

Plant Breeding Systems:

evolution and diversity of reproduction
modes in flowering plants

Mating systems in plants and animals: a comparison

.absence of active mate-choice (no central nervous system)



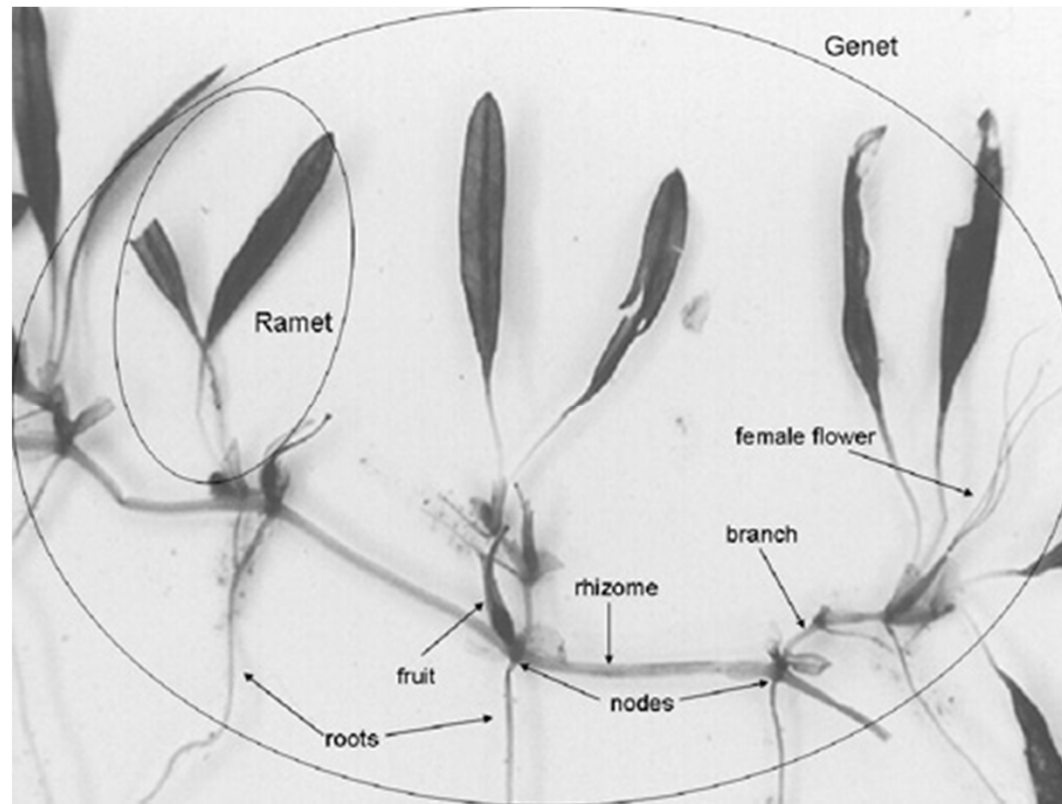
Mating systems in plants and animals: a comparison

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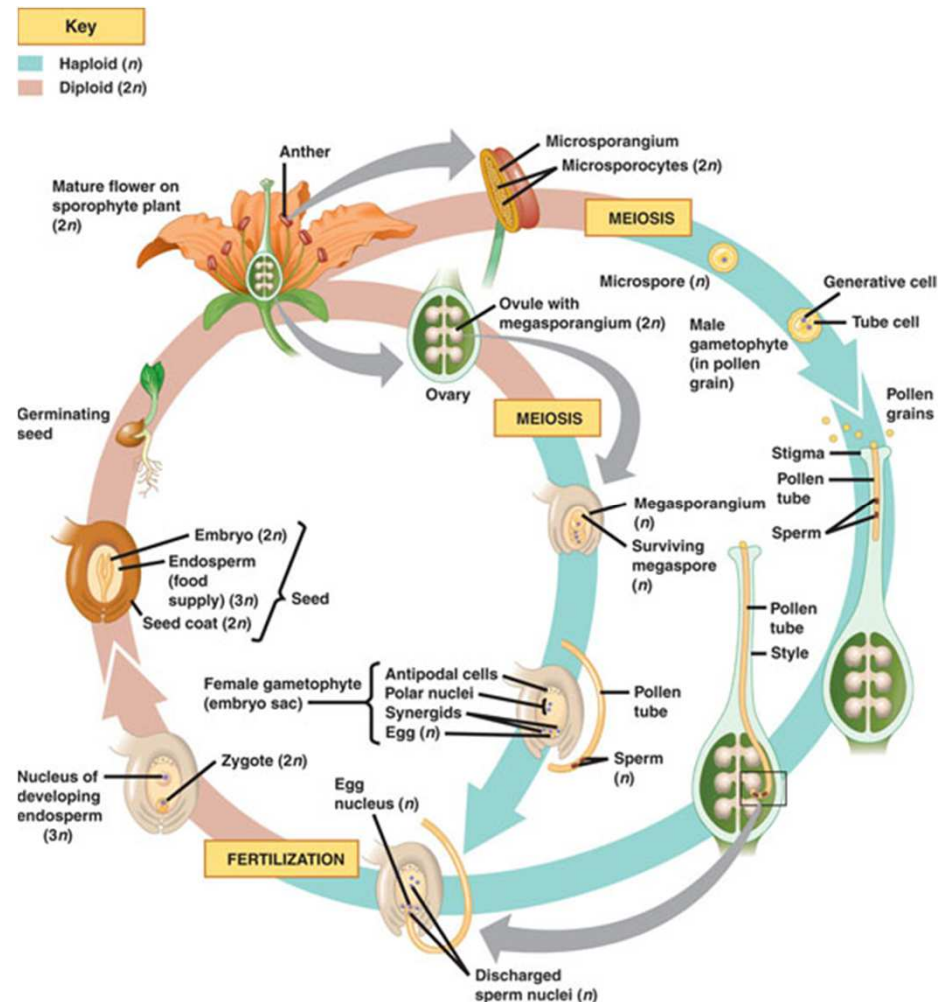
Mating systems in plants and animals: a comparison

.asexual reproduction more frequent (totipotency: genet and ramets)



Mating systems in plants and animals: a comparison

.alternation of gametophytic and sporophytic generation



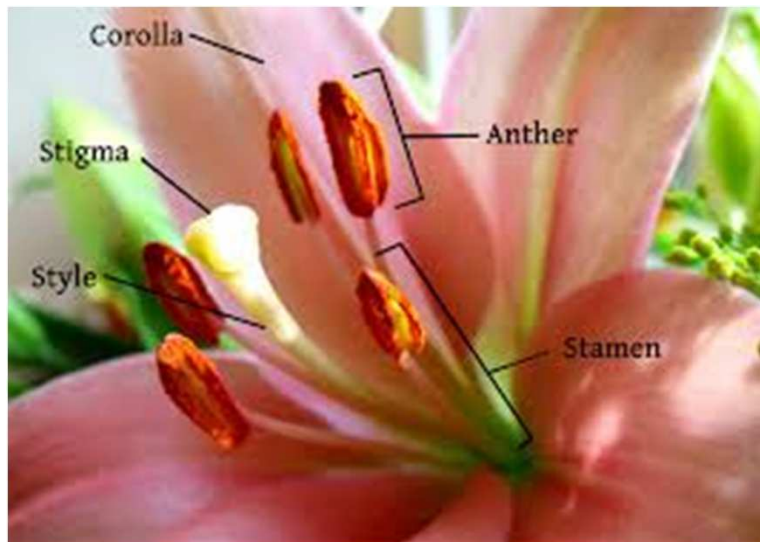
Mating systems in plants and animals: a comparison

.alternation of gametophytic and sporophytic generation

harmful mutations expressed in the gametophyte are not transferred to spor

Mating systems in plants and animals: a comparison

.predominance of hermaphrodites (72% in flowering plants)



Mating systems in plants and animals: a comparison

Plants: variable reproductive strategies

- .hermaphroditism** versus **unisexual**
- .self-pollination** versus **cross-pollination**
- .self-fertilization** versus **cross-fertilization**
- .sexuality** versus **asexuality**

