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Department of Chemistry
SEMESTER-II

Bachelor of Science in Applied Life Sciences with Agrochemicals and Pest Management

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Course Code: ALS BOT DSC 02
Course Title: Economic Botany
Discipline Specific Core Course (DSC)
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Learning Objectives:

The Learning Objectives of this course are as follows:

- To understand the economic importance of diverse plant species, identifying plants of economic importance through field visit, live plant specimens, herbarium specimens and digital resources.
- To understand the importance of various plant parts and their products used as food, fibres, medicines, oils and economically important products.
- To learn the processing of various economically important plant resources, identification and analysis of nutrients using simple microchemical tests.

Learning Outcomes:

By studying this course, students will be able to:

- acquire knowledge about the economic importance of plants, their products and their role in our daily lives.
- perform micro-chemical tests to study the presence of various biochemical constituents.
- explore the regional diversity of economically important plants.

Theory:

Unit 1. Introduction and Origin of Cultivated Plants: **Hours: 02**

Importance of Plant Resources; Vavilov's concept for the Origin of cultivated plants; Centers of Origin (Primary and Secondary); Centers of diversity, Harlan's concept of gene pools.

Unit 2. Cereals: **Hours: 04**

Wheat (Origin, Evolution of Wheat; (tetra- & hexaploid), Morphology, Production, Cultivation and Economic importance of hexaploid wheat); Rice (Origin-Monophyletic and Polyphyletic, Production, Morphology, Cultivation, Comparison between *indica* and *japonica* Rice, Parboiling, Economic Importance); Millets, man-made cereal (*Triticale*) and Pseudocereals, Green revolution (briefly).

Unit 3. Legumes: **Hours: 03**

General account (Nutritive Value of Pulses, Protein Malnutrition, Lathyrism, Favism, Ecological Importance); Chick pea, and Groundnut (Production, Morphology and Economic Importance). Fodder legumes and green manure crops.

Unit 4. Sugars and Starches: **Hours: 03**

Sugar-Different sources of sugar, Sugarcane (Morphology, Ratooning, Nobilization, Uses of products and by- products); Starch- sources, types of starch grain, Potato (Morphology, Tuber Anatomy, Seed Tubers vs True Potato Seeds and Economic uses).

Unit 5. Spices, Condiments & Flavorings: **Hours: 03**

General Account (Spices, Condiments, Culinary Herbs and Essences, with examples), Importance of Spices, Clove (Morphology, Anatomy of part used and Economic importance) and Black Pepper (Morphology, Anatomy of part used and Economic importance).

Unit 6. Beverages: **Hours: 02**

Types of Beverages (Alcoholic and Non-Alcoholic) with examples, Tea and Coffee (Morphology, Varieties, Chemistry and Economic Importance)

Unit 7. Fibres and Fibre-yielding plants: **Hours: 03**

Classification of Fibres based upon their Origin (surface fibres, bast fibres, and leaf fibres, with examples); Jute (morphology, extraction and economic importance), Cotton (*Gossypium* species, morphology and economic importance)

Unit 8. Oil-Yielding Plants: **Hours: 03**

Fatty Oils and Essential Oils, Comparison between Fatty Oils and Essential Oils; Fatty Oils (Classification with examples, keeping quality), Coconut and Mustard (Morphology and Economic Importance); Essential Oils (General characteristics, and Economic Importance, with examples).

Unit 9. Medicinal and Drug-Yielding Plants: **Hours: 02**

Brief Account of Therapeutic Drugs with Examples; Morphology, Chemical Constituents, Economic Importance of *Cinchona, Rauwolfia, Digitalis.*

Unit 10. Fumigator & Masticatory: **Hours: 02**

Tobacco **(**Morphology, species - *Nicotiana tabacum* & *N. rustica*), Products, Economic Importance and Health Hazards).

Unit 11. Rubber: **Hours: 01**

Para Rubber - *Hevea brasiliensis* (Morphology, Tapping of latex, Products and Economic Importance).

Unit 12. Vegetables and Fruits: **Hours: 02**

General account with common examples.

Practical: 60 Hours

1. **Cereals**:

   Wheat (Habit Sketch, L.S/T.S. grain, W.M. starch grains, Micro-chemical tests), Rice (Habit Sketch, Study of paddy and grain, W.M. starch grains, Micro- chemical tests). Millets (anyone) and Pseudocereals (any one) (specimens/digital resources and grains).

2. **Legumes**:

   Chickpea, Groundnut (Habit, Fruit, Seed structure, Micro-chemical tests).

3. **Sugars and Starches**:

   Sugarcane (Habit Sketch, Products and By-products, Cane Juice-Micro - chemical tests); Potato (Habit Sketch, Tuber morphology, T.S. tuber to show localization of starch grains, W.M. starch grains, Micro-chemical tests).

4. **Spices**:

   Clove and Black pepper (Habit and sections L.S./T.S.).

5. **Beverages**:

   Tea (Plant specimen, Tea leaves), Coffee (Plant specimen, Beans).

6. **Fibres**:

   Jute (Specimens/digital resources of Jute, T.S. stem, Test for cellulose and lignin on section of stem and fibre). Cotton (Specimen, W.M. seed to show lint and fuzz; W.M. fibre, Test for cellulose).

7. **Vegetable Oil-Yielding Plants**:

   Fatty Oils: Coconut; Habit (photograph), Fruit, T.S. nut, Mustard; (Habit- specimen, seeds).

8. **Essential Oils:**

   Extraction methods (Specimen/ digital resources), Habit Sketch of Rose, Jasmine, *Vetiver* sp., (specimens/photographs).

9. **Drug-Yielding plants:**

   Habit - Fever Bark Tree, Poppy, Foxglove (Specimens/ Photographs).

10. **Fumigatory Material:**

    Nicotiana sp. (specimens/photographs), Tobacco Products.

11. **Rubber:**

Para Rubber - Habit, Tapping of latex (Specimen/photograph), Rubber Products.

Suggested Readings:

1. Kochhar, S.L. (2012). *Economic Botany in Tropics.* MacMillan & Co.
2. Kochhar, S.L. (2016). *Economic Botany – A Comprehensive Study* (5th Ed.). Cambridge University Press.
3. Wickens, G.E. (2001). *Economic Botany: Principles & Practices*. The Netherlands: Kluwer Academic Publishers.
4. Chrispeels, & M.J., Sadava, D.E. (1994). *Plants. Genes and Agriculture*. Jones & Bartlett-Publishers.
5. Berg L, (2008). *Introductory Botany: Plants, People, And the Environment*. Thomson Brooks/Cole.
6. Cook F.E.M. (1995). *Economic Botany: Data Collection*. Standard Royal Botanic Garden, Kew, Richmond.

Keywords:

Cultivated plants, Plant products of economic value, Cereals, Legumes, Starches & Sugars, Spices, Oils & Fats, Drug yielding plants, Natural rubber, Fibres.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Course Code: ALS ZOO DSC 02
Course Title: Entomology
Total Credits: 04 (Theory 02, Practical 02)
Total Lectures: Theory 30, Practical 60

Learning Objectives:

Learning objectives of this course are as follows:

- The course will give knowledge of the diversity of insects.
- It will impart knowledge about the morphology, anatomy and physiology of the insects.
- It will correlate the structural organization in different groups of insects with respect to the niche they occupy.

Learning Outcomes:

By studying this course, students will be able to:

- identify and classify insects up to orders.
- learn the methods of collection, preservation and rearing of insects.
- learn about the anatomy and physiology of various organ systems in insects.
- understand the concept of insect metamorphosis.

Theory:

Unit 1: **Hours: 07**

Taxonomy: Salient features of insects, Basis of insect classification; Outline of insect classification upto orders, Characteristics of economically important orders.

Unit 2: **Hours: 12**

Morphology of insects: Segmentation in insects; Head: typical structure of head, types of head, Antenna: typical structure, modification in antennae, types of mouth parts (Biting and chewing, sponging, piercing and sucking, siphoning and lapping), Compound eyes: structure of ommatidium, superposition and appositional images, Thoracic structures: Legs: typical structure of legs, modification in legs, modification in wings, veinations, coupling mechanisms.

Unit 3: Hours: 07

Physiology of insects: Physiology of digestion, excretion, respiration, circulation, sense organs (mechano and chemoreceptors).

Unit 4: Hours: 04

Reproduction and Development: Embryonic and post-embryonic development; Types of metamorphosis, Parthenogenesis

Practical: 60 Hours

1. Collection, dry mounting, labelling and preservation of insects.
2. Study of mouth parts: biting and chewing, sponging, piercing and sucking, siphoning and lapping type through slides/ photographs.
3. Study of different types of wings, legs and antennae through slides/ photograph of insects.
4. Study of one insect from each economically important order (Thysanura, Odonata, Orthoptera, Dermaptera, Isoptera, Hemiptera, Thysanoptera, Lepidoptera, Diptera, Siphonaptera, Hymenoptera, Coleoptera and Strepsiptera) through specimens/ photographs.
5. Visit to Entomology Division IARI, Pusa, New Delhi.
6. Submission of project report on the basis of Field/Lab visit.

Suggested Readings:

1. Imms, A. D. (1977) A General Text Book of Entomology. Chapman & Hall, UK.
2. Chapman, R. F. (1998) The insects: Structure and Function. Cambridge University Press, UK.
3. Atwal, A.S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.
4. Dennis, S. Hill. (2005) Agricultural Insect Pests of the Tropics and Their Management, Cambridge University Press
5. David, B.V. and Ananthakrishnan, T.N. (2004) General and Applied Entomology. Tata-McGraw Hill, New Delhi.
6. Duntson, P.A. (2004) The insects: Structure, Function and Biodiversity. Kalyani Publishers, New Delhi.
7. Wigglesworth, V.B. (1984) Insect Physiology. VIII Edition, Chapman & Hall, New York.

E contents:

https://swayam.gov/appliedentomology.

Keywords:

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

Teaching and Learning Process:

Classroom lectures using power point presentations coupled 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 this field. Observations based on actual handling of insects, visit to observe insects in their natural environment and entomology museum will develop curiosity among learners about insect diversity.

