phospholipids, glycolipids and steroids, Amino acids and Proteins: Structural properties and functions; Nucleic acids - DNA and RNA, types and structure.

(Chapter-2, 11, 12: Stryer)

Unit 2: Metabolism 12 hrs

Carbohydrate metabolism: glycolysis, citric acid cycle, pentose phosphate pathway, gluconeogenesis; Lipids metabolism: beta oxidation of fatty acids, Protein metabolism: Overview of Protein degradation, catabolism of amino acids, transamination, oxidative deamination.

(Chapter-16, 17, 20, 22, 23: Stryer)

Unit 3: Enzymes 6 hrs
Classification, kinetics, mechanism of action, and inhibition
(Chapter 8: Stryer)

Unit 4: Introduction to Immune system and humoral Immune response 14 hrs
Historical background, Cells and organs of Immune system, Immunity: innate and acquired immunity, immunogens and haptens, factors influencing immunogenicity; Complement system; Antibody structure and types, Monoclonal and polyclonal Antibodies, Hybridoma technology
(Chapter 1, 2, 3,4, 7, 11, 22: Kuby)

Unit 5: Cell-mediated immune response 10 hrs
Structure of MHC, Antigen Processing and Presentation-MHC; Techniques based on antigen- antibody interactions
(Chapter-6, 8, 9, 10: Kuby)

Unit 6: Perspectives of Immunology 6 hrs
AIDS, Vaccines
(Chapter-20, 19, 17: Kuby)

Practical [Credit: 2]

Biochemistry

1. Study of of normal action of salivary amylase.
2. Separation and identification of amino acids by paper chromatography.
3. Qualitative estimation of proteins and carbohydrates.

Immunology

1. Demonstration of primary (bone marrow and thymus) and secondary immune organs (spleen, lymph nodes) in rat.
2. Determination of ABO blood groups and Rh-factor.
3. Ouchterlony (double diffusion) assay for antigen -antibody specificity and titre.

Teaching and Learning Process:

The course dissemination will involve blend of various teaching methodologies including lectures, project-based learning, inquiry-based learning, hands-on training, etc. Usage of general and specific information & communications technology (ICT) and digital tools such as projectors, simulations, scientific games, mind maps, wikis etc, will make the teaching learning process most rewarding.

Assessment Methods:

Students will be assessed in two ways:

- Formative assessment - will include tests involving quiz or objective questions at the end of each unit; inquiry-based learning demonstrating assignments and oral presentations. *Viva-voice* and practical work performance assessments will be carried out during the practical classes.
- Summative assessment - will include end-semester theory and practical examinations. Students will also be assessed for their project report and practical record during practical examination.

Keywords:

Biomolecules, Metabolism, Catabolism, Anabolism, Oxidative phosphorylation, Electron Transport System, Fatty acids, Enzymes, Immune system, T-cells, B-cells, Haptens, Antibodies, Hybridoma

Recommended Books:

- Stryer, L. (1995) Biochemistry. IV Edition, W.H. Freeman.
- Lehninger, A.L. Nelson, D.K. and Cox, M.M. (1993) Principles of Biochemistry. CBS Publishers and Distributors.
- Kindt, T.J., Goldsby, R. A. and Osborne, B.A. (2007) Kuby Immunology. VI Edition W.H. Freeman and Co, New York.

Suggested Readings:

- Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry. V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry. VI Edition, W.H. Freeman and Co., New York.
- Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006). Immunology, VIEdition, W.H. Freeman and Company.
- David, M., Jonathan, B., David, R. B. and Ivan, R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.

Online Tools and Web Resources:

- CEC Gurukul (www.cec.nic.in) and their YouTube webpage (https://www.youtube.com/user/cecedusat/featured)
- https://swayam.gov.in/courses/5638-biochemistry
- E-content on e-PG Pathshala portal of Government of India: https://epgp.inflibnet.ac.inFundamentals of Immunology;
- https://www.coursera.org/specializations/immunology

ALS Core Course-IV: Molecular Biology and Developmental Biology

Course Learning Objective:

The course aims to provide students with core knowledge of molecular biology and developmental biology required for foundational understanding of biology as a whole.

The course primarily involves learning about the genetic material (deoxyribonucleic acid; DNA), molecular mechanisms of its synthesis, encoding genetic information, transcribing and translating this information (mRNA and protein synthesis) and regulation of gene expression. The course also unravels initial stages of animal development: gametogenesis and embryonic development up to placentation. The course aims to strengthen the foundation of basic biology in students.

Course Learning Outcome:

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

- Describe the basic structure and types of nucleic acids - DNA and RNA.
- List salient features of the genetic code.
- Compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes.
- Elucidate the molecular machinery and mechanism of information transfer processes –transcription and translation in prokaryotes and eukaryotes.
- Discuss general principles of transcription regulation in prokaryotes by exploring the structure and function of lactose and tryptophan metabolism operons.
- Identify components of gene expression regulation in eukaryotes.
- Explain the process of gametogenesis – spermatogenesis and oogenesis.
- Describe the fertilization process and mechanisms to block polyspermy.
- Define fate-maps; explain its significance and methods of construction.
- Detail the early development of frog and chick embryo and identify its stages.
- Enlist different types of placenta, its structure and significance.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Genetic Material 4 hrs

DNA structure -Watson and Crick model, Types of DNA, Genetic code and its features

(Chapter 4: Cooper; Chapter 4 and 16: Watson)

Unit 2: DNA Replication 8 hrs

DNA polymerases and Replication enzymes; DNA replication in prokaryotes and eukaryotes

(Chapter 6: Cooper; Chapter 9: Watson)

Unit 3: Transcription and Translation 16 hrs

Types of RNA (mRNA, tRNA, rRNA); RNA polymerases—Mechanism of transcription in prokaryotes and eukaryotes; Processing of mRNA – splicing: Chemistry and spliceosome machinery; Mechanism of translation in prokaryotes and eukaryotes: Charging of tRNA, aminoacyl tRNA synthetases.

(Chapter 7and 8: Cooper; Chapter 17: Campbell; Chapter 13, 14 and 15: Watson)

Unit 4: Regulation of Gene Expression 8 hrs

Principles of transcription regulation: Lac operon and Tryptophan operon in prokaryotes; Components of gene expression regulation in eukaryotes.

