Dr.V.R.PATIL:

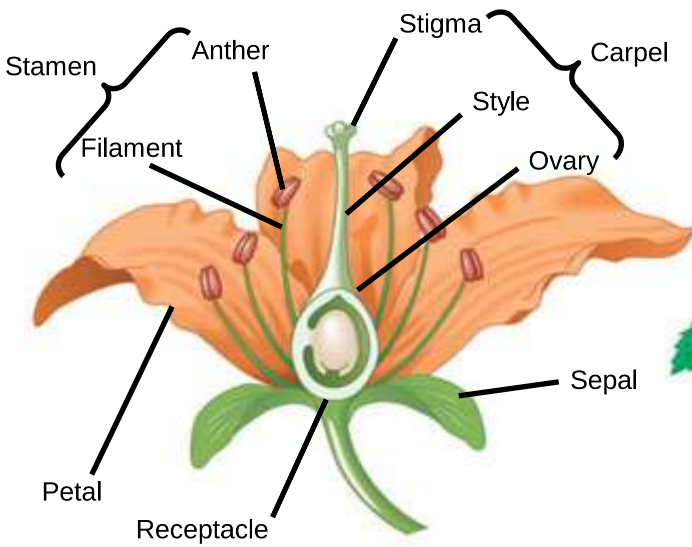
Angiosperm Reproduction and Biotechnology

Review

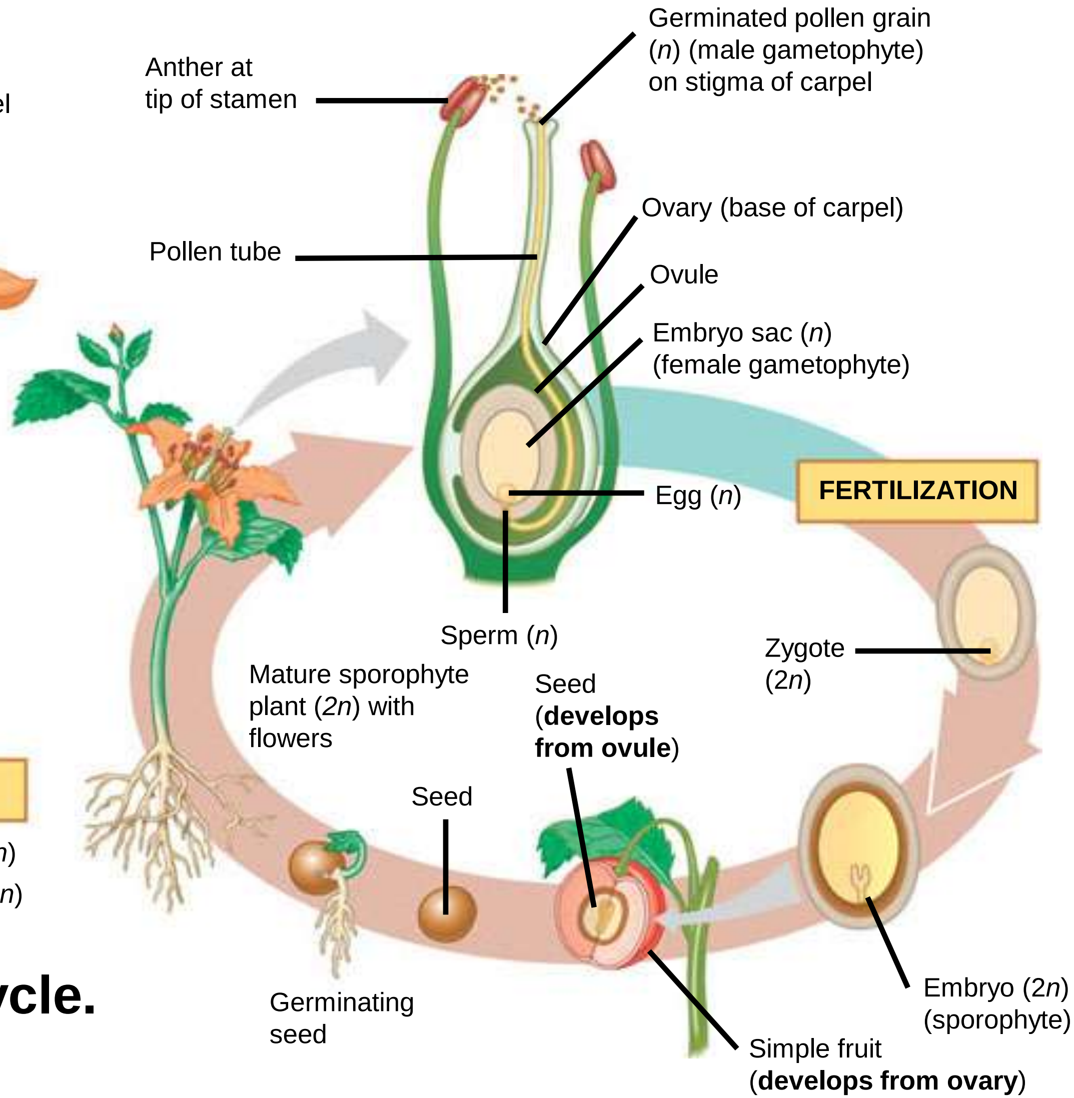
In angiosperms, the dominant sporophyte (remember that *alternation of generations* as a key plant trait)

- Produces male gametophytes (pollen grains) within anthers
- Produces female gametophytes (embryo sacs) within the ovule
- With fertilization (union of sperm and egg) the ovules develop into seeds, while the ovary becomes the fruit.

An overview of angiosperm reproduction



An idealized flower.



Key

Haploid (*n*)

