Appendix-49
Resolution No. 14-1 (14-1-6)

INDEX

DEPARTMENT OF SCIENCE

Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management

Semester-IV

BOTANY COMPONENT - DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Phytopathology ALS BOT DSC 04	4	2	0	2	Appeared in semester III	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to introduce students with various fungi, fungus like organisms, bacteria and viruses.
- to give an understanding of their characteristics, reproduction and ecology.
- to introduce students with the principles and concepts of plant pathology.
- to acquaint with various plant diseases, symptomatology, causal organisms and their control measures.

Learning Outcomes:

By studying this course, students will be able to:

- understand the world of different types of pathogens of plants.
- identify the characteristic symptoms of different groups of plant pathogens in the fields.
- understand the ecological and economical impact of plant diseases.
- identify common plant diseases and their control measures.
- understand the application and significance of integrated disease management.
- explicate the economic and pathological importance of fungi, bacteria and viruses.

Unit 1: Introduction **(3 Hours)**

Definition, Concepts and Terminology; General symptoms; Classification of diseases.

Unit 2: **Key events of Disease development** **(6 Hours)**

Disease cycle; Host pathogen relationships; Plant defence mechanism (Structural and biochemical); Epidemiology and Disease forecasting.

Unit 3: Fungal Diseases **(5 Hours)**

General symptoms; Disease cycle and Control measures - Powdery mildew of Pea.

Black stem Rust of Wheat; Smut of Barley (Loose and Covered smut).

Unit 4: Diseases caused by Oomycota **(3 Hours)**

General symptoms; Disease cycle and Control measures – White rust of Crucifers; Late blight of Potato.

Unit 5: Bacterial Diseases **(3 Hours)**

General symptoms; Disease cycle and Control measures - Citrus canker; Angular leaf spot of Cotton.

Unit 6: Viral Diseases **(3 Hours)**

General symptoms; Mode of transmission and Control measures-- Tobacco mosaic disease; Vein clearing of Bhindi.

Unit 7: Plant Disease Control **(7 Hours)**

Quarantine, Cultural practices, Physical methods, Chemical methods, Biological control (Antibiosis, Hyper-parasitism, Predation, Induced Systemic Resistance).

PRACTICAL **(60 Hours)**

1. Study of White rust of crucifers, Symptoms on leaves and hypertrophy with the help of live or preserved specimens. Study of causal organism (*Albugo candida*) with the help of temporary tease/section mount. Permanent section mount of somatic and reproductive phases.
2. Study of Late blight of Potato through specimens, temporary mounts (V.S. of leaf showing infection) and permanent slides.
3. Study of Powdery mildew of Pea, Symptoms on leaves and stem of Pea with the help of live or preserved specimens. Study of *Erysiphe* asexual stage with the help of temporary tease/ section mount and sexual stage through permanent slides.
4. Study of Black stem Rust of Wheat, Symptoms on both Wheat and Barberry with the help of live or preserved specimens/photographs. Study of *Puccinia graminis tritici* with the help of temporary tease/section mount of Wheat . Permanent slides of somatic and reproductive phases on both the hosts.
5. Study of Smut of Barley, Symptoms of Loose and Covered smut through live or preserved specimens. Study of teliospores through temporary mount.
6. Study of Bacterial Diseases through the specimens - Citrus canker; Angular leaf spot of Cotton.
7. Study of Viral Diseases through specimens - Tobacco mosaic Disease; Vein clearing of Bhindi.
8. Study of Phylloplane Mycoflora through cellotape method.
9. Study through digital images / photographs – Chlorosis, Tuber rot, Apple scab, Mycoparasite, Predaceous fungi.

Essential/ Recommended readings:

1. Oliver, R. (2023) *Agrios' Plant Pathology* 6th edition, Academic Press.
2. Agrios, G.N. (2005) *Plant Pathology* 5th edition, Elsevier Academic Press, Amsterdam.
3. Sharma, P.D. (2014) *Plant Pathology* Rastogi Publications, Meerut, U.P.

4. Singh, R.S. (2021) *Plant Diseases* 10th revised edition, Medtech, New Delhi.
5. Schumann, G.L. and D'Arcy C.J. (2009) *Essential Plant Pathology* 2nd edition, American Phytopathological Society, U.S.A.

Suggestive readings:

1. Singh, R.S. (2017) *Introduction to Principles of Plant Pathology, 5*th edition, Medtech, New Delhi.
2. Gupta, R. and Chugh, G. (2022) *Plant, Microbes and Diseases*. I.K. International Pvt. Ltd., Delhi.
3. Tronsmo A.M., Munk L., Anika D., Tronsmo A., Yuen J and Collinge D.B. (2020) *Plant Pathology and Plant Diseases*. CABI Publishing, U.S.A.
4. Ownley B.H. and Trigiano R.N. (2016) *Plant Pathology Concepts and Laboratory Exercises* 3rd edition, CRC Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 02)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Crop Genetics and Plant Breeding ALS BOT DSE 02	4	2	0	2	Appeared in semester III	NIL

Learning Objectives:

The Learning Objectives of this course are as follows:

- to develop an understanding of the concepts of plant breeding and its applications.
- to provide adequate knowledge on the natural breeding systems of different agriculturally important plant and strategies employed for crop improvement.
- to impart skills on plant genome analysis and gene mapping using DNA markers and their use in increasing efficiency of plant breeding.
- to understand the genetic basis of hybrid vigour and development of hybrid varieties.
- to make students familiar with the concept of varietal release and rights of a farmer and plant breeder.

Learning Outcome:

By studying this course, the students will be able to:

- gain knowledge on the importance of plant breeding for developing new cultivars and use of breeding strategies for improvement of crop plants.

- understand the concept of gene pool and germplasm resources that are fundamental to crop improvement.
- explicate the breeding methods for commercially important crop plants.

Unit 1: Introduction (2 Hours)

Importance of plant breeding and its history; Breeding systems in crop plants; Self-incompatibility, male sterility and apomixis, Important achievements in plant breeding.

Unit 2: Sources of Variation (4 Hours)

Plant genetic resources- their management and conservation, utilization of gene pools in breeding programs. Chromosome manipulation- induced mutations, haploidy, polyploidy, somatic hybridization, somaclonal variation.

Unit 3: Conventional Breeding Methods (8 Hours)

Selection methods for self-pollinated, cross-pollinated and vegetatively propagated crop plants; Hybridization for self-pollinated, cross-pollinated and vegetatively propagated crop plants-procedure, advantage and limitations.

Unit 4: Heterosis Breeding (3 Hours)

Genetic and molecular basis of heterosis (hybrid vigour); Development of hybrid varieties through exploitation of hybrid vigour. Inbreeding depression.

Unit 5: Molecular Genetics and Plant Breeding (10 Hours)

Molecular markers as tools in plant breeding; Principle of genetic linkage; Concept of genetic distance; Development and choice of mapping populations (F_2, NILs, RILs, BC etc); Linkage map construction; Quantitative traits - Principles and methods of QTL mapping, QTL Introgression; Marker-assisted breeding- Gene tagging; Marker-aided selection (foreground and background

selection); Elimination of linkage drags; Marker assisted recurrent selection (MARS). Novel Plant Breeding Tools (TALEN's, CRISPR-Cas9, Base editing).

