SLE 132 – Form and Function
Reproduction in Angiosperms

DEAKIN COLLEGE in association with DEAKIN UNIVERSITY AUSTRALIA

Learning Outcomes

- Male and female gametophytes develop within anthers and ovaries, respectively.
- Pollination brings male and female gametophytes together.
- Self-incompatibility prevents self-pollen from fertilising eggs of the same plant and is regulated by the S gene.
- Flowering plants have ‘double fertilisation’.
- Animals have played a role in angiosperm evolution.
- The ovule develops into a seed, containing an embryo and a supply of nutrients.
- The ovary develops into a fruit adapted for seed dispersal.
- Evolutionary adaptations of seed germination.
- Asexual reproduction produces plant clones.
- Sexual and asexual reproduction are complementary in the life histories of some plants.

Reproduction in Angiosperms

Overview

- Angiosperm flowers attract pollinators using visual cues & various chemicals
- Pollinators carry **pollen**, the male gametophyte (n) to the **carpel** of another flower, which contains the female gametophyte (n)
- Many angiosperms reproduce sexually & asexually
- **Symbiotic relationships** are common between plants and other species

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The angiosperm life cycle

- Diploid (2n) **sporophytes** produce spores by meiosis; these grow into **haploid (n) gametophytes**
- **Gametophytes** produce haploid (n) gametes by mitosis; **fertilisation** of gametes produces a sporophyte
- The sporophyte is the dominant generation
- Gametophytes are reduced in size and depend on sporophyte for nutrients
- Angiosperm life cycle is characterised by **"three Fs":**
    - **flowers**
    - **(double) fertilization**
    - **fruits**

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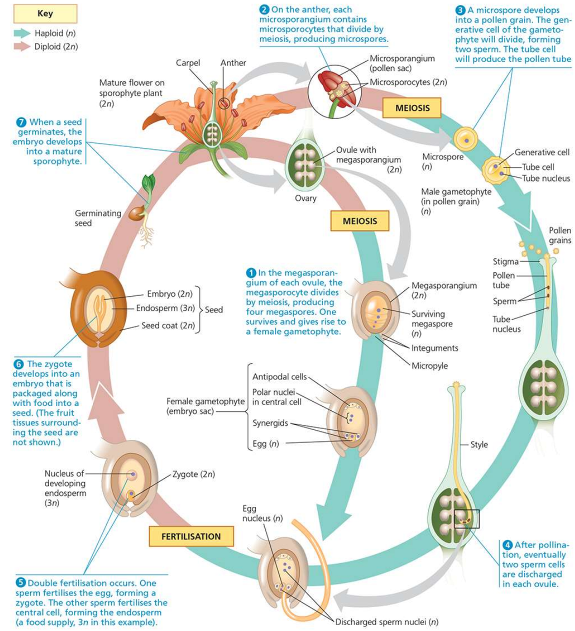
In Angiosperms we see the sporophyte, the gametophyte is reduced

- Only the pollen grains (male) and embryo sac (female)

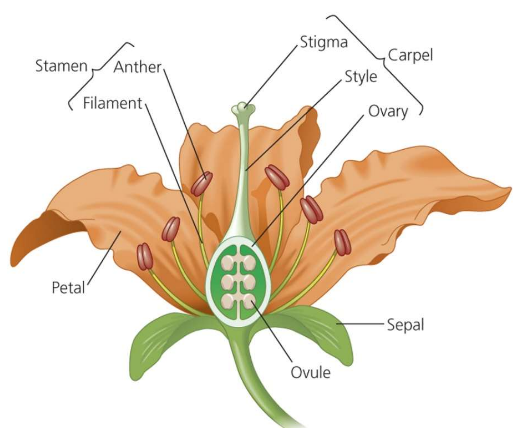


▲ **Figure 38.4** The life cycle of angiosperms.

Flower structure and function

Flowers have 4 floral organs:

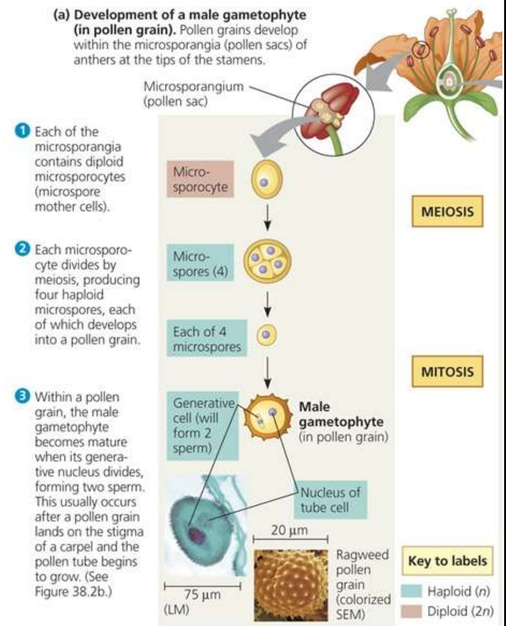
- **Sepals** (enclose flower)
- **Petals**
- **Stamens:** filament, with anther containing pollen sacs (male)
- **Carpels:** style with stigma to receive pollen (female)
  - At base of the style is an ovary containing one or more ovules



- **Complete** flowers contain all four floral organs
- **Incomplete** flowers lack one or more floral organs, for example stamens or carpels
- Clusters of flowers are called **inflorescences**

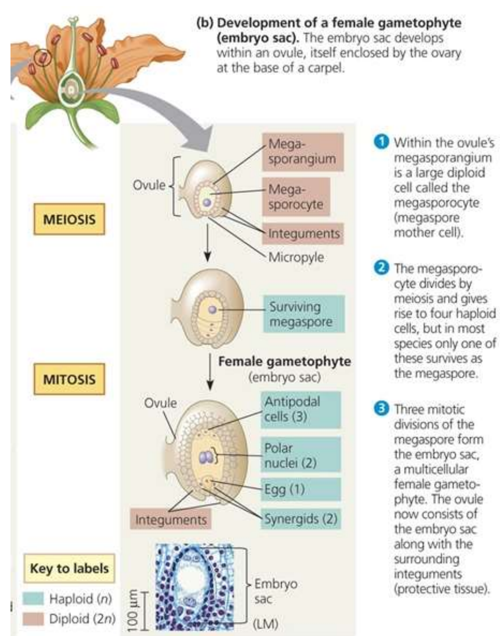
Development of male gametophytes

- **Pollen** develops from microspores within the **microsporangia**, or pollen sacs, of anthers
- If pollination succeeds, a pollen grain produces a **pollen tube** that grows down into the ovary and discharges sperm near the embryo sac
- The **pollen grain** consists of the two-celled male gametophyte and the spore wall



Development of female gametophytes

- Within an ovule, **megaspores** are produced by meiosis
- Develop into **embryo sacs**, the female gametophytes

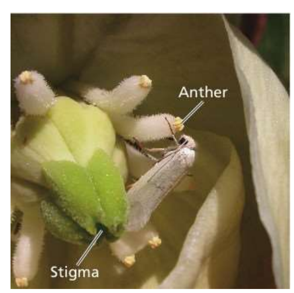


Activity 1 (10 mins) - access file in moodle in week 9: *Correa reflexa*

Label:
Stamen (anther and filament)
Carpel (stigma, style and ovary)
Ovule (where would you expect to find?)
Petals
Sepals
Microsporangium and megasporangium
Microspores and megaspores
Male and female gametophyte

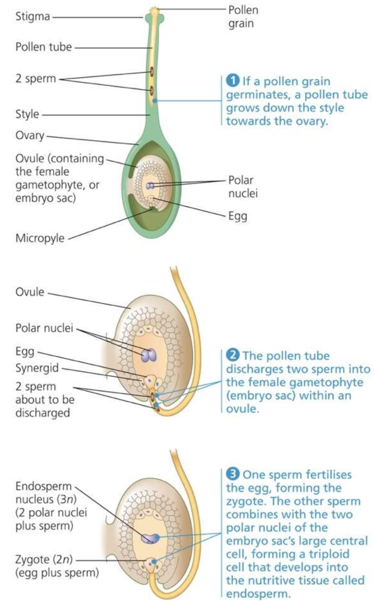
Pollination in angiosperms

- Transfer of pollen from an anther to a stigma
- Pollination can be by wind, water (abiotic), or animal (biotic)