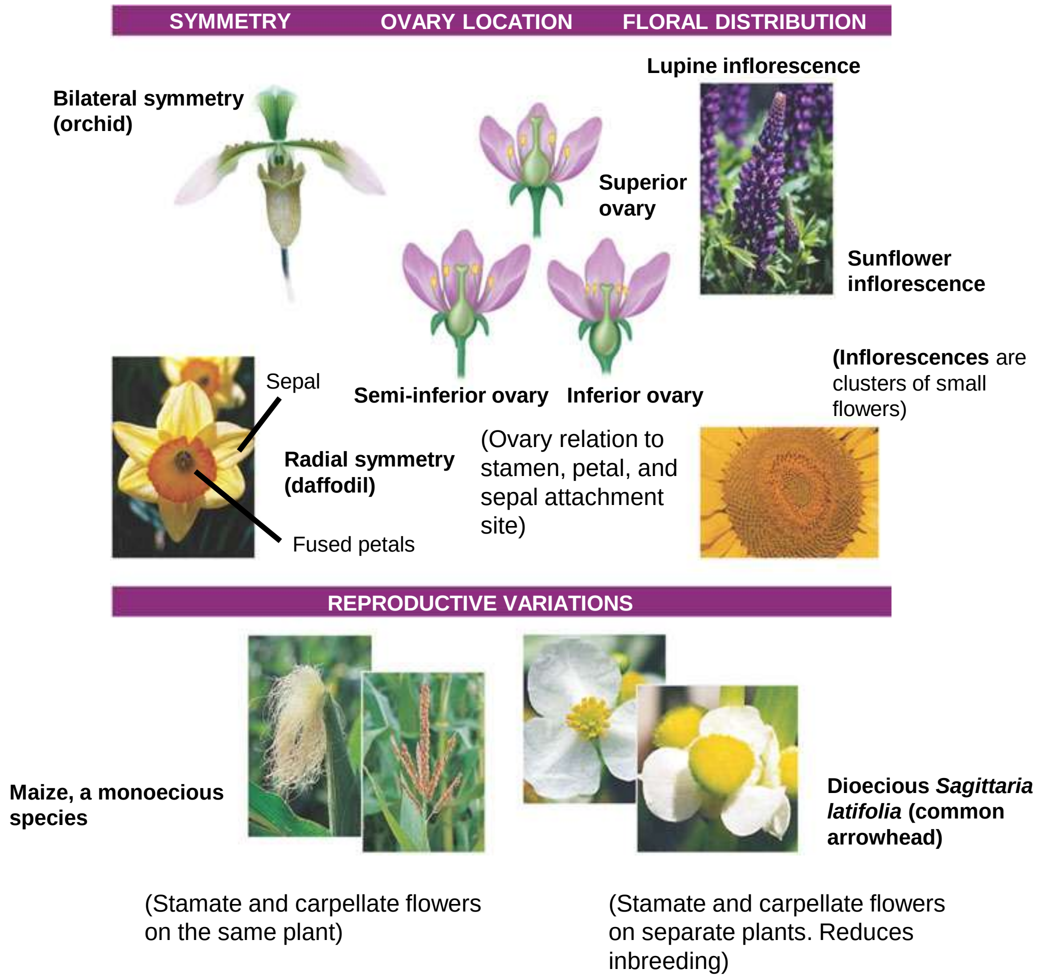
Diploid (2*n*)

angiosperm life cycle.

Flower Structure

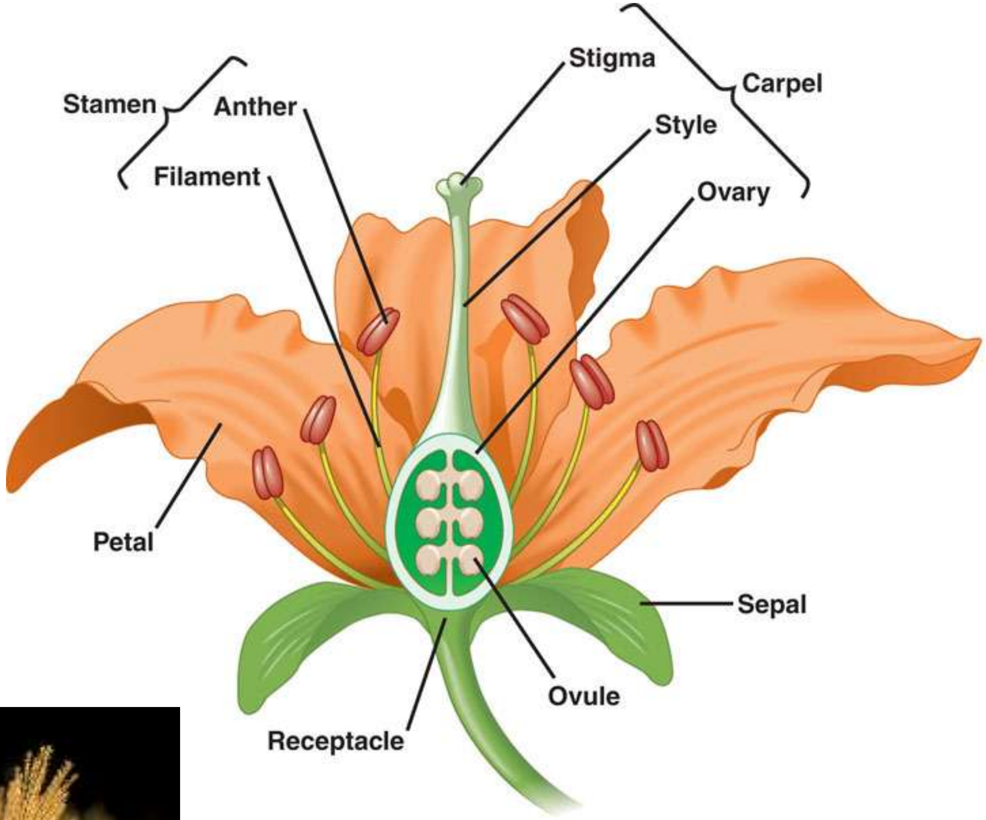
- Flowers
  - Are the reproductive shoots of the angiosperm sporophyte
  - Are composed of four floral organs: sepals, petals, stamens, and carpels
  - Many variations in floral structure have evolved

Flower variations



Flower Parts

- **Sepals** - enclose and protect flower bud before it opens
- **Petals** – may be colored to advertise the flower to pollinators
- **Carpels** – **ovary** base, slender neck (**style**), and **stigma** (a landing platform for pollen)
- **Stamen** – **filament** stalk and terminal **anther** (which contains the pollen sacs)
- **Complete flowers** have all four basic flower organs
- **Incomplete flowers** lack something (grass flower may lack petals)



Pollination

- Pollination is the transfer of pollen from an anther to a stigma
- If pollination is successful, a pollen grain produces a **pollen tube**, which grows down into the ovary and discharges sperm near the embryo sac