(Chapter 7: Cooper; Chapter 18: Campbell; Chapter 18 and 19: Watson)

Unit 5: Early Embryonic Development 14 hrs

Gametogenesis: Spermatogenesis, Oogenesis, Types of eggs, Fertilization, Blocking Polyspermy, Cleavage, Fate maps, Blastulation and Gastrulation in frog and chick.
(Chapter 47: Campbell; Chapters 7, 19, 10 and 11: Gilbert)

Unit 6: Late Embryonic Development 6 hrs

Fate of germ layers, Placenta – Types and functions.
(Chapter 47: Campbell; Chapter 12, 13, 14 and 15: Gilbert)

Unit 7: Implications of Developmental Biology 4 hrs

Assisted Reproductive Technology - IVF; Embryonic stem cells (ESC); Teratogens
(Chapter 21: Gilbert)

Practical [Credits: 2]

1. Study of special chromosomes (Polytene & Lampbrush) either by slides or through photographs.
2. Preparation of Barr body (sex chromatin).
3. Preparation of the karyotype from given photograph of somatic metaphase chromosome.
4. Study and interpretation of electron micrographs/ photographs showing:
   (a) DNA packaging (b) DNA replication (c) Transcription (d) Split genes
5. Study of whole mounts of developmental stages in frogs through permanent slides: cleavage stages, blastula, gastrula, neurula, tadpole larva
6. Study of whole mounts and sections of chick embryo at different stages: Primitive streak, 28, 33, 48, 72 and 96 hours.
7. Project report on Assisted Reproductive Technologies (ART).

Teaching and Learning Process:

The course dissemination will involve blend of various teaching methodologies including lectures, project-based learning, inquiry-based learning, hands-on training etc. Usage of general and specific information & communications technology (ICT) and digital tools such as projectors, simulations, scientific games, mind maps, etc, will make the teaching learning process most rewarding.

Assessment Methods:

Students will be assessed in two ways:

- Formative assessment - will include quiz or objective questions test at the end of each unit, inquiry-based learning demonstrating assignments and oral presentations. *Viva-voice* and practical work performance assessments will be done during the practical classes.
- Summative assessment - will include end-semester theory and practical examinations. Assessment of project report and practical record will be carried out during practical examination.

Keywords:

Genetic material, Nucleic acids, Chromatin, replication, mRNA, RNA polymerase, tRNA, Protein synthesis, Gametogenesis, Cleavage, Gastrula, Chick development, Placenta, Germ layers, Animal development

Recommended Books:

- Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA
- Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition, International Thompson Computer Press.
- Brown, T.A. (1998). Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edition, Academic Press, California, USA.
- Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology- Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.

Suggested Readings:

- Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley-Blackwell.
- Wolpert, L. (2002) Principles of Development. II Edition, Oxford University Press.
- Kalthoff, K. (2001) Analysis of Biological Development. II Edition, McGraw Hill Publishers.
- Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.
- Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company
- James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick (2017) Molecular Biology of the Gene. VII Edition, Pearson Benjamin Cummings Publishing, San Francisco.

Online Tools and Web Resources:

- https://www.hhmi.org/biointeractive/human-embryonic-development
- https://www.khanacademy.org/science/biology/developmental-biology
- https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm
- https://embryology.med.unsw.edu.au/embryology/index.php/Main_Page
- https://swayam.gov.in/courses/5065-molecular-biology
- https://www.youtube.com/user/cecedusat
- JoVE Science Education; https://www.jove.com/science-education-library

ALS DSE-I: General Entomology

Course Learning Objective:

Insects form over 70% of the fauna population on the earth. They have inhabited the earth for over 450 million years. They are the most diverse group of organisms occupying nearly all niches except for the deep sea. Learning of Morphology and Physiology of the Insects gives an overview of one of the best body designs which have survived on the earth.

Course Learning Outcome:

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

- Identify and classify insects up to orders.
- Understand methods of collection and preservation of insects and their rearing in the laboratory.
- Describe the morphology of head, thorax and abdomen of an insect.
- Explain the structure of various body appendages.
- Describe the anatomy and physiology of various organ systems in insects.
- Explain the concept of insect metamorphosis and its hormonal control.
- Understand the phenomenon of parthenogenetic development in insects.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Taxonomy 18 hrs

Salient features of Insects, Basis of insect classification; Classification of insects up to orders (economical important groups), Origin and evolution of insects, Elementary knowledge of collection, Preservation and culture techniques of insect.

(Chapter-21-31: Tembhare)

Unit 2: Morphology of Insects 13 hrs

Segmentation in Insect; Structure of Head, antennae, thorax, legs, wings; Various types of mouth parts.

(Chapter-1, 8 & 10: Chapman)

Unit 3: Physiology of Insects 13 hrs

Physiology of digestion, excretion, respiration, circulation; Insect sense organs (mechano, photo and chemoreceptors).

(Chapter-23, 24, 25, 27, 29, 30 & 32: Chapman)

Unit 4: Reproduction and Development 16 hrs

Embryonic and post-embryonic development; Types of metamorphosis, Role of Neuroendocrine system in development, Parthenogenesis.

(Chapter-19, 20, 21 & 34: Chapman)

Practical [Credits: 2]

1. Collection, dry mounting, labelling and preservation of insects.
2. Identification of stored grain pest insects; *Sitophilus oryzae, Corcyra cephalonica, Trogoderma granarium, Callosobruchus chinensis.*

3. Identification of Crop pests; *Helicoverpa armigera, Spodoptera litura, Earias vitella, Pectinophora gossypiella,* Locust
4. Culture of two insects of economic importance including one crop pest and submission of
   culture report.
5. Study of the life history of 2 different insect pests (Life Cycle drawn from culture to be submitted).
6. Study of mouth parts (sponging type, piercing type, siphoning type, lapping type), wings, legs and antennae of insects.

Teaching and Learning Process:

Classroom lectures using Power point presentations enabled with related photographs of insect vectors will clarify the concepts related to insects. Group discussions on various unique physiological processes in Insects will develop interest among students to pursue higher studies in the field. Observations based on actual handling of insects and their body parts, visit to observe insects in their natural environment and entomology museum will develop curiosity among learners about insect diversity

Assessment Method:

The learners/ students can be assessed in many different ways.

- Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation.
- Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and neuroimages to test their theoretical skills and promote practical knowledge.
- They would be provided feedback on their work with a view to improve their academic performance.