Double fertilisation

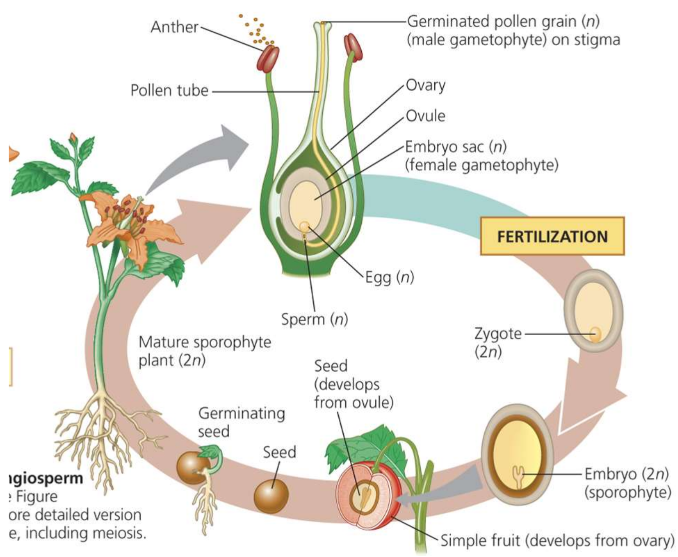
- After landing on stigma, pollen grain produces a **pollen tube** that extends towards the ovary
- **Double fertilisation** results from the discharge of 2 sperm from pollen tube into embryo sac
- One sperm **fertilises the egg**
- The other **combines with the polar nuclei**, giving rise to triploid (3n) endosperm



▲ **Figure 38.6 Growth of the pollen tube and double fertilisation.**

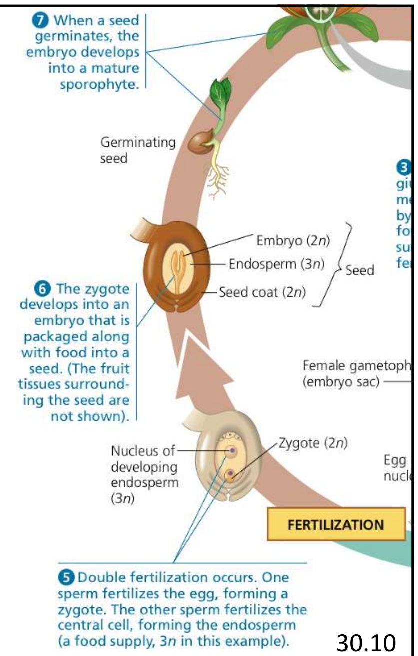
Seed development, form, and function

- After double fertilisation, each **ovule develops into a seed**
- The **ovary develops into a fruit** enclosing the seed(s)



Endosperm development

- Endosperm development usually precedes embryo development
- Endosperm **stores nutrients** that can be used by the seedling
  - most monocots & some eudicots
- In other eudicots, food reserves of the endosperm are **exported to cotyledons**



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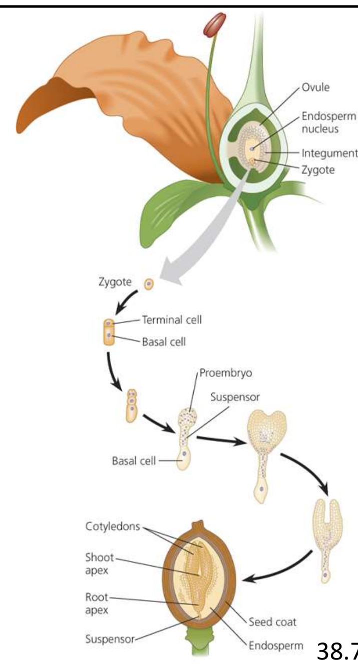
Development of the embryo inside the seed

- The embryo & its food supply are enclosed by a **hard, protective seed coat**
- The seed then enters a **state of dormancy**
- Growth and development is suspended



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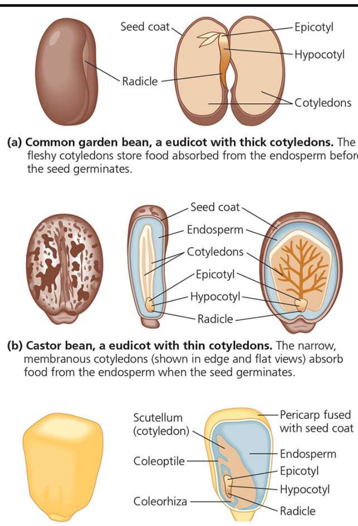
Seed Development

- After double fertilization, each ovule develops into a seed
- In mature seeds, the seed coat is dry and the **seed is dormant**
- This is an important evolutionary adaptation
  - Allows time for **seed dispersal**
  - Ensures growth starts in **favorable conditions**
- **Embryo** – has root and shoot with apical meristems

Structure of mature seed

- Below the cotyledons is the **hypocotyl** (embryonic axis) which terminates in the **radicle** (embryonic root)
- A **monocot** has 1 cotyledon
- A **dicot** (eudicot) has 2 cotyledons



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

(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.