Pollen grain development

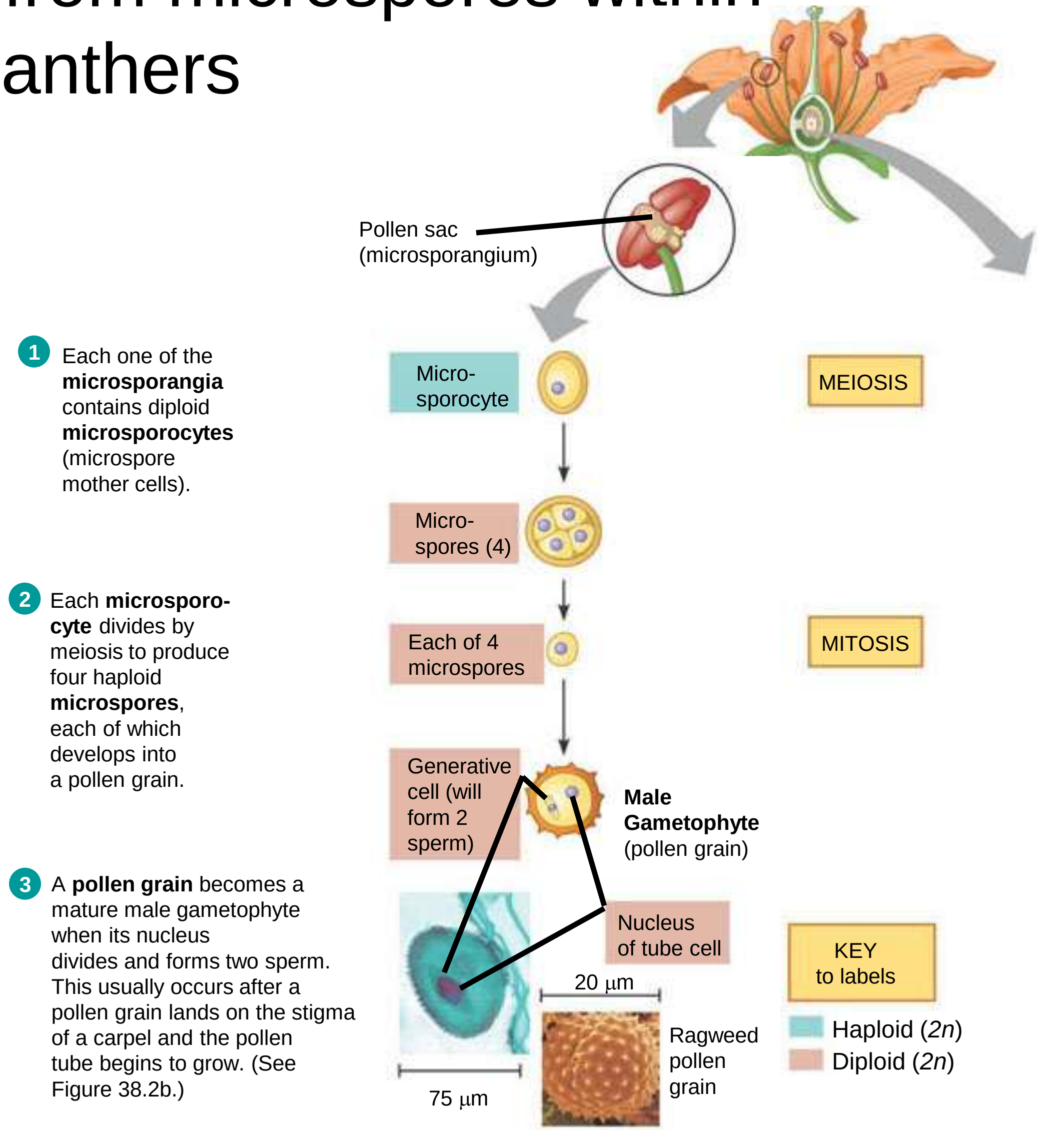
- Pollen develops from microspores within the sporangia of anthers

Microsporangium

Microsporocyte

Microspore

Pollen grain



Embryo sac development

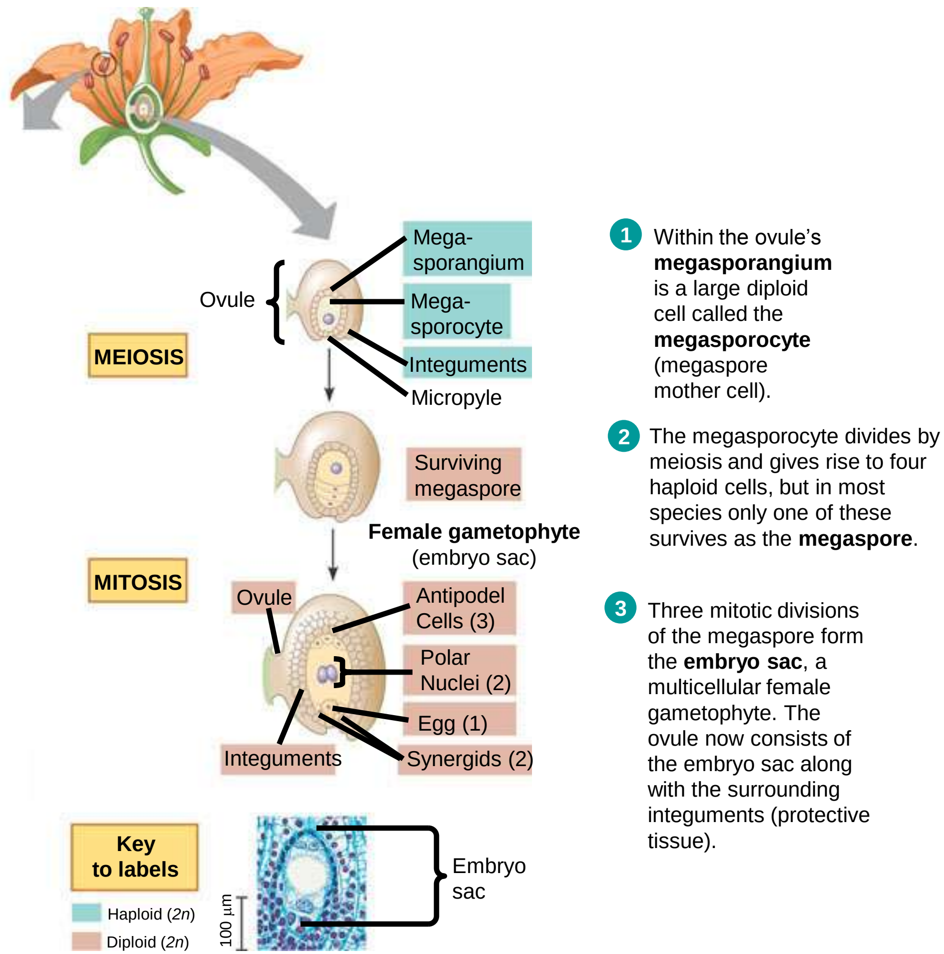
- Embryo sacs develop from megaspores within ovules

