Plant of the day

Victoria amazonica (Nymphaeaceae)

Leafs up to 3 m in diameter (can support up to 70 pounds)

Flowers up to 40 cm (soccer ball size)

Shallow waters in the Amazon River basin

Beetle pollinated (traps pollinators and colour changes once pollinated)

Thermogenic flowers (attraction and energy reward)

The evolution and maintenance of plant sexual diversity

Questions

Why are there two sexes?

Why is there so much sexual diversity in plants versus animals?

Why do not all plants (and animals) have a mixed mating system with delayed selfing?

sexual systems

Sexual system: the particular deployment of sexual structures within and among plants and the physiological mechanisms governing mating

Sexual interference: conflict in maternal and paternal functions resulting in gamete wastage and reduced fitness

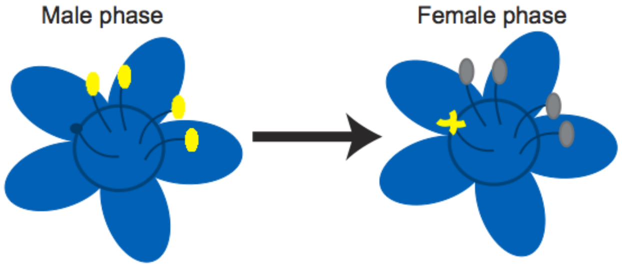
-physical interference (position of female and male sexual organs may interfere with efficient pollination)

-pollen clogging of stigmas by self or foreign pollen

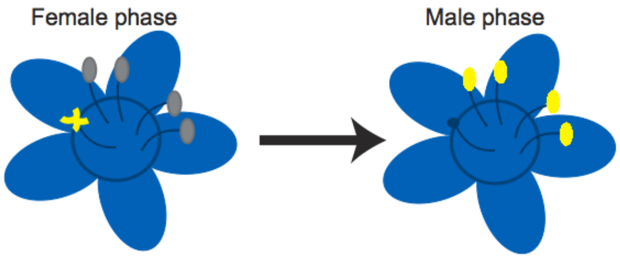
Examples of plant sexual systems

Dichogamy: differences in the timing of pollen dispersal from anthers and stigma receptivity of flowers.

- protandry: male phase comes before the female phase



- protogyny: female phase comes before the male phase



Which type of dichogamy is the better anti-selfing mechanism?

-protogyny, because it guarantees a period of stigma receptivity free from self-pollen

-more protandrous species are self incompatible than protogynous species

Examples of plant sexual systems

Why are larger floral displays beneficial?

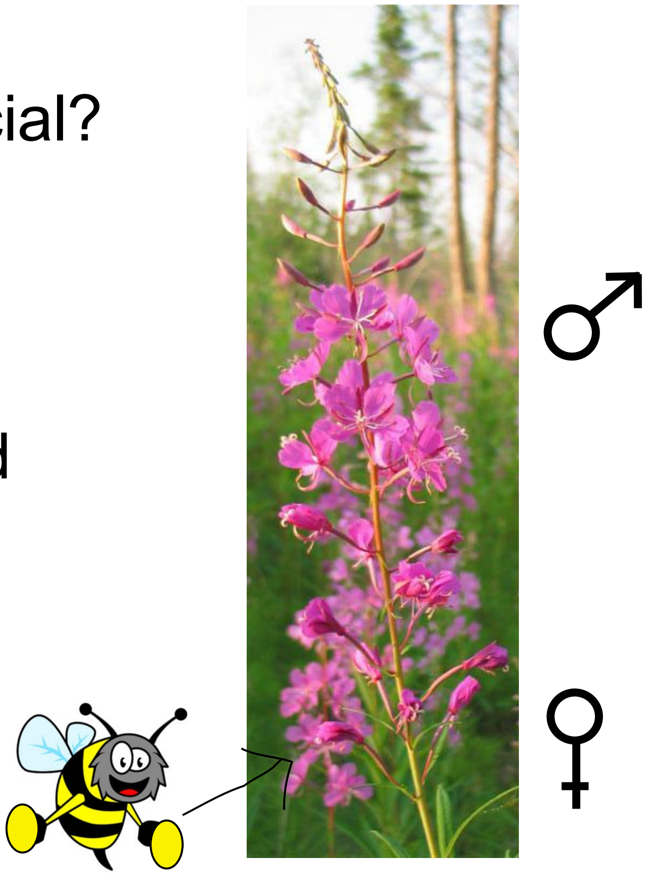
Increased pollinator attractiveness

Why are larger floral displays costly?