Unit 6: Intellectual Property Rights and Varietal Release (3 Hours)

IPR, Patenting; Breeder's Right; Release of New Varities-Trials & their evaluation, Prerelease, Notification and its Release; Plant variety protection; Farmer's Right.

PRACTICAL (60 Hours)

1. Introduction to open/controlled pollinations in field and laboratory (Breeders kit; temporal details of anthesis, anther dehiscence, CMS, stigma receptivity, emasculation, bagging).
2. Analysis of the breeding system of chosen crop species by calculating pollen:ovule ratio.
3. Calculation of Index of self-incompatibility (ISI).
4. Study of dominant/ codominant nature of different molecular markers.
5. Assessment of phenotypic diversity in different accessions of given plant material using morphological markers.
6. Assessment of genetic diversity and construction of dendrogram using molecular markers.
7. Phenotypic screening of a mapping population/ land races for biotic stress resistance and calculating the log of percentage severity and symptom score.
8. Study of floral biology, emasculation and hybridization techniques in self-pollinated and cross-pollinated crops.
9. Estimation of heterosis, inbreeding depression and heritability.
10. Project: Case study based on gene mapping.
11. Field trip to plant breeding station.

Essential/recommended readings

1. Acquaah, G. (2012). *Principles of Plant Genetics & Breeding*. 2nd edition. Hoboken, NJ, Wiley.
2. Allard, R.W. (1999). *Principles of Plant Breeding*. John Wiley, New York.

3. Singh, B.D. (2022). *Plant Breeding: Principles and Methods*, 12th edition. New Delhi, Delhi: Kalyani Publishers.
4. Frey, K. J. (1982). *Plant Breeding II.* Kalyani Publishers, New Delhi.

Suggestive readings:

1. Welsh, J. R. (1981). *Fundamentals of Plant Genetics and Breeding*. John Wiley and Sons, New York.
2. Poehlman J. M. and Sleper D. A. (1995). *Breeding Field Crops,* 4th Ed. Panima Publishing Corporation, New Delhi.
3. Chopra, V.L. (2023). *Plant Breeding: Theory and Practice* 2nd Restructured Edition, New India Publishing Agency, New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE (DSC 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Agrochemistry ALS CHEM DSC 04	**4**	**2**	**0**	**2**	**Appeared in semester III**	**NIL**

Learning Objectives:

The Learning objectives of this course are as follows:

- to develop a scientific understanding of the diverse approaches to classify the agrochemicals.
- to make them familiar of chemical structure, mode of action and uses of pesticides.
- to impart the knowledge of pesticide formulation, their types, advantages and disadvantages.
- to make them aware of the hazards of agrochemicals and their impact on human health.

Learning Outcomes:

By studying this course, students will be able to:

- learn classification of pesticides.
- analyze the impact of stereochemical aspects on pesticidal activity.
- carry out preparation of formulations and analysis.
- handle pesticides safely in view of human health and environment.

Unit 1: Pesticides (5 Hours)

Different classes of pesticides based on use or target pests (Only definitions and examples- no structural requirement): Herbicides, Fungicides, Insecticides, Rodenticides, Acaricides, Bactericides**,** Chemosterillant, Molluscicide, Nematicides, Plant growth regulators, Repellents, Antifeedants, Sex attractants, Classification of pesticides based on chemical nature, mode of entry, mode of action and toxicity.

Unit 2: Herbicides (6 Hours)

Structure, uptake, mode of action and uses along with key points on human toxicity, with special reference to the individual compounds mentioned (synthesis excluded):

a) Aryl alkanoic acids: 2, 4 D, 2,4DB, MCPA and other acid derivatives: dicamba, dichlorobenil, dalapon {along with structure-activity relationship (SAR)}
b) Aromatic carbamates: Barban and asulam.
c) Triazines: Simazine, Atrazine
d) Bipyridinium: Paraquat
e) Organophosphorous: Glyphosate
f) Sulfonylurea: Chlorosulfuron
g) Uracils: Bromacil
h) Ureas: Monuron and Isoproturon

Unit 3: Fungicides (6 Hours)

Structure, mode of action and uses along with key points on human toxicity, with special reference to the individual compounds mentioned (synthesis excluded):

a) Copper and mercury derivatives
b) Dithiocarbamates: Thiram, Ziram, Nabam
c) Dinitro phenols: 2, 4-Dinitro o-Cresol (DNOC)
d) Quinines: Dichlone
e) Benzimidazoles: Benomyl
f) Organophosphorus fungicides: Kitazine
g) Phenyl amides: Metalaxyl

h) Triazoles: Propiconazole

i) Thiophanates: Thiophanates

Unit 4: Conventional Pesticides (4 Hours)

With special reference to the individual compounds mentioned (*synthesis excluded*):

Structure, pesticidal properties and stereochemical aspects (*if any*), mode of action, uses and comments on human toxicity

a) Carbamate insecticides: Carbaryl, Methomyl

b) Organophosphorus insecticides: Malathion, Parathion

c) Organochlorine Insecticides: Chlordane, Heptachlor, DDT

Unit 5: Introduction to other Pesticides (4 Hours)

Structure, stereochemical aspects (if any), use and toxicity of the following (*synthesis excluded*):

a) Alkaloid family: Nicotine

b) Pyrethrins: Pyrethrin-I and II

c) Fumigants: Example of Halogenated Hydrocarbons

d) Rodenticides: Inorganic and organic (Two examples each)

e) Repellents: DEET, Diethylphthalate

Unit 6: Pesticide Formulations (5 Hours)

1. Definition and purpose of formulations.
2. Brief discussion on the following type of formulations:
   a) Solid formulations: dusts (D), granules (G), pellets (P), wettable powders (WP or W), dry flowable (DF), soluble powders (SP); poison baits (B)
   b) Liquid formulations: emulsified concentrates (EC or E), solutions, flowing suspensions (F or L), Suspension Concentrate (SC), aerosols (A)
   c) Other type of formulations: fumigants (F); microencapsulated product (M) for controlled-release.

PRACTICAL **(60 Hours)**

1. Preparation of Bordeaux mixture and Bordeaux paste.

2. Preparation of Dithiocarbamate fungicide analogous from aromatic/aliphatic amine and separated as sodium /zinc/ manganese salt.

3. Preparation of homemade rodent bait.

4. Preparation of Emulsifiable concentrate (EC) formulation of given organic compound as oil in water emulsion(O/W).

5. Preparation of EC formulation: Emulsifiable concentrate of neem oil.

6. Preparation of standard hard water.

7. To determine the emulsion stability of given EC formulation.

8. Determination of bulk density of WP formulation.

9. **Project Writing**: For project work pesticides to be selected from the theory portion

   (a) Use of Globally Harmonized System (GHS) of classification and labelling of chemicals
   (b) The impact of pesticides on the environment.
   (c) Pesticide exposure and its impact on human health.