Reproductive strategies options

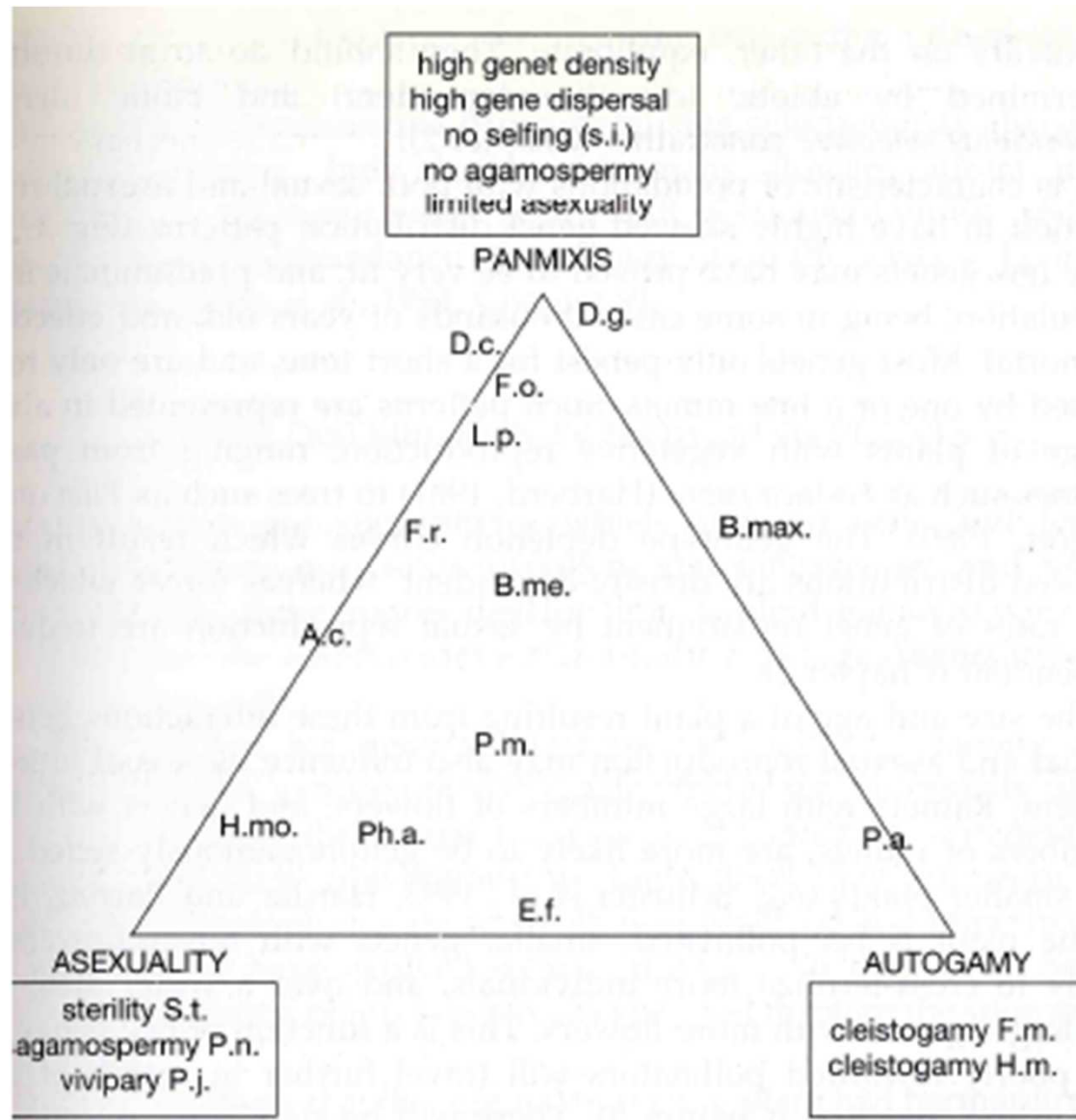
sexual

asexual

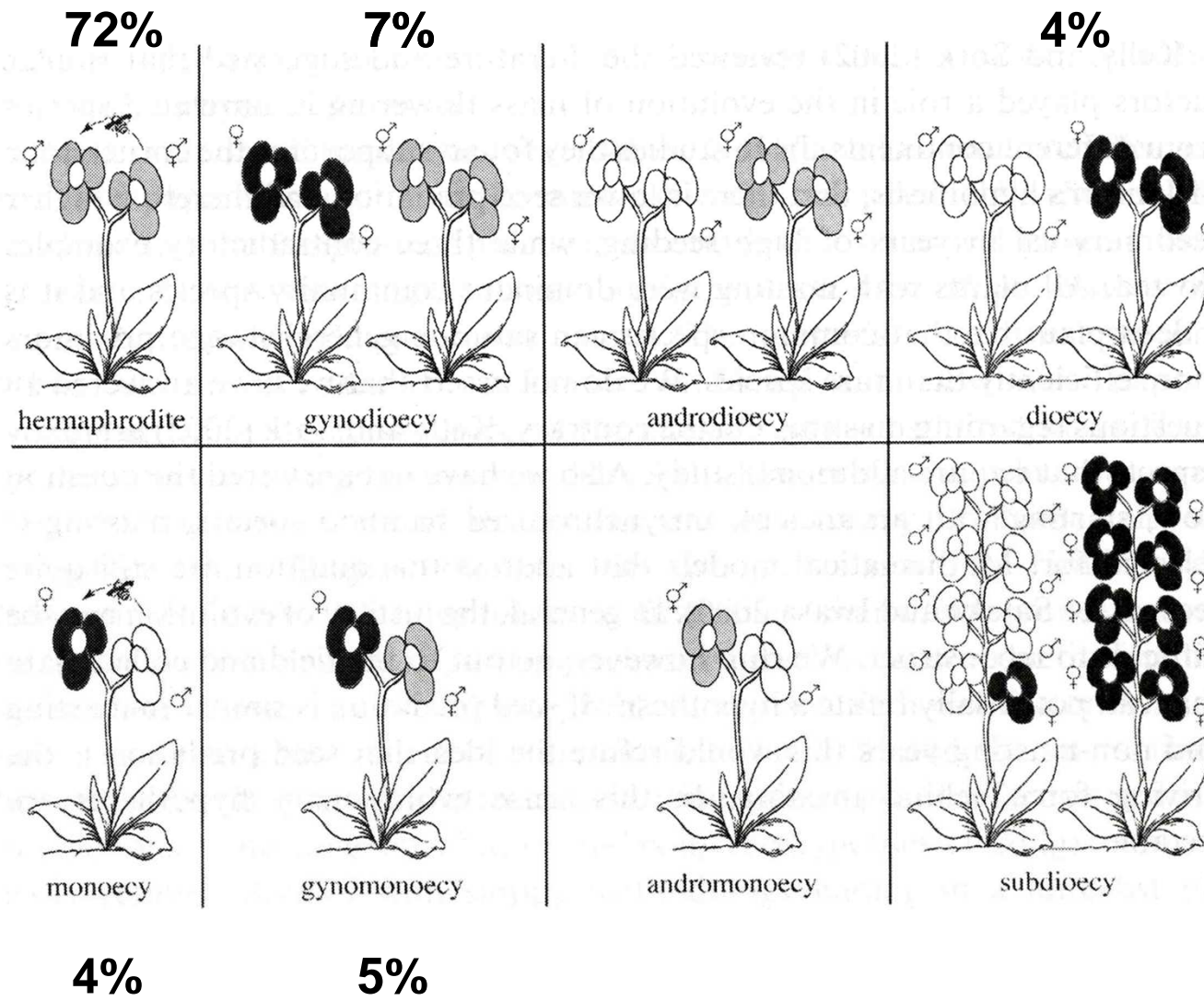
Reproductive strategies options

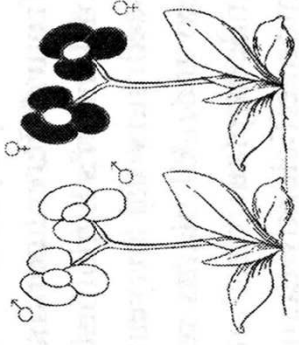


Reproductive strategies options

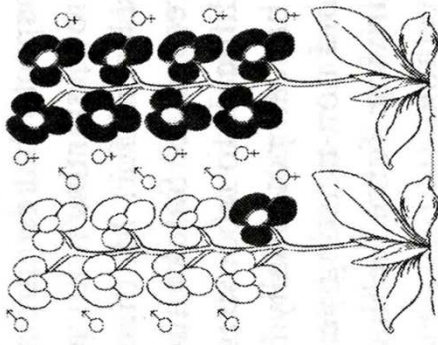


Reproductive strategies options

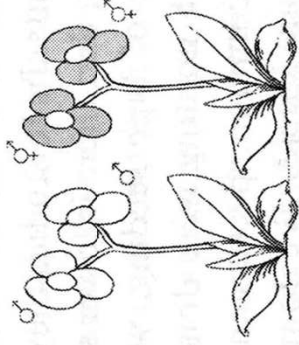




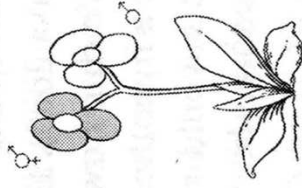
dioecy



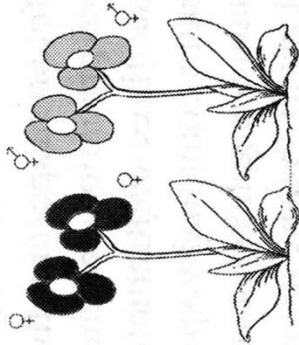
subdioecy



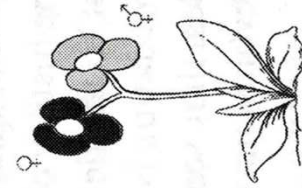
androdioecy



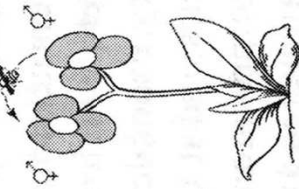
andromonoecy



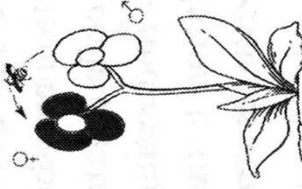
gynodioecy



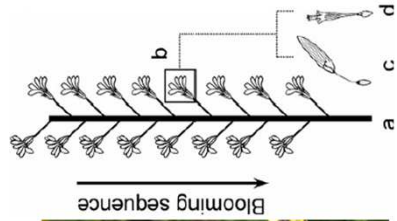
gynomonoecy



hermaphroditite



monoecy



Sexual theory

'paradox of sex': **Why so widespread when it is unsure and costly?**

Sexual theory

sexuality generates variability:

.recombination

.segregation

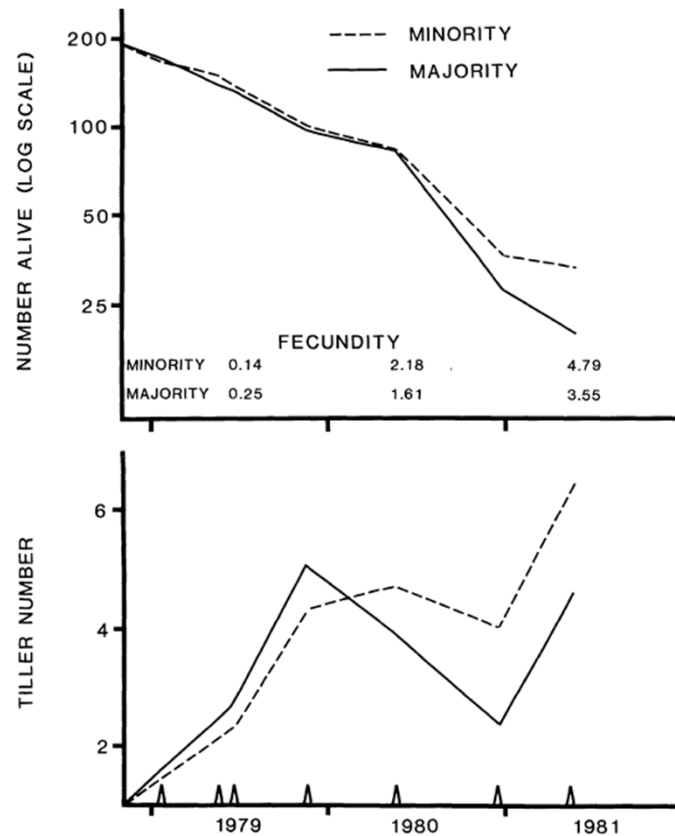
.syngamy

sexuality allows gene migration (spreading of successful mutation)

Sexual theory

Sexuality is advantageous in **heterogeneous environment**

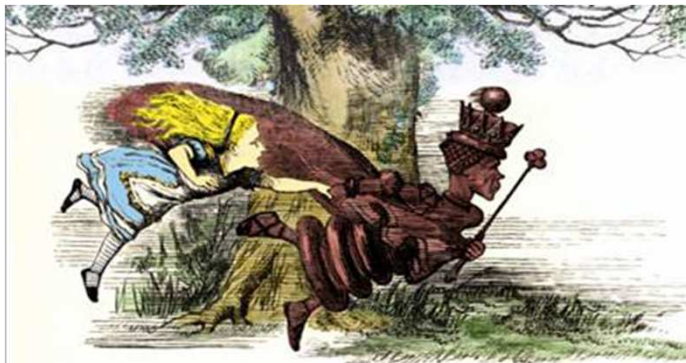
'Tangled Bank' hypothesis (Felsenstein 1974) based on 'frequency dependence



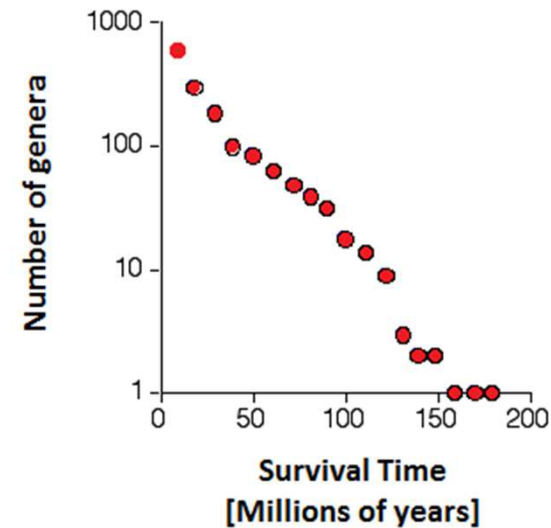
Sexual theory

Sexuality is advantageous in **heterogeneous environment**

'**Red Queen**' hypothesis (van Valen 1973) based on 'frequency dependence



"The Red Queen has to run faster and faster in order to keep still where she is. That is exactly what you all are doing!"



advantage of sex at the level of individuals, and the **constant evolution**

Sexual theory

Sexual theory

Disadvantages of sexuality (compared to asexuality)

1. **cost of sex (cost of meiosis)** = production of some portion of unfit progeny
2. **unsure reproduction** (harsh environment and limited cross-pollination)
3. **cost of sex (production of male gametes)**

Sexual reproduction in flowering plants

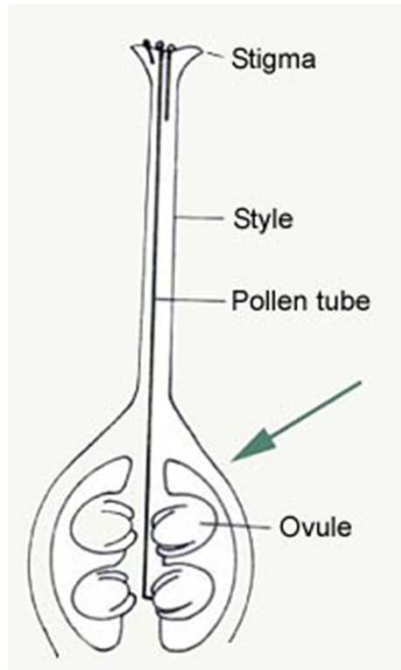
Evolutionary success of angiosperms (ca 300,000 species)

over **ferns** (ca 12,000) and **gymnosperms** (700 species)

- 1. no need of water for successful reproduction (vs ferns)**
- 2. protection and dispersion of zygote within seeds / fruits**
- 3. wide range of pollination syndroms (vs gymnosperms)**
- 4. wide range of growth forms (ecological succes) (vs gymnosperms)**