Keywords:

Insects, Taxonomy, Morphology, Physiology, Reproduction, Metamorphosis, Parthenogenesis

Recommended Books:

- Imms , A. D. A General Text Book of Entomology. Chapman & Hall, UK
- Chapman, R. F. (1998) The Insects: Structure and Function. Cambridge University Press, UK
- Snodgrass, R. E. Principles of Insect Morphology. Cornell Univ. Press, USA
- Borror, D. J., Triplehorn, C. A., and Johnson, N. F. Introduction to the Study of Insects. M Saunders College Publication, USA
- Tembhare, D.B.(2012). Modern Entomology, Himalaya Publishing House Pvt, Ltd, Mumbai-400004

Suggested Readings:

1. Atwal, A.S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.

2. Dennis, S. Hill. (2005) Agricultural Insect Pests of the Tropics and Their Management. Cambridge University Press
3. David, B.V. and Ananthakrishnan, T.N. (2004) General and Applied Entomology. Tata-McGraw Hill, New Delhi.
4. Duntson, P.A. (2004) The Insects: Structure, Function and Biodiversity. Kalyani Publishers, New Delhi.
5. Wigglesworth, V.B. (1984) Insect Physiology. VIII Edition, Chapman & Hall, New York.

ALS DSE-II: Applied Entomology

Course Learning Objective:

The study of Applied Entomology provides an insight about the role of insects as powerful competitors of man as they cause enormous injury to crops and animals and also act as vectors of many diseases. This course will help the students to understand the concept of insect pests and their population dynamics in relation to changing environmental conditions. The students will learn about various types of pests, their distinguishing features, life cycle, damage to crops and human health by them. This will be of help in choosing the appropriate control measures to manage the pest population in nature and to avoid heavy economic losses.

Course Learning Outcome:

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

- 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 of medical importance.
- Analysis of varied types of control measures for management of pest populations and list suitable control measures- specific for every pest.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Pest 4hrs

Introduction, Classification of pests, Factors responsible for emergence of pest, Pest status, Pest population dynamics, Types of crop losses

(Chapter 2: Atwal)

Unit 2: Bionomics and Control of Crop pests 16 hrs

Rice pest (*Leptocorisa acuta*); Wheat pest (*Sesamia inferens*); Pulse pest (*Helicoverpa armigera*); Sugarcane pests (*Scirpophaga nivella, Pyrilla perpusilla*); Cotton pests (*Earias vitella, Pectinophora gossypiella*); Vegetable pest (*Raphidopalpa faveicollis);* Fruit pest *(Papilio demoleus)*

(Chapter 6, 9, 10, 14, 16, 18 and 20: Atwal; Chapter 2 and 3; Pradhan)

Unit 3: Stored Grain Pests 12 hrs

Bionomics and strategies for the management of stored grain pests; *Sitophilus oryzae, Corcyra cephalonica, Trogoderma granarium, Callosobruchus chinensis.*

(Chapter 27: Atwal; Chapter 13; Pradhan)

Unit 4: Medically Important and Household Pests 10 hrs

Bionomics and management of the medically important and house hold pests; Fleas, mosquitoes, housefly, sand fly, cockroach, human louse and termites

(Chapter 28 and 29: Atwal)

Unit 5: Pest Management Tactics 18 hrs

Methods of physical, mechanical, cultural, biological, microbial, genetic control of insects; Chemical controls w.r.t. chlorinated hydrocarbons, organophosphates, carbamates and synthetic pyrethroids (BHC, Aldrin, Malathion Parathion, Carbaryl, Propoxur, Allethrin and Cypermethrin). Integrated pest management (IPM): Definition, principle, components of IPM and advantages.

(Chapter 4, 5,10, 12, 34: Atwal; Chapter 3, 5 and 6; Dennis)

Practical [Credits: 2]

1. Study of Biocontrol agents for insect pest: Pathogens (NPV); Parasitoid (*Trichogramma)*; Predators (*Gambusia* fish, lady bird beetle)
2. Study of identifying features of adult pests and damage caused: *Leptocorisa acuta*, *Sesamia inferens*, *Helicoverpa armigera*, *Pyrilla perpusilla*, *Earias vitella, Papilio demoleus, Sitophilus oryzae, Corcyra cephalonica, Trogoderma granariu, Callosobruchus chinensis*
3. Study of the morphological features of rat flea, mosquitoes, housefly and human louse and their medical importance.
4. Determination of LD_{50} or LC_{50} of insecticides based on the data provided.
5. Instruments used in chemical control.
6. Assessment of Bio-efficacy of EPN.
7. Field trips to entomological institutes, museums, laboratories – IARI fields, CWC, FCI, Stored grain institutes (any two)

Teaching and Learning Process:

Knowledge about the concept of pests, their changing populations, variations in their morphology, life cycle and consequent specific control measures will be imparted through traditional class room lectures. Regular group discussions amongst the students will enhance the learning to a great extent. Visits to agricultural fields, fruits orchards and warehouses will familiarize the students with insect-interaction with human interest in nature. Visits to Agricultural Institutes (e.g. IARI) and Medical Institutes (e.g. NCDC-National Centre for Diseases Control) will make the students aware about the ongoing Research Projects in this field and will provide a deeper understanding of the subject.

Assessment Methods:

The theory and practical components of the course will be assessed in two ways.

- Continuous assessment - To regularly check the students learning and understanding of the subject. Class room discussions and tests will help in evaluating the students grasp on the subject.
- Semester-end Examination - Performances in the semester end examination indicates their understanding of the concept and its application while solving the related problems and writing their answers.

Keywords:

Pest, Bionomics, Crop pests, Stored grain pests, Household pests, Medical pests, Pest management tactics, IPM

Recommended Books:

- Atwal, A.S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.
- Dennis, S. Hill (2005) Agricultural Insect Pests of the Tropics and Their Management, Cambridge University press.

Suggested Readings:

- Pedigo, L.P. (1996) Entomology and Pest Management. Prentice Hall, New Delhi.
- S. Pradhan. Insect Pest of Crops. National Book Trust, New Delhi.