(c) Corn, a monocot. Like all monocots, corn has only one cotyledon. Corn 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.

▲ **Figure 38.8 Seed structure.**

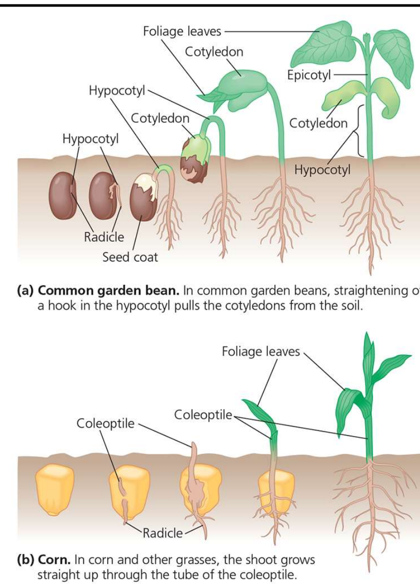
MAKE CONNECTIONS *In addition to cotyledon number, how do the structures of monocots and eudicots differ? (See Figure 30.17.)*

Seed dormancy: adaptation for tough times

- Seed dormancy increase chances that **germination** will occur at a time/space advantageous to the seedling
- Breaking of dormancy (germination) often requires environmental cures (temperature, light changes, fire etc)

Seed germination

- Germination depends on **imbibition**: the uptake of water due to low water potential of the dry seed.
  - The radicle (embryonic root) emerges first
  - Next the shoot top breaks through the soil surface



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

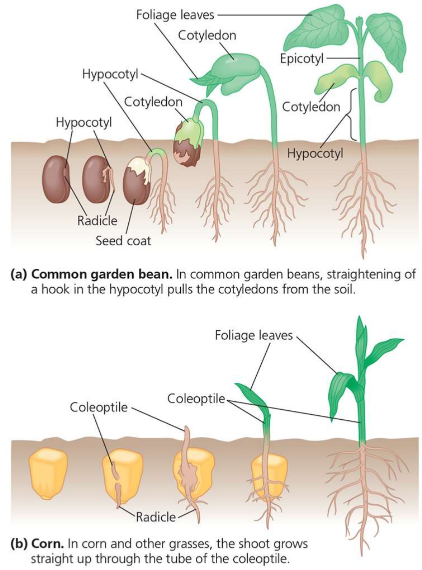
(b) Corn. In corn and other grasses, the shoot grows straight up through the tube of the coleoptile.

▲ **Figure 38.9 Two common types of seed germination.**

? *How do bean and corn seedlings protect their shoot systems as they push through the soil?*

Seedling development

- In many eudicots, **a hook forms in the hypocotyl**, growth pushes the nook above ground
  - The hook straightens and <u>pulls cotyledons and shoot tip up</u>
- In many monocots the **coleoptile** pushes up through the soil



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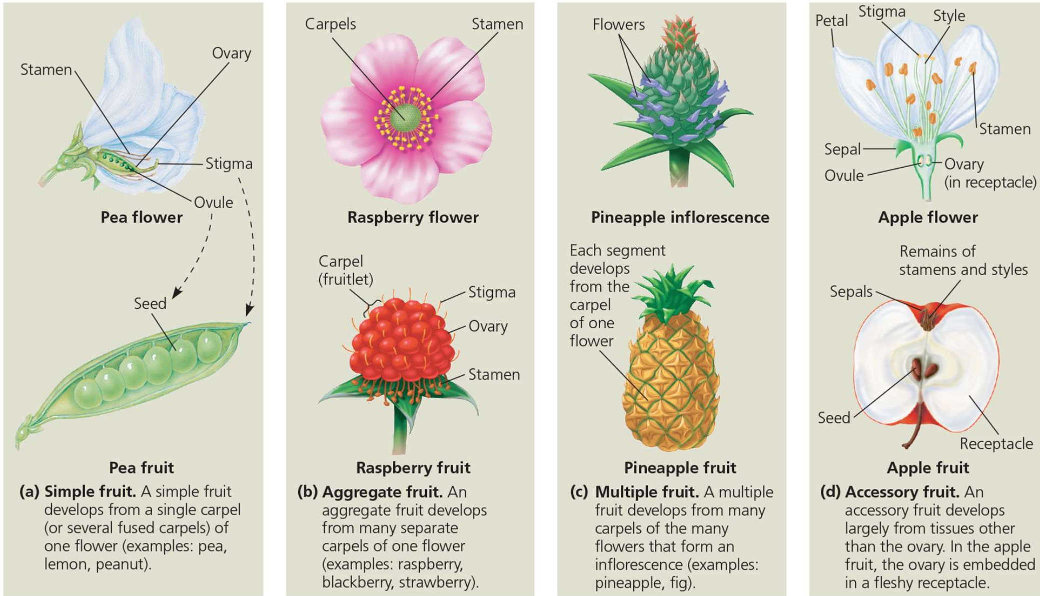
▲ **Figure 38.9 Two common types of seed germination.**