Essential /Recommended readings:

1. Buchel, K. H**.,** (1983) *Chemistry of Pesticides*, John Wiley & Sons Inc ISBN 13 978-0471056829
2. Melnikov,N.N. (1971) *Chemistry of Pesticides,* Edited By: Frances A. Gunther, Jane Davies Gunther, Springer, ISBN: 978-1-4684-6253-1
3. Cremlyn, R. (1978) *Pesticides: Preparation and mode of action*, 1st edition (October 19, 1978) John Wiley & Sons., 0471996319
4. Kenneth, A., Hessall (2013) *The chemistry of Pesticides, their Metabolism, Mode action and uses in crop*, Bio-Green Books, ISBN13: 978-9386237118
5. Sree Ramulu, U. S. (1979) *Chemistry of insecticides and fungicides,* 3rd Edition, Scientific Publishers; Edition: 2020, ISBN: 9789389832020
6. Roberts, T.R., Hutson, D.H., Jewess P.J., (1998) *Metabolic pathways of agrochemicals: insecticides and fungicides.* Royal Society of Chemistry

7. Handa, S.K., (2008) *Principles of Pesticide Chemistry*, Ed. By Agrobios (India) ISBN-13: 9788177542165
8. Singh Anupama et. al (2022) *Basics of Agrochemical Formulations*, Brillion Publishing ; ISBN: 9789392725128
9. Parmar, B.S., Tomar, S.S., (2010) *Pesticide formulation-Theory and practice* , CBS Publisher; ISBN 13: 9788123911243

Suggestive readings

1. Matolcsy,G., Nádasy,M., Andriska,V.,(1989) *Pesticide Chemistry,* 1st Edition - January 1, 1989; eBook ISBN: 9780080874913
2. Vyas, S. C. (1993) *Handbook of Systemic Fungicides: Compounds*. Tata McGraw-Hill.
3. Ashworth, R. D. B., (1970) *Analysis of technical and formulated pesticides,* Volume 1 ,*CIPAC handbook.*
4. Jim A. Turner, (2018*) The Pesticide Manual: A World Compendium*, British Crop Production Council.
5. World Health Organization. (2011). *International code of conduct on the distribution and use of pesticides: guidelines for quality control of pesticides* (No. WHO/HTM/NTD/WHOPES/2011.4). World Health Organization.
6. Zweig, G. (Ed.). (2013). *Principles, Methods, and General Applications: Analytical Methods for Pesticides, Plant Growth Regulators, and Food Additives, Vol. 1* (Vol. 1). Elsevier.

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DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 02)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Organic Chemistry in Pesticide Synthesis ALS CHEM DSE 02	**4**	**2**	**0**	**2**	**Appeared in semester III**	**NIL**

Learning Objectives:

The Learning objectives of this course are as follows:

- to familiarize students to different types of classification of pesticides.
- to familiarize with factors that make the organic compound to be considered as pesticide.
- to understand the correlation of stereochemistry of pesticide and pesticidal activity.
- to inculcate the awareness about the hazards of pesticides.

Learning Outcomes:

By studying this course, students will be able to:

- analyze important aspects attributing pesticidal activity to organic molecules.
- explain the strategies involved in synthesis of different pesticides.
- illustrate the impact of stereochemical aspects on pesticidal activity.
- handle pesticides safely in view of human health and environment.

Unit 1: Key Consideration for Pesticidal Activity of Organic Compounds (3 Hours)

a) Chemical structure (key functional groups in pesticides)

b) Mode of action to the selected target

c) Metabolism and metabolites

d) Toxicity concerns mainly human toxicity and ecotoxicity

Unit 2: Insecticides **(5 Hours)**

Structure, stereochemical aspects and toxicity of the following (synthesis excluded):

a) Alkaloid family: Nicotine

b) Nicotine analogous: Imidacloprid

c) Pyrethrins: Pyrethrin-I and II

d) Pyrethroids: Cypermethrin

Unit 3: Organic Halogenated Compounds as Pesticides **(9 Hours)**

a) Synthesis of Halogenated Hydrocarbons as Fumigants
   I. Methyl bromide (Bromomethane)
   II. 1,2-Dibromoethane
   III. 1,2-Dichloroethane
   IV. Carbon tetrachloride
b) Synthesis of DDT and Methoxychlor.
c) Synthesis of Hexachlorocyclohexane (BHC) and discussion of its stereoisomers.
d) Synthesis of Chlordane and Heptachlor from Hexachlorocyclopentadiene (HCCP) by Diels Alder reaction and discussion of their stereoisomers.

Ecological problems due to Organic Halogenated Compounds as Pesticides, their toxicity and effect on Human Health

Unit 4: Organophosphorus Insecticides: **(6 Hours)**

General chemistry of phosphate esters (Esters of Phosphoric and Phosphorothioic acids)

Synthesis of:

a) Vinyl organophosphates: Dichlorvos, Mevinphos (Phosdrin)

b) Phosphorothioates: Parathion, Methyl-parathion

c) Phosphorodithioate: Malathion

d) Heterocyclic phosphorodithioate: Phosmet

Unit 5: Carbamates **(4 Hours)**

General chemistry of carbamates: N-methyl carbamates and N, N-dimethyl (alkyl) carbamates

Synthesis of Carbaryl, Bendiocarb, MTMC, and Methomyl

Unit 6: Other Agrochemicals **(3 Hours)**

Synthesis of DNOC, Captan, 2,4-D, Ziram, Zineb, DEET and their uses.

PRACTICAL **(60 Hours)**

The following synthesis should be carried out starting from 0.5-1.0 g of the organic compound. The product to be recrystallized and melting point to be determined.

(*Experiments 1 to 6 are synthetic analogues of selected chemical class of pesticides*)

1. Synthesis of aryloxy acetic acid class of herbicide (any one of the following)
    a) 4-chlorophenoxy acetic acid
    b) 4-methylphenoxy acetic acid
    c) 2-methylphenoxy acetic acid
2. Preparation of Dithiocarbamate fungicide analogous from aromatic/aliphatic amine and separated as sodium /zinc/ manganese salt.
3. Preparation of urea derivative from phenylisocynate and aniline.
4. Preparation of carbamate derivative from phenylisocynate and alcohol/phenol.
5. Preparation of benzimidazole/2-benzylimidazole /2-Methylbenzimidazole.
6. Synthesis of 3,5-dimethylpyrazole.
7. Preparation of mosquito repellent Diethyl phthalate in two steps:
    Step-1: Preparation of phthalic anhydride

Step-2 : Preparation of Diethyl phthalate

8. To prepare Neem extract from neem leaves and/or seeds.
9. **Project Writing**: Insecticidal properties of Neem extract and its uses.