Online Tools and Web Resources:

- https://swayam.gov/appliedentomology
- http://mesamalaria.org/updates/mooc-medical-entomology-organized-institut-pasteur
- https://www.pasteur.fr/en/mooc-medical-entomology-insect-vectors-and-transmission-pathogens
- https://www.entsoc.org/resources/education/online-courses

ALS DSE-III: Integrated Pest Management

Course Learning Objective:

India is an agriculture-based country. The total annual losses caused by insect pests to major field crops and food grains in storage in India tunes to more than Rs.3500 billion per year. This course provides an insight to the students about Integrated pest management (IPM) which is based on ecological principles and involves the integration and synthesis of various pest control tactics into a pest management system. Knowledge about the different pest control tactics, their principle and methodology will help in framing the appropriate management strategy for insect pest control. Students will learn that even a simplest agro-ecosystem is a complicated network of delicately balanced ecological interactions which should not be disturbed by the indiscriminate use of agrochemicals. IPM will enable an intelligent selection and use of pest control actions that will ensure optimal economic, ecological and sociological benefits.

Course Learning Outcome:

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

- Create the awareness about adverse effects of insecticides on the environment and need for environment friendly approach for management of insect pests.
- Gain knowledge about the concepts and tools of pest management.
- Understand the planning of agricultural ecosystem, tolerance of pest damage, timing of different pest control tactics to manage the pest population effectively.
- Learn about the use of different pest control techniques in a harmonious manner.
- Understand the role of IPM in sustainable agriculture as the future of modern plant protection and pest control strategy.

Course Content:

Theory [Credit: 4] 60 hrs

Unit 1: Pest 6 hrs

History and origin, Definition of pest and its ecology, pest status, pest population dynamics, Economic Injury Level (EIL), Economic Threshold, Carrying Capacity, Secondary pest outbreak, Pest surveillance

(Chapter 2: Dennis; Chapter 1, 2, 3 and 12: Atwal)

Unit 2: Integrated Pest Management 14 hrs

Concept of IPM, Components of IPM, Major IPM strategies, IPM tactics; Strategies for integrated pest management: Mechanical, Physical, Cultural

(Chapter 3: Dennis; Chapter 4 and 12: Atwal)

Unit 3: Biological Control 8 hrs

Principle; bio-control agents: Parasitoids, predators and pathogens (NPV, Bacteria, Fungi and nematodes), Merits and demerits

(Chapter 5: Dennis; Chapter 5: Atwal)

Unit 4: Chemical Control 22 hrs

Classification of insecticide, Conventional insecticides; Insecticide adjuvants and formulations, Control with reference to Chlorinated hydrocarbons; Organophosphates;

Carbamates; Botanical; Synthetic pyrethroids; Fumigants; IGR compounds & Pheromones.
(Chapter 6: Dennis; Chapter 7: Atwal)

Unit 5: Genetic Control 7 hrs
Sterile insect techniques (SIT); Sterile insect release method (SIRM), Radio-sterilization and chemo-sterilization, Hybrid sterility and other strategies of Genetic control.
(Chapter 10: Atwal)

Unit 6: Legal or Regulatory control 3 hrs
Quarantine laws

Recommended Books:

- Atwal, A.S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.
- Dennis, S. Hill (2005) Agricultural Insect Pests of the Tropics and Their Management, Cambridge University press.

Suggested Readings:

- Pedigo, L.P. (1996) Entomology and Pest Management. Prentice Hall, New Delhi.
- S. Pradhan. Insect Pest of Crops. National Book Trust, New Delhi.

Online Tools and Web Resources:

- https://swayam.gov/appliedentomology
- http://mesamalaria.org/updates/mooc-medical-entomology-organized-institut-pasteur
- https://www.pasteur.fr/en/mooc-medical-entomology-insect-vectors-and-transmission-pathogens
- https://www.entsoc.org/resources/education/online-courses

Practical [Credits: 2]

1. Assessment of SIT efficacy through data provided.
2. Equipments used in IPM chemical control.
3. Determination of LD_{50}/LC_{50} of insecticides based on data provided.
4. Damage caused by the commonly occurring insect pests of stored grains & crops (At least 6)
5. IPM model for control of *Leptocorisa acuta* and *Scirpophaga nivella.*
6. Study of common natural enemies of crop pests (parasitoids, predators, microbes).
7. Visits to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids/ common predators, microbes and their laboratory hosts; host insects and their natural enemies (Any Two)
8. Submission of a Project report on quality control and registration standards for bio-control agents.

Teaching and Learning Process:

Knowledge about the concept of pest, IPM, principles of pest management, various pest control methods will be imparted through classroom lectures. Group discussion among students will make them aware of toxicological hazards of pesticide usage & ignite their

concern for a quality environment. Seminars on the related topics will enhance the learning of students to a great extent. Visits to agricultural fields will provide a hands-on experience about the pest management methods used by farmers. Visits to Bio-control laboratories will give the students a chance to learn about the latest techniques used in Genetic control of insects.

Assessment Methods:

The theory and practical components of the course will be assessed in two ways.

- Continuous assessment - To regularly check the students learning and understanding of the subject. Class room discussions and tests will help in evaluating the students grasp on the subject.
- Semester-end Examination - Performance in the semester end examination will indicate their understanding of the concept and its applications; while solving the related problems and writing their answers.

Keywords:

Pest, EIL, ET, Carrying capacity, Bio-control agents, Insecticides, Fumigants, SIRM, Quarantine, Genetic control, Microbial control, Chemical control, Adjuvants

Recommended Books:

- Pedigo, L.P. (1996). Entomology and pest management, prentice hall, New Delhi.
- Hill, Dennis S.(2012). Agricultural insect pests of the tropics and their control. 2nd Edition; Permission of Cambridge University, printed at Shree Maitrey Printech Pvt.
- Ltd.,Noida, India.
- Flint MC & Bosch RV. 1981. Introduction to Integrated Pest Management. 1st Ed. Springer, New York.

Suggested reading:

- Harsh Behl, Y (1995) Pest Management Practices. Published by Everest Press Chamelian Road, NewDelhi-110006, India.
- Raymond A. Cloyd , Philip L. Nixon and Nancy R. Pataky. 2004. IPM for Gardeners: A Guideto Integrated Pest Management, Timber Press
- Horowitz, A.Rami and Ishaaya, Isaac. (2009) Insect Pest Management - Field and Protected Crops by Mary Lou Flint and Robert van den Bosch, (1981).
- Introduction to Integrated Pest Management, New York: Plenum Press, Edward B Radcliffe, William D Hutchison, and Rafael E Cancelado

Online Tools and Web Resources:

- Integrated Pest Management, Cambridge University Presshttps://www.agmoocs.in>course>integratedpestmanagement
- https://www.entsoc.org/resources/education/online-courses

ALS SEC-1: Biotechnological Control of Pest

Course Learning Objective:

The study of Biotechnological Control of Pest provides alternative measures to traditional pest management practices against insects as they cause enormous injury to crops and animals. This course will help the students to understand the concept of biotechnology and its application to control insect pests and their population dynamics in relation to changing environmental conditions. The students will learn about various tools and techniques of biotechnology used for controlling insect pests concern over environmental health and public safety, has resulted in the development to the features, life cycle, damage to crops and human health by them. This will be of help in choosing this popular and appropriate control measures to manage the pest population in nature and reduced risk crop protection products so that farmer could avoid to heavy economic losses.

