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Pollination Biology

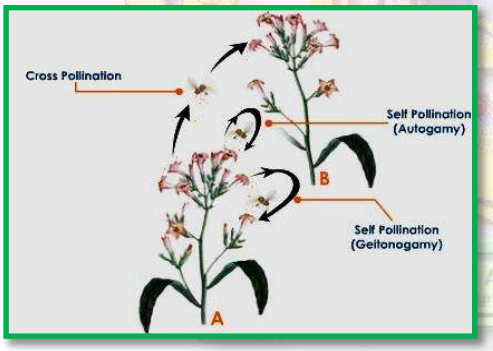
(*Niharika Sheoran, Ankush Kumar, Lovepreet Kaur and Sushil Kumar)
Chaudhary Charan Singh Haryana Agricultural University, Hisar- 125004, Haryana
*niharikamailid@gmail.com

Introduction

- **Pollination** is the process by which pollen is transferred in the reproduction of plants, thereby enabling fertilisation and the production of fruit and seeds (sexual reproduction).
- **Abiotic pollination**: pollination without the involvement of other living organisms (e.g. wind or water). Only 10% of flowering plants are pollinated without animal assistance.
- **Biotic pollination**: pollination by a pollinator (insects are the most important pollinating animals, but birds, bats and rodents are also pollinators of some plants.

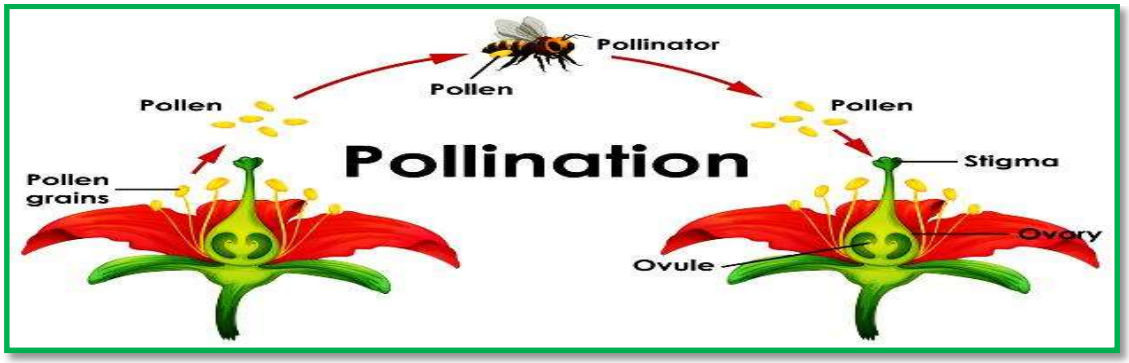
Self- & cross-pollination

- **Cross-pollination**: the transfer of pollen from an anther of the flower of one plant to a stigma of the flower of another plant.
- **Self-pollination**: fertilisation by transfer of pollen from the anthers of a flower to the stigma of the same flower (autogamy) or to the stigma of another flower on the same plant (geitonogamy)