Megasporangium

Megasporocyte

Megaspore

Embryo sac



Mechanisms That Prevent Self-Fertilization

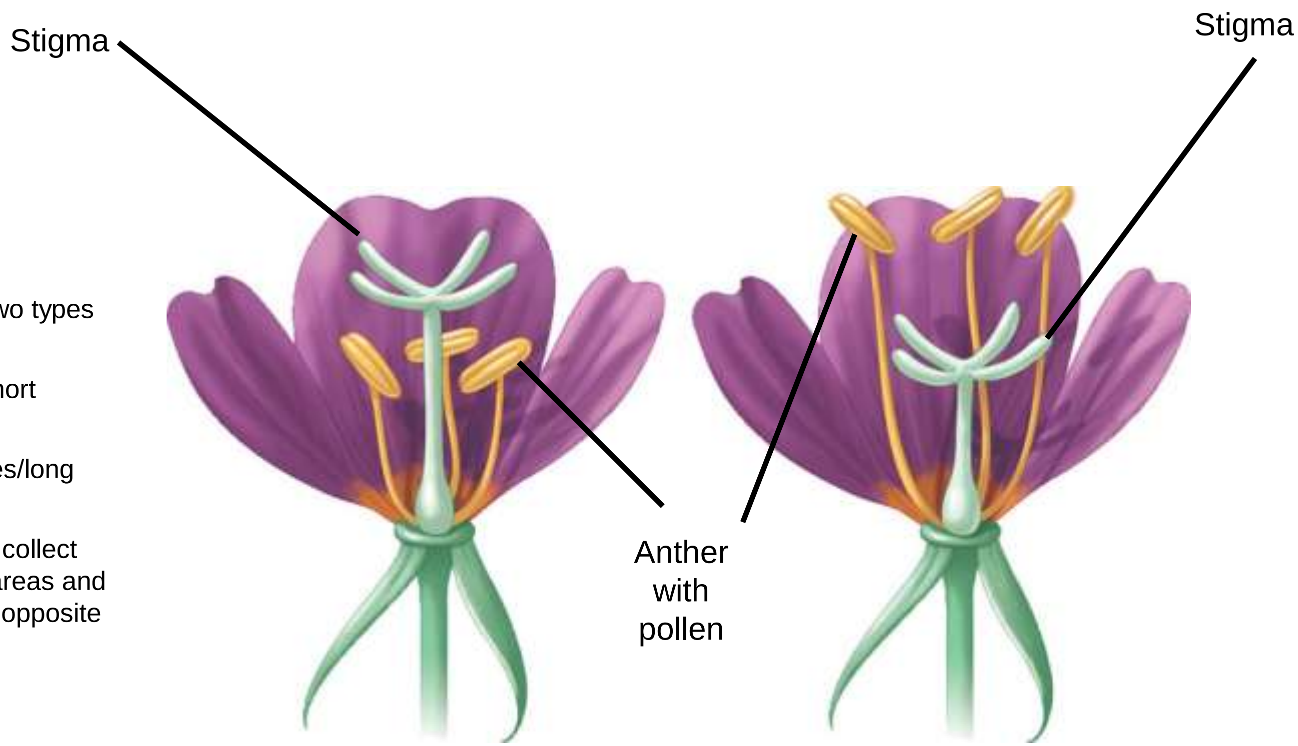
- The most common anti-selfing mechanism in flowering plants is known as **self-incompatibility**, the ability of a plant to reject its own pollen
- Some angiosperms have structural adaptations that make it difficult for a flower to fertilize itself

Some species produce two types of flowers:

Pin flowers-long styles/short stamens

Thrum flowers-short styles/long stamens

Pollinating insects would collect pollen on different body areas and deposit the pollen on the opposite flower type!



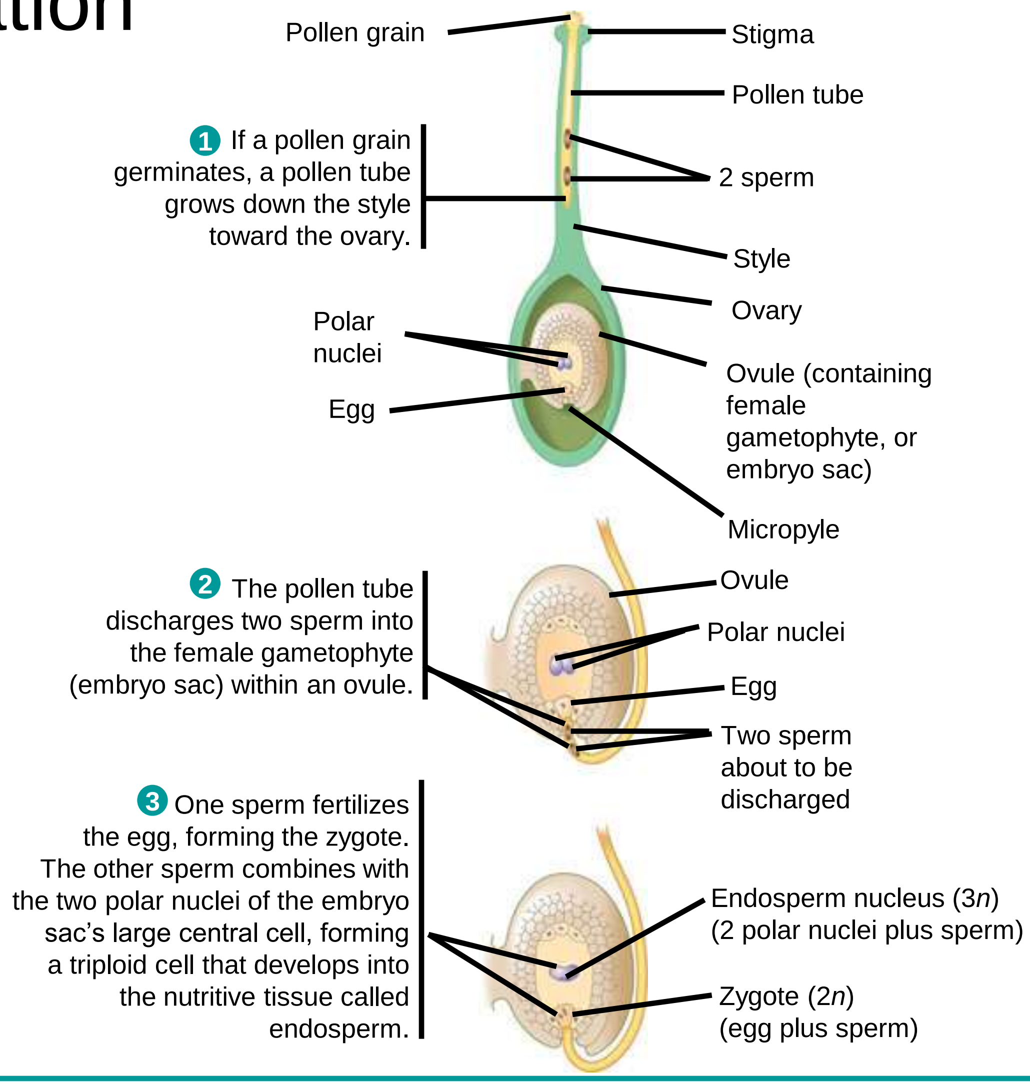
Pin flower **Thrum flower**

Double Fertilization

- After landing on a receptive stigma a pollen grain germinates and produces a pollen tube that extends down between the cells of the style toward the ovary
- The pollen tube then discharges two sperm into the embryo sac
- In double fertilization
  - One sperm fertilizes the egg
  - The other sperm combines with the polar nuclei, giving rise to the food-storing endosperm