Essential /Recommended readings:

1. Buchel, K. H**.** (1983) *Chemistry of Pesticides* **,** John Wiley & Sons, ISBN 13 978-0471056829
2. Melnikov, N.N. (1971) *Chemistry of Pesticides***,** Edited By: Frances A. Gunther, Jane Davies Gunther, Springer, ISBN: 978-1-4684-6253-1
3. Cremlyn, R. (1978) *Pesticides. Preparation and mode of action*, 1st edition John Wiley & Sons, 0471996319
4. Kenneth A, Hessall (2013), *The chemistry of Pesticides, their Metabolism, Mode action and uses in crop,* Bio-Green Books, ISBN13: 978-9386237118
5. Sree Ramulu, U. S. (1979) *Chemistry of insecticides and fungicides*, 3rd Scientific Publishers; Edition: 2020, ISBN: 9789389832020
6. Roberts, T.R., Hutson, D.H., Jewess, P.J. (1998) *Metabolic pathways of agrochemicals: insecticides and fungicides*, Royal Society of Chemistry
7. Matolcsy, G., Nádasy,M., Andriska,V. (1989) *Pesticide Chemistry* 1st Edition, eBook ISBN: 9780080874913

Suggestive readings

1. Handa, S.K. (2008) *Principles of Pesticide Chemistry*, Ed. By Agrobios (India) ISBN-13: 9788177542165
2. Vyas, S. C. (1993*) Handbook of Systemic Fungicide Compounds*. Tata McGraw-Hill.
3. Jim A. Turner (2018) *The Pesticide Manual: A World Compendium*, British Crop Production Council.
4. World Health Organization (2011) *International code of conduct on the distribution and use of pesticides: guidelines for quality control of pesticides* (No. WHO/HTM/NTD/WHOPES/2011.4). World Health Organization.

5. Zweig, G. (Ed.), (2013) *Principles, Methods, and General Applications: Analytical Methods for Pesticides, Plant Growth Regulators, and Food Additives, Vol. 1* (Vol. 1). Elsevier.
6. "IARC Monograph on Evaluation of Carcinogenic Risk of Chemicals to Humans", Supplement 7, International Agency for Research on Cancer, Lyon, 1987.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Zoology Component – DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Agricultural Pests ALS ZOO DSC 04	4	2	0	2	Appeared in semester III	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to impart knowledge about the various agricultural pests and the nature of damage caused by them.
- to apprise the students of the lifecycle of the pest and the specific stage at which it is destructive to the host.
- to acquaint them of the different control measures applied for the management of pests.

Learning Outcomes:

By studying this course, students will be able to:

- identify and differentiate among various types of pests.
- acquire knowledge of the damage caused by agricultural pests.
- better understand the methods of control for the management of the pests.

Unit 1: Introduction (3 Hours)

Classification, identification, distribution and host-range of agricultural pests; Overview of: bionomics, nature and extent of damage, seasonal abundance and management of insect pests.

Unit 2: Pests of Cereals (2 Hours)

Biology, nature, extent of damage and control: *Chilozonellus*, *Sesamia inferens*

Unit 3: Pests of Oilseeds (4 Hours)

Bionomics, lifecycle and management: *Lipaphis erysimi*, *Athalialugen sproxima*, *Achaea janata*, *Euproctis lunata.*

Unit 4: Pests of Fibre Crops (5 Hours)

Bionomics, life cycle and management*: Helicoverpa armigera, Earias vitella*, *Pectinophora gossypiella*, *Oxycarenus laetus*, *Dysdercus koenigii.*

Unit 5: Pests of Paddy and Sugarcane (5 Hours)

Biology, nature of damage and control: *Leptocorisa varicornis*, *Hispa (Dicladispa) armigera*, *Spodoptera exempta, Scirpophaga nivella*, *Pyrilla perpusilla*, *Emmalocera depressella, Aleurolobus barodensis.*

Unit 6: Stored Grain Pests (6 Hours)

Life cycle, nature of damage and control: *Sitophilus oryzae*, *Rhyzopertha dominica*, *Trogoderma granarium, Sitotroga cerealella*, *Callosobruchus chinensis, Atherigona varia*, *Calocorisan gustatus, Mythimna separate*, *Macrosiphum miscanthi /Sitobion avenae*.

Unit 7: **Polyphagus Pests (5 Hours)**

Lifecycle and control: grasshopper, locust, termite, white grub, hairy caterpillar, and non-insect pests (mites, birds, rodents, snails, slugs).

PRACTICAL (60 Hours)

1. Identification, life cycle and damage caused by following pests:

   Chilozonellus, Sesamia inferens, Lipaphis erysimi, Helicoverpa armigera, Earias vitella, *Pectinophora gossypiella*, *Oxycarenus laetus*, *Dysdercus koenigii. Athalialugen sproxima, Achaea janata, Euproctis lunata, Hispa(Dicladispa) armigera, Spodoptera exempta, Pyrilla*

perpusilla, *Emmalocera depresse, Sitophilus oryzae*, *Rhyzopertha dominica*, *Trogoderma granarium, Sitotroga cerealella*, *Callosobruchus chinensis, Atherigona varia*, *Calocorisan gustatus, Mythimna separate*, *Macrosiphum miscanthi /Sitobion avenae*.

2. Identification and life cycle of grasshoppers and locusts.
3. Study of life cycle and management of non-insect pests through specimens/photographs.
4. Collection and identification of stored grains pests and nature of damage caused by them.
5. Field visits to Central warehouse/FCI godowns/ CFTRI, IGSMRI.

Essential/recommended readings

1. Dhaliwal G.S. and Singh R. (2004) *Host Plant Resistance to Insects - Concepts and Applications*. Panima Publications., New Delhi.
2. Evans J.W. (2005). *Insect Pests and their Control.* Asiatic Publications., New Delhi.
3. Atwal A.S. and Dhaliwal G.S. (2018) *Agricultural Pests of South Asia and their Management,* 7th Edition Kalyani Publ., New Delhi.

Suggestive readings

1. Maxwell F.G. and Jennings P.R. (Eds). (1980) *Breeding Plants Resistant to Insects.* John Wiley and Sons, New York.
2. Sharma V. (2015) *Agricultural Pest Management*, Rajat Publications.
3. Awasthi V. B. (2017) Agricultural Insect Pest and their Control, 2nd edition, Scientific Publisher India.

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Zoology Component – DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 02)

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Developmental Biology of Animals ALS ZOO DSE 02	**4**	**2**	**0**	**2**	**Appeared in semester III**	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to acquaint students of different phases of development and changes from embryonic to post-embryonic stage.
- to comprehend the basic principles and concepts underlying developmental processes at the cellular and molecular level.
- to learn about gametogenesis, cleavage patterns, morphogenetic movements and the importance of extraembryonic membranes.
- to apprise the students of the applications of this course in addressing the problems of developmental abnormalities and infertility in human.

Learning Outcomes:

By studying this course, students will be able to:

- understand the events that lead to the formation of a multicellular organism from a single cell.
- learn the general patterns and sequential developmental stages during embryogenesis.
- acquire better knowledge of the mechanisms involved in morphogenesis and interactions of cells during gastrulation, placentation, regeneration and metamorphosis.