Self: no exchange of genetic material

Cross: exchange of genetic material



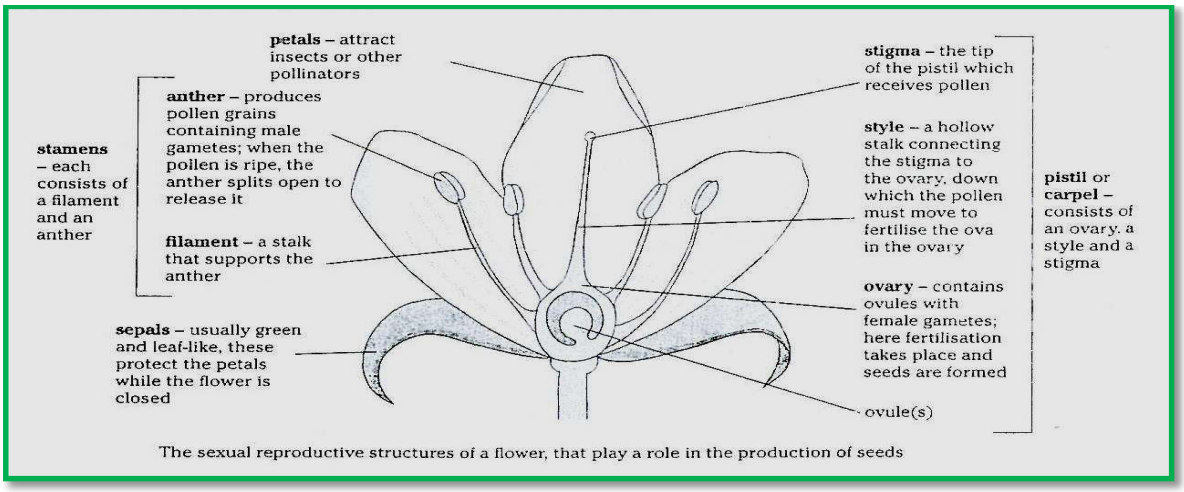
Pollination History

- The first fossil record for abiotic pollination is from fern-like plants in the late Carboniferous period (350 mya).
- Gymnosperms show evidence for biotic pollination as early as the 251-199 mya
- Many fossilized pollen grains show characteristics similar to biotically-dispersed pollen today.
- The gut content, wing structures and mouthparts morphologies of fossilized beetles and flies suggest that they acted as early pollinators.
- The association between beetles and angiosperms during the early Cretaceous (145-65.5 mya) period led to parallel radiations of angiosperms and insects into the late Cretaceous.
- The evolution of nectaries in late Cretaceous flowers signals the beginning of the mutualism between hymenopterans (with membranous wings) and angiosperms.

Agents of pollination

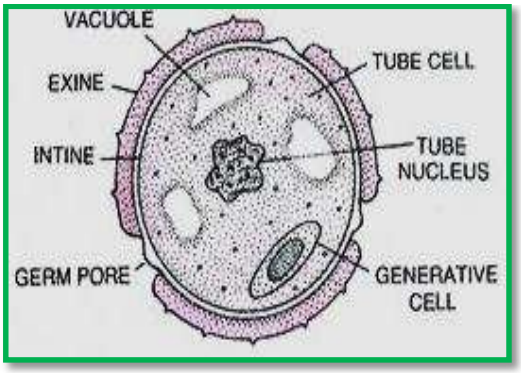
- Cross-pollination depends on insects visiting flowers of the same species in sequence. To help ensure that this happens, the plants have various characteristics that help pollinators locate the right flowers, including the colour, size, shape and scent of the flowers, as well as the food reward.
- *Sunbird: tubular, colourful flowers*
- *Beetles: flat or cup-shaped (big) flowers*
- *Honeybee: many varied flower types*

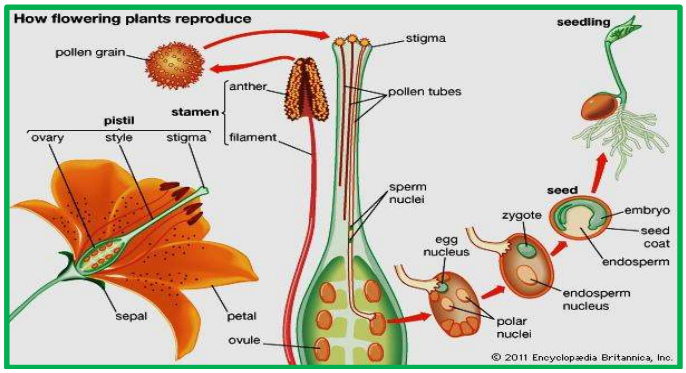
Parts of the flower



The sexual reproductive structures of a flower, that play a role in the production of seeds

Structure of Pollen





Modes of pollination

Many flowering plants rely on animals for cross-pollination:

- **Insects** – bees, wasps, flies, butterflies, moths
- **Birds** – hummingbirds, honey creepers
- **Mammals** – bats, mice, monkeys
- Bird, bat and insects are more important biotic agents
- Among insects honey bees play major role

Abiotic Pollination

- Uses a nonliving vector
- Usually considered to be a metabolically wasteful process

Two types:

- Anemophily- "wind lover"= wind pollination
- Hydrophily- "water lover" = water pollination

Anemophily

- Major type of abiotic pollination
- Usual Floral Morphology:
    - Incomplete flowers that often lack perianth
    - Color and scent lacking
    - Flowers in inflorescences elevated above the vegetation
    - Flowers often open before leaves are produced
    - Large quantities of smooth, dry pollen produced
- Hydrophily
    - Rarer type of abiotic pollination
- Usual Floral Morphology:
    - Mostly asexually reproduces by fragmentation
    - During sexual reproduction, anthers break off and float to surface
    - Releasing pollen that sinks to the female flowers that grow under the water
    - Rare pollination in one of the most primitive groups