POOL OF GENERIC ELECTIVES COURSES

Distribution and Detailed Syllabi of Generic Elective (GE) Courses - Pool of courses in odd and even semesters			
	Paper Code	**Paper Name**	
ODD SEMESTER	ALS BOT GE 01	Agricultural Botany and Weed Science	
	ALS BOT GE 02	Plant Quarantine and Seed Health Technology	
	ALS BOT GE 03	Plant Cell and Tissue Culture Techniques*	
	ALS BOT GE 04	Recombinant DNA Technology and Proteomics*	
	ALS CHEM GE 01	Bioinorganic Chemistry	
	ALS CHEM GE 02	Chemistry of Carbohydrates, Nucleic Acids and Lipids	
	ALS ZOO GE 01	Agricultural Pests of Crops**	
	ALS ZOO GE 02	Insect Vectors and Diseases	
	ALS ZOO GE 03	Techniques for Insect Collection, Rearing and Preservation	
EVEN SEMESTER	ALS BOT GE 05	Hydroponics and Organic Farming	
	ALS BOT GE 06	Informatics and Statistics for Biology and Allied Sciences*	
	ALS BOT GE 07	Genetically Modified Plants*	
	ALS CHEM GE 03	Chemistry of Amino acids, Proteins and Enzymes	
	ALS CHEM GE 04	Conductance and Chemical Kinetics	
	ALS ZOO GE 04	Animal Cell Culture Techniques	
	ALS ZOO GE 05	Locust and its management	
	ALS ZOO GE 06	Beneficial Insects and their Products**	
	ALS ZOO GE 07	Insect Ecology	

**: Only for General Pool; Not offered for ALS-ACPM students.

*: Cannot be offered to students with some combinations of DSC/DSE/GE/SEC papers due to common course contents.

Course Code: ALS BOT GE 01
Course Title: Agricultural Botany and Weed Science
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

To gain the knowledge on:

- Requirement of the conditions for seed germination.
- Growth hormones, plant development and flowering conditions.
- Weeds and methods to control weeds.

Course Learning Outcomes:

After completion of this course the students would be able to understand the following:

- How is the quality of seeds assessed and how are suitable conditions created for seed germination?
- How is growth, flowering and fruiting in plants managed through the application of hormones?
- Weed biology, ecology and management of weeds in commercial crops

Theory:

Unit 1. Seed Physiology: **Hours: 04**

Seed dormancy types, factors, mechanism and methods for breaking dormancy, seed viability, seed vigour and seed germination.

Unit 2. Physiology of Crop Growth and Yield: **Hours: 05**

Growth, methods of growth analysis, factors affecting growth, concept of phytotronics and Fertilizers (Nitrogen, Phosphorus, biofertilizers).

Unit 3. Regulation of Growth and Development: **Hours: 04**

Role of hormones in plant growth and development, growth retardant.

Unit 4. Reproductive Physiology and Senescence: **Hours: 06**

Physiology of flowering, Photoperiodism, vernalization, physiology of fruit ripening, senescence and regulation of senescence.

Unit 5. Biology of Weeds: **Hours: 04**

Ecology of weeds, competition, reproduction of weeds. Allelopathy and Invasive Plants.

Unit 6. Crop Management Practices: **Hours: 07**

Mechanical, Cultural, Biological and Chemical Weed control. Some obnoxious weeds and their management, Integrated pest management (IPM).

Practical: 60 Hours

- To study the effect of ethylene on shelf life of cut flowers. / To study the effect of cytokinin on leaf senescence.
- To test the viability of weed seeds.
- To study the allelopathic effects of weeds on germination of crop seeds.
- To study the effect of herbicides on seed germination and seedling growth of weeds.
- Determination of pH and analysis of a soil sample for carbonates, chlorides, sulphates, organic matter and base deficiency by rapid field tests.
- To perform qualitative test for Nitrogen (NH^{4+}, NO^{3-}, urea) in a fertilizer and soil sample.
- Demonstration / use of digital resources for the mechanisms used in herbicide application.
- Field trip to a crop land to study weeds.
- Submission of any two properly dried and mounted weed specimens with herbarium label.

Suggested Readings:

- Ashton, F. M., & Monaco, T. J. (2002). *Weed Science: Principles and Practices.* John Wiley and Sons. Inc.
- Hopkins, W.G. (1995). *Introduction to plant physiology.* John Wiley and Sons. Inc.
- Taiz, L., & Zeiger, E. (2006). *Plant Physiology* (5th ed.). Sinauer Associates, Inc.
- Mandal, R.C. (1990). *Weeds, weedicides and weed control: Principle and Practice.* Agro Botanical Publishers.
- Rao, V. S. (1999). *Principles of Weed Science*. Oxford and IBH Publishers.
- Subramanian, S. (2017). *All about weed control.* Kalayani publishers.

Keywords:

seed dormancy, crop growth, plant growth hormones, photoperiodism, allelopathy, weeds, management practices.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Course Code: ALS BOT GE 02
Course Title: Plant Quarantine and Seed Health Technology
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

- To acquaint the students with the Plant Quarantine Information System (PQIS).
- To familiarize the students with knowledge of export and import policies of Germplasm, Transgenic or Genetically Modified Organisms and live organisms.
- To impart knowledge about the importance of seed pathology including mode and mechanism of transmission of pathogens.
- To strengthen student's knowledge in field of quality, conditioning, drying and storage of seeds along with various acts and regulations related to seeds.

Learning Outcomes:

- Plant Quarantine Order and Amendments, and Issuance of Export and Import Permit.
- Procedures of Plant quarantine inspection for clearance.
- The need of quarantine for Germplasm, Transgenic or Genetically Modified Organisms, live insects and microbial cultures, plants, vegetative plants propagating materials and plant products.
- The laws associated with various acts of plant quarantine.
- Core competency in basic understanding about seeds, seed pathology, management and procedure for healthy seed production and seed storage.

Plant Quarantine

Theory:

Unit 1. Introduction: **Hours: 02**

Plant quarantine: Definition, General principles of Plant Quarantine, Introduction and objectives of Plant Quarantine Information System (PQIS).

Unit 2. Imports: **Hours: 05**

Plant Quarantine Order and Amendments, Issuance of the Import Permit, import inspection and clearance, Procedures of Post Entry Quarantine (PEQ) inspection, Permits required for import of Germplasm, Transgenic or Genetically Modified Plants, Plant parts and Plant products, Requirements for Import of Wood and Timber, Special conditions for Import of plant species.

Unit 3. Exports: **Hours: 04**

Export inspection and certification procedure, Post-entry Quarantine, Appeal and Revision, Power of Relaxation, Commodities not requiring Plant Quarantine clearance.

Unit 4. Phytosanitary Measures: **Hours: 03**

Phytosanitary Agreement, National Standards for Phytosanitary Measures, Accredited Treatment Facilities, Quarantine disinfestation treatment, International Standards on Phytosanitary Measures (ISPMs).

Unit 5. Laws: **Hours: 04**

The Plant Quarantine Order 2003 - Amendments, International Plant Protection Convention, WTO-SPS Agreement.

Seed Health Technology

Theory:

Unit 6. Importance and concept: **Hours: 03**

Introduction and economic importance of seed pathology in seed industry, mode and mechanism of transmission of seed-borne pathogens and microorganisms.

Unit 7. Seed Quality and Health: **Hours: 04**

Classes of seeds and Seed Quality, Seed Cleaning, Seed Treating, Seed Coating and Pelletizing, Seed certification and tolerance limits, Role and Principles of seed Conditioning. Seed moisture, Drying seed and Dehumidified Drying.

Unit 8. Seed Regulations and Management: **Hours: 05**

Role of microorganisms in seed quality deterioration, different methods for seed health testing and detection of microorganisms, Production of toxic metabolites affecting seed quality, Management and procedure for healthy seed production and seed storage, Seed Act and Regulations.

Practical: 60 Hours

1. Detection and identification of pathogens, pests and microorganisms by isolation and growth on different nutrient media.
2. Learning various techniques (Mechanical cleaning, hot water treatment, alcohol wash) for salvaging of infested/ infected/ contaminated germplasm.
3. To perform the Tetrazolium test (TTC) for seed viability.
4. To determine the moisture content of dry seeds by Soaked examination and Incubation test.
5. To inspect dry seeds and perform washing test to assess seeds' health.
6. To learn the technique of surface sterilization of seeds.
7. Evaluation of seed health of different Pulses by Incubation methods.
8. Detection of *Botrytis cinerea* in *Helianthus annuus* (Sunflower) seeds.
9. Detection of *Ustilago tritici* in *Triticum aestivum* by embryo count method.
10. A visit to the Plant quarantine station and preparation of field report.

Suggested Readings:

1. Muthaiyan, M.C. (2009). *Principles and Practices of Plant Quarantine*. Allied publisher Pvt. Ltd.
2. Ebbels, D.L. (2003). *Principles of Health and Quarantine*, CABI Publishing.
3. Lawrence O. Copeland & Miller B. McDonald (2001). *Principles of Seed Science and Technology* (4th ed.). Springer Science + Business Media, LLC.
4. S.G. Elias, L.O. Copeland, M.B. McDonald & R.Z. Baalbaki (2012). *Seed Testing: Principles and Practices*, Michigan State University Press.
5. Khare, D., & Bhale M. S. (2014) *Seed Technology* (2nd Ed.). Scientific Publishers.
6. Gregg (B. R.) B. and Billups G. L. (2010) *Seed Conditioning Technology, Advanced-level Information for Managers, Technical Specialists & Professionals* (Volume 2, Part A) Science Publishers.

Additional Readings:

- https://plantquarantineindia.nic.in/PQISMain/Default.aspx
- https://plantquarantineindia.nic.in/PQISPub/html/Laws.htm
- http://www.nbpgr.ernet.in/Divisions_and_Units/Plant_Quarantine.aspx
- Dubey S.C. & Gupta K. (2016). Plant Quarantine system for PGR in India. *Indian J. Pl. Genet. Resour,* 29, 410-413.
- *Validated Seed Health Testing Methods: International Rules for Seed Testing manual* (2022).

- *Seed Quality Assurance: Seed Toolkit,* (2018) The Food and Agriculture Organization of the United Nations and Africa (Module: 3).

Keywords:

Plant quarantine, PQIS, Imports, Export inspection, Phytosanitary, WTOSPS, seed, industry, Seed Quality, Seed certification, Seed moisture, Drying seed, Dehumidified Drying, Seed Act and Rules, seed health testing, healthy seed production, Seed storage.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Course Code: ALS BOT GE 03
Course Title: Plant Cell and Tissue Culture Techniques
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

To give students knowledge of techniques used in plant tissue culture and its applications.

Learning Outcomes:

The students will:

- learn the basic concepts, principles and processes in plant cell and tissue culture.
- gain the ability to apply concepts and principles of plant cell and tissue culture in biotechnological and agricultural fields.
- understand the role of cell and tissue culture in plant improvement.
- gain knowledge and expertise to become an entrepreneur by establishing their own plant tissue culture lab.

Theory:

Unit 1. Historical perspective and terminology used in tissue culture: Hours: 03

Introduction to Plant Tissue Culture Technique, Contributions of Haberlandt, Reinert and Steward, Murashige and Skoog, Cocking, Guha and Maheshwari, Morel and Martin. Terminology: Cell culture, tissue culture, organ culture, explant, callus, totipotency, plasticity, dedifferentiation and re-differentiation, regeneration, subculture, somaclonal variants.