- appreciate the importance of IVF and amniocentesis for tackling infertility and developmental abnormalities.

Unit 1: Introduction **(2 Hours)**

Historical background, phases of development, growth and differentiation, cytoplasmic determinants, teratogens.

Unit 2: Early Embryonic Development **(15 Hours)**

Gametogenesis: spermatogenesis, oogenesis; types of eggs, egg membranes; fertilization (External and Internal), blocks to polyspermy, planes and patterns of cleavage, types of blastula, fate maps, morphogenetic movements, gastrulation in frog and chick.

Unit 4: Late Embryonic Development **(5 Hours)**

Fate of germ layers, extraembryonic membranes in birds, placenta (structure, types and functions).

Unit 5: Post-embryonic Development **(5 Hours)**

Metamorphic changes in amphibians and insects; regeneration: modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration, limb regeneration in tailed amphibia.

Unit 6: Applications of Developmental Biology **(3 Hours)**

Embryonic stem cell; *in vitro* fertilization, amniocentesis.

PRACTICAL **(60 Hours)**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Egg, cleavage stages, blastula, gastrula, neurula (neural plate, neural fold and neural tube stages), tailbud stage, tadpole (external and internal gill stages)

2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton stages): Stage 3 (Intermediate Streak)-13 hours, stage 4 (Definitive streak)-18 hours, stage 5 (Head process)-21 hours, Stage 7- 24 hours, stage 8-28 hours, stage10-33 hours, stage 11- 40 hours, stage 13- 48 hours, stage 19- 72 hours and stage 24- 96 hours of incubation.
3. *In vivo* study of chick embryo development by windowing and candling methods. (Demonstration only).
4. Study of different stages of development of *Drosophila*.
5. Study of different types of placenta (photomicrographs/ slides).
6. Project report on *Drosophila* development/Visit to poultry farm/IVF Centre.

Essential/recommended readings:

1. Gilbert, S.F. (2016) *Developmental Biology*, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA.
2. Balinsky B. I. and Fabian B. C. (2006) *An Introduction to Embryology*. 8th Edition, International Thompson Computer Press.
3. Kalthoff, K. (2001) *Analysis of Biological Development*. 2nd Edition, McGraw Hill Publishers.

Suggestive readings:

1. Arora, R. and Grover, A. (2018) *Developmental Biology: Principles and Concepts*. 1st Edition, R. Chand & Company.
2. Baweja, V. and Misra, M. (2021) *E-book on Practical Manual of Developmental Biology*.
3. Carlson, B.M. (2007) *Foundations of Embryology*. 6th Edition, Tata McGraw-Hill Publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-V

DISCIPLINE SPECIFIC CORE COURSE (DSC 05)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Physiology and Biochemistry in Plant Development ALS BOT DSC 05	**4**	**2**	**0**	**2**	**Appeared in semester IV**	**NIL**

Learning Objectives:

The learning objectives of this course are as follows:

- to understand the fundamental concepts of plant physiology and metabolism.
- to identify the role of water, minerals, hormones, and light in plant growth and development.
- to understand the basic biochemical mechanisms and mineral nutrition of plants.
- to identify the criteria for the essentiality of elements.
- to understand the role of hormones in plant growth and development.
- to examine the commercial applications of growth regulators.
- to understand the physiology of flowering and senescence.
- to understand the mechanisms of photosynthesis and respiration.
- to examine the biological nitrogen fixation in plants.

Learning Outcomes:

By studying this course, students will be able to:

- comprehend the physiological processes that occur in plants, including the role of water, minerals, hormones, and light in plant growth and development.
- acquaint the basic biochemical mechanisms of plants, including photosynthesis, respiration, nitrogen metabolism, and chemical regulation of growth and development.
- comprehend the process of biological nitrogen fixation, reproductive physiology and senescence of plants.
- develop practical skills in plant physiology and metabolism.

Unit 1: Plant-water relations (3 Hours)

Water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation.

Unit 2: Mineral Nutrition (3 Hours)

Essential elements, Macro- and micronutrients, Criteria for essentiality of elements, Methods of studying mineral requirement (Hydroponics, Aeroponics)

Unit 3: Translocation in Phloem (3 Hours)

Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 3: Chemical Regulation of Growth and Development (3 Hours)

Role of hormones in plant growth and development, Commercial applications of growth regulators, Growth retardant and its usefulness

Unit 4: Reproductive Physiology and Senescence (3 Hours)

Photo-periodism and flowering response, Photo-perception and critical photoperiod, Phyto-chrome and its role in flowering, Vernalization and senescence.

Unit 5: Photosynthesis **(7 Hours)**

Historical contributions of Blackman, Emerson, and Hill, Photosynthetic pigments (chlorophyll-a and b, xanthophyll, carotene), Photosystem I and II, reaction center, antenna molecules, Electron transport and mechanism of ATP synthesis, C3 pathway, C4 and CAM plants (in brief, no pathways), Photorespiration.

Unit 6: Respiration **(5 Hours)**

Glycolysis, Anaerobic respiration, TCA cycle, Oxidative phosphorylation, Glyoxylate cycle, RQ

Unit 7: Nitrogen Metabolism **(3 Hours)**

Biological nitrogen fixation - nodulation in detail, Nitrate and ammonia assimilation.

PRACTICAL **(60 Hours)**

1. To determine the osmotic potential of plant cell sap by plasmolytic method.
2. Calculate stomatal index and stomatal frequency of a mesophyte and a xerophyte.
3. Study Hill's reaction.
4. To study the effect of the environmental factor light on transpiration by excised twig.
5. Study the effect of light intensity on O_2 evolution in photosynthesis.
6. Compare the rate of respiration in any two parts of a plant.
7. To study the activity of catalase and the effect of pH and heavy metals.
8. Demonstrate the effect of auxin on rooting.
9. Demonstration of Bolting.
10. Demonstration of root respiration.
11. Demonstration of suction due to transpiration
12. A field visit to Hydroponics and Aeroponics facilities.

Essential/ Recommended readings:

1. Hopkins, W. G., Huner, N. P. A. (2009) *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd
2. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018) *Plant Physiology and Development* International 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
3. Kochhar, S.L., Kaur, S. and Gujral, S.K. (2020) *Plant Physiology: Theory and Applications*. New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd.

Suggestive readings:

1. Bajracharya, D. (1999) *Experiments in Plant Physiology: A Laboratory Manual.* New Delhi, Delhi: Narosa Publishing House.
2. Bhatla S.C. and Lal, M.A. (2018) *Plant Physiology, Development and Metabolism*, Springer.
3. Salisbury F.B. and Ross C.W. (1992) Plant Physiology, 4th edition, Wadsworth Publishing Company, California.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 03)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Developmental Biology of Plants ALS BOT DSE 03	**4**	**2**	**0**	**2**	**Appeared in semester IV**	**NIL**

Learning Objectives:

The learning objectives of this course are follows:

- to acquaint the students with internal basic structure and cellular composition of the plant body.
- to correlate structure with important functions of different plant parts.
- to study of various tissue systems and their development and functions in plants
- to have knowledge of the flowering and fruiting, reproduction process, role of pollinators, ovule and seed development.