Geitenogamy (pollen discounting and selfing)

How do plants resolve this conflict?

Synchronized protandry is one way

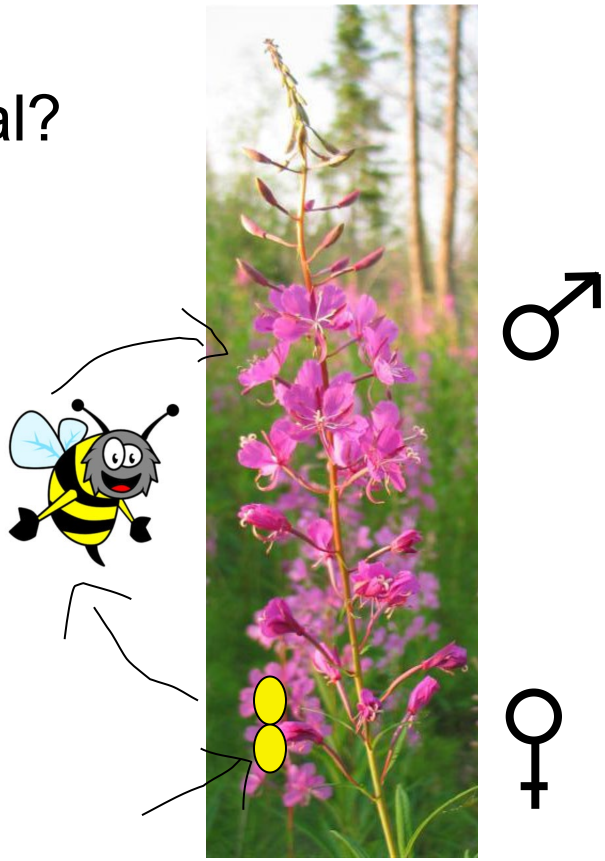


Examples of plant sexual systems

Why are larger floral displays beneficial?
Increased pollen attractiveness

Why are larger floral displays costly?
Geitenogamy (pollen discounting and selfing)

How to plants resolve this conflict?
synchronized protandry is one way



Examples of plant sexual systems

Why are larger floral displays beneficial?

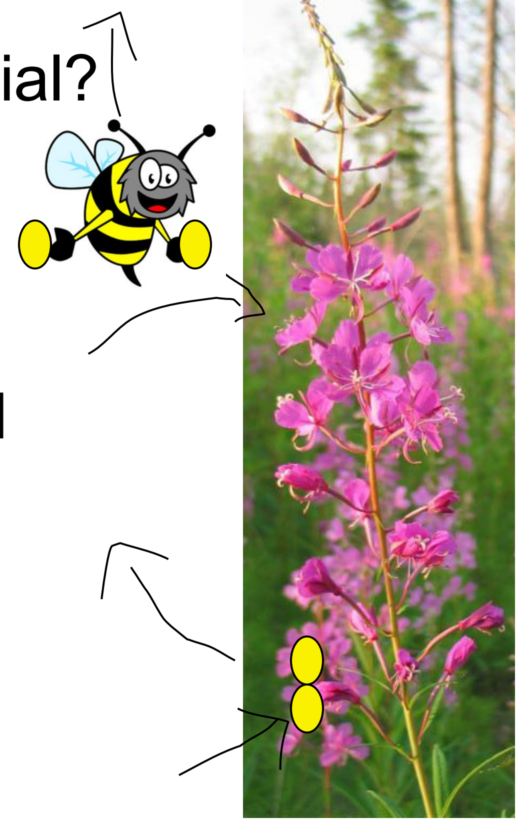
Increased pollen attractiveness

Why are larger floral displays costly?

