VIDYASAGAR UNIVERSITY

Botany

Forestry

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Lecture for both 2nd Semester

ANGIOSPERM TAXONOMY

(BOT 201 , Unit-I) &

4th Semester Special Paper

(BOT 402A & BOT 403A) :

Angiosperms Taxonomy and Molecular Systematics

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Angiosperms: Flowering Plants

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Plant Taxonomy, Biosystematics and Molecular Systematics Laboratory

UGC-DRS-SAP-II and DBT-BOOST Supported

Department of Botany & Forestry

Vidyasagar University

21st March, 2020

- **Dominant sporophyte**
  - ➢Typically bisexual flowers that contain both types of gametophytes
    - ➢*Monoecious* = gametophytes are in different flowers on same plant (typical for gymnosperms)
    - ➢*Dioecious* = gametophytes in different flowers on different plants
- **Very reduced gametophyte**
  - ✓*Microgametophyte = pollen grain* (3 cells)
  - ✓*Megagametophyte* = embryo sac (8 nuclei/7 cells)

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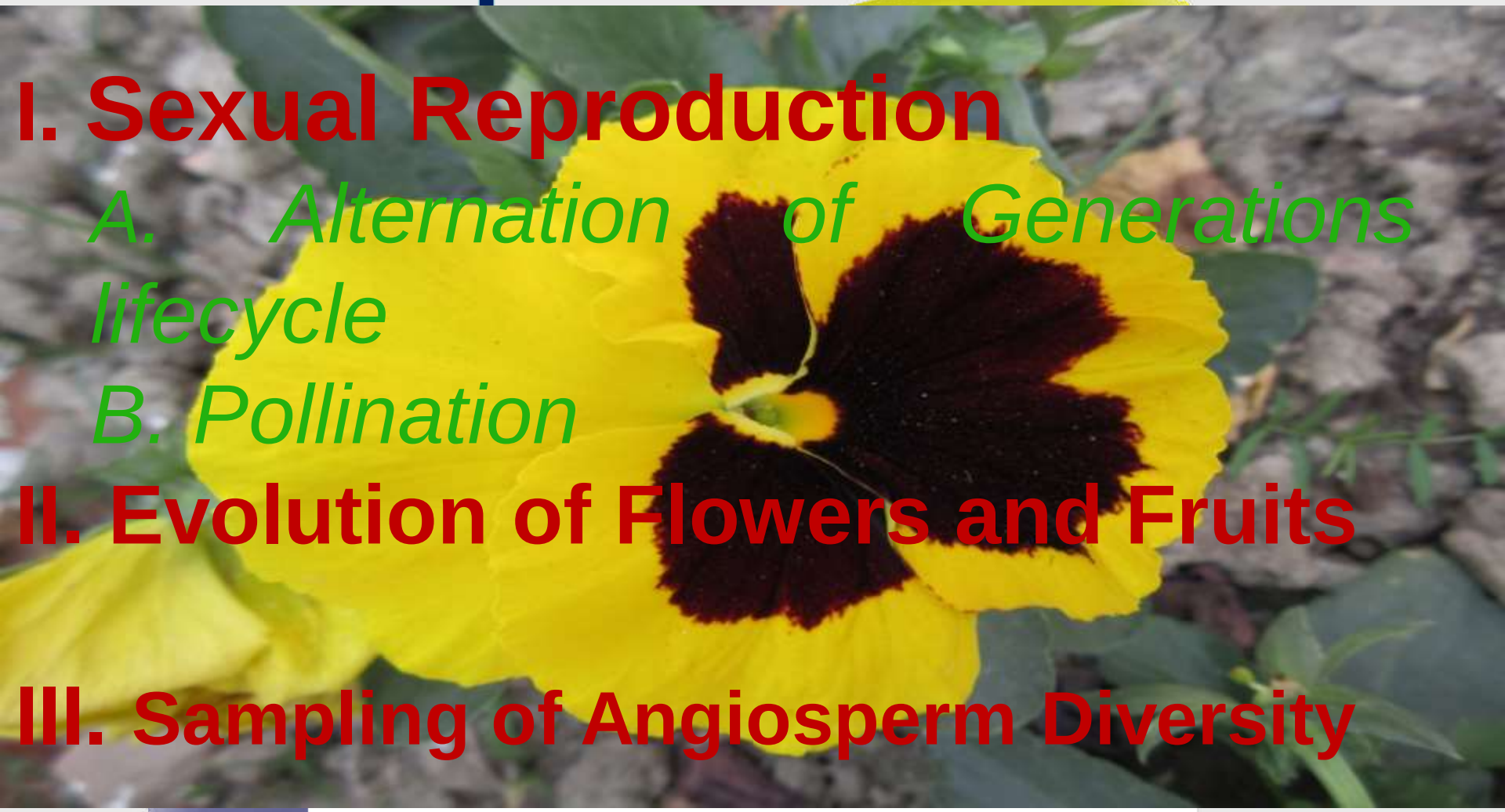
Chapter contents:



I. Sexual Reproduction

A. Alternation of Generations lifecycle

B. Pollination

II. Evolution of Flowers and Fruits

III. Sampling of Angiosperm Diversity

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Summary:

- Angiosperms are seed plants that are surrounded by a fruit at maturation
- Like all plants, angiosperms reproduce sexually with an alternation of generations lifecycle. The gametophytes are reduced to only a few cells in number.
- All flowering plants are in the same phylum, but they are the most numerous and most diverse of all living plants.

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A. Alternation of Generations lifecycle

Dominant sporophyte

Typically bisexual flowers that contain both types of gametophytes

Monoecious = gametophytes are in different flowers on same plant (typical for gymnosperms)

Dioecious = gametophytes in different flowers on different plants

Very reduced gametophyte

Microgametophyte = *pollen grain* (3 cells)

Megagametophyte = embryo sac (8 nuclei/7 cells)

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Microgametophyte

Stamen has *anther* with *microsporangia* (*pollen sacs*)

Spore mother cells undergo **meiosis** → haploid microspores → pollen grains

- Pollen contains 2 sperm (from generative cell) and 1 tube cell
- Pollen tube grows much more rapidly than in gymnosperms

Megagametophyte

Carpel has *ovary* which contains *ovule*

Ovule consists of *megasporangia* (*nucellus*) surrounded by *integuments*

Spore mother cells undergo **meiosis** → haploid megaspores → embryo sac

- Embryo sac contains 3 antipodal cells, 2 polar nuclei, 2 synergids (cells) and 1 egg cell
- Embryo sac (megagametophyte) is already mature at pollination

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Double fertilization

- One sperm fuses with 2 polar nuclei to form triploid endosperm
  - In dicots, endosperm is digested and used to form embryo (frequently in cotyledons)
  - In monocots, endosperm remains in seed until germination of seedling
- One sperm fuses with egg to form zygote

Fertilization occurs within days after pollination

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B. Pollination

Self-pollination

- Pollination takes place within one individual
- Good strategy if plants are isolated
- Bad strategy by reducing genetic variability

Cross-pollination

- Transfer of pollen from one individual to another
- Good strategy by increasing genetic variability and hybrid vigor
- Mechanisms to increase cross-pollination
  - Dioecious plants have to cross pollinate
  - Monoecious plants are more likely to cross pollinate
  - Bisexual flowers can have sperm and egg develop at different times or separate from one another
  - Self-incompatibility – plant's ability to reject its own pollen (common)

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Wind pollinated species

Small flowers without color, odor, or nectar

Must produce enough pollen for random transfer to other individuals of same species

Concern with wind-pollinated genetically modified crop plants that modified genes might transfer into native plants through hybridization