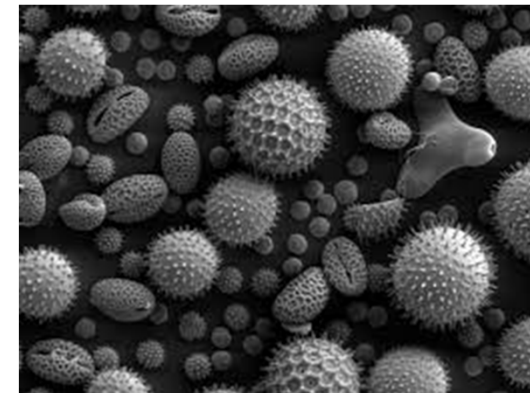
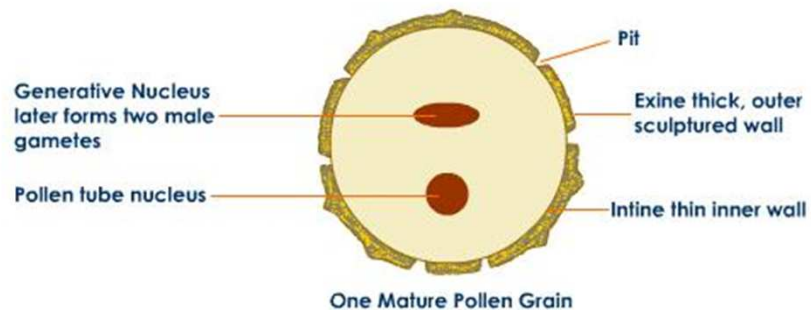
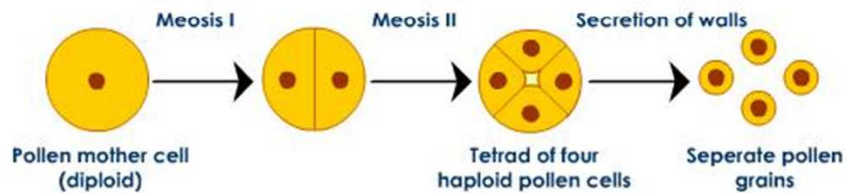
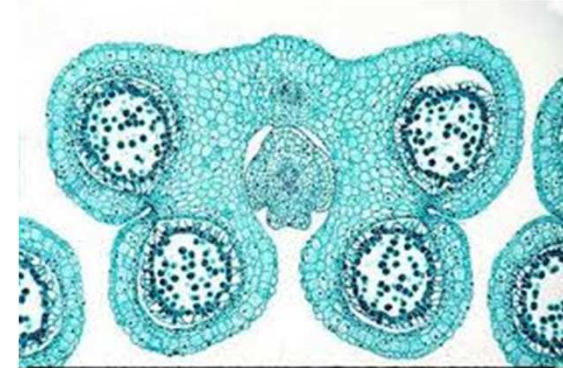
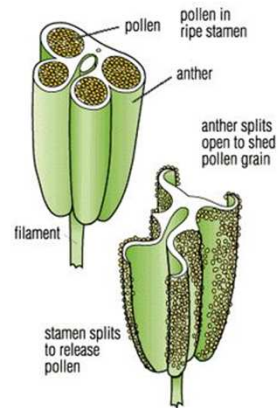
Sexual reproduction in flowering plants

Female function: gynoecium (pistils)



Sexual reproduction in flowering plants

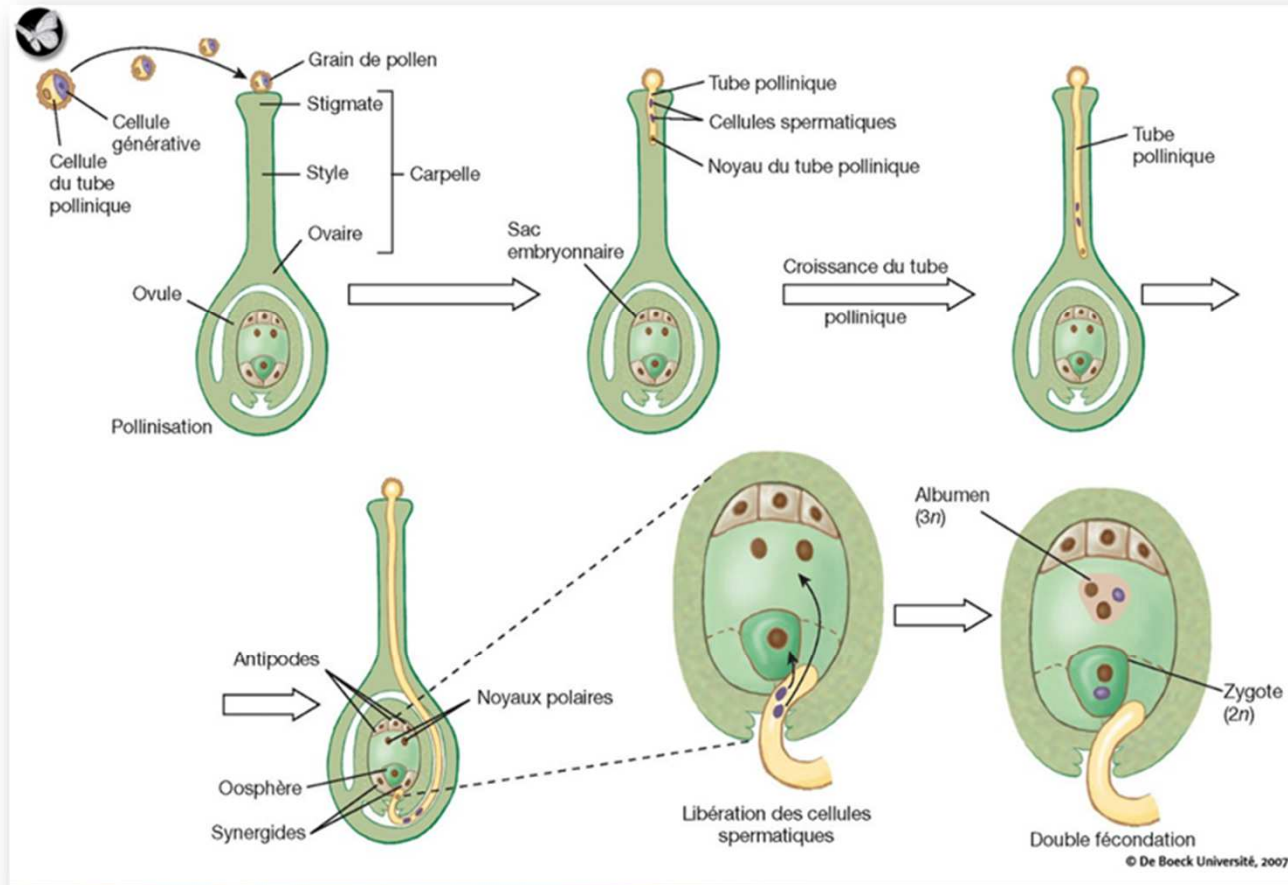
Male function: androecium (stamens)



Sexual reproduction

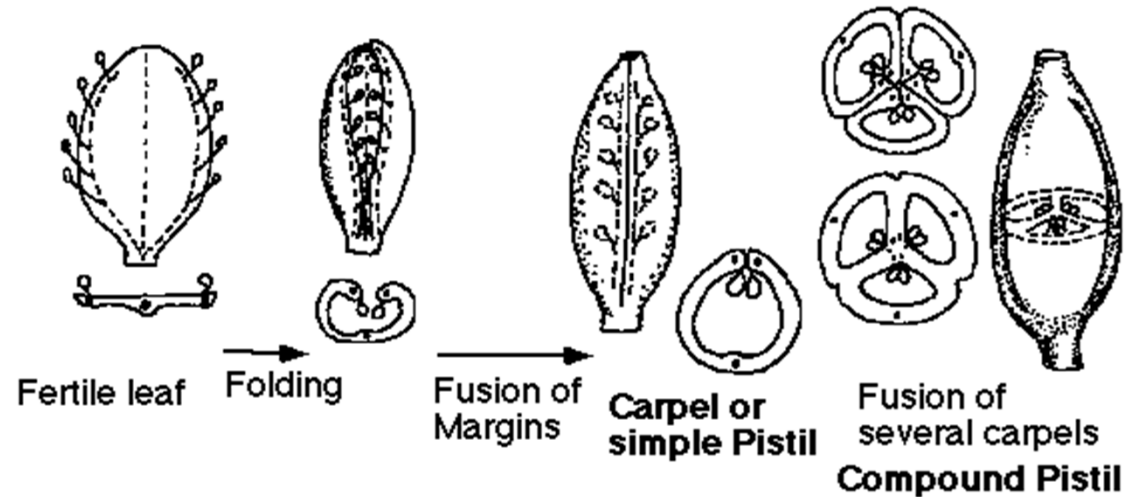
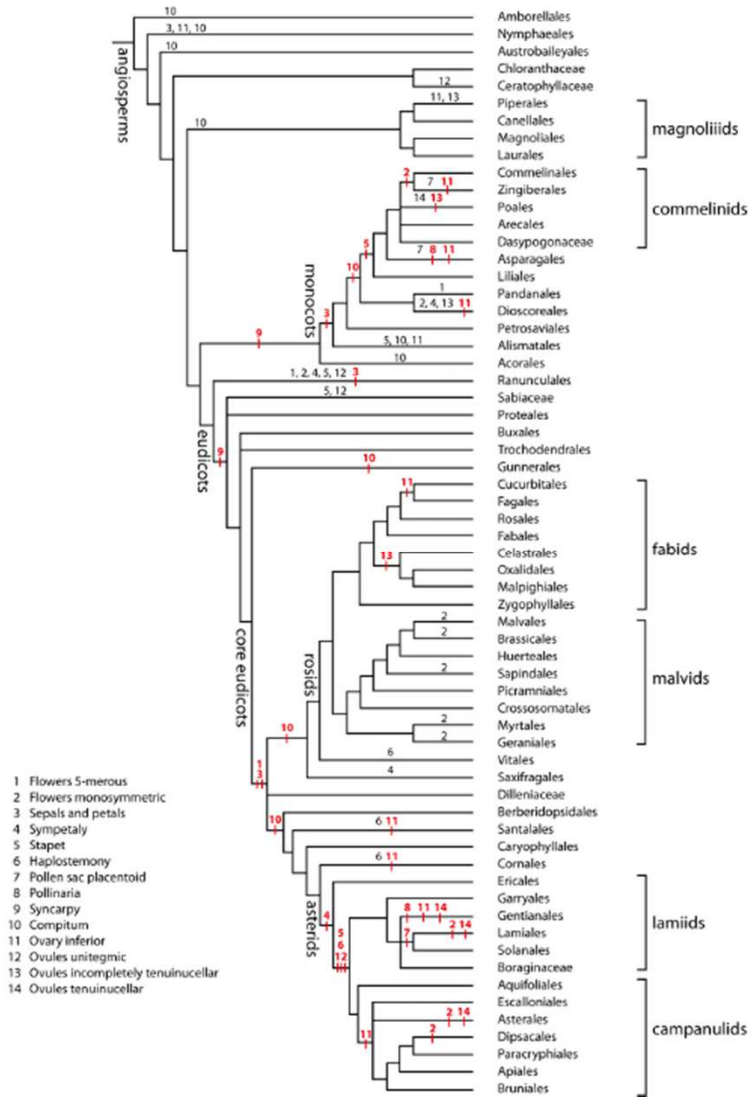
Sexual reproduction in flowering plants

Double fecondation (fusion)



Sexual reproduction in flowering plants

Evolutionary trends in ovaries and ovules



Floral diversity and pollination

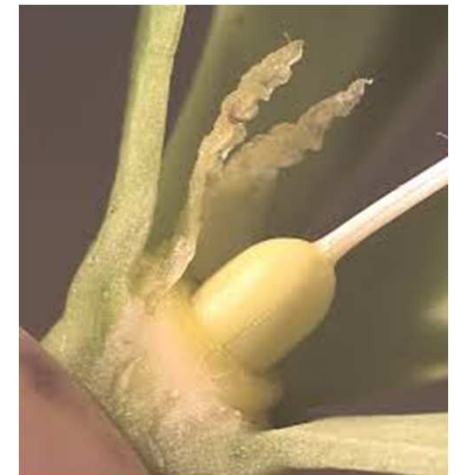
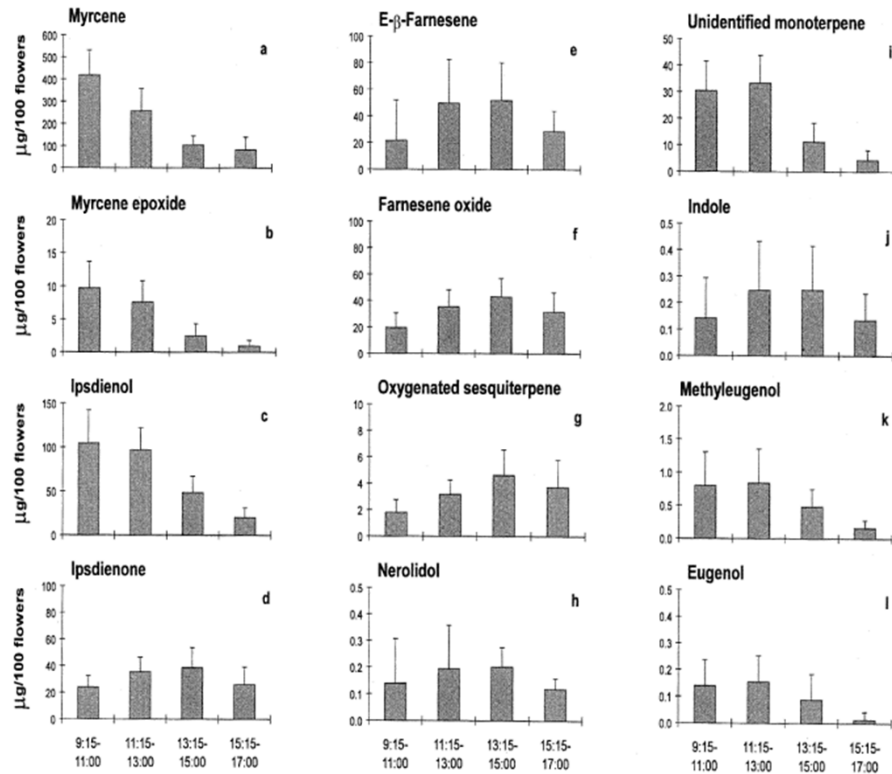
Floral evolution