Geitenogamy (pollen discounting and selfing)

How to plants resolve this conflict?

Synchronized protandry is one way

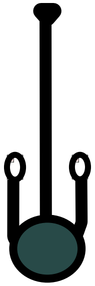


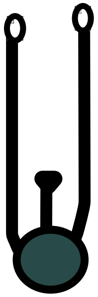
♂

♀

Examples of plant sexual systems

Herkogamy: the spatial separation of the anthers and stigmas within a flower.





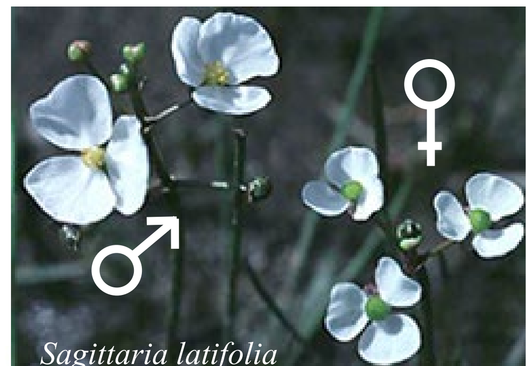
Approach herkogamy:
stigmas are above the anthers

Reverse herkogamy:
stigmas are below the anthers

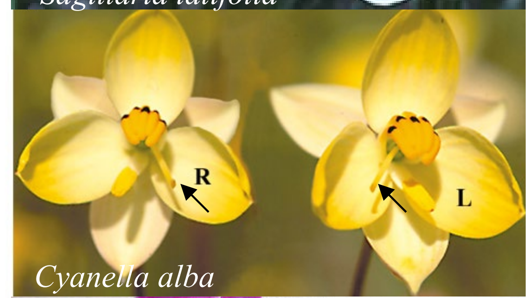
Which type of herkogamy would typically be better at preventing self pollination?
Approach herkogamy - less intrafloral self pollination

polymorphic sexual systems

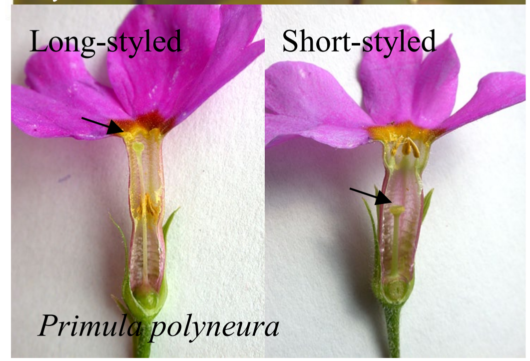
The co-occurrence within a population of morphologically distinct mating groups distinguished by differences in their sexual organs



Dioecy
(separate sexes)



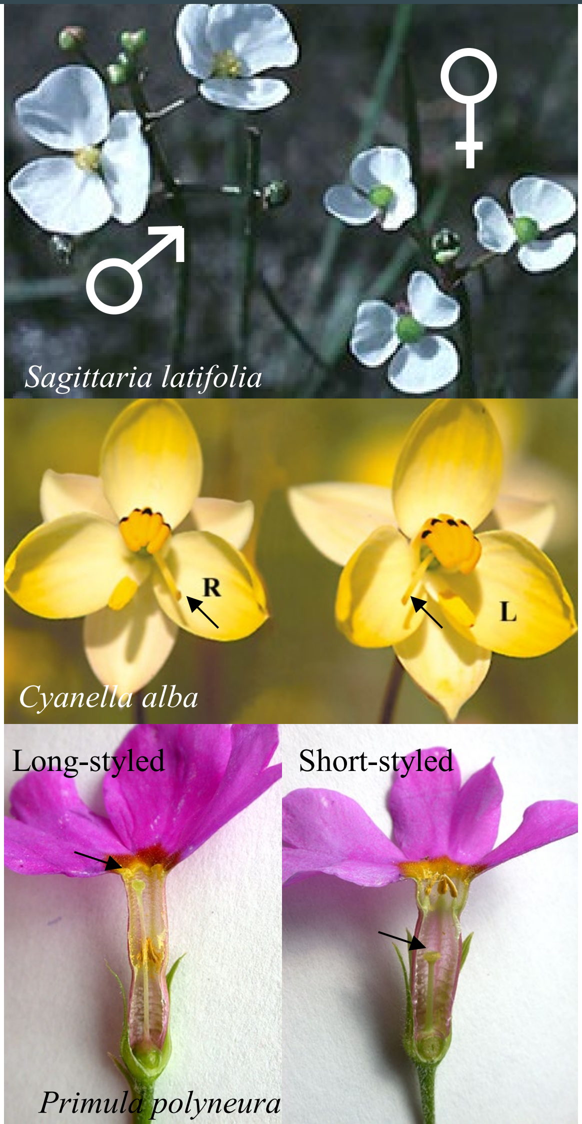
Enantiostyly
(mirror image flowers)



