Lecture Outline: Reproduction And Domestication Of Flowering Plants

I. **Introduction to Angiosperms and Sexual Reproduction**
   A. Characteristics of Flowering Plants (Angiosperms)
      1. Angiosperms are the most successful plants
      2. Flowers serve as reproductive organs and an advertisement for pollinators
      3. Plants require cooperation from other organisms to help them with their reproduction because they cannot move around
   B. Pollination Mechanics
      1. Pollinators include insects (most prevalent), birds, and bats
      2. Pollination typically involves the plant offering a reward (e.g., nectar) to entice pollinators
      3. Unusual Example: A plant tricks a bee by emitting a substance that makes the flower smell like another bee, ensuring pollen transfer without providing a reward
   C. The Three Fs of Angiosperms
      1. Flowers
      2. Fruit (develops from successfully fertilized flowers)
      3. Double Fertilization (a defining, special event)

II. **Flower Structure and Development**
   A. The Four Whorls (in a Complete Flower)
      1. A flower is only termed complete if it possesses all four whorls
      2. Whorls are classified by function:
         a. **Sterile Whorls** (do not directly produce gametes)
            (1) Sepals
            (2) Petals
         b. **Fertile Whorls** (do directly produce gametes)
            (1) Stamens (Male Parts)
               1. Filament (stalk)
               2. Anther (bag-like terminus where pollen grains containing male gametes are produced)
            (2) Carpels (Female Parts)
               1. Ovary (bulbous base where eggs/ovules are made)
               2. Style (slender structure)

3. Stigma (sticky end for pollen attachment)

B. ABC Hypothesis of Whorl Development
   1. Four whorls are concentric layers (Sepals → Petals → Stamens → Carpels)
   2. Three genes (A, B, C) control the development of the whorls
   3. Gene combinations determine the developing structure:
      a. A gene only → Sepals
      b. A gene + B gene → Petals
      c. B gene + C gene → Stamens
      d. C gene only → Carpels
   4. Mutants lacking one of the genes result in abnormal or sterile flowers

III. **Angiosperm Life Cycle and Double Fertilization**

A. Ploidy and Alternation of Generations
   1. Ploidy is how many of each type of chromosome a cell has (N is haploid, 2N is diploid)
   2. Plants exhibit alternation of generations where both the haploid (N) and diploid (2N) stages are multicellular
   3. The visible plant is the diploid (2N) **Sporophyte** generation
   4. The haploid (N) **Gametophyte** generation is small and hidden inside the flower

B. Female Gametophyte Development
   1. The Ovule (2N) contains the Megasporangium tissue (produces comparatively bigger spores)
   2. Meiosis produces four haploid cells (N)
   3. Unequal division results in one large, surviving **Megaspore**; the other three disintegrate
   4. The Megaspore nucleus undergoes three rounds of mitosis, resulting in eight nuclei
   5. Partial cytokinesis results in the seven-cell female gametophyte:
      a. Three Antipodal cells (at the end opposite the opening, function often unknown)
      b. One **Egg** cell (N)
      c. Two Synergids (produce chemical attractants to guide the pollen tube)
      d. One large **Central Cell** (contains two haploid nuclei, making it functionally 2N)

C. Male Gametophyte Development
   1. The Anther (2N) contains Microsporangium tissue (produces smaller spores)
   2. Meiosis produces four equally viable haploid **Microspores** (N)
   3. Microspore undergoes mitosis and specific cytokinesis, resulting in a pollen grain (the male gametophyte)
   4. The Pollen grain contains two cells:
      a. Tube cell (outer cell, forms the pollen tube)

    b. Generative cell (inner cell)
  5. The Generative cell divides again to produce two **Sperm Cells**, both housed within the Tube cell