Course Learning Outcome

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

- Learn about the concept of biotechnology and its application in the field of agricultural management practices.
- Understand the difference between various types of pests and their host plants, extent of damage caused by them.
- Gain knowledge about important tools and techniques of biotechnology useful for management of pests of crops, fruits, vegetables and stored grains.
- Emphasize an overview of biotechnological control measures for management of pest populations with critical evaluation in the larger context of ecologically based pest management.

Course Content:

Theory [Credits: 2] 30 hrs

Unit 1: Introduction 6 hrs

Biotechnological approaches: Developments in biotechnology, Molecular taxonomy, International project on barcode of life, Host–plant resistance: Mechanism of resistance-antibiosis, Antixenosis, Tolerance, Factors mediating resistance.
(Chapter-10: Dhaliwal and Singh)

Unit 2: Insect Growth Regulators, Toxic proteins and Inhibitors 6 hrs

JH Mimics, MH-agonist; Vegetative Insecticidal proteins, Biotin-binding proteins and plant Lectins; Enzymes: Chitinases, Proteinase Inhibitors, Bean α-Amylase, Insect immunity.
(Chapter-3, Dhaliwal and Singh)

Unit 3: Techniques Used in Insect Pest Management 6 hrs

Recombinant DNA technology, Molecular markers, Transgenesis, Genetic engineering of biological control agents: *Bacillus thuringiensis*, Entomopathogenic Fungi, Baculoviruses, Entomopathogenic nematodes (EPNs); Molecular mechanisms of pesticide resistance in insect pest.
(Chapter-12: Pedigo)

Unit 4: Genetically Modified Crop Plants and Insect Pest Management 6 hrs

Transgenic plants: History, *Bacillus thuringiensis* and its mode of action on insects,

Different subspecies of *Bt, Bt* plants, Resistance management of *Bt* crop, Prospective and controversies of *Bt* crop; Transgenic mosquito, Spider venoms, Scorpion venoms; Genetic control through sterile insect techniques
(Chapter- 12: Pedigo; Chapter-17: Noris)

Unit 5: Applications of Biotechnology in Pest Management 6 hrs
Derived benefits from DNA barcode-based molecular taxonomy; Metabolic pathways as a source of useful genes and products; Silencing of genes using RNAi approach for developing pest-resistant plants; Use of tissue culture techniques in plant protection, Use of bioinformatics for insect pest management.
(Chapter-16: Abrol)

Practical [Credits: 2]

1. Colorimetric estimation of total protein of insect haemolymph.
2. Isolation of amino acids by using Paper Chromatography.
3. Isolation of Plasmid DNA from *E. coli.*
4. To perform SDS-Polyacrylamide Gel Electrophoresis and Western Blotting.
5. Quasi-mass rearing of *Spodoptera litura.*
6. To understand the basics of Bioinformatics.
7. To study Applications of rDNA Technology through photograph (w.r.t. insect pest control).
8. Biostatistical methods.

Teaching and Learning Process:

Knowledge about the concept of pest, IPM, principles of pest management, various pest control methods will be imparted through classroom lectures. Group discussion among students will stimulate their concern for a quality environment; make them aware about toxicological hazards of pesticide usage. Seminars on the related topics will enhance the learning of students to a great extent. Visits to agricultural fields will provide a hands-on experience about the pest management methods used by farmers. Visits to Bio-control laboratories will give the students a chance to learn about the latest techniques used in Genetic control of insects.

Assessment Methods:

The theory and practical components of the course will be assessed in two ways.

- Continuous assessment - To regularly check the students learning and understanding of the subject. Class room discussions and tests will help in evaluating the students grasp on the subject.
- Semester-end Examination - Performances in the semester-end examination will indicate their understanding of the concept and its applications, while solving the related problems and writing their answers.
- Practical exercise to study life cycle of model insects and biocontrol agents, their rearing in laboratory conditions.
- To study the genetic control of insect pest e.g. radio-genetic control method
- Continuous and comprehensive assessment by attendance and tests
- Submission of report on modern trends in biotechnology and its implication for insect pest management.

Keywords:

Biotehnology, JH mimics, Antixenosis, rDNA technology, *Bacillus thuringiensis,* RNAi, Entomopathogens, Transgenics, Molecular taxonomy, Barcoding

Recommended Books:

- Dhaliwal G.S. and Singh R. (Eds). (2004) Host Plant Resistance to Insects - Concepts and Applications. Panima Publ., New Delhi.
- Maxwell F.G. and Jennings P.R. (Eds). (1980) Breeding Plants Resistant to Insects. John Wiley & Sons, New York.
- Painter R.H. (1951) Insect Resistance in Crop Plants. MacMillan, London.
- Pedigo, L.P. (1996). Entomology and Pest Management. Prentice hall, New Delhi.

Abrol, D.P. (2014) Integrated Pest Management. Elsevier Inc

DOI:http;//dx.doi.org/10.1016/

B978-0-12-398529-3.00018-X

Suggested Readings:

- Dharam P. Abrol (2014) Integrated Pest Management: Current Concepts and Ecological Perspective**.**I Edition), Academic Press. ISBN: 9780123985293
- Smith C.M. (2005) Plant Resistance to Arthropods – Molecular and Conventional Approaches. Springer, Berlin.
- Wheeler, M.B. (2013) Transgenic Animals in Agriculture. Nature Education Knowledge 4 (11):1

Online Tools and Web Resources:

- UGC INFONET / DU E-Resources & SciFinder Web Version registration

ALS SEC-II Biological Control of Crop Pests

Course Learning Objective:

Insects are important for survival and maintenance of ecosystem on earth. Many insects are identified as being beneficial, vectors of pathogens and pests. The study of insects and biocontrol agents will serve to provide the basic information of an ecofriendly, economically viable method for insect pest management. In fact the concept of biological control of insect pest will definitely a technique leads to production of food and fibre and its proper storage, biological diversity in terms of insect species, host plants/crops and biocontrol agents. This knowledge shall enable the students to do further research on insect management for the benefit of human being. Being a subject of applied science, expertise in entomology will enhance career opportunities for students in public and private sectors.