Heterostyly

Why study plant polymorphic sexual systems?

- simple inheritance
- sexual morphs easily identified in the field
- under strong frequency-dependent selection
- theoretical models provide predictions
- manipulative experiments possible



The evolution of separate sexes

~ 1/2 of flowering plant families have species with separate sexes

~6% of species have separate sexes

How do separate sexes evolve from cosexuality?

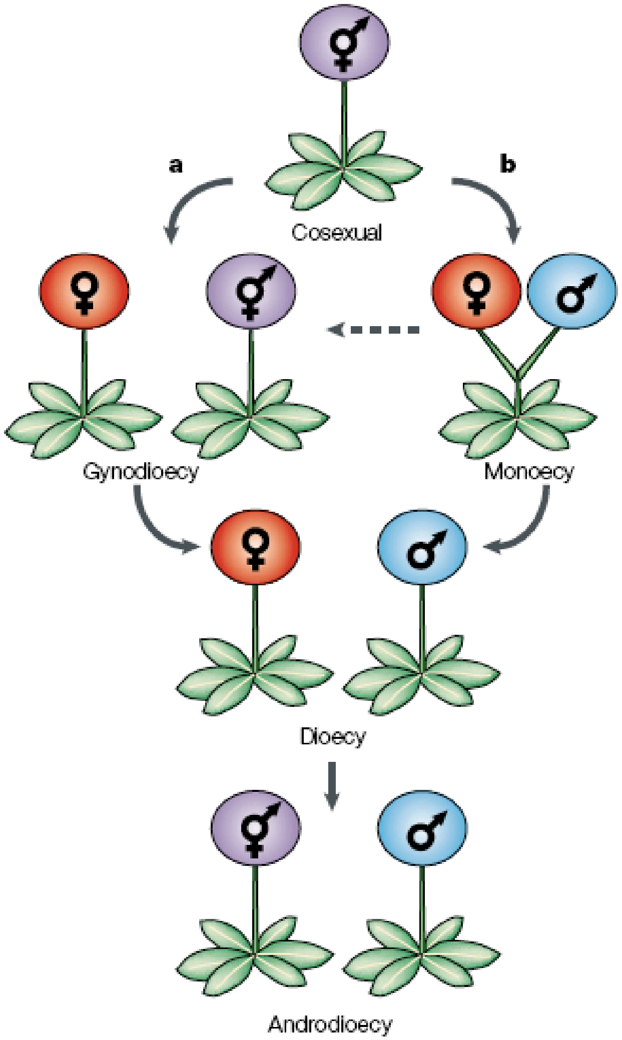
The evolution of separate sexes

- Gender: is the relative contributions that plants make to the next generation as a male and female parent (quantitative measure)
- Monomorphism - continuous variation in gender
- Dimorphism - two distinct sexual morphs that function primarily as a male or female parent

Dioecy

Gynodioecy

Evolutionary pathways to gender dimorphism



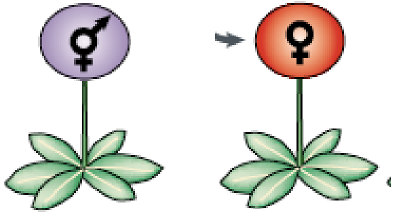
- Gynodioecy pathway
- Monoecy pathway

Selective mechanisms and the evolution of separate sexes

The evolution of dioecy from gynodioecy

Nuclear inheritance of male sterility (female)

Females spread if they produce at least two times as many seeds as hermaphrodites



How might females produce more seeds than hermaphrodites?