Unit 2. Media Preparation and Sterilization: Hours: 05

Media composition - role of organic and inorganic nutrients, vitamins, hormones and supplements. Preparation of nutrient medium. Sterilization of medium, containers and small equipment (steam, dry, filter, UV light, alcohol and flame). Collection and sterilization of plant material, maintenance of aseptic conditions by use of autoclave and laminar flow chamber.

Unit 3. Micropropagation: Hours: 05

Selection of plant material, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis. Advantages.

Unit 4. Protoplast culture: Hours: 05

Protoplast isolation (mechanical and enzymatic), role of osmoticum, culture, purification, viability test and protoplast fusion (spontaneous, induced), selection of fused protoplasts, applications. Somatic hybrids and Cybrids.

Unit 5. *In vitro* Haploid and Triploid Production: **Hours: 04**

Haploids - Anther culture and microspore culture, Applications. Triploids - Endosperm culture and Applications.

Unit 6. Applications of Tissue culture: **Hours: 08**

Embryo rescue, Artificial seeds, virus elimination, secondary metabolite production, Cryopreservation, Germplasm conservation.

Practical: 60 Hours

1. (a) Equipment used in tissue culture: autoclave and laminar air flow chamber.
   (b) Preparation of Murashige & Skoog's (MS) medium.
   (c) Demonstration of *in-vitro* sterilization and inoculation methods using leaf and nodal explants.
2. Study of anther, embryo and endosperm culture.
3. Study of micropropagation, somatic embryogenesis & artificial seeds.
4. Isolation of protoplasts.
5. Visit to a plant tissue culture laboratory and submission of field report.

Suggested Readings:

1. Bhojwani, S. S. (1990). *Plant Tissue Culture: Applications and Limitations, Developments in Crop Science* (1st ed., Volume 19). Elsevier Science.
2. Bhojwani, S.S, & Bhatnagar, S.P. (2011). The Embryology of Angiosperms (5 ed.). Vikas Publication House Pvt. Ltd.
3. Bhojwani, S. S., & Dantu, P. K. (2013). *Plant Tissue Culture: An Introductory Text.* Springer.

- Bhojwani, S. S., & Razdan, M. K. (1996). *Plant Tissue Culture: Theory and Practice* (Revised Ed.). Elsevier.
- Newmann, K.-H., Kumar, A., & Imani, J. (2020). *Plant Cell and Tissue Culture: A Tool in Biotechnology* (2nd Ed.). Springer.

Additional Readings:

- Park, S. (2021). *Plant Tissue Culture: Techniques and Experiments* (4th Ed.). Elsevier
- Razdan, M. K. (2019). *Introduction to Plant Tissue Culture* (3rd Ed.). CBS / Oxford & IBH
- Gamborg O. L & Phillips G. C. (Eds.). *Plant Cell, Tissue and Organ Culture: Fundamental Methods.* Springer-Verlag
- Smith, R. H. (2013). *Plant Tissue Culture: Techniques and Experiments* (3rd Ed.). Elsevier.
- Stewart, C.N. Jr. (2016). *Plant Biotechnology and Genetics: Principles, Techniques and Applications* (2nd Ed.). Wiley.
- Trigiano, R. N. (2011). *Plant Tissue Culture, Development, and Biotechnology.* CRC Press.

Keywords:

Tissue culture, micropropagation, organogenesis, totipotency, protoplast isolation, culture and fusion, somatic embryogenesis, artificial seeds, cryopreservation, germplasm conservation.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Course Code: ALS BOT GE 04
Course Title: Recombinant DNA Technology and Proteomics
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

- To illustrate the use of modern techniques for the manipulation and analysis of DNA sequences.
- To learn to clone, analyse and modify the genetic material
- To understand the applications of recombinant DNA technology for the generation of commercial biotechnological products of diverse usage.
- To gain knowledge about biosafety and ethical concerns associated with recombinant DNA technology.
- To acquaint the students with proteome and its analysis
- To train students in strategizing research topics employing genetic engineering techniques.

Learning Outcomes:

Students would learn about

- technical know-how on modern techniques involved in manipulation and analysis of nucleic acids, Gene cloning for the creation of genetically modified organisms (GMOs).
- details of restriction endonucleases, marker and reporter genes, the repertoire of various vectors, construction of genetic libraries, screening methods and gene identification.
- applications of PCR, hybridization techniques and sequencing in basic and applied experimental biology.
- biosafety and ethical issues associated with rDNA technology
- designing and conducting experiments involving genetic manipulation.

Theory:

Unit 1. Introduction to Recombinant DNA technology and Gene cloning:

Hours: 05

Introduction to rDNA and Genetic Engineering, Restriction endonucleases - Discovery, Nomenclature and applications of Type I - Type IV, Gene cloning - steps and applications, Bacterial transformation, strategies for selection and screening, Introduction to marker and reporter genes (GUS, GFP and Luciferase).

Unit 2. Vectors in gene cloning and transfer: **Hours: 09**

Plasmids (pBR322, pUC18/19, Blue-white screening and α-complementation); Lambda based vectors and derivatives (Insertion vectors, replacement vectors, cosmids, phagemids); Artificial Chromosomes (BACs and YACs), plant transformation vectors (Ti plasmid), Gene construct, Protein Expression Vectors for use in *E. coli*. Construction of genomic and cDNA libraries, screening methods for locating the desired gene (Replica plating, Complementation screening, Heterologous gene probe-based hybridizations). Biosafety concerns.

Unit 3. Polymerase chain reaction (PCR), nucleic acid hybridization and sequencing technologies: **Hours: 07**

PCR technique and its applications, RT-PCR, Hybridization based assays (Southern blotting and hybridization and detection of RFLPs), Northern and Western blotting and hybridization, Restriction maps: construction and importance in navigating genomes, Sanger's di-deoxy chain termination method of sequencing and autoradiography and fluorescence dye chemistry, slab gel-based electrophoresis (semi-automated) to capillary-based gel electrophoresis (automated sequencing).

Unit 4. Proteomics: **Hours:09**

Introduction and Scope of Proteomics, Post-translational modifications, Protein separation techniques - Electrophoresis (PAGE, SDS-PAGE, 2D-gel electrophoresis) and Column chromatography, Protein identification through Mass Spectroscopy - principle, ionization (MALDI, MALDI-TOF, ESI), Structural Proteomics - through NMR and X-ray crystallography, protein-protein interaction.

Practical: 60 Hours

- Isolation of genomic and plasmid DNA from bacteria.
- Quantification of extracted DNA by DPA (Diphenylamine) method.
- Estimation of proteins by Lowry's method.

- Restriction digestion and AGE (Agarose gel electrophoresis) of DNA.
- Restricting Mapping of linear and circular DNA.
- Study of techniques using digital resources/demonstration: PCR, RT-PCR, Real-time PCR, Southern, Northern and Western blotting and hybridization.
- Study of techniques using digital resources/demonstration: SDS-PAGE, 2D-PAGE, MALDI, NMR, X-ray crystallography.
- Study of applications of rDNA technology using digital resources/ in silico studies: recombinant insulin, interferon and human growth hormone.
- Demonstration of equipment used in rDNA technology: Thermocycler, Laminar air flow, Autoclave, Incubator shaker, Refrigerated centrifuge.

Suggested Readings:

- Green, M.R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual* (4th Ed.). Cold Spring Harbor.
- Wink, M. (2011). *An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology* (2nd Ed.). Wiley.
- Glick B.R., & Patten C.L. (2022). *Molecular Biotechnology: Principles & Applications of Recombinant DNA* (6th Ed.). ASM Press.
- Snustad, D. P., & Simmons. M.J. (2012). *Principles of genetics* (6th ed.). John Wiley & Sons.
- Brown, T.A. (2010). *Gene cloning and DNA analysis: an introduction.* John Wiley & Sons.
- Primrose, S. B., & Twyman, R. (2009). *Principles of gene manipulation and genomics.* Wiley.
- Howe, C. J. (2007). *Gene cloning and manipulation*. Cambridge University Press.
- Liebler D. C. (2002) *Introduction to Proteomics: Tools for the New Biology*. Humana Press Inc.
- Scopes R. K. (1994) Protein Purification: Principles and Practice, Springer.
- Albala J.S. & Smith I.H. (Eds.). (2003). *Protein Arrays, Biochips and Proteomics: The Next Phase of Genomic Discovery* (1st ed.). CRC Press. https://doi.org/10.1201/9780203911129.

Additional Readings:

- Burell, M.M. (1993). *Enzymes of Molecular Biology*. Humana Press.
- Eun, H.M. (1996). *Enzymology. Primer for Recombinant DNA Technology*. Academic Press.
- Primrose, S. B., Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.). Wiley-Blackwell.
- Lehninger, A. L., Nelson, D.L., & Cox, M.M. (2017) *Principles of Biochemistry* (7th ed.). W.H. Freeman and company.
- Cooper, T.G., (1977; Reprint 2011) *The Tools of Biochemistry*. Wiley India Pvt. Ltd.

Keywords:

Gene cloning, Recombinant DNA (rDNA), Vectors, Genetic libraries, Blotting techniques, PCR, RFLPs, DNA sequencing, Biosafety concerns, Ethical issues.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Course Code: ALS BOT GE 05
Course Title: Hydroponics and Organic Farming
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

- To provide knowledge and expertise of various aspects of hydroponics, aeroponics and organic farming to the students.
- To make students economically self-reliant by growing and marketing organic herbs, vegetables, micro greens and fruits.

Learning Outcomes:

- Students will develop a thorough understanding of the concept of Hydroponics, Aeroponics and Organic farming.
- Students will be trained in establishing a hydroponic facility. Students will learn the development of various organic products such as biopesticides, biofertilizers and biogrowth promoters.
- Students will understand various government policies in marketing of hydroponic and organic produce.
- Students will understand Good Agricultural Practices associated with protected agriculture.

Theory:

Unit 1. Introduction to Protected Agriculture: Hours: 02

Types of Protected Agriculture (hydroponics, aquaponics and organic farming), definition history, terminology, importance and advantages over traditional agriculture, limitations and challenges.

Unit 2. Plant Growth Requirements and Media formulations: Hours: 05

Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen - DO, Total Dissolved Solid - TDS) and temperature;

Chemical parameters - mineral nutrient requirements, deficiencies, toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media - types, properties, uses, nutrient formulae, preparation of solutions, solid Media and nutrient film.

Unit 3. Hydroponic growing systems: **Hours: 07**

Basic concepts and designs (closed and open systems techniques Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), Systems layout, Strengths and weaknesses of various systems, site considerations, componentry, nutrient delivery, pumping, Principles of aeroponics.