Course Learning Outcome:

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

- Understand the different types of biological control agents.
- Know how the parasites and pathogens infect the hosts.
- Learn the basic principles of biological control - conservation, augmentation and importations of biocontrol agents
- Recognize the quarantine regulations involved in insect pests control

Course Content:

Theory [Credit: 2] **30 hrs**

Unit 1: Introduction 6 hrs

Principles and scope of biological control; Important groups of parasitoids, predators and pathogens; Classical biological control- importation, augmentation and conservation. *(Chapter-9: Pedigo)*

Unit 2: Biocontrol agents 10 hrs

Biology, Host seeking behaviour of predatory and parasitic groups of insects; Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc; Their mode of action. *(Chapter-6: Dent)*

Unit 3: Methods of Biocontrol 8 hrs

Mass production of quality biocontrol agents: Criteria, improvements, evaluation, field-release; Inoculative and innundative
(Chapter-6: Pedigo)

Unit 4: Perspectives 6 hrs

Successful biological control projects, analysis, trends and future possibilities of biological control; Importation of natural enemies - Quarantine regulations, Biotechnology in biological control; Semiochemicals, Kairomones in biological control.
(Chapter-8: Dent)

Practical [Credits: 2]

1. Study of Biocontrol agents for insect pest: Biological Agents; (Pathogens – NPV); Parasites; (*Trichogramma ,Cotesia*); Predators (lady bird beetle), Nematodes (EPN)
2. Damage caused by the commonly occurring insect pests – Infested plant/plant parts

3. Statistical methods (Central tendency, Test of Significance- ANOVA and t-Test)
4. Instruments used in biocontrol of crop pest
5. Bio-efficacy of EPN, *S. glaceri* and Egg parasitoid, *Trichogramma chitonis*
6. Visit to biocontrol laboratories – NCIPM, IARI and Entomology Lab, DU

Teaching and Learning Methods:

Classroom teaching using power-point presentations will be adopted to acquaint students with diversity of insects, biocontrol agents, their morphology and behaviour. Demonstration of bio efficacy in terms of parasitization efficacy, growth index, longevity of egg parasitoid will be held. Study of insects in their natural habitat through visits to agricultural fields/sanctuary/biodiversity park will enhance their learning.

Assessment Methods:

- Summative assessment: Includes term-end practical examinations and continuous evaluation throughout the semester based on practical attended/performed; test/*Viva*, Project Report and Record book.
- Formative assessment: Includes Practical exercise, continuous and comprehensive assessment by attendance and tests, report, presentations, etc.

Keywords:

Biological control, Model Insect, Natural enemies, Fictious host, Rearing Techniques, Semiochemicals, Kairomones, Parasitoids, Parasites

Recommended Books:

- Burges H.D. and Hussey N.W. (Eds). (1971) Microbial Control of Insects and Mites. Academic Press, London.
- De Bach P. (1964) Biological Control of Insect Pests and Weeds. Chapman & Hall, New York.
- Dhaliwal G.S. and Arora R. (2001) Integrated Pest Management: Concepts and Approaches. Kalyani Publ., New Delhi.
- Dent, D.(2000). Insect Pest Management; II edition. CABI Publishing.CAB International Wallingoford oxon OX10 8DE, UK.

Suggested Readings:

- Huffaker C.B. and Messenger P.S. (1976) Theory and Practices of Biological Control. Academic Press, London.
- Ignacimuthu S.S. and Jayaraj S. (2003) Biological Control of Insect Pests. Phoenix Publ., New Delhi.
- Saxena A.B. (2003) Biological Control of Insect Pests. Anmol Publ., New Delhi.
- Van Driesche and Bellows TS. Jr. (1996) Biological Control. Chapman & Hall, New York.

Online Tools and Web Resources:

- UGC INFONET / DU E-Resources &SciFinder Web Version Registration

ALS SEC-III Insect Toxicology

Course Learning Objective:

Since ages, insecticides have been used for killing insect pests of various kinds. The course on 'Insect Toxicology' deals with the biological effects of toxic chemicals on the insects and how insects can metabolize these poisonous substances to develop resistance against them. The course will also emphasize on the factors affecting toxicity of insecticides and synergistic substances which can be used to increase their efficacy. Such information can play an important role in the selection of insecticides to control pests in the field of agriculture, forestry and public health.

Course Learning Outcome:

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

- Demonstrate fundamental knowledge and understanding of the principles of insecticide toxicity, and its evaluation for insect pest control.
- Explain pest resistance to insecticides and its management, and best practices for safe use of toxic insecticides as well as treatments for insecticide poisoning.
- Acquire practical skills of pest management in public buildings; like termite proofing, rodent control, etc.

Course Content:

Theory [Credits: 2] 30 hrs

Unit 1: Definition and Scope of Insecticide Toxicology 6 hrs

History of chemical control, Pesticides registration, Pesticide industries and markets
(Chapter-1: Gupta)

Unit 2: Principles of Toxicology 8 hrs

Evaluation of insecticide toxicity; Joint action of insecticides synergism, Potentiation and antagonism; Factors affecting toxicity of insecticides; Insecticide compatibility.
(Chapter-4: Perry)

Unit 3: Insect Growth Regulators 10 hrs

Insecticides and its metabolism - phase I and phase II reactions; Pest resistance to insecticides; Mechanisms and types of resistance; Insecticide resistance management and pest resurgence; Insecticide Act registration and quality control of insecticides; Safe use of insecticides; Diagnosis and treatment of insecticide poisoning, Health hazards: carcinogenic, mutagenic and teratogenic effects.
(Chapter-12, 13, 14: Gupta)

Unit 4: Pest Management in Residential and Public Places 6 hrs

Principles and methods of pest management in residential places and public buildings, Insecticides for domestic use and their safety, Pre- and post-construction termite proofing of buildings, Appliances for domestic pest control; Rodent control methods; Organic methods of domestic pest management.
(Chapter-15 and 17: Gupta)

Practical [Credits: 2]

1. To calculate LD_{50}/LC_{50} of an insecticide from data provided.
2. Demonstrate the extraction of an organophosphate pesticide from larva & analyse it by TLC.
3. Demonstration of the effect of pesticide Chloropyriphos on insects after topical application
4. Tools and techniques used for analytical study of toxicity (Spectroscopy, Chromatography instruments: HPLC & GC).
5. To study the equipment used for spraying and dusting of insecticides.
6. Submission of project report on visit to IARI, IPFT, Hindustan Insecticides Ltd., FCI complex, etc.