Learning Outcomes:

By studying this course, students will be able to:

- gain knowledge of various cells and tissues, meristem, epidermal and vascular tissue

system in plants.

- get an insight of various aspects of growth, development of the tissues and differentiation of various plant organs.
- gain the knowledge of basic structure and organization of plant parts in angiosperms and its correlation with morphology and functions.
- get acquainted with pollen development and pollination, ovule development and fertilization, endosperm development and its importance.

Unit 1: Meristematic and permanent tissue: (4 Hours)

Meristems and derivatives- structural organization of shoot and root apices; permanent tissue: simple and complex tissues.

Unit 2: Dermal System (2 Hours)

Epidermis, stomata, trichomes and glands

Unit 3: Organs (4 Hours)

Structure of dicot and monocot root, stem and leaf

Unit 4: Secondary Growth (4 Hours)

Vascular cambium – structure and function, Secondary growth in root and stem, periderm.

Unit 5: Anther (4 Hours)

Structure and development, microsporogenesis, Pollen Development, structure of pollen and pollen wall (Basic Concepts).

Unit 6: Ovules **(4 Hours)**

Structure and types, megasporogenesis and mega gametogenesis, mature embryo sac.

Unit 7: Pollination and Fertilization **(4 Hours)**

Pollination mechanisms and adaptations; double fertilization; sexual incompatibility- basic concepts

Unit 8: Endosperm and Embryo **(3 Hours)**

Types and function of endosperm, embryogenesis, dicot and monocot embryo

Unit 9: Seed development **(1 Hours)**

Basic concepts of seed development

PRACTICAL **(60 Hours)**

1. Study of root and shoot apex through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma, sclerenchyma and their types); Macerated xylary elements, Phloem (Permanent slides/ Photographs/ Digital resources)
3. To cut transverse section of stem: Monocot: *Zea mays*; Dicot: *Helianthus*; Study of secondary growth in *Helianthus* stem.
4. To cut transverse section of root: Monocot: *Zea mays*; Dicot: *Cicer*; Study of secondary growth in *Helianthus* .
5. Study of structure of Dicot and Monocot leaf.
6. Study of anther structure (young and mature).

7. Calculation of percentage of germinated pollen in a given medium through hanging drop/sitting drop method.
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
9. Female gametophyte: Mature embryo sac (photographs). Ultrastructure of mature egg apparatus cells through electron micrographs.
10. Dissection of embryo and endosperm from developing seeds.

Essential/ Recommended readings:

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjamin/Cummings Publisher.
3. Franklin, E. R. (2006). *Esau's Plant Anatomy: Meristems, Cells, And Tissues of the Plant Body: Their Structure, Function, and Development.* New Jersey, U.S.: John Wiley & Sons, Inc., Hoboken.
4. Shivanna, K.R. (2003). *Pollen Biology and Biotechnology.* Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Suggestive readings:

1. Raghavan, V. (2000). *Developmental Biology of Flowering plants*. Netherlands, Europe:

Springer.

2. Johri, B.M. (1984). *Embryology of Angiosperms.* Netherlands, Europe: Springer-Verlag.

3. Bhojwani S.S., Dantu P.K. and Bhatnagar, S.P. (2015) The Embryology of Angiosperms, 6th edition. Vikas Publication House Pvt. Ltd. New Delhi.

4. Tayal, M.S. (2021). Plant Anatomy, 4th Edition. Meerut, U.P.: Rastogi publications.

5. Crang, R., Lyons-Sobaski, S., and Wise, R., (2018) Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants, 1st Edition, Springer Nature Switzerland AG.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE (DSC 05)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Physical Chemistry; ALS CHEM DSC 05	4	2	0	2	Appeared in semester IV	NIL

Learning Objectives:

The Learning Objectives of this course are as follows:

- to make students able to understand thermodynamic concepts, properties of thermodynamic systems, laws of thermodynamics and thermochemistry.
- to introduce the basic concept of chemical equilibrium, ionic equilibria and conductance and their correlation among themselves and with other branches of chemistry.
- to provide basic understanding of the behavior of electrolytes and their solution.

Learning Outcomes:

By studying this course, students will be able to:

- understand the laws of thermodynamics, thermochemistry and equilibria.
- explain the concept of pH and its effect on various physical and chemical properties of the compounds.
- use the concepts learnt to predict feasibility of chemical reactions and to analyse the behaviour of reactions in equilibrium.
- apply classroom knowledge to local environmental phenomena and interpret them in relation to the chemistry involved in both conceptual and experimental aspects.

Unit 1: Chemical Energetics (8 Hours)

Review of thermodynamics and the laws of thermodynamics

Thermochemistry: Important principles and definition of thermochemistry, *Conventions* about the *thermochemical equation,* Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of ionization, enthalpy of hydration, enthalpy of formation, *enthalpy of solution: integral and differential enthalpies of solution and dilution, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data,* the effect of temperature (Kirchhoff's equations) on the enthalpy of reactions.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit 2: Chemical Equilibrium (6 Hours)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and $\Delta G^{\ominus}$, Le Chatelier's principle, relationship between Kp, Kc and Kx for reactions involving ideal gases.

Unit 3: Ionic Equilibria (10 Hours)

Strong, moderate, and weak electrolytes, degree of ionization, factors affecting the degree of ionization, Ostwald's dilution law, ionization constant, and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect, Buffer solutions, Henderson- Hasselbach equation, salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH of different salts, solubility and solubility product of sparingly soluble salts-applications of solubility product principle. Qualitative treatment of acid-base titration curves (calculation of pH at various stages).

Unit 4: Conductance (6 Hours)

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions. 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).

PRACTICAL **(60 Hours)**

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of the enthalpy of ionization of ethanoic acid.
4. Determination of integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of enthalpy of hydration of copper sulphate.

Ionic equilibria:

6. Preparation of buffer solutions:

   (i) Sodium acetate-acetic acid

   (ii) Ammonium chloride- ammonium hydroxide.

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

7. pH metric titration:

   (i) Strong acid vs strong base

   (ii) Weak acid vs strong base

Determination of dissociation constant of a weak acid.

Conductance

8. (i) Determination of cell constant

(ii) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

9. Conductometric titration:

   (i) Strong acid vs strong base

   (ii) Weak acid vs strong base

   (iii) Mixture of strong and weak acid vs strong base

Essential/Recommended readings:

1. Peter, A., Paula, J. de. (2011), "*Physical Chemistry*", Fifth Ed., Oxford University Press.
2. Castellan, G. W. (2004), "*Physical Chemistry*", Fourth Ed., Narosa.
3. Kapoor, K. L. (2015), "*A Textbook of Physical Chemistry*", Vol 1, 6th Edition, McGraw Hill Education.
4. Kapoor, K. L. (2015), "*A Textbook of Physical Chemistry*", Vol 2, 6th Edition, McGraw Hill Education.
5. Puri, B.R; Sharma, L.R; Pathania, M.S. (2017), "*Principles of Physical Chemistry*", Vishal Publishing Co.