Sexual reproduction

Floral diversity and pollination

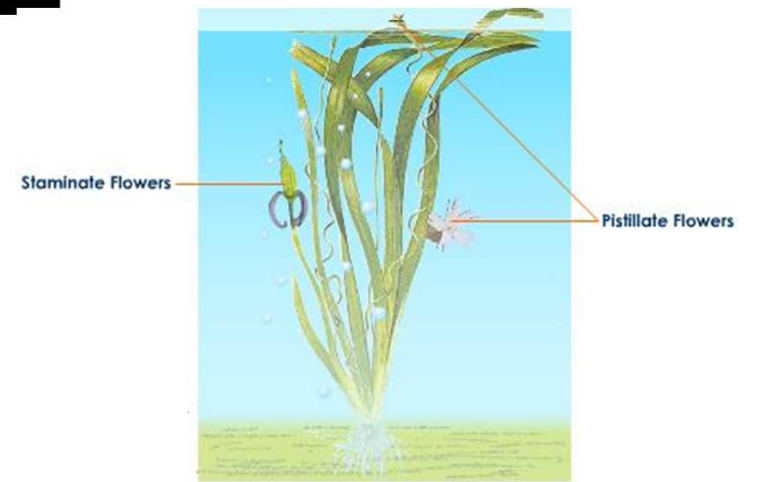
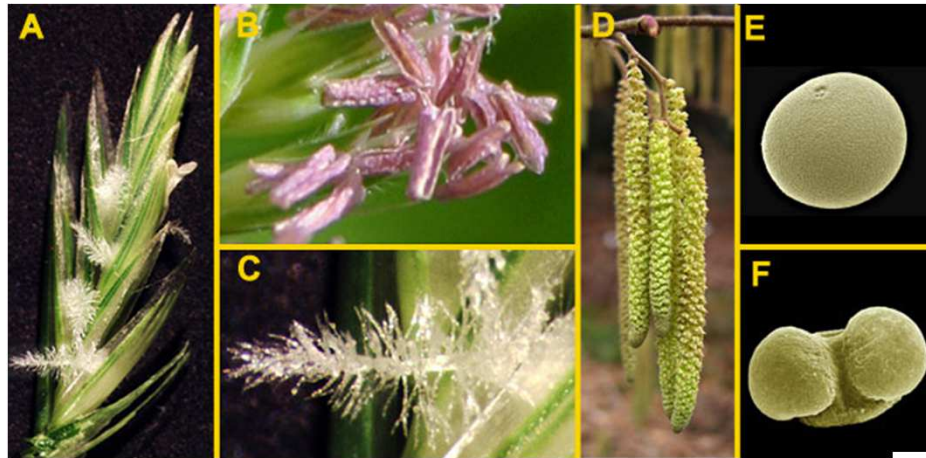
Scent attraction and nectar reward



Pollination biology

Floral diversity and pollination

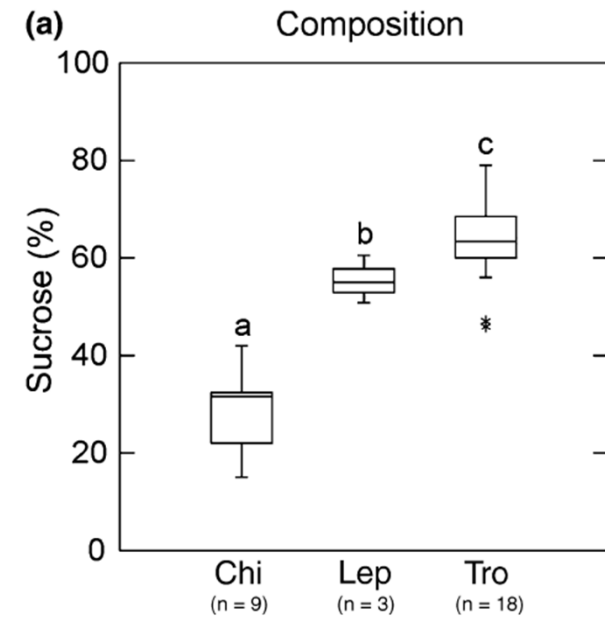
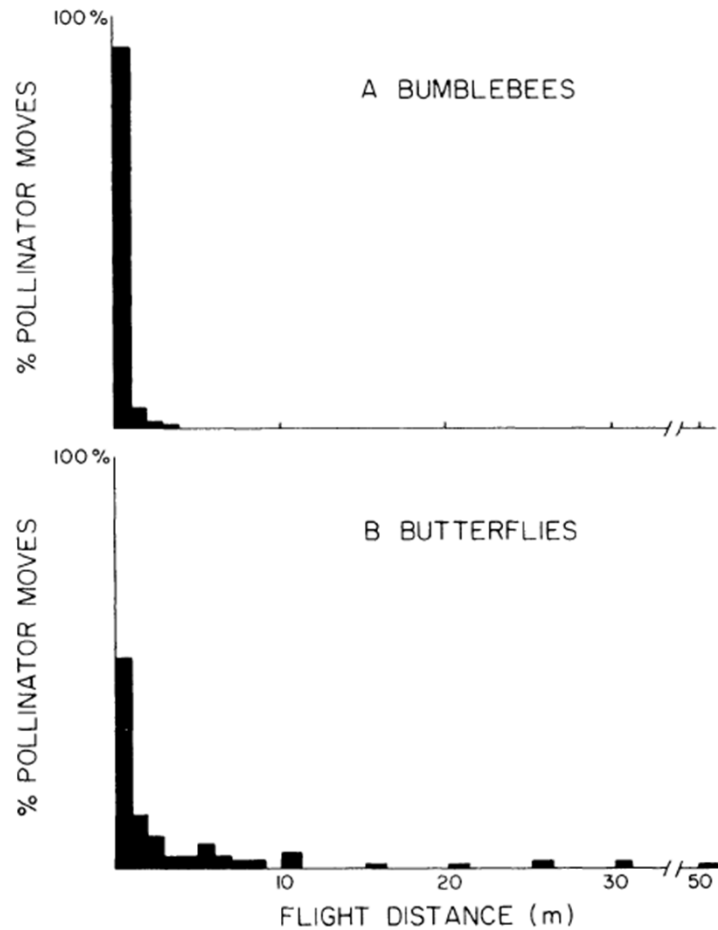
Pollination (zoo-, anemo-, hydro-)



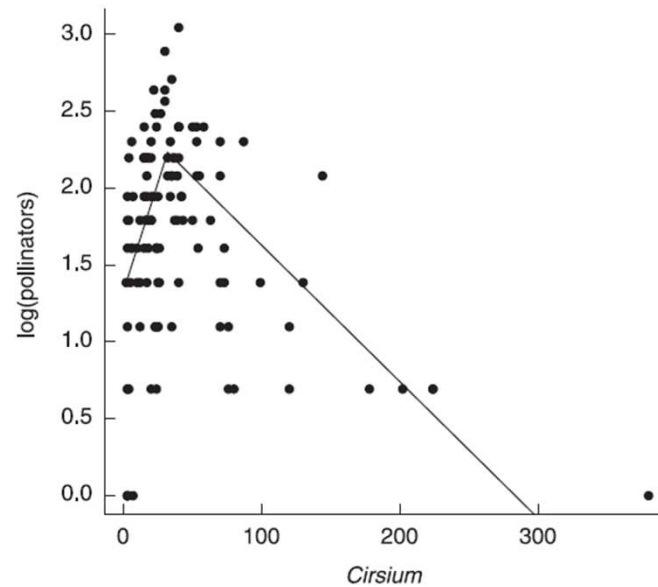
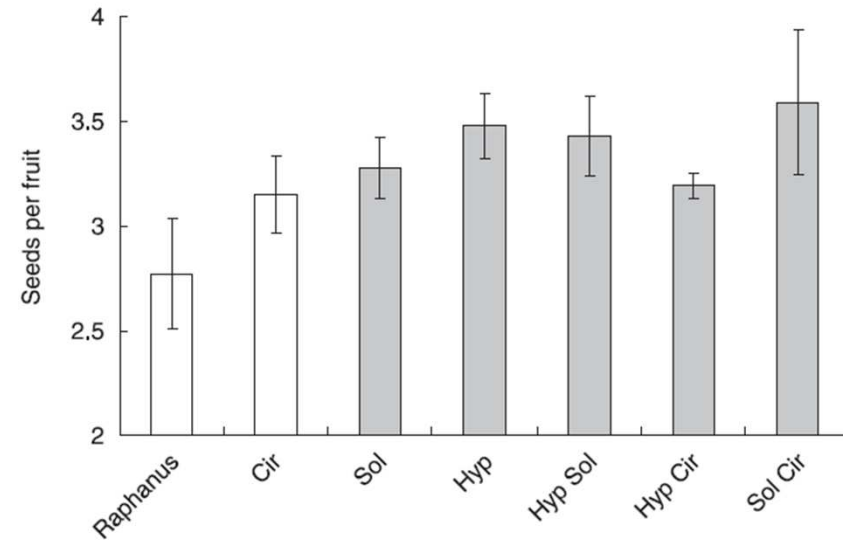
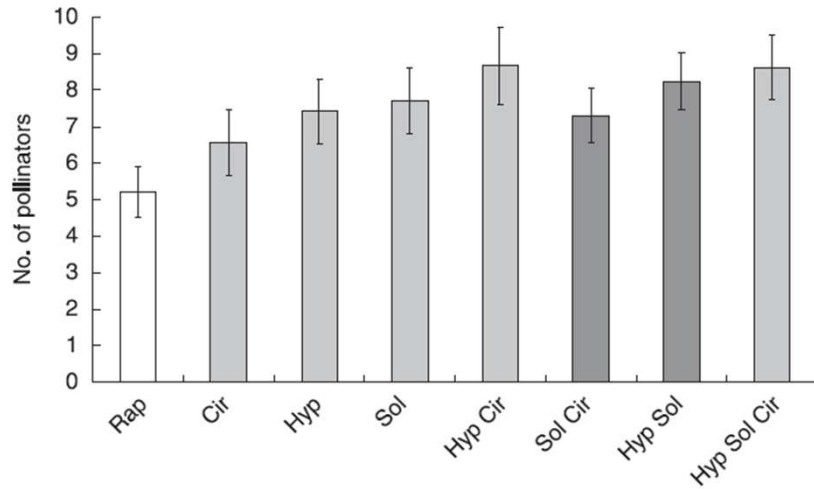
Sexual reproduction

Pollination biology and gene flow

Pollinator behaviour and foraging strategies



Floral diversity and pollination



hermaphrodites **95%** (Richards 1997)

potential for selfing



40% can do, **20%** usually

(ii) Why outcrossing is more frequent than self-fertilization?

How do plants avoid self-pollination?

Mechanisms:

mechanistic

temporal

genetic

Mechanistic separation of male and female functions

allowing flower structures for cross-pollination:

