Female Gametophyte Development

Objectives

- Ovary & ovule structure
- Megaspore development
- Female gametophyte development
- Endosperm & embryo development

Sporic Meiosis

Key: Haploid  Diploid

Megasporogenesis, Megagametogenesis & Ovule Development

- Ovules
- Ovary Wall
- Ovary
- Funiculus

Ovule & Megasporangium Structure

- Ginkgo ovules
- Pine ovule
- Megasporangium in a spike moss (Selaginella)
- Ovuliferous scale
Ovule Structure

Micropylar end
Chalazal end

Megasporogenesis

Meiosis I Megaspore Mother Cell
Meiosis II Haploid megaspore nuclei

Micropyle
Nucellus
Integuments
Micropyler end
Stalk of ovule (funiculus)

Megaporogenesis

Meiosis I
Meiosis II
Haploid megaspore nuclei

Migration and fusion of 3 megaspore nuclei to chalazal end
Chalazal nucleus (3n) dividing
Micropylar nucleus (n) dividing

Early stages of megaagametogenesis
Lilium megagametogenesis

1. Megaspore segregation
2. Nuclear fusion of micropylar and chalazal nuclei
3. First mitosis of micropylar and chalazal nuclei produces 2 cells at both ends
4. Second mitosis micropylar nuclei
5. Second mitosis chalazal nuclei

Polar nucleus (3n) at chalazal end
Antipodal cell (3n)
Antipodal cells (3n)
Polar nucleus (3n) at chalazal end

Megagametophyte = Embryo Sac

2 Antipodals (3rd antipodal not visible)
2 Polar nuclei
Egg
Synergids

Tetrasporic Development in Lilium

Monosporic Development in Polygonum
Angiosperm Female Gametophyte Development

1. Megasporogenesis produces megaspores
2. Megaspore produces female gametophyte
   ▶ Female gametophyte = embryo sac
3. Embryo sac produces an egg cell

Types of embryo sac development

1. Monosporic – Polygonum type
   – 1 functional megaspore
   – 7-celled, 8 nucleate embryo sac
   – All haploid cells

2. Tetrasporic – Lilium type
   – 4 functional megaspores
   – 7 celled, 8 nucleate embryo sac
   – Haploid: egg cell, synergids + 1 polar cell nucleus
   – Triploid: 3 antipodal nuclei + 1 polar cell nucleus

Embryo Sac Structure

- 3 Antipodal cells
- 1 central cell with 2 nuclei
- 1 egg cell
- 2 synergid cells

Double Fertilization in Angiosperms

- Three antipodal cells
- Sperm nuclei
- Zygote
- Egg
- Polar nuclei
- Synergids
- Generative nucleus
- Tube nucleus
- Tube
- Pollen tube
Double Fertilization = Two Fusions

Fertilization of egg cell
Sperm fusion with central cell nuclei - Lilium

Egg Cell
Sperm Nucleus
1n polar nucleus
3n polar nucleus
Sperm nucleus

Zygote
Endosperm

Early Endosperm Development

Endosperm

1. Definition
2. Functions
1. Support Embryo Development
2. Support Seedling Development after Germination
**Endosperm Presence in Mature Seed**

1. Transient Endosperm – absent in seed
   1. Many Dicots
      1. e.g. Soybean, Peanut, *Phaseolus*, Lettuce

2. Persistent endosperm – present in seed
   1. Endospermic Dicots: Castor bean, Fenugreek, Carob, Locust
   2. Most Monocots

**Modes of Endosperm development**

1. **Free Nuclear Endosperm** - Karyokinesis Only
   A. Cellularization From Periphery
   B. Limited Cellularization around Embryo
   C. No Cellularization

2. **Cellular Endosperm** - Karyokinesis followed by Cytokinesis
   A. Normal Cell Replication

3. **Helobial Endosperm** (some Monocots)
   Large Micropylar Cell → Free Nuclear Division → Cellularization
   Small Chalazal Cell → Limited Karyokinesis → No Cellularization

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**Free-Nuclear Endosperm Formation During Pea Seed Development**

**Cellular Endosperm Formation in Barley**
Variation in endosperm distribution within a mature seed

Monocot endosperm
Cellular & persistent

Dicot endosperm
Free-nuclear & transient

Mature Embryo

Shoot Apical Meristem
Embryonic Axis
Hypocotyl
Radicle
Cotyledons
Root Apical Meristem

Embryogenesis: Proembryo formation

2-celled
8-celled (octant)
16-celled

16-celled Proembryo

Protoderm
Separate Upper & Lower Tiers
Hypophysis
Suspensor
Early Heart-shaped stage & Histogenesis
- Shoot apical meristem
- Cotyledon primordia
- Protoderm
- Ground Meristem
- Procambium
- Hypophysis

Embryogenesis: Later Stages
- Cotyledons
- Heart
- Torpedo
- Bent cotyledon Walking Stick

Apical-Basal Organization during Embryogenesis
- Octant Stage
- Heart stage
- Early seedling
- Root cell of suspensor

Radial Organization during Embryogenesis
- Dermal Tissue System
- Fundamental Tissue System
- Vascular Tissue System

Apical-Basal Organization during Embryogenesis
- Terminal cell
- Basal cell
- Two-cell stage
- Apical cells
- Central cells
- Hypophysis
- Shoot apical meristem
- Cotyledons
- Root meristem
- Quiescent center
- Columella root cap

Apical cells → cotyledons & Shoot Apical Meristem
Central cells → stem, hypocotyl, root and root apical meristem
Hypophysis → Columella of root cap & Quiescent Center
Plant Embryogenesis

Stages of embryo development
- 1. 2 → 16 cell globular proembryo
- 2. Heart → Torpedo → Walking Stick → Bent Cotyledon

Polarity established during development
- 1. Zygote → Terminal cell & basal cell
- 2. Transition from radial to bilateral symmetry
- 3. Establish a longitudinal axis: shoot - root
- 4. Establish a radial axis: core to circumference
- 5. Establish apical meristems
  - 1. Shoot
  - 2. Root