Suggestive readings:

1. Khosla, B. D., Garg, V. C., Gulati, A. (2011), "*Senior Practical Physical Chemistry* ", R. Chand & Co., New Delhi.
2. Athawale, V. D., Mathur, P. (2001), "*Experimental Physical Chemistry*", New Age International: New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 03)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanotechnology in Agriculture; ALS CHEM DSE 03	4	2	0	2	Appeared in semester IV	NIL

Learning Objectives:

The Learning objectives of this course are as follows:

- to create foundational knowledge of Nanotechnology.
- to educate students about the current green and sustainable methods of preparation of nanomaterials.
- to teach difference between conventional and modern agriculture.
- to give idea about the importance of nanomaterials in agriculture.
- to impart knowledge on toxicity of nanomaterials.

Learning Outcomes:

By studying this course, students will be able to:

- identify the different types of nanomaterials and their properties.
- understand the role of nano- agrochemicals in enhancing crop productivity.
- articulate the study of nanomaterials in the treatment of soil.
- summarize the toxicity risks of nanomaterials on soil and environment.

Unit 1: Introduction (6 Hours)

Basics of nanoscience and technology: Definition, Classification of nanoparticles based on dimension and origin, Quantum confinement, properties of nanoparticles (optical only).

Synthesis of nanoparticles: Overview of physical and chemical routes, green methods of nanoparticles synthesis.

Introduction to agriculture: Limitations of conventional farming, role of nano- agrochemicals in modern agriculture. Benefits of nanomaterials in agriculture (plant growth, crop protection, crop nutrients, etc.).

Unit 2: Application of Nanomaterials in Agriculture (14 Hours)

Nano fertilizers: Types and synthesis: Nitrogen-based, Phosphate based and Iron based. Role towards enhancement of crop productivity. Molecular mechanism of nano- fertilizer for plant growth and mechanism.

Advantages over conventional fertilizers, limitations, optimization of nutrient use efficiency (NUE) and environment sustainability.

Nano pesticides: Brief discussion about nano- insecticides, nano- herbicides and nano-fungicides, role in agriculture. Advantages over conventional pesticides and limitations.

Unit 3: Treatment of Soil using Nanomaterials (6 Hours)

Treatment of polluted soil by nanoremediation. Utilization of nanoparticles like nanoclay and zeolites in soil boosting. Smart pest control.

Unit 4: Nanotoxicity in Agriculture (4 Hours)

Toxicity of nanoparticles. Toxic effects of metal nanoparticles on soil ecosystem. Toxicity of nanoparticles to crop production. Health and environmental concerns related to nanomaterials.

PRACTICAL **(60 Hours)**

1. Basic introduction to the characterization of nanoparticles employing the following techniques (Data and/or images for few reference compounds will be provided for analysis):
    i. UV-Visible spectroscopy
    ii. Fourier transform infrared spectroscopy (FT-IR)
    iii. Powder X-ray diffraction (PXRD)
    iv. Scanning electron microscopy (SEM)
    v. Transmission electron microscopy (TEM)
2. Sol-gel synthesis of nanoparticles.
3. Synthesis of metal and metal oxide nanoparticles by green methods:
    i. Silver nanoparticles and their characterization using UV-visible spectrophotometer.
    ii. Zinc oxide nanoparticles.
    iii. Iron oxide nanoparticles using potato extract.
4. Synthesis of Nano urea.
5. Analysis of soil:
    i. Comparative study of pH of untreated and nano fertilizer treated soil
    ii. Estimation of composition of zinc in nano fertilizer treated soil using complexometry.

Essential/Recommended readings:

1. Varghese, T., Balakrishna, K.M., (2020) *Nanotechnology- An Introduction to synthesis, properties and applications of nanomaterials.* Atlantic Publishers & Distributors (P) Ltd; ISBN: 9788126916375.

2. Shah, M.A.; Shah, K.A., (2019) *Nanotechnology-The Science of Small*. Wiley; ISBN: 9788126579976.

3. Swayam (MHRD) Portal online: Nanotechnology in Agriculture (https://nptel.ac.in/course/102104069); Book download link: 102104069.pdf - Google Drive .

4. Axelos, M. A., & Van de Voorde, M. (Eds.). (2017). *Nanotechnology in agriculture and food science*. John Wiley & Sons, ISBN: 3527339892.

5. Chattopadhyay K.K., Banerjee A.N., (2009) *Introduction to Nanoscience and* Technology; PHI Learning Pvt. Ltd. ISBN: 9788120336087.

6. Jogaiah, S., Singh, H. B., Fraceto, L. F., & De Lima, R. (Eds.). (2020). *Advances in Nano-Fertilizers and Nano-Pesticides in Agriculture: A Smart Delivery System for Crop Improvement*. Woodhead Publishing; ISBN: 978-012-820092.

7. Singh, H. B., Mishra, S., Fraceto, L. F., & De Lima, R. (Eds.). (2018). Emerging trends in agri-nanotechnology: fundamental and applied aspects; CABI Publishing, ISBN: 9781786391445.

8. Mallick, M. A., Solanki, M. K., Kumari, B., & Verma, S. K. (Eds.). (2021). *Nanotechnology in Sustainable Agriculture*. CRC Press; ISBN: 9780367369408.

9. Subramanian, K. S., Gunasekaran, K., Natarajan, N., Chinnamuthu, C. R., Lakshmanan, A., & Rajkishore, S. K. (2015). *Nanotechnology in Agriculture*. New India Publishing Agency; ISBN: 9789383305209

10. Tarafdar, J. C. (2021). Nanofertilizers: challenges and prospects.; Scientific Publishers (India); ISBN: 978938889696931.

11. Fraceto, L. F., De Castro, V. L. S., Grillo, R., Ávila, D., Oliveira, H. C., & Lima, R. (2020). *Nanopesticides*. Springer International Publishing. ISBN: 978-3-030-44873-8.

Suggestive readings:

1. Craig, E. (2019) Nanomaterials: An Introduction to Properties, Synthesis and Applications. Larsen and Keller Education (New York). ISBN: 1641721065.
2. Fraceto, L. F. (2022). *Inorganic Nanopesticides and Nanofertilizers: A View from the Mechanisms of Action to Field Applications*. Springer Nature; ISBN: 9783030941543.
3. Prasad, R., Kumar, M., & Kumar, V. (Eds.). (2017). *Nanotechnology: an agricultural paradigm*. Springer.ISBN:9789811045721.
4. Kumar, V., Guleria, P., Ranjan, S., Dasgupta, N., & Lichtfouse, E. (Eds.). (2021). *Nanotoxicology and Nanoecotoxicology Vol. 1* (Vol. 59). Springer International Publishing; ISBN: 978-3-030-63241-0.