cleistogamy vs chasmogamy



Mechanistic separation of male and female functions

enlarging the distance between male and female structures



Mechanistic separation of male and female functions

enlarging the distance between male and female structures

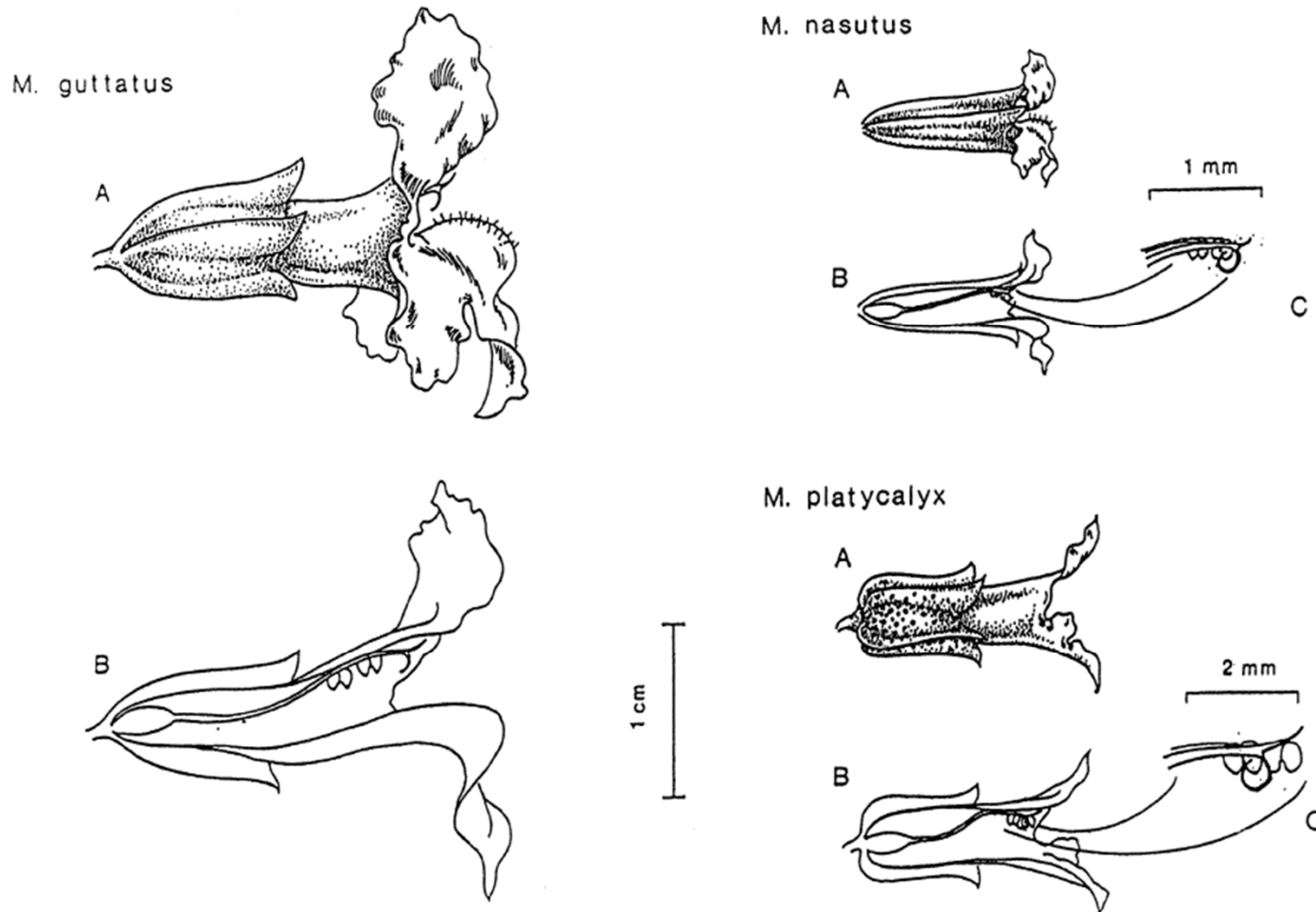
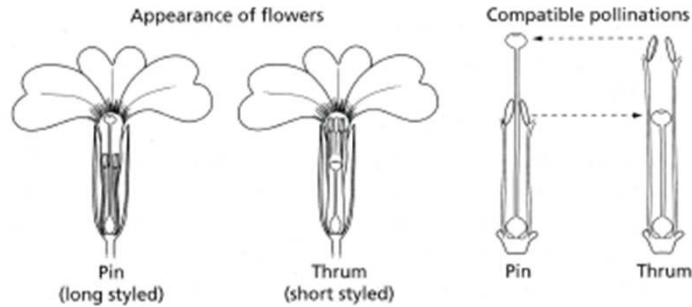
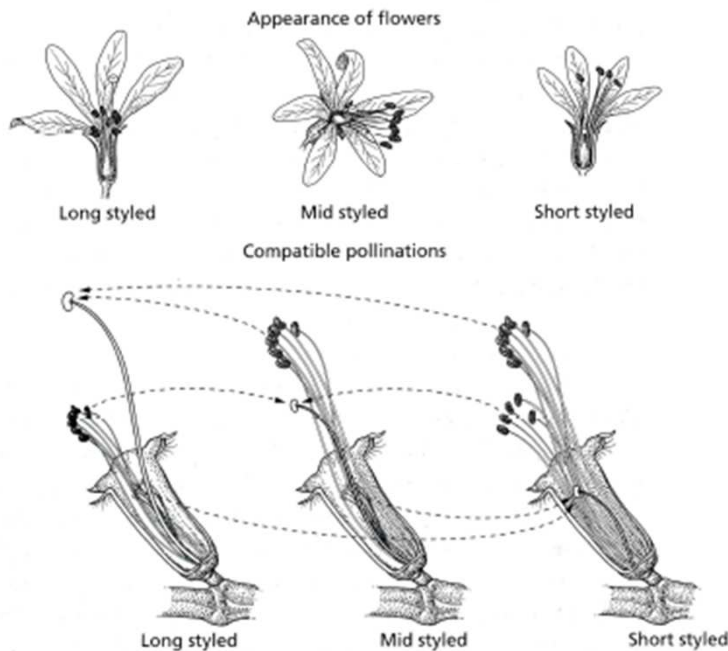


Fig. 1. Variation in floral morphology of *M. guttatus*, *M. nasutus*, and *M. platycalyx*. A. Lateral view. B. Cross section. C. Enlargement of stigma/anther region.

Mechanistic separation of male and female functions - herkogamy (heterostyly)



(b) Distyly in the primrose, *Primula vulgaris*



(c) Tristyly in *Lythrum salicaria*

Temporal separation of male and female functions - Dichogamy

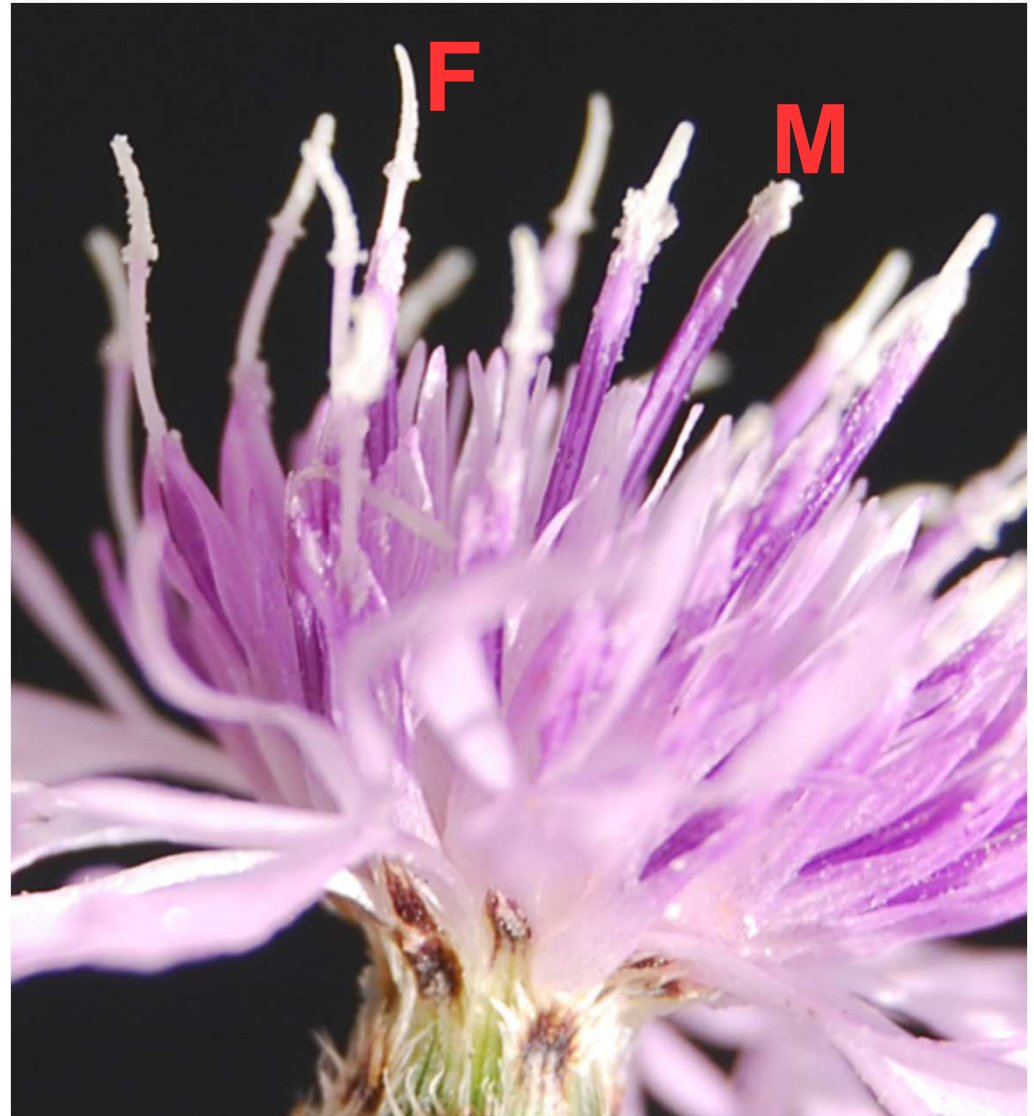
A. protandry (male first)



Centaurea stoebe s.l.

Temporal separation of male and female functions - Dichogamy

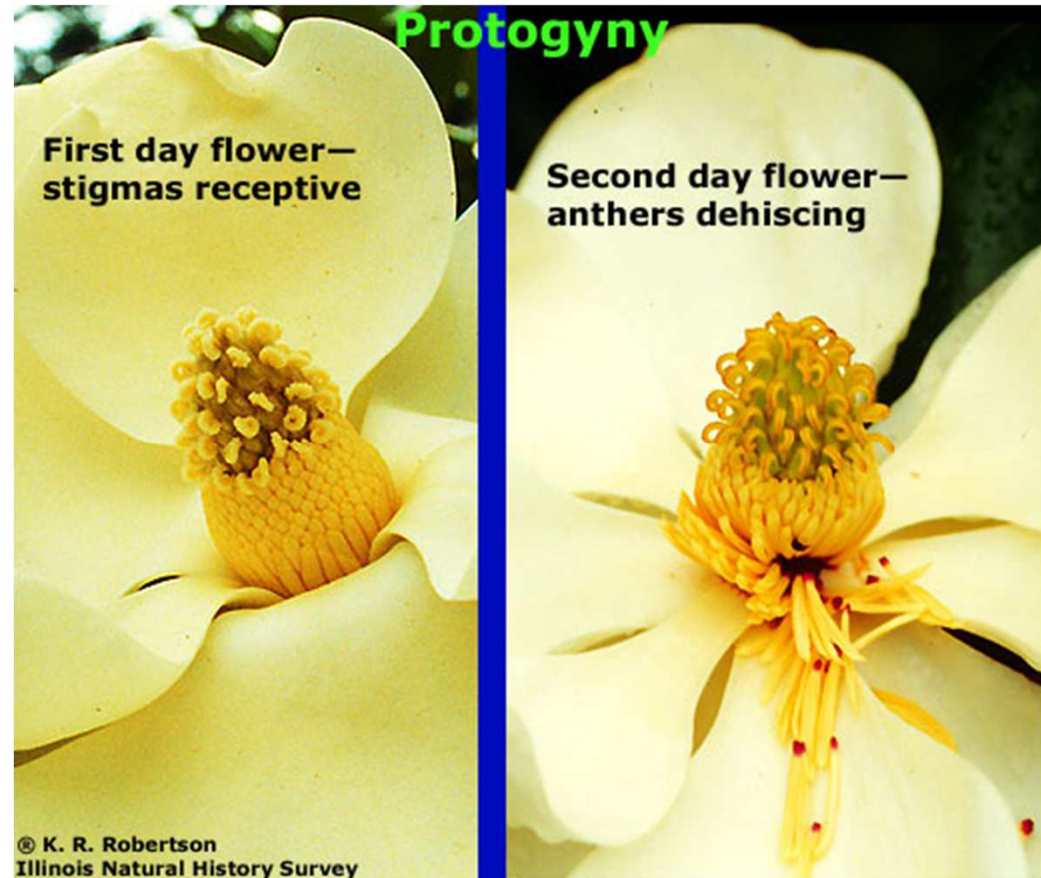
A. protandry (male first)



Centaurea stoebe s.l.