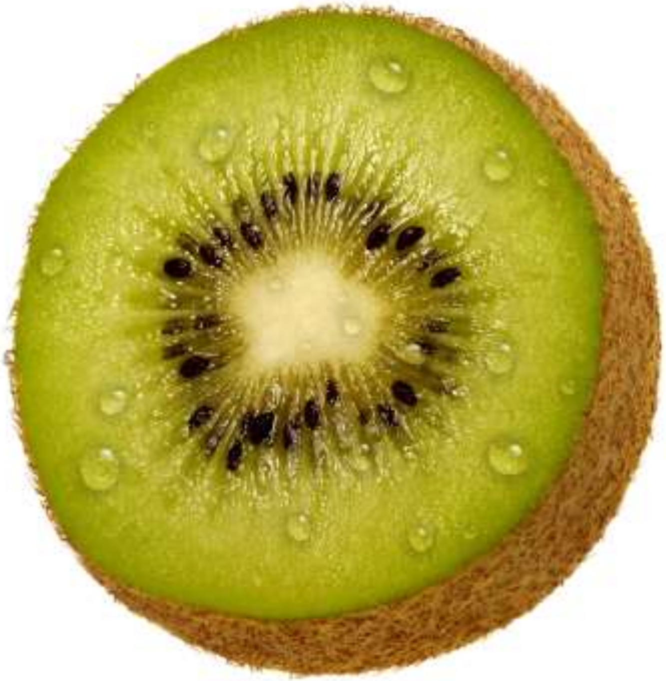
Pollen tube development

- Growth of the pollen tube and double fertilization



From Ovule to Seed

- After double fertilization
  - Each ovule develops into a seed
  - The ovary develops into a fruit enclosing the seed(s)



Endosperm Development

- Endosperm development
  - Usually precedes embryo development
- In most monocots and some eudicots
  - The endosperm stores nutrients that can be used by the seedling after germination
- In other eudicots
  - The food reserves of the endosperm are completely exported to the cotyledons (see bean seed→)

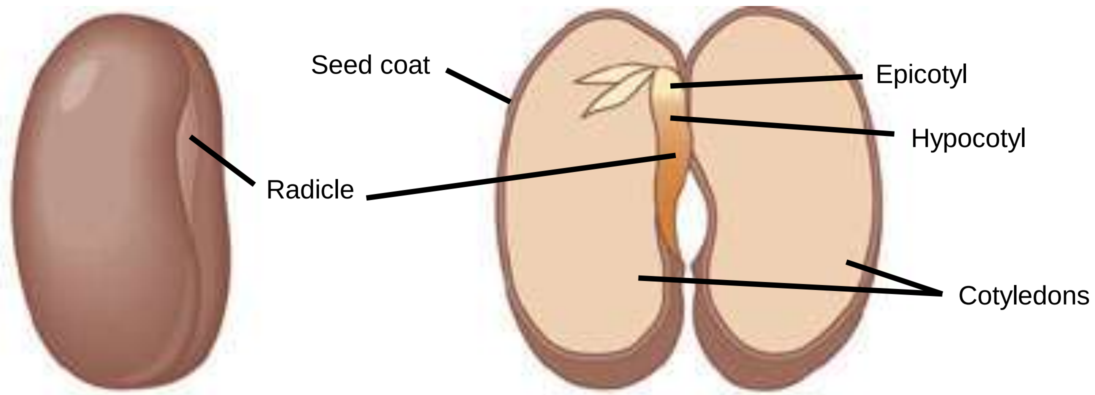
Seed Structure

- The embryo and its food supply are enclosed by a hard, protective seed coat
- In a common garden bean, a eudicot, the embryo consists of the hypocotyl, radicle, and thick cotyledons (seed leaves)

Hypocotyl : The embryonic axis below cotyledon attachment point and above radicle

Epicotyl: The embryonic axis above point of cotyledon attachment

Radicle: The embryonic root

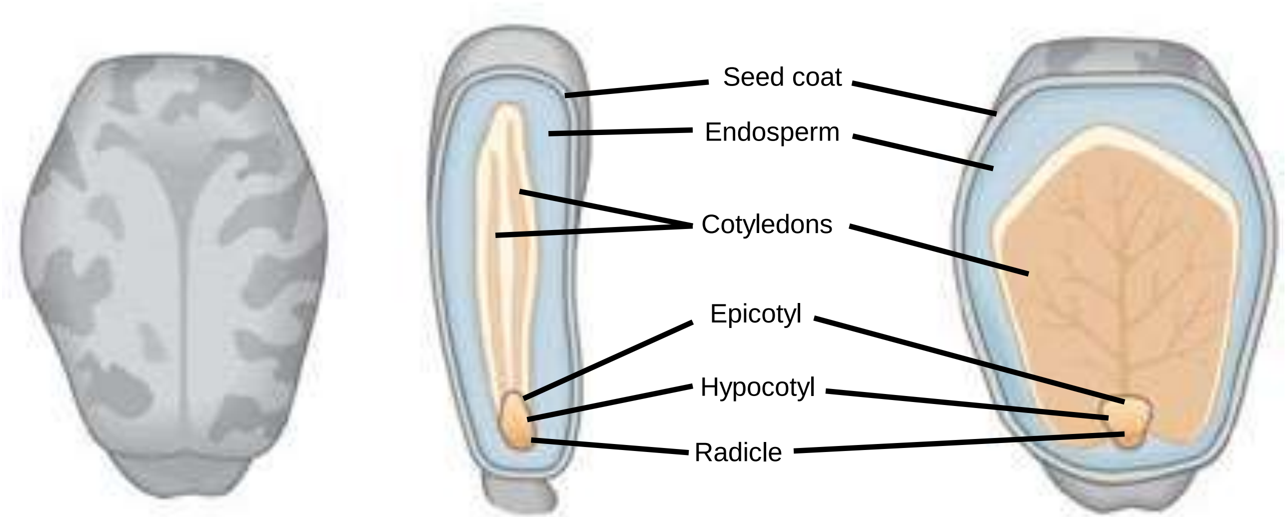


Common garden bean, a eudicot with thick cotyledons. The fleshy cotyledons store food absorbed from the endosperm before the seed germinates.