Unit 4. Hydroponics associated pest and diseases: **Hours: 04**

Hydroponics associated pests - mites, thrips, whiteflies, leaf miners; Identification and management of diseases - bacterial, fungal and viral diseases; safety practices (Good Agricultural Practices (GAP) and Integrated Pest Management (IPM).

Unit 5. Organic farming and its management: **Hours: 08**

Introduction to Organic farming and associated management practices (nutritional requirements, pest, diseases, weeds); use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas*, neem oil, garlic etc.) in management, Different concepts of organic farming – Natural farming, Biodynamic farming, Permaculture and Zero Budget Farming

Unit 6. Produce Marketing and Policies **Hours: 04**

Marketing of the produce, Government institutes and policies related to protected farming (hydroponics and organic farming).

Practical: 60 Hours

- Study of various instruments used in hydroponics.
- Preparation of growth media for hydroponics.
- Estimation of NPK, DO, TDS, pH of growing media
- Study of techniques used in hydroponics (Circulating methods such as Nutrient Film Technique (NFT), Deep Flow Technique (DFT), Dutch bucket; Non circulating methods

such as Root dipping, Floating, Capillary action; Aeroponics such as root mist and fog feed techniques.

- Demonstration of construction of a sustainable hydroponic unit.
- Perform rapid tests for estimation of NPK in different soil samples (at least three).
- Bulk density and porosity of soilless media e.g., coco-peat, perlite, vermiculite, expanded clay, rockwool (any two media).
- Study of suitable conditions for Hydroponics - quality, light intensity, photoperiod and temperature.
- Demonstration of growing a leafy vegetable/ fruity vegetable/ medicinal herb/aromatic plant in Hydroponics solution.
- Study of traditional organic inputs and formulation of biofertilizer.
- Preparation of biopesticides, plant health promoters like *Panchgavya, Beejamrut* etc.
- Field visit to organic farm/hydroponic farm and submission of visit report.

Suggested Readings:

1. Schwarz, M. (1995). *Soilless Culture Management*, *Advanced Series in Agricultural Sciences* (vol. 24). Springer, Berlin, Heidelberg.
2. Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., & Pragnya, P. (2018). *Hydroponics Technology for Horticultural Crops*. Tech. Bull. TB-ICN188/2018. Publ. by I.A.R.I.
3. Misra S., Misra S., & Misra R.L. (2017). *Soilless Crop production*. Daya Publishing House, Astral International (P) Ltd.
4. Palaniappan S. P., & Annadurai K. (2018). *Organic Farming: Theory & Practice*. Scientific Publisher.
5. Goddek, S., Joyce, A., Kotzen, B., & Burnell, G.M. (2019). *Aquaponics Food Production Systems*. Springer, Cham.

Additional Readings:

- Jones, J. B. (2014). *Complete Guide for Growing Plants Hydroponically*. CRC Press.
- Vayas, S.C, Vayas, S., Modi, H.A. (1998). *Bio-fertilizers and organic Farming*. Akta Prakashan.
- Jones, J. Benton (2005). *Hydroponics: A Practical Guide for the Soilless Grower* (4th Edition). CRC Press.
- Roberto, K. (2003). *How to Hydroponics* (4th Ed.). The Future Garden press.

Keywords:

Hydroponics, Aquaponics, Organic Farming, Dissolved Oxygen-DO, Total Dissolved Solid – TDS**,** Good Agricultural Practices (GAP) and Integrated Pest Management (IPM), Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Course Code: ALS BOT GE 06
Course Title: Informatics and Statistics for Biology and Allied Sciences
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

- To build an understanding *in silico*/computational approaches in various aspects of understanding biology and biological research.
- To build analytical skills and integrate the principles of statistical analyses for robust interpretation of biological observations.

Learning Outcomes:

The student will understand

- the basics of bioinformatics and develop awareness of the interdisciplinary nature of this field.
- learn about biological databases, sequence retrieval, alignment, and phylogenetic analysis using various tools.
- understand the basic concept of sampling methods, data classification, presentation and statistical analysis.

Theory:

Unit 1. Introduction to Bioinformatics: **Hours: 03**

Historical background, Aims and scope, bioinformatics in Genomics, Transcriptomics, Proteomics, Metabolomics, Systems biology and drug discovery, Applications and Limitations in bioinformatics.

Unit 2. Biological databases: **Hours: 04**

Introduction to biological databases - Primary, secondary and composite databases. Study of following databases: NCBI (GenBank, PubChem, PubMed and its tools (BLAST)), introduction to EMBL, DDBJ, UniProt, PDB and KEGG.

Unit 3. Basic concepts of Sequence alignment: **Hours: 04**

Similarity, identity and homology. Concepts of alignment (gaps and penalty); Alignment – pairwise and multiple sequence alignments.

Unit 4. Molecular Phylogeny: **Hours: 04**

Introduction to Molecular Phylogeny, methods of construction of phylogenetic trees: maximum parsimony (MP), maximum likelihood (ML) and distance (Neighbor-joining) methods.

Unit 5: Biostatistics: **Hours: 02**

Biostatistics – definition, Basics of descriptive and inferential statistics; Limitations and applications of biostatistics.

Unit 6: Data types and presentation: **Hours: 03**

Primary and secondary data; Sampling methods (in brief); tabulation and presentation of data

Unit 7: Descriptive Statistics: **Hours: 04**

Measures of central tendency - mean, median, and mode; Measures of dispersion - range, standard deviation, and standard error.

Unit 8: Correlation and Regression: **Hours: 03**

Types and methods of correlation, Introduction to simple regression equation; similarities and dissimilarities between correlation and regression.

Unit 9: Statistical inference: **Hours: 03**

Hypothesis – (simple hypothesis), student's t test, chi-square test.

(Note: Numerical based questions of unit 7, 8 and 9 should be covered only in practical).

Practical: 60 Hours

- Biological databases (NCBI, EMBL, UniProt, PDB)
- Literature retrieval from PubMed

- Sequence retrieval (protein and gene) from NCBI (formats - FASTA, GenBank and GenPept formats)
- Protein Structure retrieval from PDB (in pdb format) and visualization by viewing tools (Ras Mol/ J mol/Mol*/Swiss 3D Viewer/Pymol)
- Multiple sequence alignment (MEGA/Clustal omega)
- Construction of phylogenetic tree (PHYLIP/ MEGA/ Clustal omega).
- Making of Bar diagrams, Pie chart, Histogram, Frequency polygon, Cumulative frequency curve (any four) in the given data set using Microsoft Excel
- Calculation of mean, mode, median, standard deviation and standard error (through manual calculation and using Microsoft Excel) (use only ungrouped data)
- Calculation of correlation coefficient values by Karl Pearson's /Spearman Rank methods (through manual calculation and using Microsoft Excel)
- Student's t-test (using Microsoft Excel only), chi square test (Manual and using Microsoft Excel).

Suggested readings:

- Ghosh, Z., & Mallick, B. (2008). *Bioinformatics – Principles and Applications* (1st ed.). Oxford University Press.
- Baxevanis, A.D., Ouellette, B.F., John (2005). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd ed.). Wiley & Sons, Inc.
- Roy, D. (2009). *B* (1st ed.). Narosa Publishing House.
- Andreas, D., Baxevanis, B.F., Francis, & Ouellette. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins* (3rd ed.). John Wiley and Sons.
- Khan, I.A., & Khanum, A. (2004). Fundamentals of Biostatistics (5th ed.). Ukaaz publications.
- Campbell, R.C. (1998). *Statistics for Biologists*. Cambridge University Press

Additional Readings:

- Pevsner, J. (2009). *Bioinformatics and Functional Genomics* (2nd ed.). Wiley Blackwell.
- Xiong, J. (2006). *Essential Bioinformatics* (1st ed.). Cambridge University Press.
- Mount, D.W. (2004). *Bioinformatics: Sequence and Genome analysis* (2nd ed.). Cold Spring Harbor Laboratory Press, USA.
- Zar, J.H. (2012). *Biostatistical Analysis* (4th ed.). Pearson Publication.

• Pandey, M. (2015). *Biostatistics Basic and Advanced*. M V Learning.

Keywords:

GenBank, PubChem, PubMed, BLAST, EMBL, Multiple Sequence Alignment, Measures of Central Tendency, Measures of Dispersion, Student's t-test.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Course Code: ALS BOT GE 07
Course Title: Genetically Modified Plants
Generic Elective – (GE)
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

- To illustrate the use of modern techniques for genome analysis and manipulation
- To understand the strategies involved and the need for developing transgenic crops
- To gain knowledge about biosafety and ethical concerns associated with Genetically Modified DNA.
- To train students in strategizing research topics employing genetic engineering techniques.

Learning Outcomes:

Students would learn about modern techniques involved in the manipulation of nucleic acids and creation of genetically modified organisms (GMOs).

- Applications of PCR, hybridization techniques and sequencing.
- Commercial application of Genetically Modified Plants in research, agriculture and human health.
- biosafety and ethical issues associated with Genetic engineering.
- designing and conducting experiments involving genetic manipulation of plants.

Theory:

Unit 1. Introduction to Transgenics: **Hours: 02**

First and Second-generation transgenic crops. Terminology: Transgenics, Transgene, Genetic transformation, recombinant DNA, Putative Transgenic, Stable gene integration. Gene Construct. Introduction to selectable marker (*npt II, hpt, spt*) and reporter (*GUS, GFP* and Luciferase) genes.

Unit 2. Gene Isolation and Genetic Transformation: **Hours: 10**

Methods for gene isolation - Direct selection, construction and screening of genomic and cDNA libraries (Replica plating, Complementation screening, heterologous gene probe-based hybridizations); Gene transfer methods - Direct (*Agrobacterium* mediated transformation, molecular basis of T-DNA transfer); Indirect methods (Electroporation, Microinjection and Particle Bombardment). Screening for putative transgenics through PCR and Southern blotting. Gene expression analyses at transcriptional level (Northern blotting, DNA microarrays) and translational level (Western blotting, ELISA). Generation of marker-free transgenics. Chloroplast transformation.

Unit 3. Transgenics for Resistance to Biotic and Abiotic Stress: **Hours: 09**

Biotic stress - Strategies for developing Insect resistant plants (Bt toxin, protease inhibitor, *α-amylase* inhibitor and other protein genes), Virus resistant plants (Coat protein mediated protection, Pokeweed antiviral protein, *RNaseIII*, micro-RNA and other viral genes), Fungal and Bacterial disease resistant plants (Genes for PR proteins like *Chitanase*, β-1,3 *Glucanase*, Thaumatin like, Osmotin; Antimicrobial proteins like Ribosome Inactivating Proteins, Lectins, Lysozyme; Phytoalexins etc.); Abiotic Stress - Strategies for overcoming Oxidative, Salt & Drought, Chilling stress through transgenics approach. Herbicide Resistance - Strategies, Roundup Ready Soybean.