Water pollinated species

For some aquatic plants, pollen can float on the surface

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Animal pollinated species

Mutualism that evolved (*coevolution*) out of self-interest

Animals attracted by colors and odors as they search for food: nectar or pollen

- Bird → flowers produce lots of nectar, are usually large, odorless and frequently red
- Bat → nectar-rich flowers that bloom at night and have wide corolla tubes
- Bees → brightly colored flowers, often with blue or yellow petals
- Butterflies → brightly colored flower, with long narrow corolla
- Moths → flowers that bloom late in the evening or at night; typically white flowers with long, narrow corolla and sweet, strong odor
- Flies → flowers with strong, putrid odor (carrion flowers)
- Ants → flowers with sugar secretions

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II. Evolution of Flowers and Fruits

A. General Information

B. Flowers as Modified Leaves

C. Evolution of Angiosperms

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A. General Information

~ 285,000 known species

Advantages of flowering plants

- pollen tubes → fertilization without water needed by swimming sperm (also gymnosperms)
- Seed coats → protect against drying (both during and after development) (also gymnosperms)
- Seeds → dormancy during times of unsuitable conditions (also gymnosperms)
- Ovary/fruits → provide additional protection
  - OR protection of eggs may prevent self-pollination?
- Flowers → more efficient cross-pollination by animals
- Double fertilization/ endosperm → nourishes embryos
- Fruits → aid in seed dispersal
- Xylem vessels and deciduous leaves → efficient use of water

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B. Flowers as Modified Leaves

Stamen

- Evolved from modified sporophyll
- Exposed microsporangia become enclosed, while lower part of leaf became reduced → filament

Carpel

- Evolved from modified sporophyll
- Sporophylls may have folded in, enclosing megasporangia inside
- Several carpels might fuse to form a compound carpel with chambers

Sepals and petals

- Evolved from sterile modified leaves
- Probably started out very similar in appear, but diverged over time

Other trends:

- Number of floral parts becomes reduced from many to four, five, or multiples of three
- Arrangement of floral parts evolves from spiral (cone-like) to whorled Radial symmetry → bilateral symmetry

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C. EVOLUTION OF ANGIOSPERMS

1. Beginnings of Angiosperms
   - Geologic time scale on page 329
   - Eras
     - Periods
       - Epochs
2. Four groups of angiosperms, not two

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1. Beginnings of Angiosperms

Late Precambrian Era

~ 700 mya

Bryophytes evolved? (no fossils)

Paleozoic Era

~ 430 mya = *Silurian period*

Land plants appear in fossil record

~ 360 mya = *Late Devonian period*

Earliest complete bryophyte fossils

Appearance of seedless vascular plants

~350 mya = *Carboniferous period*

Seedless vascular plants are dominant

Appearance of gymnosperms

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Mesozoic Era

~ 245 mya = *Triassic period*

Gymnosperms are dominant

~ 200 mya = *Jurassic period*

Some angiosperm traits appear in fossils

Molecular data suggests angiosperms may have separated 280 mya

~ 142 mya = *early Cretaceous period*

Angiosperms appear in fossil record

Cenozoic Era

~ 65 mya = Paleocene epoch

Angiosperms are dominant

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1. Beginnings of Angiosperms

Rapid adaptive radiation occurred during the late Cretaceous period

Pollen grain structure has been used to classify angiosperms

- Single opening = *monoapertuate*
  - Seen in gymnosperms, primitive angiosperms, monocots
- Three openings = *triapertuate*
  - Seen in eudicots

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2. Four groups of angiosperms, not two

Traditionally two groups of angiosperms

Monocots and dicots

Molecular data indicates that dicots aren't monophyletic (they have had several lines of evolution)

- Monocots (~28%)
- Dicots
  - ✓Basal angiosperms (~0.5%)
  - ✓Magnoliids (~2.5%)
  - ✓Eudicots (~69%)

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Basal angiosperms

Are the most primitive flowering plants

Includes several families of herbs and woody shrubs

Share 3 important traits that are regarded as primitive

1. **Single pollen grain opening**
2. **Carpels form a tube with edges sealed by secretions**
3. **Stigma extends down the side of the carpel (isn't restricted to top)**