Biotic Pollination

- Co-evolution between plant and animal based on mutual benefit
- Mutualism or where the plant benefits and animal is harmed
- Parasitism or deceit pollination

Co-evolution of plants and insect pollinators

- Co-evolution term was coined by P.R. Ehrlich and P.H. Raven in 1964 from a study of butterflies and their host plants.
- Co-evolution is a change in the genetic composition of one species (or group) in response to a genetic change in another species.
- Reciprocal interactions over evolutionary time between insects and their niche, have been described as coevolution.
- Flowering plants have co-evolved with their pollinator partners over million of years producing a fascinating and interesting diversity of floral strategies and pollinator adaptation.
- The great variety in colour, form and scent we see in flower is a direct result of the intimate association of flowers with pollinators.

Characteristics of flower favoured by pollinators:

In insect pollinated plants, flowers should be-

- Large,
- Brightly colour
- Distinct fragrance
- Presence of nectar and sticky pollen.

Entomophily: refers to cross pollination aided by insects.

S. No.	Pollination classes	Types of insects
1.	Melitophily	Bees
2.	Cantharophily	Beetles
3.	Myophily	Flies
4.	Sphingophily	Syrphid and bombylid flies
5.	Psychophily	Butterflies
6.	Phalaeophily	Small moths

Insect pollinators

- *Apis* species- *mellifera, cerana, dorsata* and *florea*.
- Stingless bees
- Bumble bees
- Alkali bees
- Scolids
- Andrenids
- Xylocopids
- Halictids
- Megachilids
- Anthophorids
- Syrphids
- Other dipterans like *Musca*, midges, calliphorids
- Some lepidopterans.

Invertebrate Pollinators -Flies (Dipterophily)

Hover Flies

- Usual Floral Morphology:
- Long tubular flowers with corolla marked as a guide for fly's siphoning mouthparts

Carrion Flies (Sapromyophily) "flies that are decay lovers"

- Usual Floral Morphology: deceit pollination with bilateral perianth with hairy opening and odors that mimics a corpse

Invertebrate Pollinators -Beetles (Coleopterophily)

- Usual Floral Morphology: radial symmetry with many free parts and lots pollen

Invertebrate Pollinators -Bees and Wasps (Hymenopterophily)

Bee Pollination (Melittophily = "bee lover")

- 20,000 different species of bee pollinators
- Usual Floral Morphology: sterile stamen that is pubescent called a staminode gives them
- Their common name beard tongue
- Bilabiate with staminode acting like a "tail hook" for bees
- White to lavender-blue corolla with purple and UV nectar guides

Invertebrate Pollinators -Bees and Wasps (Hymenopterophily)

- Wasps

- Floral morphology is highly variable.
- Flowers enclosed in inflorescence have eggs that hatch and
- Males mate with females and die.
- Females leave inflorescence and lay eggs in another inflorescence ensuring cross pollination

Invertebrate Pollinators -Butterflies and Moths (Lepidopterophily)

Examples of moth pollinated plants – Liliaceae, Yucca

- Carries balls of pollen from one plant to another and cross-pollinates flowers.
- Lays eggs in one locule of ovary and larvae consume seeds that develop there.
- Other 2/3s of seeds are dispersed.

Importance of honeybees & their relationship to our food

Ecological value of pollination

- Valuable in their own right
- Part of ecology

Human value of pollination

- Crops for human food + animal fodder
- Fibres, wood and other materials
- Plant breeding & flowers
- Medicines
- Aesthetic value

Pollinators and our food

- Insect pollination is essential for 35% of global food production. "*You can thank an insect pollinator for 1 out of every 3 bites of food you eat!"*
- Insects pollinate the flowers of the fruit and vegetable plants we rely on for a healthy and balanced diet (apples, melons, pumpkin, etc) while most of the staple food plants can self-pollinate or are wind-pollinated (like maize and wheat), or reproduce vegetatively (like potatoes).
- A world without insect pollinators would mean a world of far fewer food choices, more expensive food, and vastly different agriculture
- Out of 95% of the flower which are cross-pollinated, >85% depend on insect for pollination.
- ~50% of the plant species propagated by seeds are dependent on insect pollination.
- In the world about 1/3rd of the food supply is either directly or indirectly dependent on insect pollinated plants.