Note lack of obvious endosperm

Seed structure

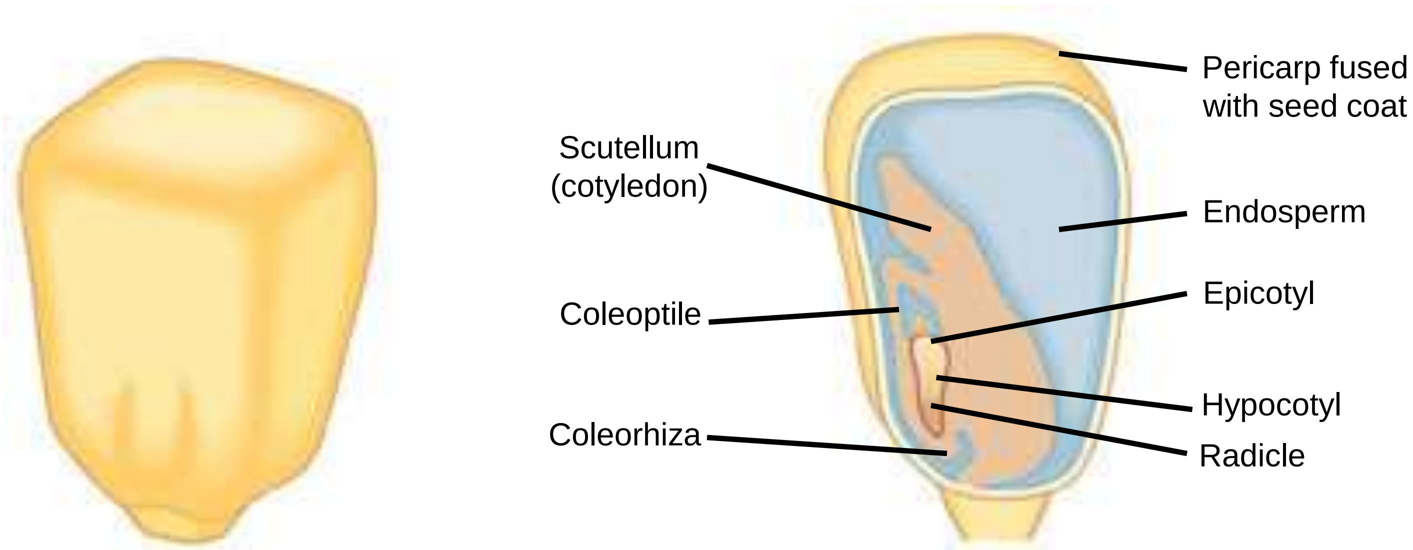
- The seeds of other eudicots, such as castor beans have similar structures, but thin cotyledons



(b) Castor bean, a eudicot with thin cotyledons. The narrow, membranous cotyledons (shown in edge and flat views) absorb food from the endosperm when the seed germinates.

Monocot seed

- The embryo of a monocot as a single cotyledon, a coleoptile, and a coleorhiza



(c) Maize, a monocot. Like all monocots, maize has only one cotyledon. Maize and other grasses have a large cotyledon called a scutellum. The rudimentary shoot is sheathed in a structure called the coleoptile, and the coleorhiza covers the young root.

Coleoptile: protective sheath enclosing the shoot tip and embryonic leaves of grasses.

Coleorhiza: protective sheath enclosing the embryonic root of grasses

Fruit

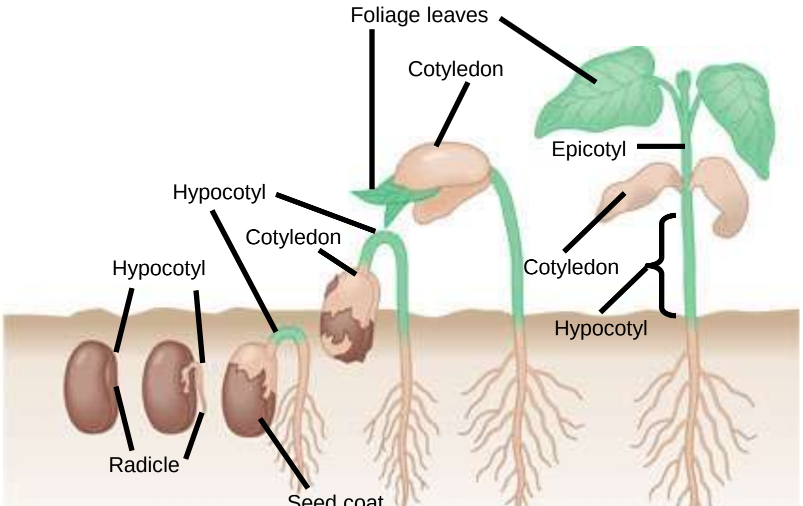
- A fruit
  - Develops from the ovary
  - Protects the enclosed seeds
  - Aids in the dispersal of seeds by wind or animals
  - Fruits are classified into several types (Review Lab)

Seed Germination and Seed Dormancy

- Seed dormancy
  - As a seed matures it dehydrates and enters a phase referred to as **dormancy**
  - increases the chances that germination will occur at a time and place most advantageous to the seedling
  - The breaking of seed dormancy often requires environmental cues, such as temperature or lighting cues
- Germination of seeds depends on the physical process called **imbibition** (the uptake of water)
  - this triggers metabolic changes in the embryo that promote growth

Dicot germination

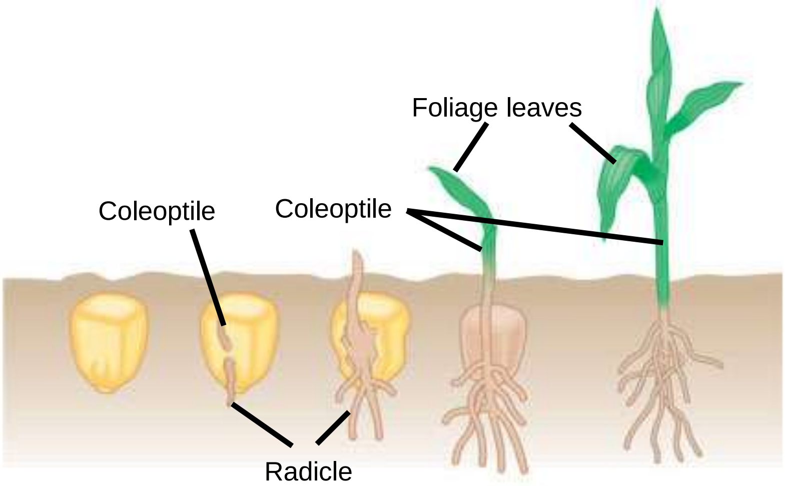
- The radicle is the first organ to emerge from the germinating seed
- In many eudicots a hook forms in the hypocotyl, and growth pushes the hook above ground



(a) Common garden bean. In common garden beans, straightening of a hook in the hypocotyl pulls the cotyledons from the soil.

Monocot germination

- Monocots
  - Use a different method for breaking ground when they germinate
  - The coleoptile pushes upward through the soil and into the air



(b) Maize. In maize and other grasses, the shoot grows straight up through the tube of the coleoptile.

Asexual Reproduction

- Many angiosperm species reproduce both asexually and sexually
- Sexual reproduction generates the genetic variation that makes evolutionary adaptation possible
- Asexual reproduction in plants
  - Is also called vegetative reproduction
  - Results in a clone (a genetic duplicate to the parent plant)

Mechanisms of Asexual Reproduction

- **Fragmentation** (the separation of a parent plant into parts that develop into whole plants) is one of the most common modes of asexual reproduction

- In some species the root system of a single parent gives rise to many adventitious shoots that become separate shoot systems

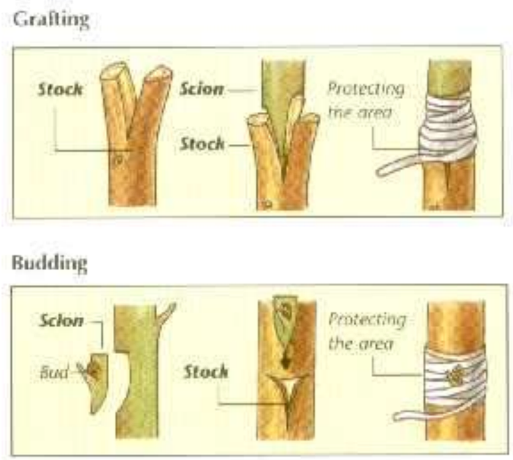
Photo shows groups of aspen trees that have descended by asexual reproduction from root system of parent trees.