-s* $\delta > 0.5$ (more than 1/2 the offspring of hermaphrodites die due to inbreeding depression)

-resource reallocation from male function to female function (females produce >2x as many ovules)

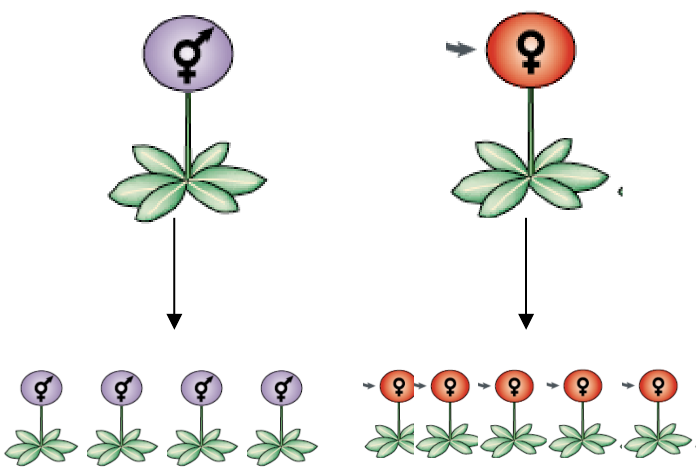
		w for invasion
Pollen	1	0
Seed	1	>2

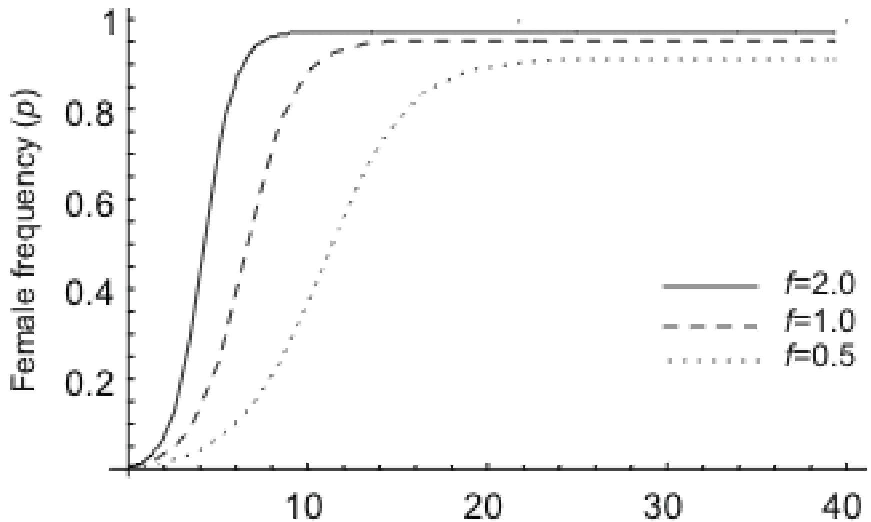
Cyto-nuclear control of gender dimorphism

What would happen if the male sterility mutation was in a mitochondrial gene?