Bees as pollinator

- Bees – are the most important group of flower pollinators.
- They live on the nectar and feed larvae, also eat the pollen.
- Bees are guided by sight and smell.
- See yellow and blue colours, also ultraviolet light (not red).

Qualities of honeybees which make them good pollinators

1. Body covered with hairs and have structural adaptation for carrying nectar and pollen.
2. Not injurious to plants
3. Adult and larva feed on nectar and pollen - Available in plenty
4. Superior pollinators - Since store pollen and nectar for future use
5. No diapause - Need pollen throughout year
6. Body size and proboscis length - Suitable for many crops

7. Pollinate wide variety of crops
8. Forage in extreme conditions also (weather)

Honeybees

- Many commercial pollinator-dependent crops are reliant on the honeybee as their pollinator.
- For most crops, *honeybees are the most economically valuable pollinators* because they are:
    - Very effective pollinators.
    - Indigenous (i.e., they are naturally found here).
    - They can be managed in the huge numbers needed to supply the pollination service to our large-scale commercial crops.
- Beekeepers supply the pollination service to growers/farmers, as well as harvest the honey from the bees to bottle and sell.

% Increase in yields by bee pollination over self pollination of different field and horticultural crops.

S. No.	Crop	% Increase
1.	Apple	180 to 6950
2.	Cherry	56 to 1000
3.	Citrus varieties	21 to 411
4.	Guava	70 to 140
5.	Litchi	4538 to 10246
6.	Orange	471 to 900
7.	Pears	240 to 6014
8.	Persimmon	20
9.	Plum	6.7 to 2739
10.	Strawberry	38 to 68
11.	Cabbage	100 to 300
12.	Carrot	9 to 135
13.	Onion	354 to 9878
14.	Radish	22 to 100
15.	Turnip	100 to 125
16.	Brown mustard	13 to 222
17.	Linseed	2 to 40
18.	Rai	18
19.	Rape	12 to 139
20.	Sunflower	72 to 82
21.	Toria	66 to 120
22.	White mustard	128 to 152
23.	American cotton	5 to 20
24.	Alfalfa	23 to 19733
25.	Berseem	23 to 150
26.	Brood beans	7 to 90
27.	Coffee	17 to 83

Honeybee Pollination

A worker bee travels to collect nectar and pollen for its hive. When it visits a flower, the bee's feet collect bits of pollen from the male part of the flower (the anther). The bee

travels to another plant of the same type with the pollen clung to its feet. While slurping nectar at the second flower, the bee deposits the pollen on that flower's stigma (the female part).

Planned Honey Bee Pollination and Crop Productivity

- India sustains a variety of temperate to tropical crops, most of which depend upon bees for their pollination.
- Our country have over 50 million hectares land under various oilseed, legumes, vegetables, orchard and plantation crops that require cross pollination by bees to realize their potential yields.
- Increase in yield under open pollination depends upon natural densities of bees and other pollinators in the local context.
- The number of average sized bee colonies needed for effective pollination of different crops ranges from 3 to 9 per hectare for *Apis cerana indica* and 2 to 5 colonies for *A. mellifera.*
- The total no. of colonies needed for crop production in India have been estimated to the tune of 150 million of *A. cerana* or 100 million of *A. mellifera.*
- It can be concluded that in India where more than 65 % of crops are insect pollinated, in addition there exists a wide plethora of flowering weeds, herbs, shurbs, trees, creepers and bushes which are available to pollinators.
- In this scenario where several essential agri- inputs viz. seeds, fertilizers, irrigation, implement, pesticides etc. came to a standstill and fail to add even marginally to the returns, planned pollination through honey bees is essential for further improvements in agricultural production in our country.

Butterflies and moths

- Also guided by sight and smell.
- Butterflies can see red and orange flowers.
- Usually shaped as a long tube because of insect's proboscis- to get nectar.
- Moth-pollinated flowers are usually white or pale, with sweet, strong odour- for night pollination.