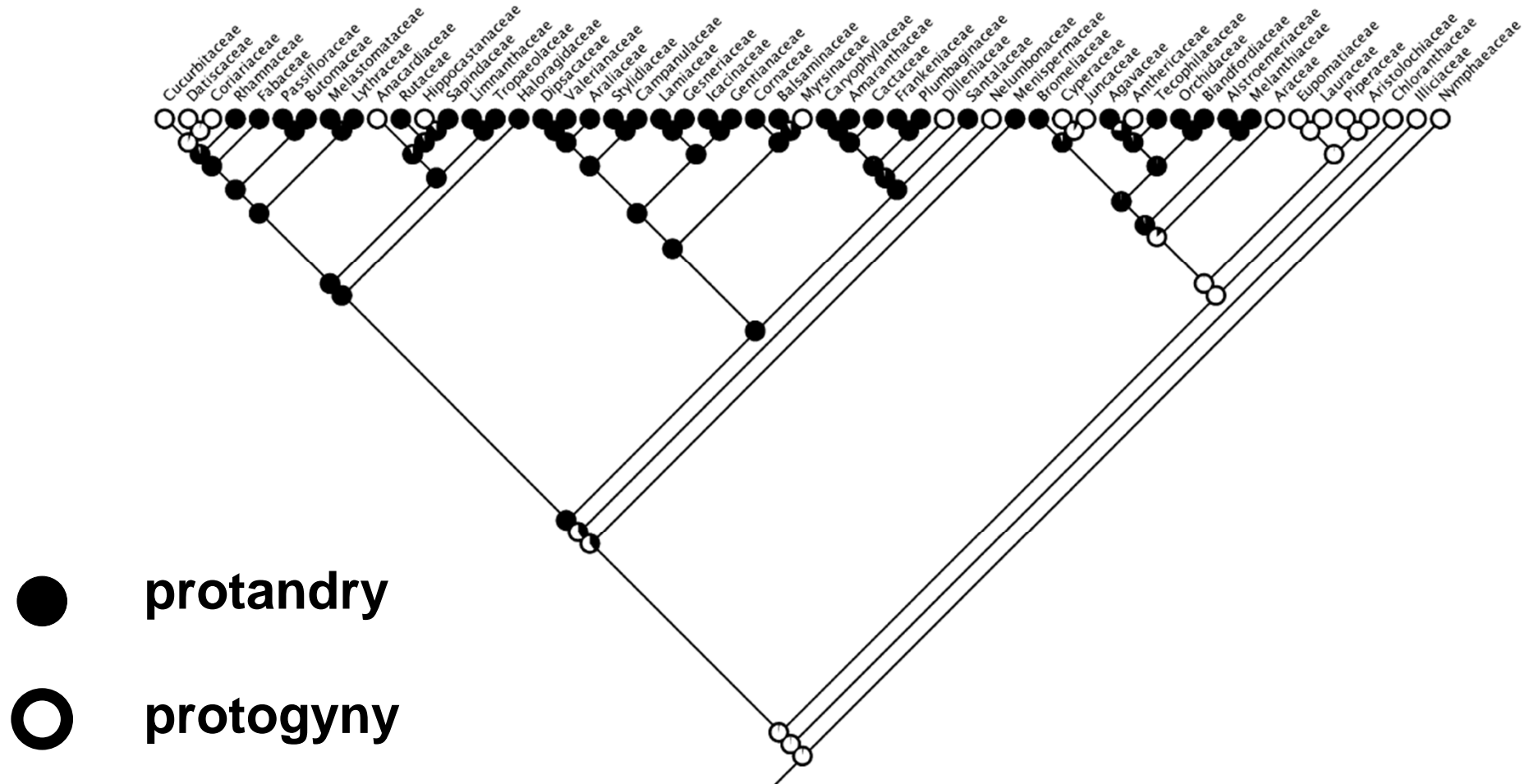
Temporal separation of male and female functions - Dichogamy

B. progyny (female first)

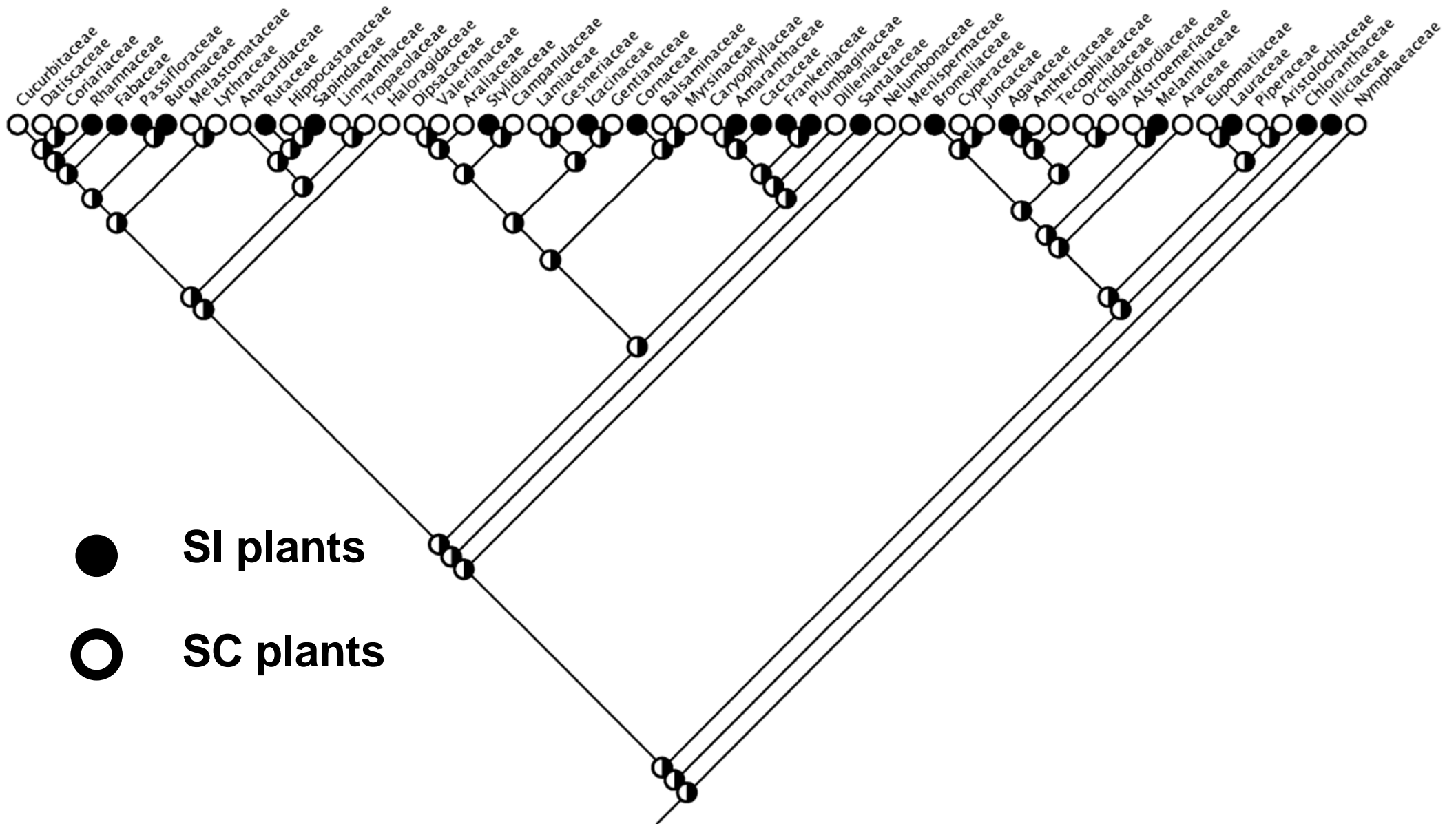


Magnolia grandiflora

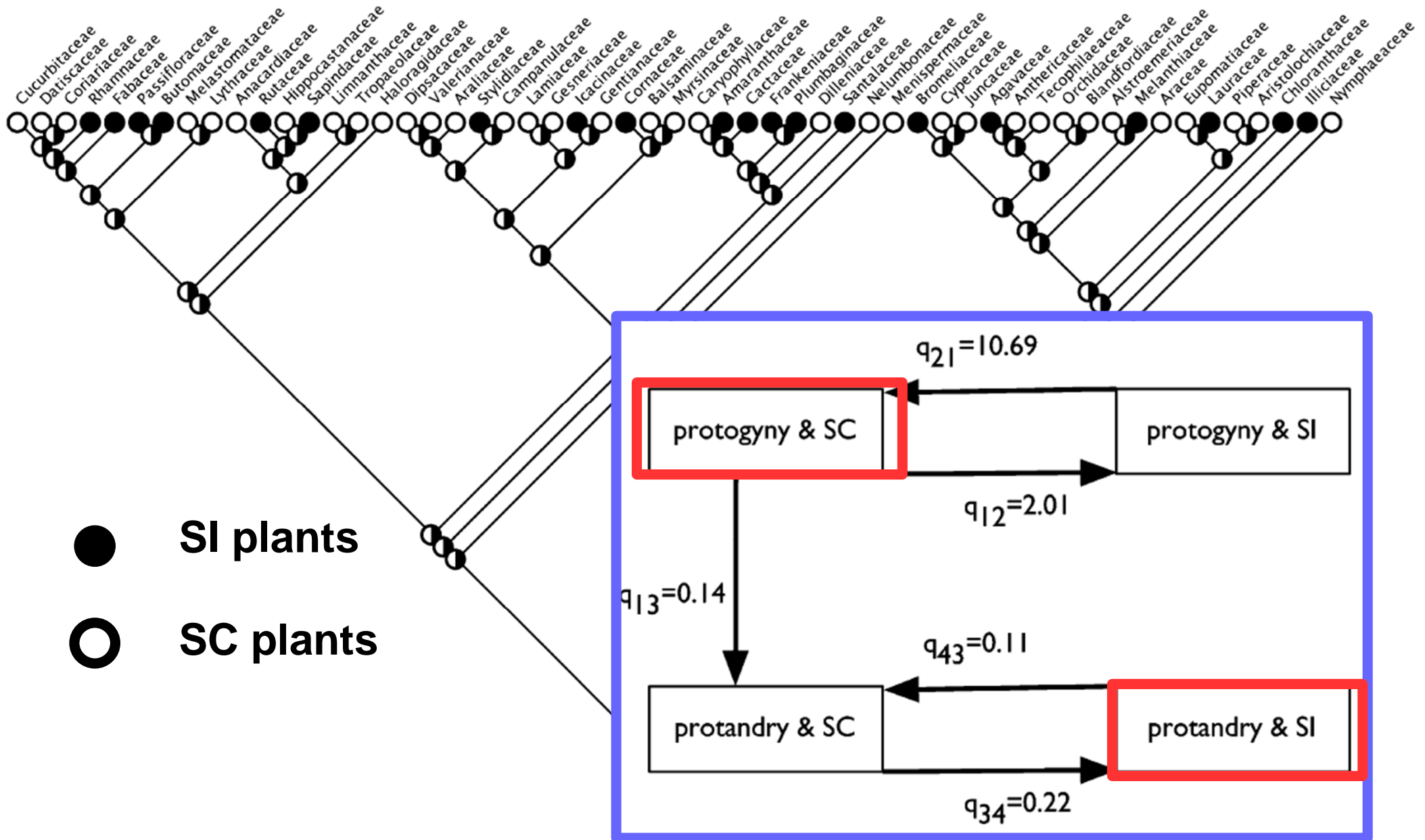
Temporal separation of male and female functions - Dichogamy



Temporal separation of male and female functions - Dichogamy



Temporal separation of male and female functions - Dichogamy



Temporal separation of male and female functions - Dichogamy

A. protandry - reducing the impact of pollen-pistil interference on pc

B. protogyny - reducing the negative impact of inbreeding (usually in

Genetic mechanism: multiallelic self-incompatibility

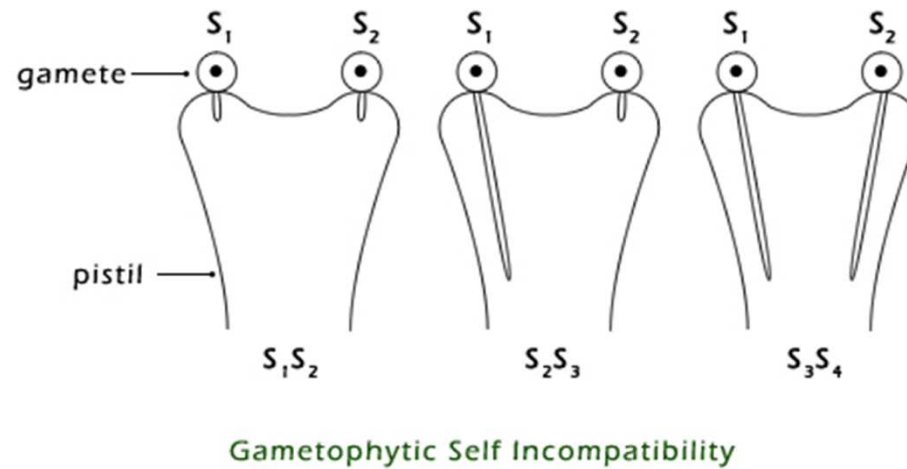
Self-incompatibility (SI) - the inability of fertile hermaphrodite plant to p

Genetically based (S-alleles, frequency dependent system)

Two types: **Sporophytic SI and Gametophytic SI**

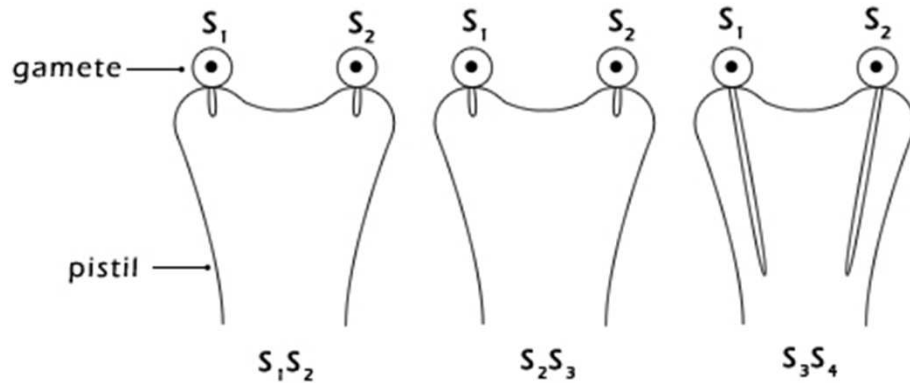
Multiallelic self-incompatibility

Gametophytic self-incompatibility (most of plants)