? *How do bean and corn seedlings protect their shoot systems as they push through the soil?*

Fruit Development

- Fruits develop at the same time as seeds
- The **ovary develops into a fruit** enclosing the seed(s)
- Fruit Types
  - **Simple Fruit** – develop from 1 ovary of every single flower
  - **Aggregate fruit** – develops from flower with a number of separate ovaries
  - **Multiple Fruit** – development of separate flowers clustered closely – ovaries fuse as fruit develops
  - **Accessory Fruit –** develops primarily from tissues other than the ovary



▲ **Figure 38.11** **Developmental origin of different classes of fruits.**

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Activity 1 (5 mins) - access file in moodle in week 9

Correa reflexa

Label:
Where does fertilization occur?
Which structures develop into the seed and fruit?

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Sexual reproduction is a source of genetic diversity

- Ideally plants want to cross fertilise, **to introduce new, potentially beneficial genes.**
- Asexual reproduction and self-fertilisation do not provide genetic diversity
- Plants therefore have methods to **promote cross fertilisation** and/or inhibit self-fertilisation.

Plants reproduce sexually, asexually or both

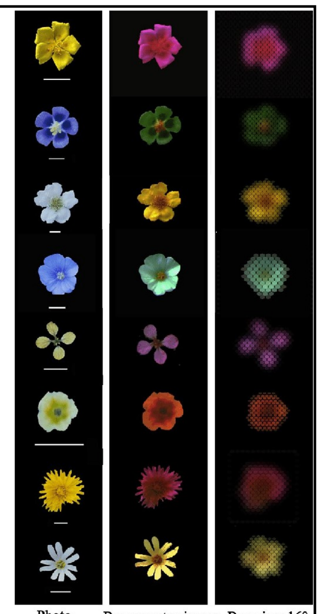
- Many angiosperm species reproduce **sexually and asexually**
- Sexual reproduction results in offspring that are genetically different from their parents
- Asexual reproduction results in a clone of genetically identical organisms

Advantages and disadvantages of asexual versus sexual reproduction

- Most common method of asexual reproduction is through vegetative reproduction – **fragmentation**
  - Can be beneficial to a successful plant in a <u>stable environment</u>
  - Clones of plants **vulnerable to local extinction** if there is an environmental change
- Sexual reproduction generates **genetic variation** (evolutionary adaptation)
  - However only a fraction of seedlings survive

Features that promote cross fertilisation

- Attracting particular pollinators
- Development of male flowers above female
- Production of lots of pollen
- Orientation of flowers, branched stigmas
- Various shapes, bright colours
- Promotion of warmth, rooting in ants nests
- And many more

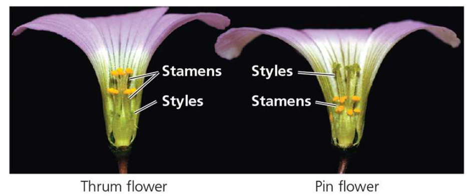


https://www.researchgate.net/publication/262342869_Mechanisms_functions_and_ecology_of_colour_vision_in_the_honeybee

Many angiosperm species have mechanisms that make it difficult or impossible for a flower to self fertilise

- Dioecious species have male and female flowers on different plants
- Others have stamen and carpels that mature at different times or arranged to prevent self fertilisation

(a) Some species, such as *Sagittaria latifolia* (common arrowhead), are dioecious, having plants that produce only staminate flowers (left) or carpellate flowers (right).



(b) Some species, such as *Oxalis alpina* (alpine woodsorrel), produce two types of flowers on different individuals: "thrums", which have short styles and long stamens, and "pins", which have long styles and short stamens. An insect foraging for nectar would collect pollen on different parts of its body; thrum pollen would be deposited on pin stigmas, and vice versa.

▲ Figure 38.14 Some floral adaptations that prevent self-fertilisation.

Most common anti-self mechanism = self incompatibility

- A biochemical block based on self incompatibility genes called **S genes**
- If pollen grains **have an allele that matches** an allele of the stigma, the pollen tube fails to grow.
- Prevents self fertilisation