Flies and beetles

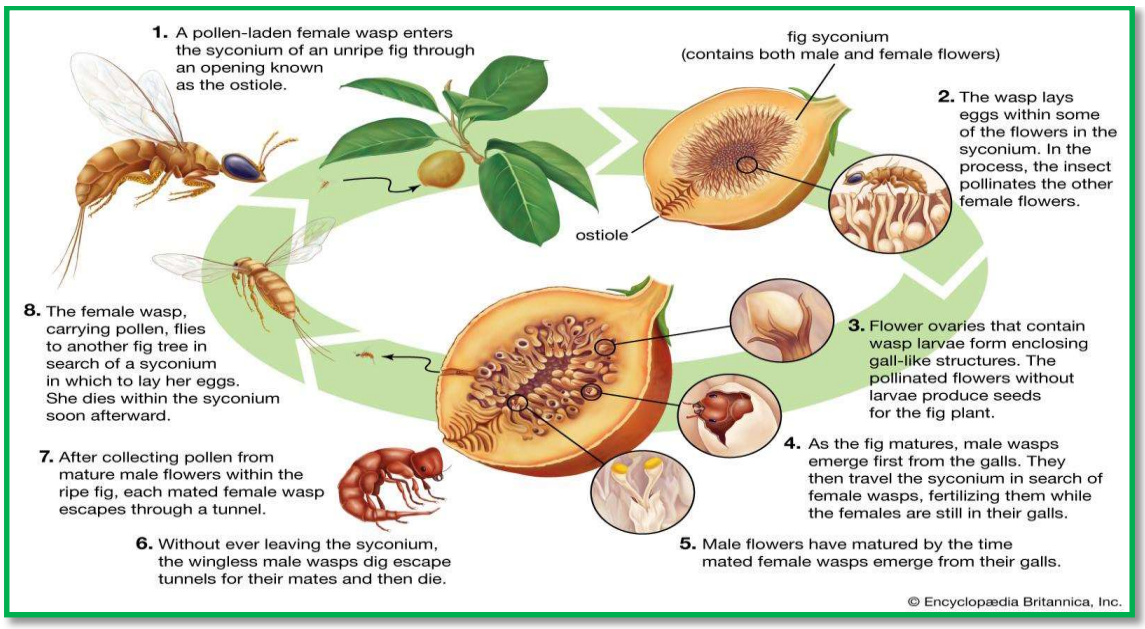
- Flies like flowers that smell like dung or rotten meat and lay their eggs there.
- Beetles pollinate flowers that are dull in colour, but have very strong odour.

Fig wasp

- Fig wasp : *Blastophaga psenes* (Agaonidae:Hymenoptera)
- Fig is pollinated by fig wasp only.
- There is no other mode of pollination.
- There are two types of fig Capri fig and Symrna fig

Capri fig	Smyrna fig
1. It is a wild type of fig- not edible	1. It is the cultivated type of fig- Edible
2. Has both male and female flowers	2. It has only female flowers
3. Pollen is produced in plenty	3. Pollen not produced
4. Natural host of fig wasp	4. Not the natural host of fig wasp

- Fig wasp: Male - wingless, present in caprifig Female – winged



Pollination – mutually beneficial

- Approximately two-thirds of the flowering plants are pollinated by insects.
- In return for pollen transfer, plants provide food to its pollinators in the form of nectar and pollen.

Adaptations for insect pollination

- **Plant perspective**

The pollens are adapted for adhering to the body of the insects, as it is sculptured and coated with a sticky oil.

- **Insect perspective**

Hairs on the body aid in carrying the pollen from one flower to the next.

Attractants for pollinator

a. Primary attractants:

They satisfies demands for foods e. g. pollen and nectar

b. Secondary attractants:

They advertise the presence of the primary attractants e. g. color, scent and shape of the flowers

Flower colours

- Bees can recognize four color groups as yellow, blue- green, blue and ultraviolet, but are not attracted toward red color flowers.
- *Aquilegia formosea* the crimson coloumbine has red flowers and is pollinated by humming-bird. But, *A. pubescens* has whitish flowers and is pollinated by the hawk moths.

Flower shapes

- In plant, *Digitatis purpurea* the flowers are sufficiently wide for pollinator (bumblebee) to creep into it, as in a bell shaped bloom.

Plant Mimicry

- Certain orchids look like female wasps, and even smell like them! The orchid gets pollinated,
  but the male wasp.