Several groups also lack vessels (or have tracheid-like vessels)

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Magnoliids

- Monophyletic group of about 20 families
- Arose about 125 – 130 mya
- Traits
  - Primitive: spirally arranged flower parts, numerous flower parts, pollen grains with only 1 opening
  - Advanced: carpels sealed by cells
  - Produce ethereal oils
    - Also occurs in monocots

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Monocots

- Grouped with magnoliids
- Traits
  - Single pollen opening
  - Flower parts in multiples of three
  - Embryos with one cotyledon
  - Morphology
    - Leaves typically with parallel veins
    - Stems typically with scattered vascular bundles
    - Fibrous root system

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EUDICOTS

- Traits
  - ➢ Pollen with three openings (unique feature)
  - ➢ Embryo with two cotyledons (same as basal angiosperms and magnoliids)
  - ➢ Flower parts typically in multiples of four or five
  - ➢ Stamen with well-differentiated anthers and filaments

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III. Sampling of Angiosperm Diversity

a. How are plants classified?

b. Examples of plant families

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a. How are plants classified?

- **Three types of data used:**
  1. Observable structural (flowers, fruits) and biochemical (secondary metabolites) traits
  2. traits that require microscopes or analytical equipment
  3. molecular data

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- **Families are distinguished by a combination of characters, rather than by any single trait**

  Flowers with parts in multiples of 5, petals fused into a ruffled corolla, fruits that are berries, individual flowers with superior ovaries, round stems, frequently have distinctly unpleasant odors when the leaves are crushed, produce similar, toxic, secondary metabolites

  Ex: Solanaceae (nightshade or potato family)

- Although sets of characteristics are used for classification, a diagnostic trait is often useful
  - Diagnostic trait = strong indicator that species is in a family, but not proof
  - Ex: Laminaceae (mint family) typically have square stems and aromatic leaves, but not all do, and some plants in other families have one or both of these traits
    - Other characteristics for mints: bilaterally symmetrical flowers, fused petals with 2 lips, superior ovaries, opposite leaves

b. Examples of plant families

1. Grass family (Poaceae or Graminae)
   - ~ 10,000 monocot species including nearly all the cereals
   - All are herbaceous (no wood production)
   - Wind pollinated
   - May have *perfect* or *imperfect* flowers
   - Fruit is a caryopsis (ex: corn grain)

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2. Orchid family (Orchidaceae)

- 20 – 38,000 monocot species (largest plant family)
- All are herbaceous; many are epiphytes
- Typically bilaterally symmetrical flower
- Many specialized pollination interactions
- Fruit is a capsule with many small seeds inside
- Seeds typically need a fungal partner in order to germinate and have seedling development

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3. Sunflower family (Asteraceae or Compositae)

- > 23,000 eudicot species (2nd largest plant family)
- Includes herbs, shrubs, and trees
- Inflorescences appear to be a single, radially symmetrical flower, but are complex structures with many disk and ray flowers
- Includes sunflowers, daisies, dandelions
- "Seeds" are actually achene fruits with seeds inside

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4. Legume family (Fabaceae or Leguminosae)

- > 18,860 eudicot species (3rd largest plant family)
- Includes herbs, shrubs, trees, and vines
- Many species form mutualistic associations with N-fixing bacteria in root nodules
- Bilaterally symmetrical flowers with one carpel, other parts occurring in multiples of 5
- Fruits typically legumes; embryos frequently have fleshy cotyledons

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5. Gourd family (Cucurbitaceae)

- > 800 eudicot species including squash, melons, pumpkins
- Includes herbs and vines
- Usually imperfect flowers (requires pollinators)
- Flowers radially symmetrical
- Fruit is a specialized berry (pepo) with many seeds

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6. Duckweed family (Lemnaceae)

- World's smallest flowering plants (< 1mm across)
- Leaf-like structures are actually reduced stem; some species are rootless
- Duckweeds serves as food for aquatic animals, and makes an excellent Biol 300 organism for population studies.

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Thank you