Teaching and Learning Process:

Knowledge about the concept of chemical control of pests, and various factors involved will be imparted through classroom lectures. Group discussion among students will make them aware of toxicological hazards and development of insecticide resistance in pests. Seminars on the related topics will enhance the learning of students to a great extent. Visits to fields and laboratories will provide a hands-on experience about the mode of action and resistance mechanism to pesticides.

Assessment Methods:

The theory and practical components of the course will be assessed in two ways.

- Continuous assessment - To regularly check the students learning and understanding of the subject. Class room discussions and tests will help in evaluating the students grasp on the subject.
- Semester-end Examination - Performance in the semester end examination will indicate their understanding of the concept and its applications; while solving the related problems and writing their answers.

Keywords:

Insecticides, Toxicology, Carcinogenic, Mutagenic, Teratogenic, Pest resurgence, Synergism, Antagonism, Potentiation, Metabolism, Resistance

Recommended Books:

- Greim, H., and Snyder, R. (ed). Toxicology and Risk Assessment: A Comprehensive Introduction. John Wiley and Sons, UK
- Whitford, F. The Complete Book of Pesticide Management. Wiley Interscience, John Wiley and Sons, UK
- Chattopadhyay, S.B. (1985) Principles and Procedures of Plant Protection. Oxford & IBH, New Delhi.
- Gupta, H.C.L. (1999) Insecticides: Toxicology and Uses. Agrotech Publ., Udaipur.

Suggested Readings:

- Ishaaya, I, and Degheele (Eds.) (1998) Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
- Matsumura, F. (1985) Toxicology of Insecticides. Plenum Press, New York.
- Perry, A.S., Yamamoto, I., Ishaaya, I and Perry, R. (1998) Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.

- Prakash, A. and Rao, J. 1997. Botanical Pesticides in Agriculture. Lewis Publ., New York.
- Dhaliwal, G.S. & Singh, Balwinder (1993). Pesticides: Their Ecological Impact in Developing Countries , Commonwaelth Publishers, New Delhi.

ALS SEC IV: Quality Control in Integrated Pest Management

Course Learning Objective:

The study of quality control in IPM will serve to provide the basic information for successful biological control of insect pests. The course emphasizes that quality of mass produced bio-control agents should be assessed periodically for such attributes to determine their control efficiency. After studying this paper, students shall be well acquainted with procedures for testing various quality indicators of natural enemies.

Course Learning Outcome:

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

- Explain basic concepts of quality control attributes, mass rearing and maintenance of biological control agents.
- Understand quality control criteria of bio-control agents, *viz.* sex-ratio, emergence, fecundity, longevity, parasitism, pupal and adult body size.
- Identify quality control measures in relation to locomotor behavior and bio-efficacy of egg-parasitism.

Course Contents:

Theory [Credits: 2] **30 hrs**

Unit 1: Concepts of Quality Control 6 hrs

Definition, Attributes, Biological control agent, their mass rearing and maintenance, Implementation of QC (Production control and Process control)

(Chapter-5: Wajnherg and Hassan)

Unit 2: General Quality Control Criteria for Mass-Reared Natural Enemies 10 hrs

Quantification: number of live natural-enemy organisms in container; Sex ratio: minimum % females (male-biased ratio may indicate poor quality); Emergence: emergence rate to be specified for all organisms; Fecundity: number of offspring produced during a certain period

Longevity: minimum longevity in days; Parasitism: number of hosts parasitized during a certain period; Pupal size; Adult size: hind tibia length of adults

(Chapter-3: Wajnherg and Hassan)

Unit 3: Mechanism of Quality Control 10 hrs

With reference to Quality control in *Trichogramma* Production; Locomotor behaviour: Crucial host seeking behaviour during pre-parasitization phase to gain momentum for reach out host eggs; Types of behaviour: Walks, hops, flight. Bio-efficacy: Parasitization efficacy (number of host eggs parasitized); Development (developmental period of parasitoid within host egg); Emergence (% emergence of adult wasps from host); Longevity (adult life span of parasitoid); Sex-ratio (ratio of male: female)

(Chapter-19: Lenteren)

Unit 4: Quality issues 4 hrs

Genetic and environmental components, International Standard for quality control of commercially produced natural enemies.

(Chapter-19: Lenteren)

Practical [Credits: 2]

1. To study the bioefficacy of egg parasitoid, *Trichogramma*
2. To study the host seeking/searching behaviour of EPNs
3. Locomotor behavior of natural enemies, Trichogramma, Cotesia (Walking, hops and flying)
4. Tools like Polyacetate cylinder (version1,2 & 3); methods of use
5. Study of International Standard for quality control
6. Visit to biocontrol laboratories – NCIPM, IARI and Entomology Lab, DU

Teaching-Learning Methods:

Classroom teaching using power-point presentations will be employed to acquaint students with diversity of insects and their natural enemies and behaviour. Demonstration of various methods to evaluate the efficacy of commonly available biocontrol agents, e.g. *Trichogramma* will be used to enhance the student's learning. Study of insects (prey/host), predators, parasitoids will be held in their natural habitat through visits to agricultural fields/sanctuary/biodiversity park. Demonstration of various simple, economical and short duration quality testing methods of biocontrol agents will be conducted in the laboratory.

Assessment Methods:

- Summative assessment: Term-end practical exam and Continuous Evaluation; which includes: No. of practical attended/Performed, Test/*Viva*, Project Report and Record book.
- Formative assessment: Practical exercises to study life cycle of host insects and their rearing artificial diet/natural diet in laboratory conditions; different tools and criteria for quality control of *Trichogramma*; Continuous and comprehensive assessment by attendance and tests and Report on study of quality parameters to validate the natural enemies

Key words:

Biocontrol agents, Quality control, IPM, Bioefficacy, Polyacetate cylinders

Recommended Books:

- Wajnberg, E. and Hassan, S. A. Biological Control with Egg Parasitoids. CAB International and IOBC (International Organization for Biological Control of Noxious Animals and Plants).
- van Lenteren, J. C. and Hale, A. Guidelines for Quality Control of Commercially Produced Natural Enemies. Nature's Alternative International, Canada.