E-contents:

1. E-content on e-PG Pathshala portal of Government of India: (**P08**) Nanoscience and Nanotechnology (**33**) (https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=5VgWkgm+I3FGq9cGlsbNmQ==).
2. Swayam (MHRD) Portal online: Nanotechnology in Agriculture (https://nptel.ac.in/course/ 102104069); study material, videos and other material link for course (NPTEL).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE (DSC 05)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Animal Physiology and Metabolism ALS ZOO DSC 05	**4**	**2**	**0**	**2**	**Appeared in semester IV**	**NIL**

Learning Objectives:

The learning objectives of this course are as follows:

- to impart knowledge about the functions of organs and organ systems of the body.
- to distinguish between normal and diseased states of the body functions.
- to apprise the students about correlation of the structure of organs with their functions.
- to enable the students to learn the working of different metabolic pathways of the body.

Learning Outcomes:

By studying this course, students will be able to:

- understand the physiology of different systems of the human body.
- comprehend and analyse problem-based questions on physiological aspects.
- recognize and explain the working of physiological systems in unison to maintain homeostasis in the body.

Unit 1: Nerve and Muscle **(5 Hours)**

Types of muscles, ultrastructure of muscle, characteristics of muscle twitch. Structure of

neuron, action potential, propagation of nerve impulse (myelinated and non-myelinated nerve fibre).

Unit 2: Digestion **(5 Hours)**

Digestion and absorption of carbohydrates, fats and proteins.

Unit 3: Respiration **(4 Hours)**

Ventilation, external and internal respiration, transport of oxygen and carbon dioxide in blood.

Unit 4: Heart **(4 Hours)**

Structure of heart, origin and conduction of heart beat, cardiac cycle.

Unit 5: Excretion **(3 Hours)**

Structure of nephron, mechanism and regulation of urine formation.

Unit 6: Endocrine Glands **(2 Hours)**

Structure and function of endocrine glands.

Unit 7: Metabolism of Carbohydrates, Proteins and Lipids **(7 Hours)**

Glycolysis, TCA cycle, electron transport chain (respiratory chain), Urea cycle, β-oxidation of fatty acids.

PRACTICAL **(60 Hours)**

1. Preparation of temporary mount of neuron and striated muscle.
2. Estimation of haemoglobin using Sahli's Haemoglobinometer.
3. Preparation of haemin crystals.
4. Study of oesophagus, stomach, duodenum, ileum, liver, pancreas, trachea, lung, kidney (of mammals) through permanent slides.

5. Study of endocrine glands of mammal using permanent slides: pituitary, thyroid parathyroid, pancreas, adrenal, ovary and testis.
6. Study of the activity of salivary amylase under optimal conditions.
7. Interpret the recording of frog's heartbeat (*in situ)* under normal conditions.
8. Study of muscle twitch through videos/photographs and interpret the recording of muscle twitch.

Essential/recommended readings:

1. Tortora, G.J. and Derrickson, B. H. (2017) *Principles of Anatomy and Physiology*. 15th Edition, Wiley Publishers.
2. Campbell and Reece (2020). *Biology.* Pearson Education, (Singapore) Pvt. Ltd.

Suggestive readings:

1. Vander A., Sherman J. and Luciano D. (2017) *Vander's Human Physiology: The Mechanism of Body Function*. 7th Edition, McGraw Hills.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 03)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Integrated Pest Management ALS ZOO DSE 03	4	2	0	2	Appeared in semester IV	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to familiarize the students with the ecology of pests and the damage caused by them.
- to acquaint the students of the concept of Integrated Pest Management (IPM) using different models.
- to apprise the students of various components of IPM *viz*. chemical, biological and genetic control.
- to impart knowledge about the various pest surveillance techniques and forecasting of pest outbreaks.

Learning Outcomes:

By studying this course, students will be able to:

- better understand the effects of insecticides on the environment and need for ecofriendly approach for management of insect pests.
- learn the management of agricultural ecosystem using effective pest control strategies and techniques.
- appreciate the role of IPM in sustainable agriculture.

Unit 1: Concept of Pest and its Ecology **(5 Hours)**

Pest population dynamics, Economic Injury Level (EIL), Economic Threshold Level (ETL), carrying capacity, secondary pest outbreak.

Unit 2: Overview of Integrated Pest Management **(4 Hours)**

Concept of IPM and its components, major IPM strategies.

Unit 3: Insect Pest Management **(6 Hours)**

Types of pest management: cultural, physical and mechanical; pest survey (types) and surveillance: factors affecting surveys; forecasting; pest and pesticide risk analysis; political, social and legal implications of IPM; case studies of successful IPM programmes.

Unit 4: Chemical Control **(5 Hours)**

Classification of insecticides, insecticide adjuvants and formulations, mechanism of insecticide action with reference to chlorinated hydrocarbons, organophosphates, carbamates, plant products, synthetic pyrethroids, fumigants, IGR compounds and pheromones.

Unit 5: Biological Control **(6 Hours)**

Principle; biocontrol agents: parasitoids, predators and pathogens (NPV, bacteria, fungi and nematodes).

Unit 6: Genetic Control and Legislation **(4 Hours)**

Sterile Insect Release Method (SIRM): radio and chemo sterilization, hybrid sterility; other strategies of genetic control; quarantine laws.

PRACTICAL **(60 Hours)**

1. Study of damage caused by the common insect pests of stored grains and crops (any 6).
2. Study of life history of important insect pests and non-insect pests.

3. Study of common natural enemies of crop pests (parasitoids, predators, microbes).
4. Study of IPM model for control of *Leptocorisa acuta* and *Scirpophaga nivella.*
5. Learn algorithm (flow chart) of IPM strategies for the sustainable agriculture.
6. Study of tools and techniques of IPM: mechanical, physical, cultural control.
7. Study of the equipments used for spraying and dusting of insecticides.
8. Determination of LD50/LC50 of insecticides based on assessment of SIT efficacy through data.
9. Submission of project report on visit to IARI, IPFT, Hindustan Insecticides Ltd., FCI complex.

Essential/recommended readings:

1. Atwal A.S. and Dhaliwal G.S. (2018) *Agricultural Pests of South Asia and their Management,* 7th Edition Kalyani Publ., New Delhi.
2. Dhaliwal G.S. and Singh R. (2004) *Host Plant Resistance to Insects – Concepts and Applications.* Panima Publ., New Delhi.
3. Hill, Dennis S (2012) *Agricultural insect pests of the tropics and their control*, 2nd Edition; Permission of Cambridge University, printed at Shree Maitrey Printech Pvt.
4. Horowitz, A. Rami and Ishaaya, Isaac. (2009) *Insect Pest Management - Field and Protected Crops* by Mary Lou Flint and Robert van den Bosch**,** (1981).
5. Flint MC & Bosch RV. (2012). *Introduction to Integrated Pest Management.* Springer, New York.

Suggestive readings:

1. Pedigo, L.P. (1996) *Entomology and pest management*, prentice hall, New Delhi
2. Raymond A. Cloyd, Philip L. Nixon and Nancy R. Pataky. 2004. *IPM for Gardeners: A Guide to Integrated Pest Management*, Timber Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.