Unit 4. Transgenics for Improved Quality and Other Traits: **Hours: 03**

Engineering for shelf-life (Antisense *Polygalacturanase* gene, *SAM hydrolase*) and nutritional quality (β-carotene production). Transgenics as bioreactor - plantibodies and edible vaccines. Biodegradable Plastics.

Unit 5. Safety and Ethical Issues: **Hours: 06**

Field testing and commercialization, Rules and Regulations for handling rDNA/ GMOs, Terminator technology, Ethics: Impact and safety, moral, social, regulatory & ethical issues.

Practical: 60 Hours

1. Isolation of plasmid DNA from bacteria
2. Isolation of genomic DNA from plant (Cauliflower head/ *Brassica* seedlings)
3. Preparation of competent cells in *E. coli*.

4. Transformation of *E. coli* cell by $CaCl_2$ method and calculation of transformation efficiency.
5. Restricting Mapping of linear and circular DNA.
7. Study of direct and indirect gene transfer methods by photographs: Electroporation, Microinjection and Particle Bombardment, Ti-plasmid mediated gene transfer
8. Study of techniques using digital resources/ demonstration: PCR, Southern, Northern and Western blotting, ELISA, DNA Microarray.
9. Study of Sequencing techniques (Whole Genome Shot Gun Approach, Clone by Clone Sequencing, Sanger's Dideoxy Sequencing) through digital resources.
10. Study of Genetically Modified Plants using digital resources: Bt-Cotton, Golden rice, Flavr Savr tomato, Round-up Ready Soybean
11. Visit to a research laboratory/field.

Suggested Readings:

1. Brown, T. A. (2016) *Gene Cloning and Analysis: An Introduction.* Wiley-Blackwell Publishing.
2. Chrispeels M.J., & Sadava D. E. (1994). *Plants, Genes and Agriculture.* Jones and Bartlett Publishers.
3. Glick B.R., & Patten C.L. (2022). *Molecular Biotechnology: Principles & Applications of Recombinant DNA* (6th Ed.). ASM Press.
4. Green, M.R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual* (4^{th} Ed.). Cold Spring Harbor.
5. Wink, M. (2011). *An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology* (2nd Ed.). Wiley.
6. Primrose, S. B., & Twyman, R. (2009). *Principles of gene manipulation and genomics.* Wiley.
7. Howe, C. J. (2007). *Gene cloning and manipulation.* Cambridge University Press.

Additional Readings:

1. Primrose, S. B., & Twyman, R. (2006) *Principles of Gene Manipulation and Genomics* (7th ed.). Wiley-Blackwell.

2. Dale J. W., Schantz M. V. and Plant N. (2011) *From Genes to Genomes: Concepts and Applications of DNA Technology.* John Wiley & Sons.

Keywords:

Transgenic plants, gene transfer, Gene library, Blotting techniques, biotic and abiotic stress resistant, plantibodies, edible vaccine, Biosafety concerns, Ethical issues.

Teaching Learning Process:

Learning material will be delivered through a series of lectures with conventional chalk and talk method, supported by power point presentations, charts, flow charts and video education resources. Emphasis would be on an interactive classroom environment so as to encourage students to ask questions and clarify their doubts. Students would also be encouraged to refer to the referenced books in the library to inculcate reading habits for better understanding of the subject.

Course Code: ALS CHEM GE 01
Course Title: Bioinorganic Chemistry
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

The purpose of the course is to introduce students to bioinorganic chemistry, currently a frontier area of chemistry providing an interface between organic chemistry, inorganic chemistry, and biology. The student would learn about the importance of inorganic chemical species, especially metals in biological systems, through discussions on topics such as the sodium-potassium pump, the applications of iron in physiology, including iron transport and storage system, role of magnesium in energy production and chlorophyll, toxicity of heavy metal ions and their antidotes.

Learning Outcomes:

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

- Classify metal ions in biological systems as essential, non-essential, trace and toxic.
- Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it.
- Understand the role of metal ions such as Mg, Ca and Fe in biological systems.
- Understand the toxicity of heavy metal ions (Hg, Pb, Cd and As) in the physiological system.

Theory:

Unit 1. Introduction: **Hours: 07**

A brief introduction to bio-inorganic chemistry. Metal ions present in biological systems and their classification on the basis of action (essential, non-essential, trace & toxic). Classification of metallobiomolecules (enzymes, transport and storage proteins and non-proteins). Brief idea about membrane transport, channels and pumps.

Unit 2. Role of Metals in Biological Systems: **Hours: 08**

Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} and Ca^{2+} ions: Na/K pump; Ca pump, role of Mg^{2+} ions in energy production and chlorophyll. Role of calcium in bone formation.

Unit 3. Role of Iron in Biological Systems: **Hours: 08**

Role of iron in oxygen transport and storage (haemoglobin and myoglobin), Perutz mechanism, Cooperative effect, Bohr effect, comparison of oxygen saturation curves of haemoglobin and myoglobin, carbon monoxide. Storage and transport of iron in humans (ferritin and transferrin).

Unit 4. Bio-Inorganic Chemistry: **Hours: 07**

Toxicity of heavy metal ions (Hg, Pb, Cd and As), reasons for toxicity and their antidotes.

Practical: 60 Hours

- Preparation of Nickel-DMG complex and its estimation.
- Estimation of Zn^{2+} using EBT / Xylenol orange as indicator
- Estimation of Mg^{2+} by direct complexometric titrations using EDTA.
- Estimation of Ca^{2+} by substitution method.
- To estimate the concentration of Ca in commercially available medicines.
- To estimate the Mg present in multivitamins (take at least two types of Vitamin tablets from the market).
- Isolation of Chlorophyll from plant leaves and its purification.
- Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
- Separation of Fe (III) and Al (III) using chromatographic techniques.
- Estimation of copper as CuSCN.

Suggested Readings:

Theory:

1. Huheey, J. E., Keiter, E.A., Keiter, R. L., & Medhi, O.K. (2009). *Inorganic Chemistry- Principles of Structure and Reactivity*. Pearson Education.

2. Shriver, D. D., Atkins, P., & Langford, C.H. (1994). *Inorganic Chemistry* (2nd Ed.). Oxford University Press.
3. Cotton, F. A., Wilkinson, G., & Gaus, P. L. (2021) *Basic Inorganic Chemistry* (3rd Ed.). Wiley India.
4. Crichton, R. R. (2008). *Biological Inorganic Chemistry: An Introduction*. Amsterdam, Elsevier.
5. Kaim, W., Schwederski B., Klein, A. (2014). *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide* (2nd Ed.). Wiley.
6. Inorganic Chemistry; Sahoo, et al; PHI Learning Private Limited; ISBN 978-81-203-43085.
7. Balaram Sahoo, Nimai Charan Nayak, Asutosh Samantaray, & Prafulla Kumar Pujapanda. (2012). *Inorganic chemistry*. Prentice-Hall of India Pvt Ltd.

Practical:

• Jeffery, G.H., Bassett, J., Mendham, J., & Denney, R.C. (1989). Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Keywords:

Bioinorganic chemistry, Sodium potassium pump, chlorophyll, ATP, Hemoglobin, myoglobin, ferritin, transferrin, toxicity, heavy metal ions, antidote.

Teaching Learning Process:

- Conventional chalk and board teaching.
- Class interactions and discussions.
- Power point presentation on important topics.

Course Code: ALS CHEM GE 02
Course Title: Chemistry of Carbohydrates, Nucleic Acids and Lipids
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

This course aims to introduce the learner to the fascinating chemistry of some molecules, *i.e.,* carbohydrates, nucleic acids and lipids that work within biological systems. The basic concept of heredity, which is imparted through replication, transcription and translation processes will be discussed.

Learning outcomes:

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

- Understand and demonstrate how structure of biomolecules (carbohydrates, nucleic acids and lipids) determine their reactivity and biological functions.
- Understand the concept of heredity through replication, transcription, and translation processes.

Theory:

Unit 1. Chemistry of Carbohydrates: **Hours: 10**

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of the configuration of glucose (Fischer proof), the cyclic structure of glucose. Haworth projections. The cyclic structure of fructose. The linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Unit 2. Nucleosides, Nucleotides and Nucleic Acids: **Hours: 10**

Components of Nucleic acids: Adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA (types of RNA), difference between DNA and RNA, genetic code, biological roles of DNA and RNA: replication, transcription and translation.

Unit 3. Lipids: **Hours: 10**

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity. Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins. Properties, functions and biochemical functions of steroid hormones.

Practical:

1. Preparation of osazone of glucose, fructose and Maltose (Comparing the time of formation of the two and the shape of crystals using microscope).
2. Identification of given carbohydrates as
    a) Reducing and Non-reducing
    b) Monosaccharide and Disaccharide
    c) Aldose and Ketose
3. Estimation of glucose by Fehling's solution.
4. Determination of acid value of fats and oils.
5. Determination of the iodine number of oils.
6. Determination of the saponification number of oils.
7. Identification and separation of mixture of sugars by paper chromatography.
8. Isolation of DNA from cauliflower/ onion.
9. Estimation of DNA by diphenylamine reaction.
10. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).

Suggested Readings:

Theory

- Vogel, A., Jeffery, G., Bassett, J., & Mendham, J. (1989). *Vogel's textbook of quantitative chemical analysis*. John Wiley and Sons.
- Finar, I. L. (2002). *Organic Chemistry* (Volume 1 & 2). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Morrison, R. N., & Boyd, R. N. (2016). *Organic Chemistry.* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Mehta, B., & Mehta, M. (2015). *Organic Chemistry* (2nd ed.). PHI Learning Pvt. Ltd.
- Satyanarayana, U., & Chakrapani, U. (2017). *Fundamentals of Biochemistry.* Books and Allied (P) Ltd.

- Lehninger, A. L., & Nelson, D. L. (2009). *Principles of biochemistry*. W. H. Freeman.
- T. W. Graham Solomons, Craig B. Fryhle, & Scott A. Snyder. (2013). *Solomons's Organic Chemistry 7th edition*. Pearson Education India.
- Jr. Leroy G. Wade, Jan William Simek, & Maya Shankar Singh. (2019). *Organic Chemistry.* Pearson Education India.
- Ghatak, K. L. (2014). *A textbook of organic chemistry and problem analysis*. PHI Learning.

Practical:

1. Mann, F. G., & Saunders, B. C. (2009). Practical organic chemistry. Pearson Education.
2. Dean, J. R., Jones A.M, Holmes, D., & Reed, R. (2011). Practical Skills in chemistry. Prentice-Hall.
3. Wilson, K., & Walker, J. M. (2000). Principles and techniques of practical biochemistry. Cambridge University Press.
4. Gowenlock. A.H. (1988). Varley's Practical Clinical Biochemistry. CRC Press.
5. Pasricha, S., & Chaudhary, A. (2021). Practical Organic Chemistry: Volume II. IK International Publishing House Pvt. Ltd.