Separate groves derived from the root systems of different parents show a genetic variation in timing of fall color and leaf drop

Vegetative Propagation and Agriculture

- Humans have devised various methods for asexual propagation of angiosperms

- Many kinds of plants are asexually reproduced from plant fragments called **cuttings**
- **Grafting**: Cuttings a twig or bud from one plant can be grafted onto a plant of a closely related species or a different variety of the same species



Test-Tube Cloning (Plant tissue culture)

- Plant biologists have adopted *in vitro* methods
  - To create and clone novel plant varieties

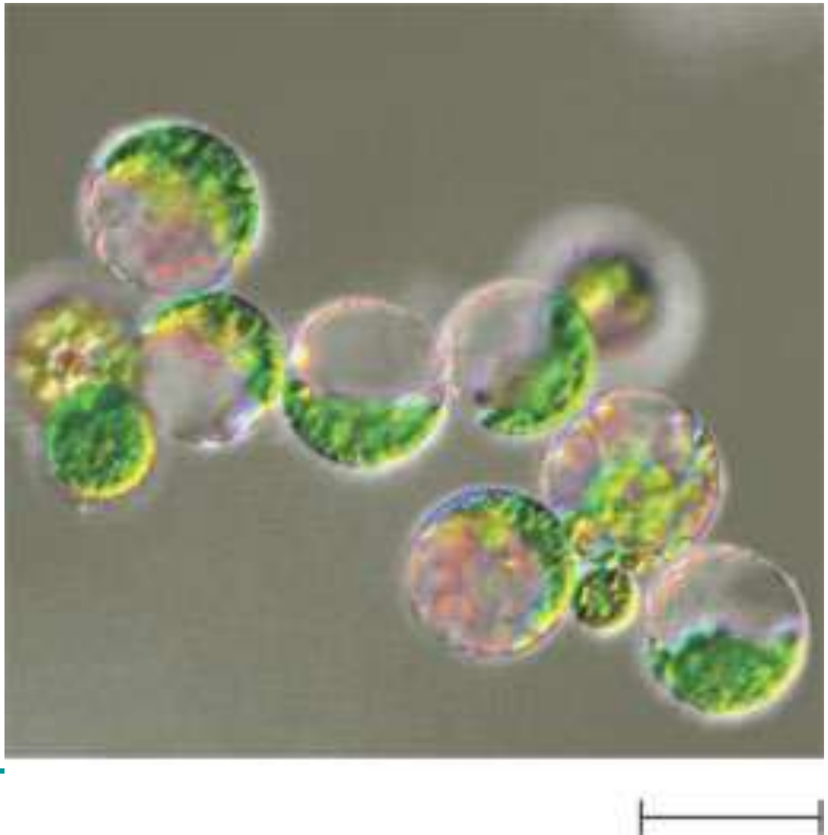
(a) Just a few parenchyma cells from a carrot gave rise to this callus, a mass of undifferentiated cells.

(b) The callus differentiates into an entire plant, with leaves, stems, and roots.

Protoplast Fusion

- Fusion of protoplasts, plant cells with their cell walls removed, to create hybrid plants.

- Hybrids can be created from two different plant species that would otherwise be reproductively incompatible



Plant Breeding…Artificial Selection

- Humans have intervened in the reproduction and genetic makeup of plants for thousands of years
- Maize is a product of artificial selection by humans. It is a staple in many developing countries, but is a poor source of protein for human and livestock

Hybridization

- Interspecific hybridization of plants
  - Is common in nature and has been used by breeders, ancient and modern, to introduce new genes into important crops
  - Modern wheat was developed in this fashion

Plant Biotechnology

- Plant biotechnology has two meanings
  - It refers to innovations in the use of plants to make products of use to humans
  - It refers to the use of genetically modified (GM) organisms in agriculture and industry
- It will dramatically change agriculture

Reducing World Hunger and Malnutrition

- Genetically modified plants
  - Have the potential of increasing the quality and quantity of food worldwide

Papaya has been engineered to resist

Ring spot virus

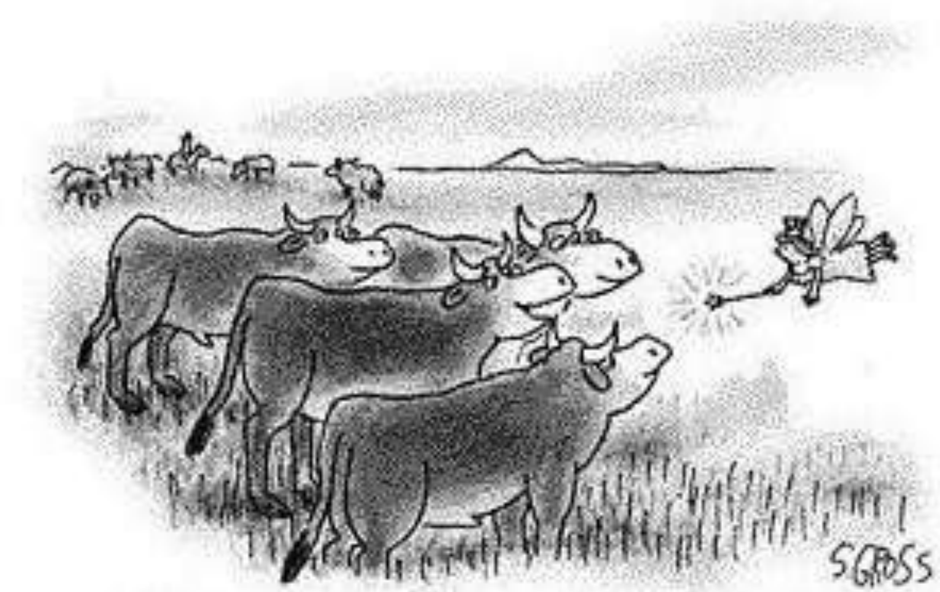
Transgenic Non-transgenic

Genetically modified **Golden Rice**

Ordinary rice

Daffodil genes allowing for the production of Beta-carotene were introduced into rice