ALS SEC-V Use of Nuclear Technology for Agro-Pest Management

Course Learning Objective:

Nuclear energy has been greatly explored for its use in various disciplines of entomology related to agriculture, medicine and industry. The exposure to ionizing radiation is now the principal method for inducing reproductive sterility in mass-reared insects. Irradiation of insects is a relatively straightforward process with reliable quality control procedures. Using radiation may offer other advantages, such as insignificant increase in temperature during the process, use of treated insects immediately after processing, no addition of any residues harmful to human health or environment, etc. The course highlights various pragmatic perspectives of utilization of radiation as a tool in entomological research studies, in relation to noxious insects as well as ecologically beneficial insects.

Course Learning Outcome:

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

- Demonstrate the knowledge of radiation, types of irradiators and radiation dosimetry in relation to safety and security.
- Understand use of radiation technology for production of insect host as well as natural enemies.
- Develop skills for applying Sterile Insect Technology (SIT) in pest management.

Course Content:

Theory [Credits: 2] 30 hrs

Unit 1: Radiation 10 hrs

Definition, Types: Ionizing radiation and Non-ionizing, Sources, Production of Ionizing radiation: Gamma irradiators, Electron irradiators, X-rays irradiators and Dosimetry (radiation doses and dose rate), Safety and security

(Chapter-17,19 and 21: Ghatak)

Unit 2: Radiation Technology in Agriculture 15 hrs

Colonization and production of insect host and their natural enemies, Combating pests and diseases, The principle of SIT and its uses in different order of insects, Modified Sterile Insect Technique (F_1 sterility), Phytosanitary Treatments (post harvested), Quarantine control.

(Supplement 1: Mark Goettel)

Unit 3: Future Trends 5 hrs

Integration of Radio-Genetic tactic with Biological Control and Synergistic impact on pest control.

(Supplement 1: Mark Goettel)

Practical [Credits: 2]

1. Study about Ionising and non-ionizing radiations
2. Sources of radiation, principle and application in insect pest management.
3. Study of the SIT/F_1 sterility techniques and the efficacy (Dry lab exercises).
4. Integration of F_1 sterility and other biorational control techniques.
5. Use of radiation for storing and packaged agricultural produce.

6. Study of some major insect pests for the use of F_1 sterility.
   (Control of reproduction and corrected sterility)

Teaching and Learning Process:

Classroom lectures using Power point presentations enabled with e-resources will clarify the concepts. Group discussions on radiation technology will develop interest among students to pursue higher studies in the field. Observations based on actual handling of insects and visit to laboratories to observe irradiation of insects will develop curiosity among learners about the technique.

Assessment Method:

The learners/ students can be assessed in many different ways.

- Formative feedback throughout the course and summative feedback as mid-semester and semester-end evaluation.
- Presenting the topics in the class *via* blackboard teaching/presentations, group discussions etc.
- Students would be provided feedback on their work with a view to improve their academic performance.
- From time to time, learners will be given practical problems and neuroimages to test their theoretical skills and promote practical knowledge.
- They would be provided feedback on their work with a view to improve their academic performance.

Key Words:

Radiation, Radiators, SIT, F_1 Sterility, Phytosanitary, Quarantine, Dosimetry

Recommended Books:

- Jorge Hendrichs (1990) Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Austria
- Lide, D.R. (ed.), CRC Handbook of Physics and Chemistry. Boca Raton, FL; CRC Press.
- Mark Gottel (2009). Bicontrol Science and Technology. Taylor and Francis, Vol 19, Supplement 1.
- Ghatak, K.L.(2014). Techniques and methods in Biology. II edition: PHI Learning Pvt. Ltd, Delhi-110092

Suggested Readings:

- McLaughlin, W.L., Boyd, A.W., Chadwick, K.H., McDonald, J.C., and Miller, A. (1989)
  Dosimetry for Radiation Processing. New York: Taylor & Francis, p. 251.
- International Atomic Energy Agency (IAEA) (1996c), International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, Vienna Austria: Jointly published by FAO, IAEA, ILO, OECD/NEA, PAHA and WHO.

Acknowledgements

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CC-I	Animal Form, Structure and Function	Smita Ray Chaudhary P.P. Saini Supriya Singh	Anita K. Verma Sarita Kumar
CC-II	Cell and Cellular Processes	Surender Kumar Monika Sharma Lathika Nair	Debjani D Mukhopadhyay Neera Mehra
CC-III	Biochemistry and Immunology	Anita Gulati Neha Niharika Jasvinder Kaur	Anita K. Verma Vandna K Singh Sunil Kumar
CC-IV	Molecular Biology and Developmental Biology	Charu Dogra Rawat Nimita Kant Gauri Garg Dhingra	Sukanya Lal Chitra Bhasin Sarita Kumar
DSE-I	General Entomology	S. K. Sagar Jeepinder Kaur Tarkeshwar	S. K. Sagar K.K. Gupta
DSE-II	Applied Entomology	Renu Gupta Anita Verma S. K. Sagar	S. K. Sagar K.K. Gupta
DSE-III	Integrated Pest Management	Renu Gupta Anita Verma S. K. Sagar	Anita K Verma Anita Verma Sarita Kumar
SEC-I	Biotechnological control of pest	S.K. Sagar Manas Dhall Anita K Verma Anita Verma	Anita K Verma Anita Verma Sarita Kumar
SEC-II	Biological Control	S.K. Sagar Manas Dhall Anita K Verma Anita Verma	Anita K Verma Anita Verma Sarita Kumar
SEC-III	Insect Toxicology	S.K. Sagar Manas Dhall Anita K Verma Anita Verma	Anita K Verma Anita Verma Sarita Kumar
SEC-IV	Quality control in IPM	S.K. Sagar Manas Dhall Anita K Verma Anita Verma	Anita K Verma Anita Verma Sarita Kumar

Course Type	Course Name	Contributors Name	Reviewers Name
SEC-V	Use of Nuclear technology for agro-pest management	S.K. Sagar Manas Dhall Anita K Verma Anita Verma	Anita K Verma Anita Verma Sarita Kumar