Keywords:

Carbohydrates, Amino acids, Peptides, Proteins

Teaching Learning Process:

- Learning Process for the course is visualized as largely student-focused
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Course Code: ALS CHEM GE 03
Course Title: Chemistry of Amino acids, Proteins and Enzymes
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

The objectives of this course is to deliver information about biochemically significant features of the chemistry of peptides, proteins, enzymes, using suitable examples. This includes classification, reaction chemistry and biological importance of these biomolecules. This course extends the knowledge gained from synthetic organic chemistry to chemistry of biomolecules. Key emphasis is placed on understanding the structural principles that govern reactivity/physical /biological properties of biomolecules as opposed to learning structural detail. It also aims to build the concept of metabolism by the study of chemistry and energetics of biological system.

Learning Outcomes:

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

- Learn and demonstrate how the structure of biomolecules (proteins, enzymes) determines their chemical properties, reactivity and biological uses.
- Gain an insight into mechanism of enzyme action and inhibition.
- Understand the basic principles of drug-receptor interaction and SAR.
- Understand the concept of metabolism and metabolic processes through specific examples.

Theory:

Unit 1. Amino acids, Peptides & Proteins: **Lecture: 12**

Amino Acids and Peptides -Zwitterion, isoelectric point and electrophoresis. Preparation of amino acids: Strecker synthesis and using Gabriel's phthalimide synthesis. Reactions of amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Determination of the primary structure of peptides by degradation Edman degradation (N-terminal) and C– terminal (thiohydantoin and with carboxypeptidase enzyme).

Synthesis of simple peptides (up to dipeptides) by N-protection (*t*-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. An Overview of primary, secondary, tertiary and quaternary structure of proteins.

Unit 2. Enzymes : Hours: 08

Classification of enzymes and their uses (mention ribozymes). Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereo-specificity), enzyme inhibitors and their importance, and the phenomenon of inhibition (competitive and non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure – activity relationships of drug molecules, binding role of –OH group, $-NH_2$ group, double bond and aromatic ring.

Unit 3. Concept of Energy in Biosystems: Hours: 10

Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD+, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle. The caloric value of food, the standard caloric content of food types.

Practical: 60 Hours

1. Qualitative tests for amino acids and proteins.
2. Separation and identification of mixture of amino acids by paper chromatography.
3. Study the action of salivary amylase on starch under optimum conditions and determine the enzyme activity.
4. Study the effect of temperature and pH on the activity of salivary amylase.
5. Isolation of casein from milk.
6. Estimation of protein by Lowry's method.
7. To study the effect of concentration, temperature and pH on the activity of catalase.
8. Estimation of glycine by Sorensen's method.
9. To study the titration curve of glycine and determine the isoelectric point of glycine.

Suggested Readings:

Theory:

1. Lubert Stryer, Jeremy Berg, John Tymoczko, & Gregory Gatto. (2019). *Biochemistry* (9^{th} ed.). W.H. Freeman.
2. Lehninger, A. L., & Nelson, D. L. (2009). *Principles of biochemistry*. W. H. Freeman.
3. Finar, I. L. (2007). *Organic chemistry* (Vol 1 & 2). Pearson education.
4. Mehta, B., & Mehta, M. (2015). *Organic Chemistry* (2nd ed.). PHI Learning Pvt. Ltd.
5. T. W. Graham Solomons, Craig B. Fryhle, & Scott A. Snyder. (2013). *Solomons's Organic Chemistry* (7th ed.). Pearson Education India.
6. Ghatak, K. L. (2014). *A textbook of organic chemistry and problem analysis*. PHI Learning.

Practical:

1. Dean, J. R., Jones A.M, Holmes, D., & Reed, R. (2011). *Practical Skills in chemistry*. Prentice-Hall.
2. Wilson, K., & Walker, J. M. (2000). *Principles and techniques of practical biochemistry*. Cambridge University Press.
3. Varley, Harold., Gowenlock, A. H., McMurray, J. R., McLauchlan, D. M., & Varley, Harold. (1988). *Varley's practical clinical biochemistry*. CRC Press.
4. Mann, F. G., & Saunders, B. C. (2009). *Practical organic chemistry*. Pearson Education.
5. Pasricha, S., & Chaudhary, A. (2021). *Practical Organic Chemistry* (Volume II). IK International Publishing House Pvt. Ltd.

Keywords:

Biomolecules, Enzymes, Mechanism of enzyme action and inhibition, SAR, Drug Receptor Theory.

Teaching Learning Process:

- The teaching learning process will involve the traditional chalk and black board method. Along with pedagogy of flipped classroom.
- Certain topics like mechanism of enzyme action and enzyme inhibition, transcription and translation etc. where traditional chalk and talk method may not be able to convey the concept, are taught through audio-visual aids.
- Students are encouraged to participate actively in the classroom through regular presentations on curriculum-based topics, peer assessment, designing games based on specific topics etc.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Course Code: ALS CHEM GE 04
Course Title: Conductance and Chemical Kinetics
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

- The students will learn about electrochemical cells – electrolytic and galvanic cells, measurement of conductance and its applications, measurement of emf and its applications.

Learning Outcomes:

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

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand different types of galvanic cells, their Nernst equations, measurement of emf, of thermodynamic properties and other parameters from the emf measurements.
- Understand the concept of rate laws e.g., order, molecularity, half-life, and their determination.

Theory:

Unit 1. Conductance: **Hours: 08**

Conductivity, equivalent and molar conductivity, and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions, Transference number, Ionic mobility, applications of conductance measurements: determination of degree of ionization of weak electrolytes, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit 2. Electrochemistry: **Hours: 10**

Reversible and irreversible cells, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes, Standard electrode potential, Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data, Liquid junction potential and salt bridge, pH determination using hydrogen electrode and quinhydrone electrode.

Unit 3. Chemical Kinetics: **Hours: 12**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, derivation of integrated rate equations for zero, first and second order reactions (for equal concentrations of reactants), half–life of a reaction, general methods for determination of order of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Practical: 60 Hours

Conductance

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform Conductometric titrations:
   - (a) Strong acid vs strong base
   - (b) Weak acid vs strong base.

Potentiometry

1. Perform the potentiometric titrations of
   - (a) Strong acid vs strong base and
   - (b) Weak acid vs strong base

Chemical Kinetics

1. Study the kinetics of the following reactions by integrated rate method:
   - (a) Acid hydrolysis of methyl acetate with hydrochloric acid.
   - (b) Compare the strength of HCl and H_2SO_4 by studying the kinetics of hydrolysis of methyl acetate.

Suggested Readings:

Theory:

1. Castellan, G. W. (2004). *Physical Chemistry* (Vol.). Narosa.
2. Kapoor, K. L. (2015). *A Textbook of Physical Chemistry* (6th ED., Vol. 1). McGraw Hill Education.
3. Kapoor, K. L. (2013). *A Textbook of Physical Chemistry* (3rd ed., Vol. 3). McGraw Hill Education.

4. Puri, B. R., Sharma, L. R., & M. S. Pathania. (2017). *Principles of Physical Chemistry*. Vishal Publishing Co.

Practical:

1. Khosla, B. D., Garg, V. C., & Gulati A. (2015). *Senior Practical Physical Chemistry*. R. Chand & Co.

Keywords:

EMF, Transference number, Kohlrausch Law and Arrhenius equation etc.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Course Code: ALS ZOO GE 01
Course Title: Agricultural Pests of Crops
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

The study of agricultural pests focusses on identification of different types of pests, their life cycle and the harm they cause to the crops and stored grains. 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 be taught the appropriate control measures to manage the pest population in nature so as to avoid heavy economic losses.

Learning Outcomes:

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

- Learn about the variety of important pests of crops, fruits, vegetables and stored grain.
- Understand the difference between various types of pests and extent of damage caused by them.
- Learn varied types of control measures for management of pest populations and list suitable control measures specific for each pest.

Theory:

Unit 1: Hours: 05

Introduction and Classification of pests, Factors responsible for emergence of pest, Pest status, Pest population dynamics.

Unit 2: Hours: 12

Bionomics and control of crop pests: 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, Leucinodes orbonalis),* Fruit pest *(Papilio demoleus)***.**

Unit 3: Hours: 08

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

Unit 4: Hours: 05

Bionomics and management of Grass hopper (*Schistocerca Americana*), White grubs, Bihar hairy caterpillar and Termites.

Practical: 60 Hours

1. Identification of crop pests-

(a) Rice pest: *Leptocorisa acuta,*

(b) Wheat pest: *Sesamia inferens,*

(c) Pulse pest: *Helicoverpa armigera,*

(d) Sugarcane pests: *Scirpophaga nivella, Pyrilla perpusilla,*

(e) Cotton pests: *Earias vitella, Pectinophora gossypiella, Dysdercus koenigii,* (f) Vegetable pest: *Raphidopalpa faveicollis, Leucinodes orbonalis,*

(g) Fruit pest: *Papilio demoleus.*

2. Identification of stored grain insect pests: *Sitophilus oryzae, Corcyra cephalonica, Trogoderma granarium, Callosobruchus chinensis.*
3. Culture of two crop insects of economic importance and submission of culture report.
4. Study of the life history of two different insect pests (Submission of life cycle stages from culture).
5. Visit to IARI (Pusa), and other ICAR Institutes.

Suggested Readings:

1. Pedigo, L.P. (1996) *Entomology and Pest Management*. Prentice Hall.
2. S. Pradhan. *Insect Pest of Crops* (2011). National Book Trust.
3. Atwal, A.S. (1993) *Agricultural Pests of India and South East Asia*. Kalyani Publishers.
4. Dennis, S. Hill (2005) *Agricultural Insect Pests of the Tropics and Their Management*. Cambridge University press.
5. Tembhare, D. B. (2017). Modern Entomology. Himalaya Publishing House Pvt. Ltd. Mumbai.

E- contents:

- https://swayam.gov/appliedentomology.
- https://www.entsoc.org/resources/education/online-courses.

Keywords:

Pest, Bionomics, Polyphagous, Pest control.

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.

Course Code: ALS ZOO GE 02
Course Title: Insect Vectors and Diseases
Total Credits: 04 (Theory-02, Practical-02)
Total Hours: Theory 30, Practical 60

Objectives:

Insect vectors spread a variety of diseases, resulting in millions of fatalities each year around the world, particularly in developing countries. The transmission by Insect-borne pathogen is increasing at an alarming rate, posing an increasing menace to human health. The transmission of disease by the insects can only be controlled and prevented by studying their biology, modalities of pathogen transmission by them, evaluating associated risk factors and by devising efficient techniques to control these insects.