- D. Double Fertilization and Seed Formation
  1. The Tube cell bores a tunnel through the style toward the ovule, attracted by synergid chemicals
  2. The two sperm cells are released upon reaching the ovule opening
  3. First fertilization: One sperm (N) fertilizes the Egg (N) → Diploid **Zygote** (2N)
  4. Second fertilization: The other sperm (N) fertilizes the Central Cell (2N) → Triploid **Endosperm** (3N)
  5. The Zygote undergoes mitosis to become the multicellular **Embryo** (the next sporophyte generation)
  6. The Endosperm provides nutrients (food source) for the growing embryo
  7. The Ovule is renamed the **Seed** once successful fertilization occurs and the embryo begins developing
  8. Hypothesis for Double Fertilization: It saves energy by shutting down fruit development if fertilization fails

IV. **Seed and Fruit Structures**

- A. Embryo and Germination
  1. The early embryo (pro-embryo) differentiates into a terminal cell and a basal cell
  2. Terminal cell develops into the embryo and the seed leaves (**Cotyledons**)
  3. Cotyledons transfer nutrients to the rest of the embryo
  4. Nutrient storage depends on the species:
     - a. Some species retain large endosperm tissue (e.g., common garden bean), with cotyledons acting as middlemen
     - b. Other species absorb the nutrients early, making the cotyledons large and the endosperm small (e.g., castor bean)
  5. Eudicot Germination: Root system (taproot) emerges first; a hook shape drags the exhausted cotyledons out of the soil, which then wither as conventional leaves begin photosynthesis
  6. Monocot Germination (e.g., corn/maize): Two structures erupt:
     - a. Radical (develops into a fibrous root system)
     - b. Coleoptile (a tough cylinder that burrows through the soil, protecting the tender developing leaves)
- B. Fruit Classification
  1. Botanical Definition: Fruit is the structure that flowers turn into, bearing the seeds

2. Simple fruit: Develops from a single carpel containing a single ovary (e.g., pea pod)
3. Aggregate fruit: Develops from a single flower with multiple carpels; multiple fruitlets grow together (e.g., raspberry)
4. Multiple fruit: Develops from an inflorescence (multiple tiny flowers grouped together); fruits grow together (e.g., pineapple sections)
5. Accessory fruit: The fleshy, edible part develops from the receptacle, not the ovary (the ovary forms the inedible core, e.g., apple)

V. **Reproductive Strategies and Domestication**

A. Seed Dispersal

1. Abiotic dispersal: Primarily by wind or by water (for buoyant seeds)
2. Biotic dispersal (animals):
    a. Seeds carried by sticking to the animal's hide (e.g., puncture vine)
    b. Seeds consumed in edible fruit, surviving digestion, and being deposited along with fertilizer

B. Minimizing Self-Fertilization (Inbreeding)

1. Inbreeding is evolutionarily disfavored because it maximizes the chance of deleterious recessive alleles combining
2. Dioecious species (Two houses): Male (staminate) and female (carpellate) flowers are on separate plants, requiring outbreeding
3. Complete flowers minimize self-fertilization via structure: differences in stamen and carpel length (Thrum vs. Pin flowers) ensure pollen transfer occurs only between different flower types

C. Asexual Reproduction and Cloning

1. Asexual reproduction creates exact genetic duplicates (clones) from a single parent
2. Advantage: Maintains high fitness when the environment is stable
3. Disadvantage: Lack of genetic variability makes the species vulnerable to a changing environment
4. Example: Aspen trees form massive clones
5. Plants are easier to clone than animals because their meristems contain **totipotent** stem cells throughout their lifetime

D. Biotechnology and Genetic Modification

1. Biotechnology (general definition): Using an organism to create a humanly beneficial product
2. Agriculture is an old form of genetic modification via artificial selection (e.g., selecting traits that led to modern corn)
3. Modern Genetic Modification (GMOs) involves directly altering genes

4. Types of Molecular Genetic Modification:
    a. Transgenesis: Transferring a gene between highly unrelated organisms (e.g., jellyfish gene into a mouse)
    b. Cisgenesis: Transferring a gene between closely related organisms (e.g., similar types of plants)
5. Benefits of GMOs:
    a. Reducing the need for chemical pesticides
    b. Improving food quality (e.g., Cassava modified to increase vitamins and reduce natural toxins)