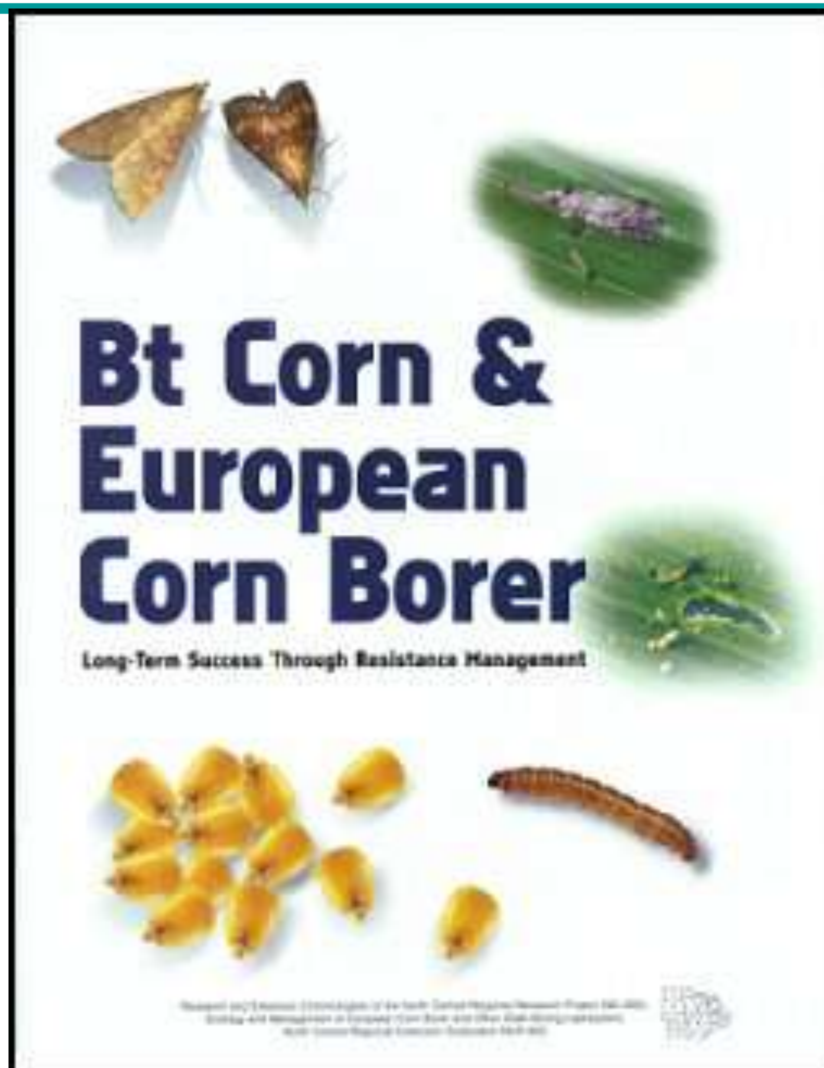
Future



"We would like to be genetically modified to taste like Brussels sprouts."

BT Corn

YieldGard Corn Borer®



BT Corn basics

- BT protein is produced by the bacterium *Bacillus thuringiensis*. Toxic to some insects, nontoxic to all other life forms

- BT corn has the gene inserted so that the corn plant makes the BT protein.

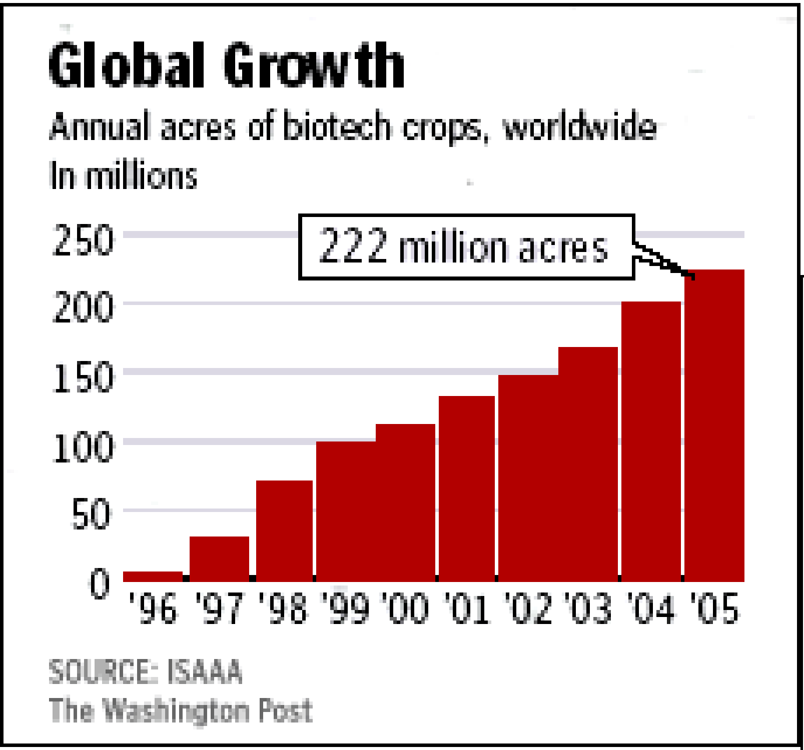
- Ingestion of BT protein by the larvae of the European Corn Borer kills the larvae

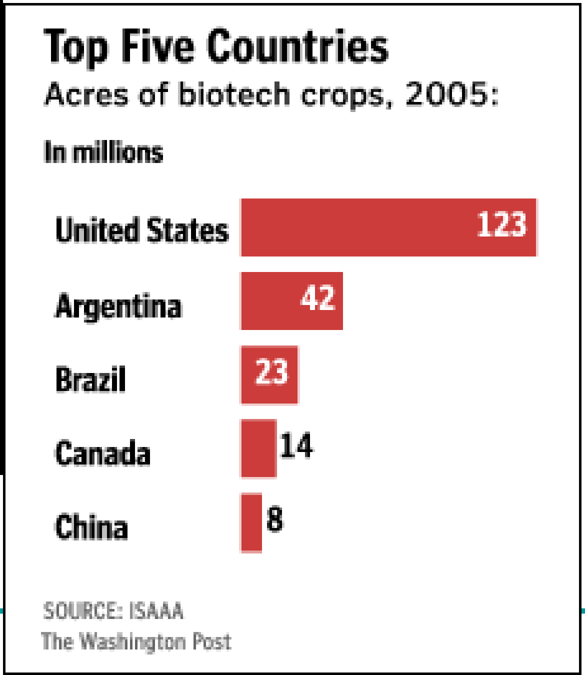
- The corn plant now has it's own defense

How widespread?

- 2006 - 250 million acres grown by 10 million farmers in 22 countries were planted with transgenic crops.
- United States > Argentina > Brazil > India> Canada > China
- Soybeans 57% of biotech acreage, corn 25%, cotton 13%, canola 5%
- What's next
  - Bananas that produce human vaccines
  - Fish that mature more quickly
  - Plants that produce plastics
  - Fruit/nut trees that yield years earlier
  - Crops that grow where they could not before

The Biotech Floodgate





Transgenic plants and vaccines