Learning Outcomes:

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

- Identify different insects and classify them based on their morphology and behaviour
- Describe the host-pathogen relationships and the role of the host reservoir on transmission of parasite
- Explain various modes of transmission of parasite by insect vectors
- Recognize various possible modern tools and methodologies for laboratory diagnosis, surveillance and treatment of diseases
- Define various terms related to insect transmitted diseases such as Zoonotic, Vertical and Horizontal transmission, host specificity etc.
- Identify the risk groups and design methodology to protect them.
- Spread awareness on public health programs about insect borne diseases and their control
- Employ the use of advanced management strategies in disease control with respect to parasite evolution.

Theory:

Unit 1. Introduction to Insects: **Hours: 08**

General Features of Insects, Classification of insects up to Orders- General features of orders, Morphological features: Head, legs and types of antennae. Types of Insects mouth parts w.r.t.

feeding habits: siphoning type (butterfly), sponging type (housefly), biting and chewing type (cockroach), piercing and sucking type (mosquito), chewing and lapping type (honeybee).

Unit 2. Concept to Vectors: **Hours: 05**

Brief introduction to Carriers and Vectors (mechanical and biological vector); Insect reservoirs; Host-vector relationship; Vectorial capacity; Host Specificity; Modes of disease transmission - vertical and horizontal transmission; Insects as vectors: General adaptations in insects to act as vectors.

Unit 3. Dipterans as disease Vectors-I: **Hours: 05**

Dipterans as important insect vectors–Mosquitoes. Study of mosquito-borne diseases–Malaria, Dengue, Chikungunya, Filariasis, Viral encephalitis. Control and prevention/cure of diseases caused by mosquitoes.

Unit 4. Dipterans as disease vectors-II **Hours: 04**

Dipterans as important insect vectors –Sand flies (*Phlebotomus* or *Lutzomyia*), Houseflies (*Musca domestica*); Study of sand-fly borne diseases – Leishmaniasis, phlebotomus fever; Study of house fly as important mechanical vector; Myiasis; Control and prevention/cure of diseases caused by sandfly and house fly.

Unit 5. Siphonapterans as disease vectors. **Hours: 03**

Fleas as insect vectors; Study of flea-borne diseases – Plague, typhus fever; Control and prevention/cure of diseases caused by fleas.

Unit 6. Siphunculata as disease vectors: **Hours: 05**

Human louse (head, body and pubic louse) as disease vectors; study of louse-borne diseases: Typhus fever, relapsing fever, vagabond's disease, Phthiriasis; Control of human louse and prevention/cure of diseases caused by them.

Practical:60 Hours

1. Study of different kinds of mouthparts and legs of insects through slides/specimens.

2. Study of insect vectors through permanent slides or photographs: Mosquitoes (Aedes, Culex, Anopheles), lice [head, body (*Pediculus*), pubic (*Pthirus*)], Flea (*Xenopsylla cheopis*), sand fly (*Phlebotomus*), house fly (*Musca domestica*).
3. Study of different diseases transmitted by the above insect vectors using photographs.
4. Project report on any one disease transmitted by an insect vector.
5. Optional field trip/Lab. visit institutes such as NIMR, NCDC.

Suggested Readings:

- Mullen & Darden. *Medical and Veterinary Entomology* (3rd Ed.). Academic Press.
- Service, M.W. (1980). *A Guide to Medical Entomology*. Macmillan Press.
- Burgess, N. R. H. & Cowan, G. O. (1993). *A colour atlas of medical entomology*. Springer Science and Business Media, B. V.

E-content:

- **http://publichealth.lacounty.gov/acd/Vector.htm**
- **https://www.cdc.gov/ncezid/dvbd/index.html**

Keywords:

Vectors, Diseases, Prevention, Control, Carrier.

Teaching Learning Process:

Classroom teaching using power point presentations enabled with related photographs or specimens/slides of insect vectors, their life stages and disease diagnosis will be employed to clarify concepts. Case studies of epidemics caused by insects as vectors will be discussed to make the students aware about their importance. Visit to local diagnostic centre will provide an overview of various medical tests conducted to detect and confirm vector transmitted diseases.

Course Code: ALS ZOO GE 03
Course Title: Techniques for Insect Collection, Rearing and Preservation
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

The course aims to give knowledge to the student about the broad categories of insects. They will be taught about the various insect collection techniques as well as their preservation for future studies. They will also be trained about the maintenance of insectary and rearing of insects for their use in research as well as for commercial purposes.

Learning outcomes:

- Students will understand the use of different tools and techniques for the collection and preservation of insects belonging to various economically important insect orders.
- Students will be equipped with rearing techniques of insects.
- They will be able to set up an insectary.

Theory:

Unit 1: **Hours: 04**

Class Insecta

Characteristics of class Insecta and outline classification upto orders

Unit 2: **Hours: 06**

Insect collection Techniques :

Tools and techniques: Collecting bag and other containers, Insect nets, collecting jars, alcohol vials, Envelopes, Forceps, Sieve, Aspirator, various types of Traps, Berlese funnel, beating tray, Beat sheet

Unit 3: **Hours: 08**

Insect Preservation

Dry preservation: Different types of Killing bottles- Cyanide bottle, Chloroform bottle, Ethyl acetate, Preservation in triangles, Gutting, Drying, Relaxing, Pinning (direct and micro pinning), Staging, Carding, Spreading, Setting; Wet Preservation: Ethanol and Lactic acid

preservatives, Fixatives, Microscope slide mounting: stains, mountants; Mountings and preservation of individual orders; curation: labelling, insect box, Riker Mounts and cabinents, care of collection, Identification keys.

Unit 4: **Hours: 05**

Rearing of Lepidopteran and Dipteran pests

Methods for the rearing: *Spodoptera litura*/*Helicoverpa armigera* both in natural and semi-synthetic diet, House fly and Mosquitoes.

Unit 5: **Hours: 04**

Rearing of stored grain Insect pests

Rice meal moths (*Crcyra cephalonica)*, Red cotton bugs *(Dysdercus cingulatus)*, Pulse beetle (*Callosobruchus chinensis).*

Unit 6: **Hours: 03**

Maintenance of Insectary Containers for rearing, rearing condition and problems: Moisture, Temperature, Light, Food, Dormancy and Diapause. Glass house Insectary, Sterilization techniques/ fumigation.

Practical:60 Hours

1. Study of Insect collection equipment through specimens/ Photographs
2. Dry mounting, labelling and preservation of insects.
3. Study of insect box and it's preparation.
4. Temporary preparation of slide of microscopic insects.
5. Study of different types of traps through specimens/ photographs.
6. Culture of any one pest (agriculture/ stored grain) and submission of different life stages.
7. Visit to any Insectary and submission of project report.

Suggested Readings:

- Atwal, A. S., & Dhaliwal, G. S. (2015). *Agricultural pest South Asia and their management* (8th Ed.). Kalyani publishers.
- Padhan, S. (2016). *Agricultural Entomology and Pest Control*. ICAR publication.

- Gullan, P. J., & Cranston, Peter (2004). *The Insects: An Outline of Entomology* (3rd Ed.). Edition. Blackwell publication.
- Tembhare, D. B. (2017). *Modern Entomology*. Himalaya Publishing House Pvt. Ltd.

E-content:

https://www.ars.usda.gov/ARSUserFiles/80420580/CollectingandPreservingInsectsandMites/collpres.pdf.

https://mississippientomologicalmuseum.org.msstate.edu/collecting.preparation.methods/Collecting.methods.html.

Key words:

Insect, Rearing, Insectary, Preservation, Lepidoptera, Diptera.

Teaching and Learning Process:

Knowledge about the techniques for Insect collection, rearing and preservation will be imparted through classroom lectures/ practical class. Group discussion/field survey among students will make them aware of importance of collection, rearing methods of insect pest in controlled condition and their preservation. Seminars on the related topics will enhance the learning of students to a great extent. Visits to fields, museum and laboratories will provide a hands-on experience about the techniques of collection, rearing and preservation.

Course Code: ALS ZOO GE 04
Course Title: Animal Cell Culture techniques
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

The aim of the paper is to give knowledge to students about cell and tissue culture technology. Students will learn how to set up an animal cell culture laboratory. Students will be taught about the instruments and chemicals required to run and maintain a tissue culture lab. Learning of cell culture technology will train them to undertake research projects in relevant fields.

Learning Outcomes:

By the end of the course, the students will have following expertise

- To set up animal cell culture laboratory
- Instruments and chemicals required to run and maintain a tissue culture lab.
- Challenges of maintaining a cell culture laboratory and how to overcome these challenges.
- Learn about various types of media.
- Learn about the maintenance and manipulation of animal cells *in vitro*.

Theory:

Unit 1: Hours: 04

Introduction to Animal cell culture; Historical background, Biology of animal cell and cell-cell interactions, good laboratory practices, Sterilization methods and techniques.

Unit 2: Hours: 08

Equipment: Laminar-Flow Hood, Autoclave, Inverted Microscope, Centrifuge, Haemocytometer, Humidified CO_2 Incubator, Cryostorage Container.

Media and Buffers: Types of culture media, Physicochemical characteristics of medium - pH, O_2 CO_2 and Bicarbonate buffering, Osmolality, Temperature, Viscosity and Surface Tension. Importance of Serum and Serum-free media, Balanced salt solutions, Antibiotics and other supplements.

Unit 3: Hours: 10

Tissue Culture: Primary Cell Culture- Isolation of the tissue, Initiation of culture: Types of primary culture. Subculture **and** cell lines; culture of tumor cells, principles of cryopreservation of cell lines. *in vitro* transfection of animal cells-chemical method, lipid mediated gene transfer (lipofection), Electroporation. Microbial contaminants (Bacteria, Yeast, Fungi, Mycoplasma and Virus) in cell line.

Unit 4: Hours: 08

Applications of Animal Cell Culture**:** Toxicology studies, Vaccine production, Gene therapy, Stem cell therapy, Production of recombinant proteins, Cancer Research.

Practical: 60 Hours

- Packing and sterilization of glassware and plasticware for cell culture.
- Study of different sterilization techniques used in cell culture laboratory.
- Preparation and sterilization of culture medium, buffers and solutions.
- Sub-culturing of cell lines.
- Counting of cells in given cell line sample using hemocytometer.
- To study about cytotoxicity and cell viability.
- Demonstration of Transfection in cell lines using Photographs/Videos.
- Demonstration of working of the following instruments:
  i) Laminar Flow Hood ii) Autoclave iii) Humidified CO_2 Incubator iv) pH Meter.
- Project report on visit to animal cell culture labs

Suggested Readings:

- Freshney, R. IAN. (2021). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (8th Ed.).
- Masters, John. R. W. (2000). *Animal Cell Culture: A Practical Approach* (3rd Ed.).
- Butler, M. (2003). *Animal Cell Culture and Technology.* (2nd Ed.).
- Davis, John. M. (2011). *Animal Cell Culture: Essential Methods*.
- Bhatt, Sheelendra. M. (2011). *Animal Cell Culture: Concept and Application.*

Keywords:

Cell Culture, Tissue Culture, Transfection, culture medium.