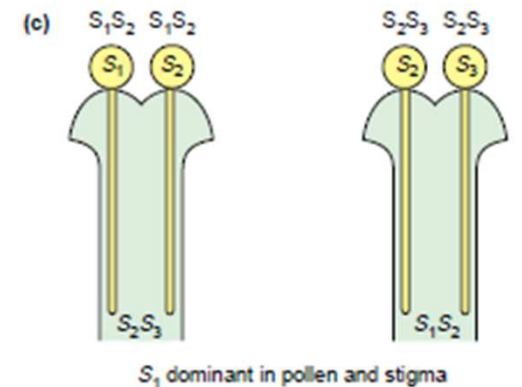
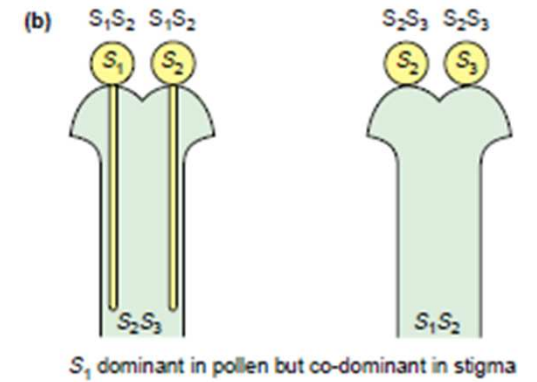
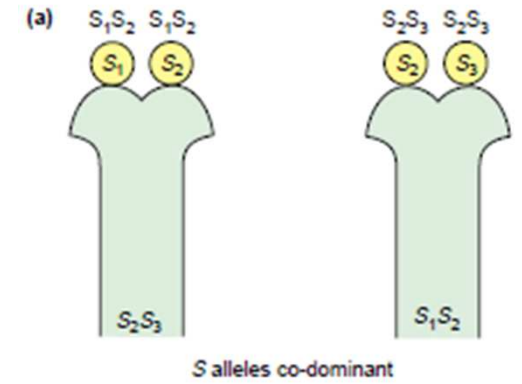
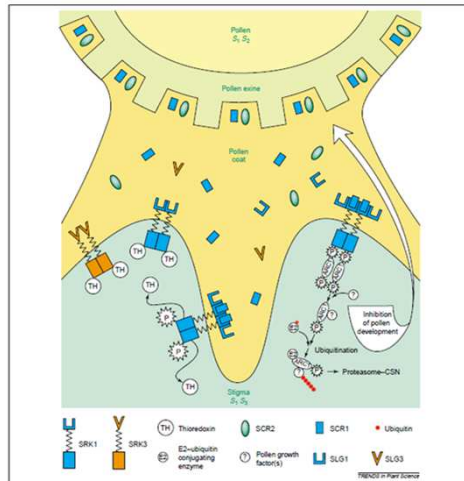


Multiallelic self-incompatibility

Sporophytic self-incompatibility (Asteraceae, Brassicaceae)



Sporophytic Self Incompatibility



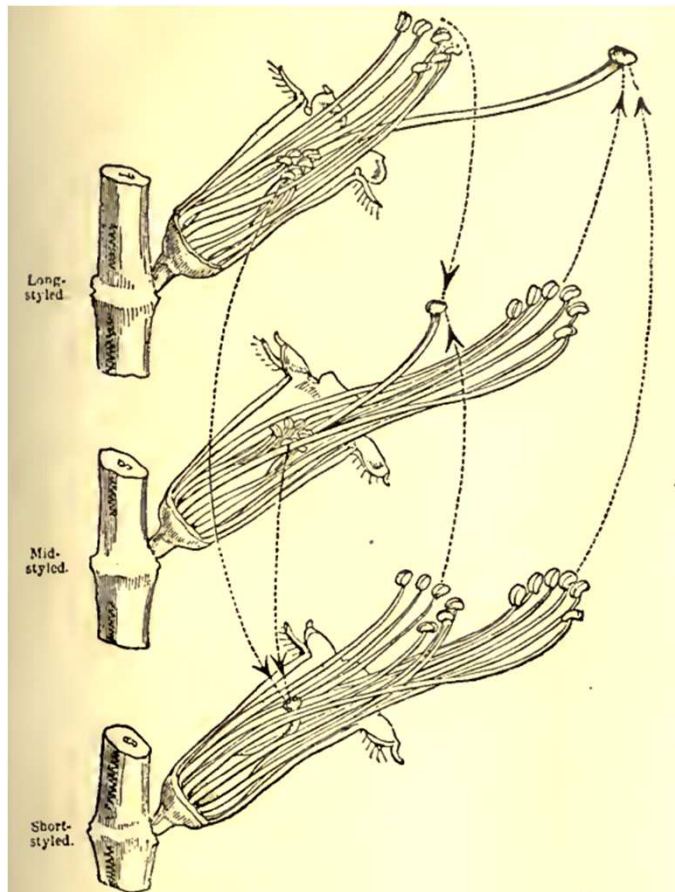
Multiallelic self-incompatibility

Break-down of SI system

Self-incompatibility

Floral heteromorphy

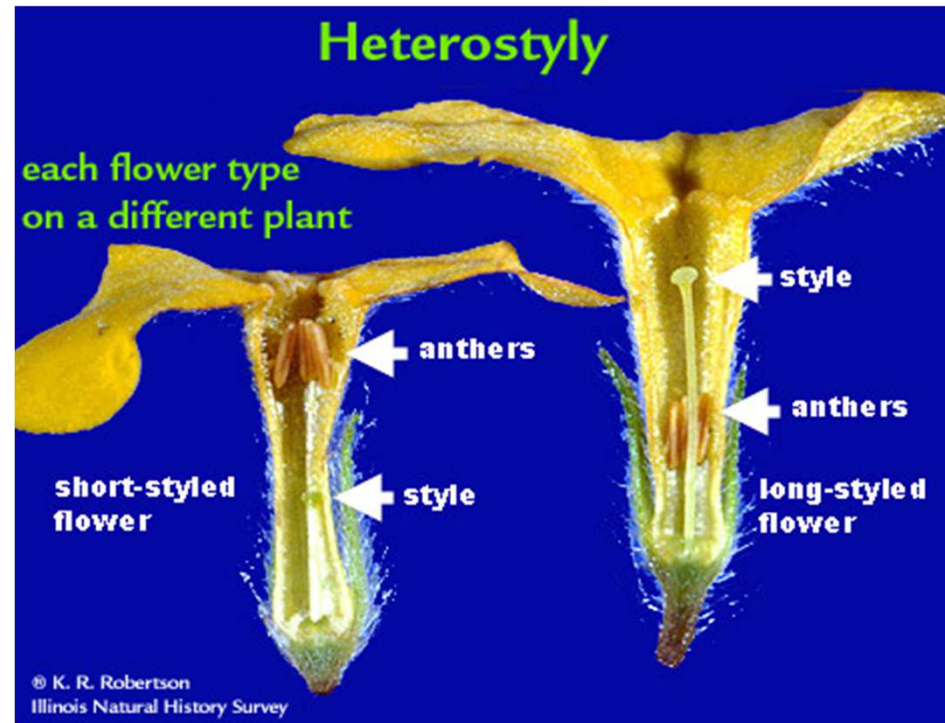
phenomenon when **2 or 3 different floral morphs** occur within population
mating compatible between morphs, incompatible within



(From Darwin's *Different Forms of Flowers* by permission.)

FIG. 2.—Diagram of the flowers of the three forms of *Lythrum salicaria* in their natural position, with the petals and calyx removed on the near side. (X 6 times.)

The dotted lines with the arrow show the directions in which pollen must be carried to each stigma to ensure full fertility.



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Illinois Natural History Survey

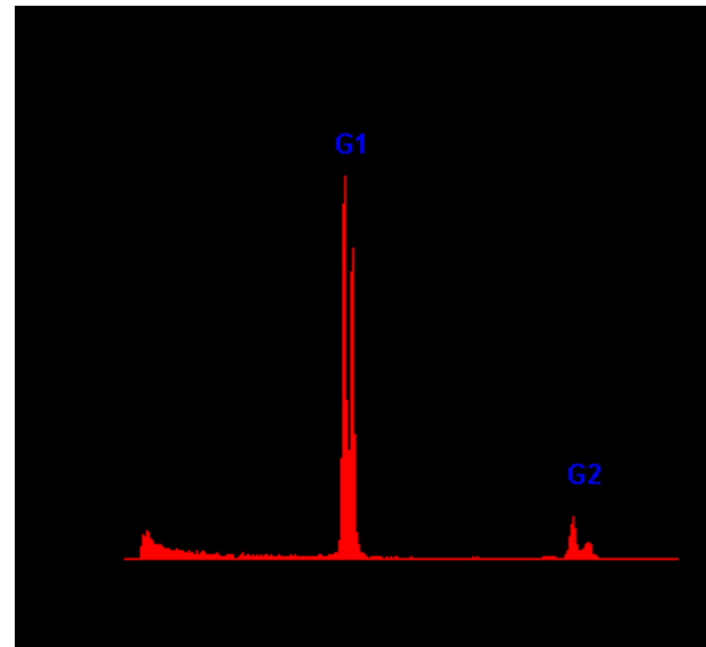
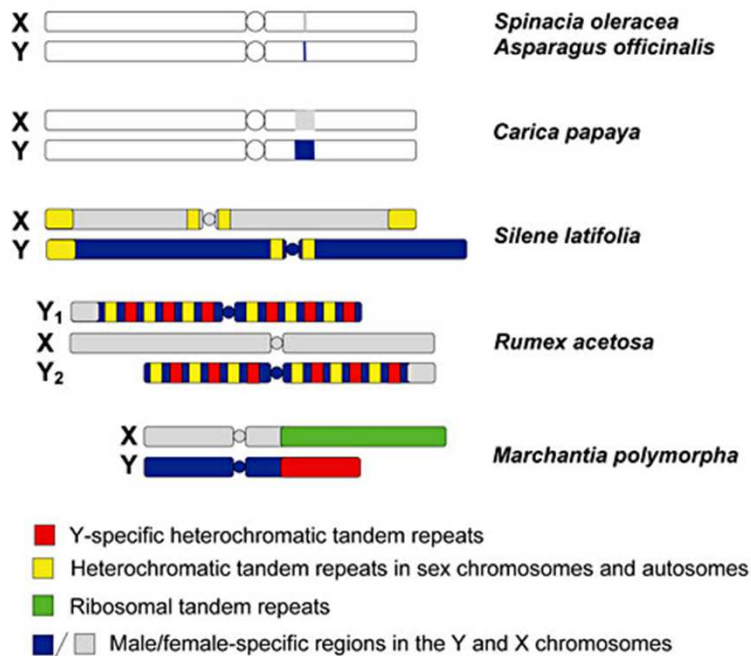
Self-incompatibility

Dioecy

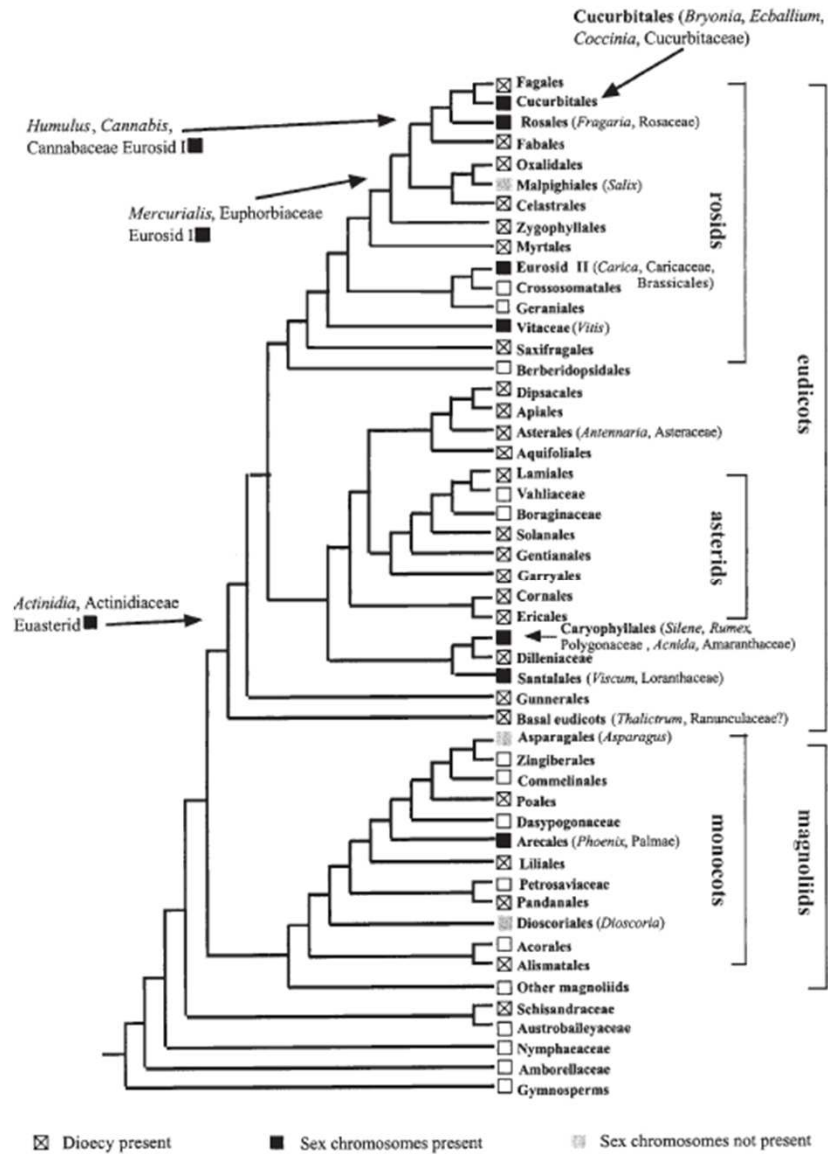
4% of flowering plants

more often in **trees & shrubs** than in perennial herbs

sometimes associated with 'sexual chromosomes'



