

DISCIPLINE SPECIFIC CORE COURSE – 14: Reproductive Biology of Angiosperms

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		
Reproductive Biology of Angiosperms – DSC 14	4	2	0	2	Class XII pass with Biology/ Biotechnology	Nil

Learning Objectives:

- To understand the scope of reproductive biology, development and structure of male and female reproductive units of the flower, organization of male and female gametophytes, pre-fertilization, fertilization and post-fertilization events.
- To understand the processes and significance of pollen--pistil interactions, apomixis and polyembryony.
- Significance of seed as a diaspore.

Learning Outcomes:

Upon completion of the course, the students will become familiar with:

- The significance and scope of reproductive biological studies in crop production and conservation. Structure and function of anther and ovule, male and female gametophyte.
- The significance of associations of MGU, FGU and double fertilization; embryo and endosperm development, genomic imprinting.
- Pollination and seed dispersal mechanisms, apomixis and polyembryony as alternate pathways of angiosperm reproduction.
- Experiential learning through field trips, scientific photography, videography and documentary preparation. The students will also learn to write scientific reports and present scientific data.

Unit 1: Introduction

01 Hour

Introduction about Reproductive biology and its scope; significant contributors to the field (SG Nawaschin, Heslop-Harrison, Jensen, Strasburger, P Maheswari, BM Johri, Amici, KR Shivanna); structure of flower.

Unit 2: Anther and Pollen

05 Hours

Anther wall: Structure and functions, microsporogenesis, microgametogenesis; Pollen wall: Structure and functions, Number Position Character (NPC), pollen viability and storage, Male Germ Unit (MGU) – structure and significance.

Unit 3: Pistil

04 Hours

General structure and types of pistil and ovules; megasporogenesis (monosporic, bisporic and tetrasporic-*Fritillaria* and *Plumbago* type) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac; cell specification; Female Germ Unit – structure and significance.

Unit 4: Pollination

04 Hours

Types (Self, cross, geitonogamy, xenogamy), significance; Structure of the stigma and style; Pollen-pistil interactions- capture, adhesion, hydration, pollen tube penetration; Path of pollen tube in the pistil; Role of synergids in pollen tube attraction; Double fertilization; Polyubey block

Unit 5: Self-Incompatibility

04 Hours

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self-incompatibility (in brief): mixed-pollination, intraovarian and in vitro pollination and fertilization, modification of stigma surface, parasexual hybridization.

Unit 6: Endosperm

02 Hours

Types (2 examples each), development, structure and functions; Genomic imprinting

Unit 7: Embryo

04 Hours

General pattern and comparison of development of dicot and monocot embryo (initial apical cell and basal cell polarity, globular embryo with radial polarity, mature embryo); Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo, haustorial systems: Embryo patterning.

Unit 8: Seed

02 Hours

Structure and importance of seed as diaspore, as storage organ; germination and seedling formation.

Units 9: Polyembryony and apomixis

02 Hours

Introduction, types, causes and applications.

Unit 10. Applications of Reproductive Biology

02 Hours

Haploid embryos (androgenesis and gynogenesis in brief)- concept and significance; crop productivity and conservation (5-6 points with special reference to reproductive biology)

Practicals

60 hours

- Anther: Wall and its ontogeny (permanent slides/photomicrographs of pollen wall layers: epidermis, middle layer and endothecium can be studied in young anther and mature anther), tapetum (amoeboid and glandular), Microspore mother cell, spore tetrads, uninucleate, bicelled, and dehiscent anther; Temporary stained mounts of T.S. anther to study the organization.
- Pollen: General morphology, dyad, pseudomonads, polyads, massulae, pollinia (slides/digital resources, fresh material); Ultrastructure of pollen wall (micrograph); Pollen viability: tetrazolium test/FDA; Pollen fertility test: acetocarmine test; Germination: calculation of percentage germination in different media using hanging drop/sitting method. (*Suggestion: Standard medium should be Brew-Baker & Kwack's medium. Comparison can be made between Brew-Baker & Kwack's medium with calcium/ Boron/ Sucrose and without calcium/ Boron/ Sucrose. This will help students to comprehend the importance of Calcium Sucrose and/or Boron in pollen germination*).
- Temporary mounts of pollen grains cleared with 1N HCl/KOH to study germ pores; Ultrastructure of male germ unit (MGU) through micrographs.
- Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; tenuinucellate and crassinucellate; Special structures: endothelium, obturator, hypostase, caruncle, elaiosomes, and aril (permanent slides/specimens/digital resources).
- Female gametophyte: developmental sequence of monosporic embryo sac only; Ultrastructure of Female Germ Unit (transmission electron micrographs of: egg cell, synergid); central cell; antipodals.
- Pollination Adaptations/Syndrome (1 example of each): Diurnal: (Insect {any 1-2 types} and Bird), Nocturnal (Bat and Moth)); bagging experiment (only demonstration); **project on pollination.
- Intra-ovarian pollination; Test tube pollination (through digital resources).
- Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria (Suggested material: *Cucumis sativa*, *Grevillea robusta*, *Croton*).
- Apomixis: Study of organization of aposporous and diplosporous embryo sac using photomicrographs of cleared ovule (DIC and/or confocal generated images)
- Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages (Suggested material: *Crotalaria*, *Calendula*); Study of suspensor through electron micrographs.
- Seed dispersal mechanisms (adaptations through live specimens/e resources: Autochory, Anemochory, Hydrochory, Zoochory, Myrmecochory, describe any 3 of them with 2 examples each), **project on seed dispersal

** The projects can be on pollination/ seed dispersal or any other topic based on the scope of reproductive biology. It can be a write-up with photographs. The students can also make a digital project submission in the form of a documentary of 5-10 min.

Suggested Readings:

- Bhojwani S.S., Bhatnagar S.P. & Dantu P.K. (2015). The Embryology of Angiosperms, 6th Edition. By VIKAS PUBLISHING HOUSE. ISBN: 978-93259-8129-4.
- P. Maheshwari, (2004). An introduction to the embryology of Angiosperms. Tata McGraw-Hill Edition, ISBN: 0-07-099434-X.

- Johri, B.M. (1984). Embryology of Angiosperms. Netherlands: Springer-Verlag. ISBN: 13:978-3-642-69304-5
- Raghavan, V. (2000). Developmental Biology of Flowering plants. Netherlands: Springer. ISBN: 978-1-4612-7054-6.
- Shivanna, K.R. (2003). Pollen Biology and Biotechnology. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.
- Mangla,Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Methods.Cambridge University Press ISBN 978-1-009-16040-7.
- Tandon R, Shivanna KR, Koul M Reproductive Ecology of Flowering Plants: Patterns and Processes 1st ed. 2020 Edition ISBN 978-9811542091.Springer Verlag
- Kapoor, R., Kaur, I. Koul M.2016. Plant Reproductive Biology and Conservation IK International Publishing House Ltd. India ISBN: 9789382332909 36

Additional Resources:

- Shivanna, K.R., Tandon, R. (2020). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London
- Shivanna, K. R., & Rangaswamy, N. S. (2012). Pollen biology: a laboratory manual. Springer Science & Business Media.

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- Shivanna, K.R., Tandon, R. (2020). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London
- Shivanna, K. R., & Rangaswamy, N. S. (2012). *Pollen biology: a laboratory manual*. Springer Science & Business Media.