Teaching Learning Process:

Blend of conventional blackboard teaching, modern teaching learning tools and computer-based instructions and practical training. Problem solving and quizzes for enhanced understanding of the concepts. Visit to various animal cell culture labs will create interest, enhance their understanding of their basic concept.

Course Code: ALS ZOO GE 05
Course Title: Locust and its management
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

The course aims to apprise the students of locust as one of the most dangerous pests of agricultural crops. It focusses on identification of locust, reasons of their swarming and migratory nature which gives immense economic loss leading to national emergency of food and fodder. The students will be taught about their control, monitoring and management strategies.

Learning Outcomes:

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

- Understand about the locust as serious pests that cause damage to the agroecosystems affecting the economy.
- Understand the habit, habitat, behaviour, morphology and different phases.
- Know the different species and their comparison with grasshoppers.
- Study their biology, monitoring techniques, and various methods of control measures.
- Know the role of national and international organizations to manage locust.

Theory:

Unit 1: Hours: 6

Introduction, historical background, locust plague and upsurges, Systematic position of locusts and grasshoppers; habitat, behaviour and morphology of locusts. Difference between locusts and grasshoppers.

Unit 2: Hours: 9

Locusts in India, distribution, life cycle: *Schistocerca gregaria, Patanga succincta, Locusta migratoria;* damage caused by them.

Unit 3: Hours: 7

Breeding seasons and breeding areas, swarming. biological phases: solitary, transients and gregarious and changes in their behavior, color and structure. Biotic theory of periodicity.

Unit 4: Hours: 6

Locust management: National and international organizations - LWO, SALO, CALO, FAO, NLCC, IRLCO-CSA (International Red Locust Control Organization for Central and Southern Africa), swarm monitoring. Control methods- Mechanical and traditional, regulatory practices, Chemical methods: ULV Sprays, dusting, baits, IGRs; advantages and disadvantages of different chemical control methods, biological practices: biopesticides, predators, parasitoids; Integrated Pest Management; Plant quarantine.

Unit 5: Hours: 2

Socio-Economic importance: Impact on the health of fauna and humans; on agriculture.

Practical: 60 Hours

1. Comparative study of different species of locusts through specimens /photographs.
2. Study of mouthparts, wings and legs of locust through specimens /photographs.
3. Study of sexual dimorphism in locust through specimens /photographs.
4. Study the life stages of the locust through specimens/slides/photographs.
5. Study of different tools used in the management of locust.
6. Study of different host plants of locust.
7. Visit to different institutes/stations/laboratories (submit a Report on visit/current status of locusts in India).

Suggested Readings:

- Ritchie, J. M., & Dobson, H. (1995). *Desert Locust, control operations and their environmental impact*. NRI bulletin 67, Hopps the printers Ltd.
- Atwal, A. S.; & Dhaliwal, G. S. (2015). *Agricultural pest South Asia and their management* (8th Ed.). Kalyani publishers.
- Pradhan, S. (2016). *Agricultural Entomology and Pest Control*. ICAR publication.
- Pandey, & Kumari R. (2021) *Locust in Indian Agriculture*. Notion press India.
- Rachadi, Tahar (2010). *Locust control handbook*. CTA publication, AJ Wagningen-The Netherlands.
- Krall, S; Peveling, R & Diallo, D. Ba. (1997). *New strategies in Locust Control*. Pirahauser Basel springer.

E- contents:

- https://link.springer.com/book/10.1007/978-3-0348-9202-5? No Access=true.
- https://www.researchgate.net/publication/349553095_Locust_Introduction_biology_and HYPERLINK "https://www.researchgate.net/publication/349553095_Locust_Introduction_biology_and_%09%09%09Management_in_Pakistan"_ Management_in_Pakistan.
- http://ppqs.gov.in/divisions/locust-control-research/organizations-locust-control-campaign.

Keywords:

Locust, grasshopper, swarm, locust outbreak, *Schistocerca*.

Teaching Learning Process through:

Specimen pictures/slides, related photographs, powerpoint presentations, maximizing interaction with students**,** Analysis of Scientific articles**,** Observation based on actual handling of insects and their body parts.

Course Code: ALS ZOO GE 06
Course Title: Beneficial Insects and their products
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

The course will make the students aware about the significance of beneficial insects. It will help the students to understand the various products of insect origin and their uses. This course will also focus on how to maximize commercial production for economic benefits. It will also help the learner in developing entrepreneurial skills required for self-employment.

Learning Outcomes:

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

- Attain knowledge of beneficial insects and their products.
- Develop an understanding of the biology of beneficial insects, their interactions with each other and with the environment.
- Enhance knowledge of sericulture, apiculture etc.

Theory:

Unit 1: **Hours: 5**

An introduction to the beneficial insects and their applications in agriculture - (Pollination and dispersal; decomposition - dung, carrion and plant materials), in medicine, in veterinary and in forensic entomology. Bioagents: Insects as natural enemies of pests and as scavengers.

Unit 2: **Hours: 7**

Honey and Wax: Introduction and history of bee-keeping; Honey bees: species type, morphology, biology, conservation, seasonal management, hives, diseases; Honey and wax production and their uses, Ripening of honey, Propolis.

Unit 3: Hours: 7

Silk: History and development of silkworms in India, different species, voltinism and biology of silkworm, main and alternate host plants, method of harvesting and preservation of mulberry leaves, types of silk, silk production.

Unit 4: Hours: 6

Lac: Species of lac insects, morphology, biology, host plants, Lac production and its uses, Types of lac; seed lac, button lac, shellac, and lac-products.

Unit 5: Hours: 5

Dyes: Insect derived - Cochineal dye: *Dactylopius coccus*; Polish cochineal dye: *Porphyrophora polonica*; Carmine dye: *Kermes varmilo* and other insects.

Insect induced plant products: Tannic acid.

Other products: Honeydew.

Practical:60 Hours

1. Study of different species of honeybees (mouthparts, legs of worker, stinging apparatus) through specimens/photographs/slides.
2. Study of adult lac insect through photographs and slides.
3. Study of different species of silk moth (mouthparts and legs)
4. Study of biocontrol agents/natural enemies of insect pests through photographs/slides. .
6. To study the adulterations/purity of honey/shellac/silk.
7. Visit to research and training Institutions/Unit of Beekeeping, Sericulture, Lac culture.

Suggested Readings:

- David, V. Alford. (2019). *Beneficial insects*. CRC Press, taylor and francis, vocaraton, Florida.
- Sathe, T. V., and Jadhav, A. (2002). *Sericulture and Pest Management.* Daya Publishing House.
- Yonemura, M., and Rama Rao, N. (1951). *A Handbook of Sericulture. I. Rearing of silk-worms*. Government Branch Press, Mysore.

E-contents:

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

Keywords:

Pollination, Carrion, Propolis, Bee Conservation, Honeydew, Lac, Silk, Honey, Wax.

Teaching Learning Process through:

Specimen pictures/slides, related photographs, powerpoint presentations, maximizing interaction with students, Analysis of Scientific articles, Observation based on actual handling of insects and their body parts.

Course Code: ALS ZOO GE 07
Course Title: Insect Ecology
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Theory 30, Practical 60

Objectives:

The course aims to give knowledge to the students about the basic ecology and role of different biotic and abiotic factors. It introduces the learner to concepts of ecosystem, energy flow, attributes of insect population and different factors affecting the distribution, abundance and prey- predator relationship of insects. Students will be taught about the insect population interactions and their role in different ecosystems.

Learning Outcomes:

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

- Understand the key concepts in ecology and role of insects in ecosystem.
- Learn about abiotic and biotic factors
- Comprehend the population characteristics, dynamics, growth models and interactions.
- Understand the community characteristics, ecosystem development and climax theories.
- Know about the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies.

Theory:

Unit 1: Hours: 3

Fundamentals of Insect ecology, abiotic factors and biotic factors, Laws of limiting factors.

Unit 2: Hours: 5

Ecosystem: Concept types, role of insects in ecosystems. Food chain, Food web and energy flow through the ecosystem, Productivity, Ecological pyramids and ecological efficiencies, interactions of insects and their environment.

Unit 3: Hours: 12

Population: Attributes of Insect population: Density, Natality, Mmortality, Life tables, Survivorship curves, Dispersal and Dispersion, Exponential *vs* Logistic Growths, Carrying capacity. Population regulation, Basic concepts of Insect abundance: factors responsible for changes in the distribution and abundance of insects. Density dependent and independent factors.

Unit 4: Hours: 5

Insect Population interactions: Basic factors governing the interspecific interactions, Classification of interspecific interactions, Understanding of Gause's principle with insects as examples, Prey-predator interactions, Lotka-Volterra Model. Functional and numerical response.

Unit 5: Hours: 5

Community ecology: Characteristics, Abundance and diversity of insects, Species richness, Ecotone and edge effect. Food as a limiting factor for distribution. Insects as regulators of ecosystem processes. Ecological succession.

Practical:60 Hours

- Study of Life tables and plotting of survivorship curves of different types from the hypothetical data provided/real data of insect population obtained from the field.
- Determination of insect population density in a natural or hypothetical community by quadrate method and calculation of the Shannon Wiener Index.
- Study of abiotic factors in aquatic ecosystems: Temperature, turbidity, pH, dissolved oxygen content (by Winkler's method) and light intensity.
- Biochemical estimation of nitrates and phosphates from the pond water samples.
- Estimation of water quality using insects/other organisms as bio-indicators.
- Estimation of primary productivity by light and dark bottle method.
- Field visits to understand different ecosystems and to study insect diversity.

Suggested Readings:

- Odum, E.P. (2008) Fundamentals of Ecology. Indian Edition. Brooks/Cole.
- Smith, R. L. (2000) Ecology and field biology. Harper and Row publisher.
- Krebs, C. J. (2001) Ecology. VI Edition. Benjamin Cummings.
- Schowalter D.Timothy, (2006) Second edition, Insect Ecology an ecosystem approach, Academic Press.
- Ricklefs, R.E. (2000) Ecology. V Edition. Chiron Press.

Keywords:

Ecosystem, Energy flow, Food chain, Food web, Energy pyramids, Population ecology, Abundance, Survivorship curves, Density, Natality, Mortality.

Teaching Learning Process:

Field study for terrestrial ecosystem/aquatic ecosystem, PowerPoint Presentations, Maximizing interaction/Group discussion with students, Analysis of Scientific Articles. Observation based on actual handling of insects and their body parts. Visit to observe insects in their natural environment. Inculcate quantitative and analytical skills.