Dioecy



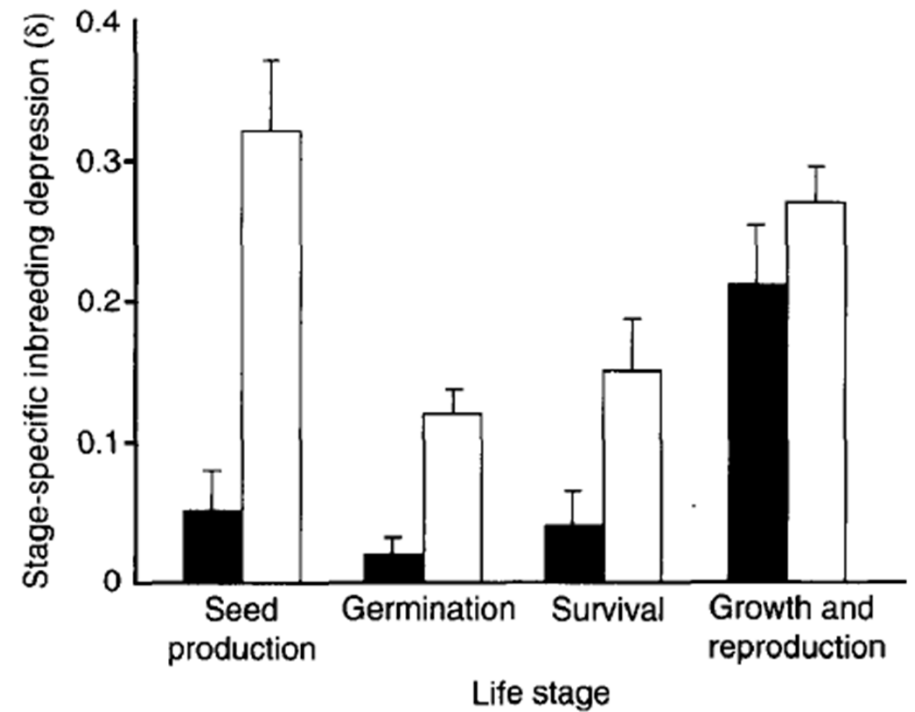
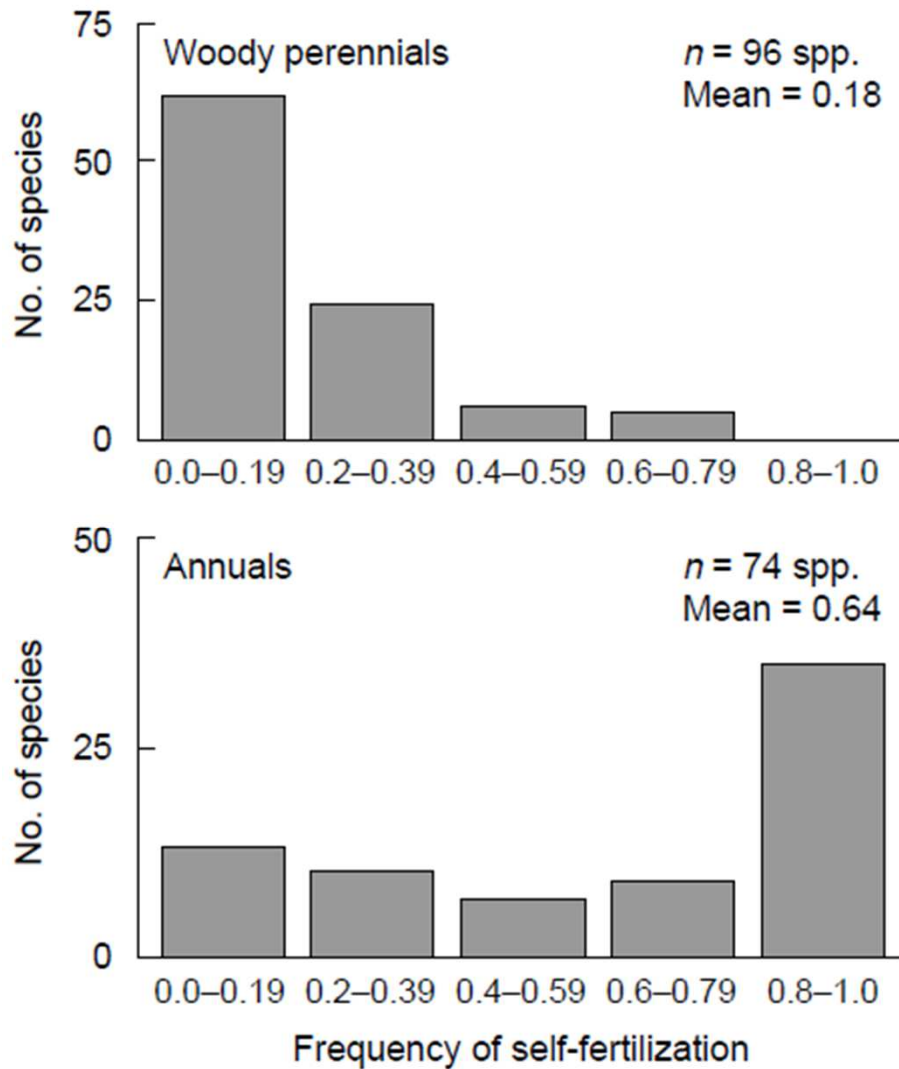
Self-fertilization & inbreeding

As **ca 95% species** are hermaphrodites > **potential for selfing**

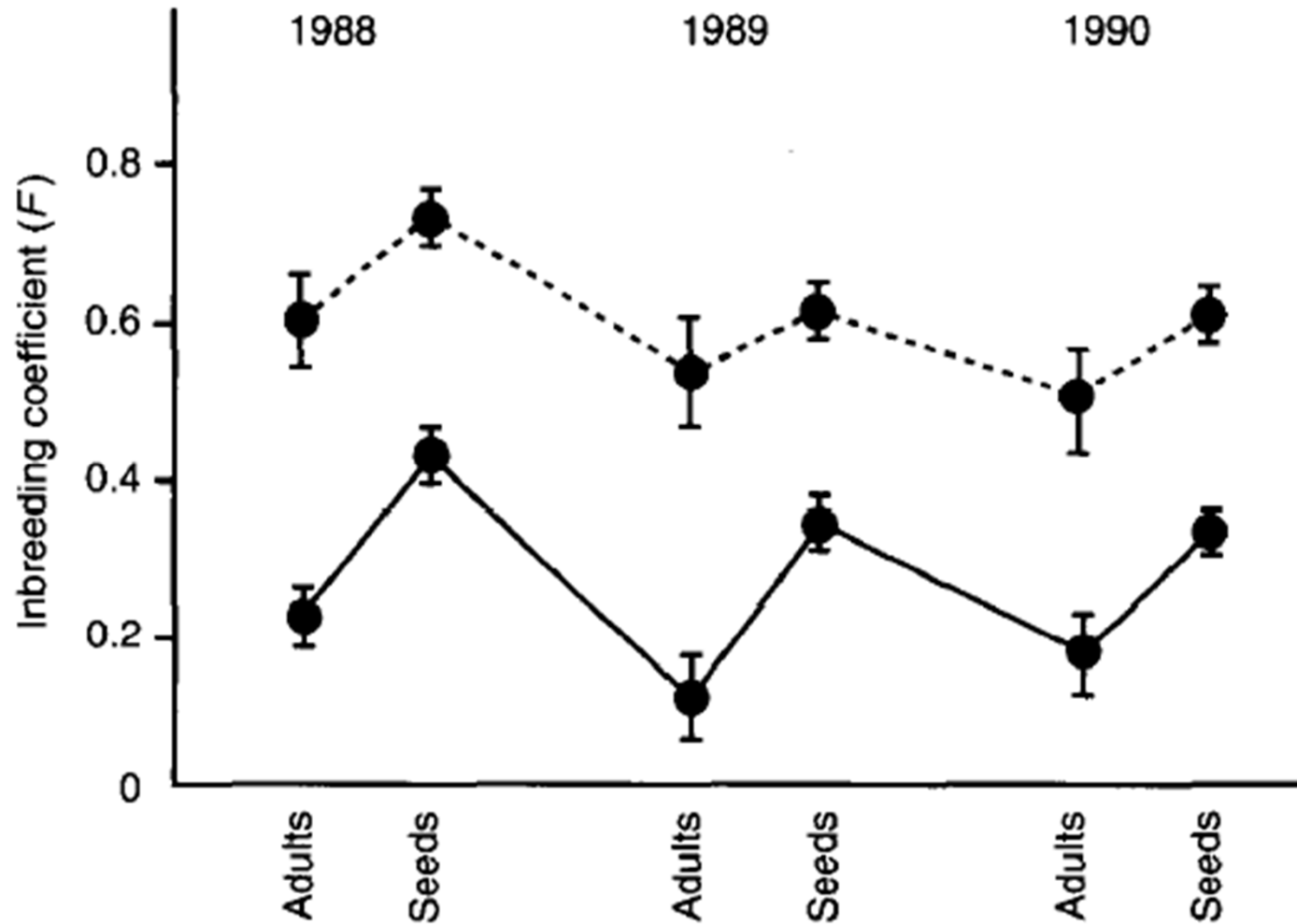
Advantages?

Disadvantages?

Self-fertilization & inbreeding



Self-fertilization & inbreeding



Inbreeding depression

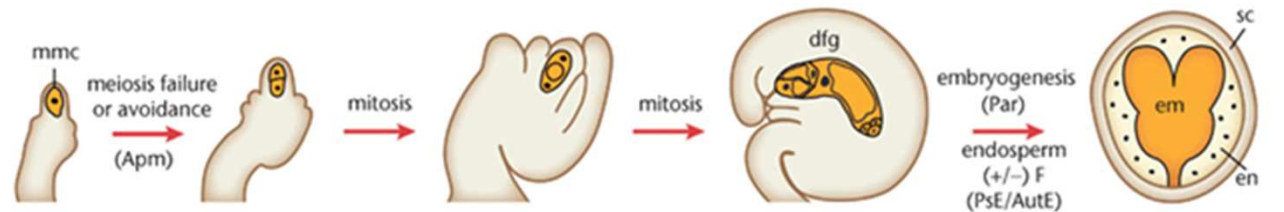
Agamospermy

asexual seed production: progeny is a genetic copy of maternal plant

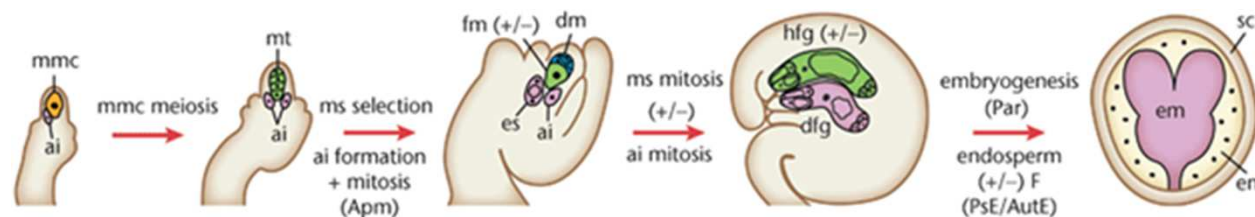
21 angiosperm families, **Asteraceae, Poaceae & Rosaceae**

associated with **polyploidy, interspecific hybridization, SI** (in sexual rela

diplospory
(*Hieracium*,
Taraxacum)



apospory
(*Pilosella*,
Rubus,
Potentilla)



Agamospermy

Agamospermy

Advantages

Disadvantages