All offspring of the male sterile mutant with be female

Females can spread with only a slight female fertility advantage





Cytoplasmic male sterility in plants is relatively common in nature

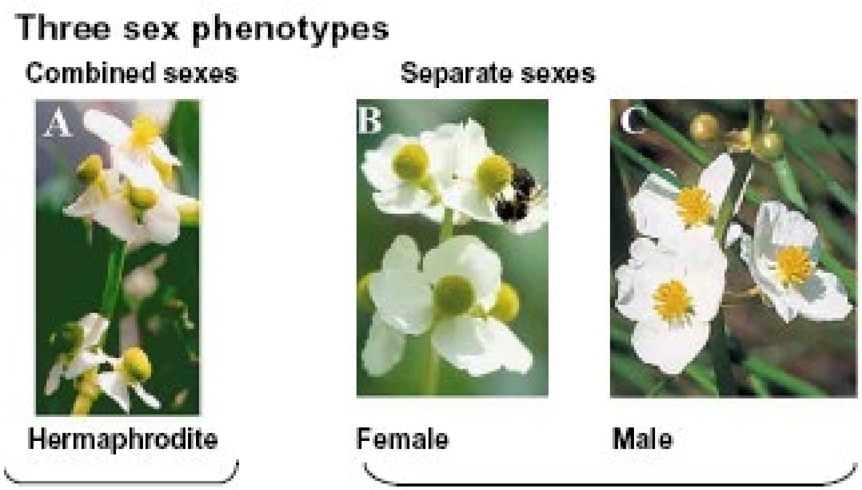
The next step to dioecy

In a gynodioecious population hermaphrodites pass on most of their genes through pollen

Selection for enhanced male function in hermaphrodites can lead to separate sexes

Selective mechanisms and the evolution of separate sexes

Large plant size (e.g. clonal)->higher selfing rates
Geitonogamy (transfer of self pollen between flowers)



Sagittaria latifolia

Dioecious = large clones
Monecious (hermaphrodites) = smaller plants

s* δ > 0.5 in some monecious populations

Dorken et al 2002

Selective mechanisms

Resource allocation:

•resource poor environments hermaphrodites unable to maintain both sex functions

- •e.g. *Wurmbea dioica*
- •gynodioecy in good environments
- •dioecy in poor environments

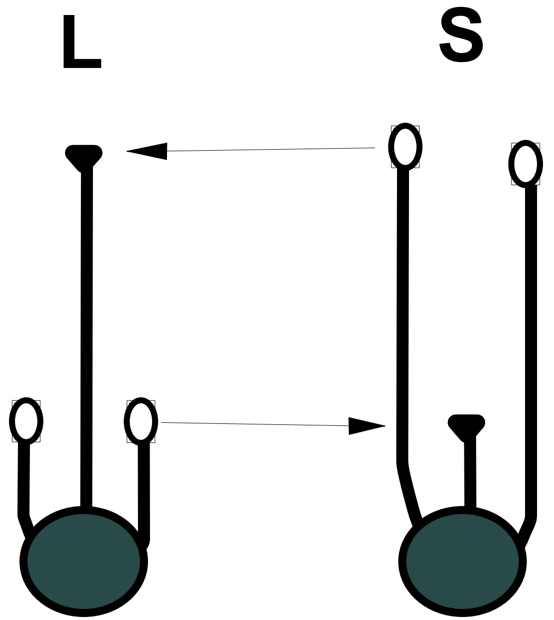
Floral design and pollen transfer: heterostyly

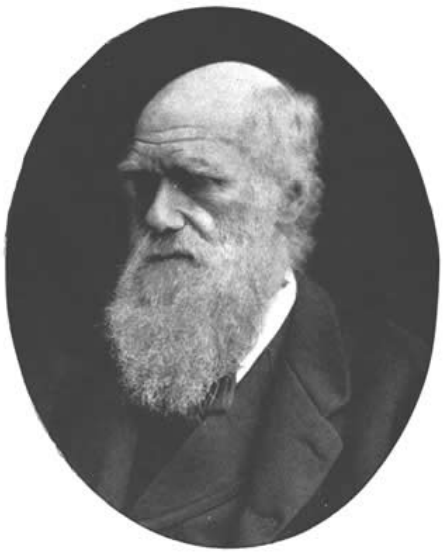
Heterostyly: two (distyly) or three (tristyly) style morphs differ in the reciprocal placement of anthers and stigmas.

•reciprocal sex-organ placement

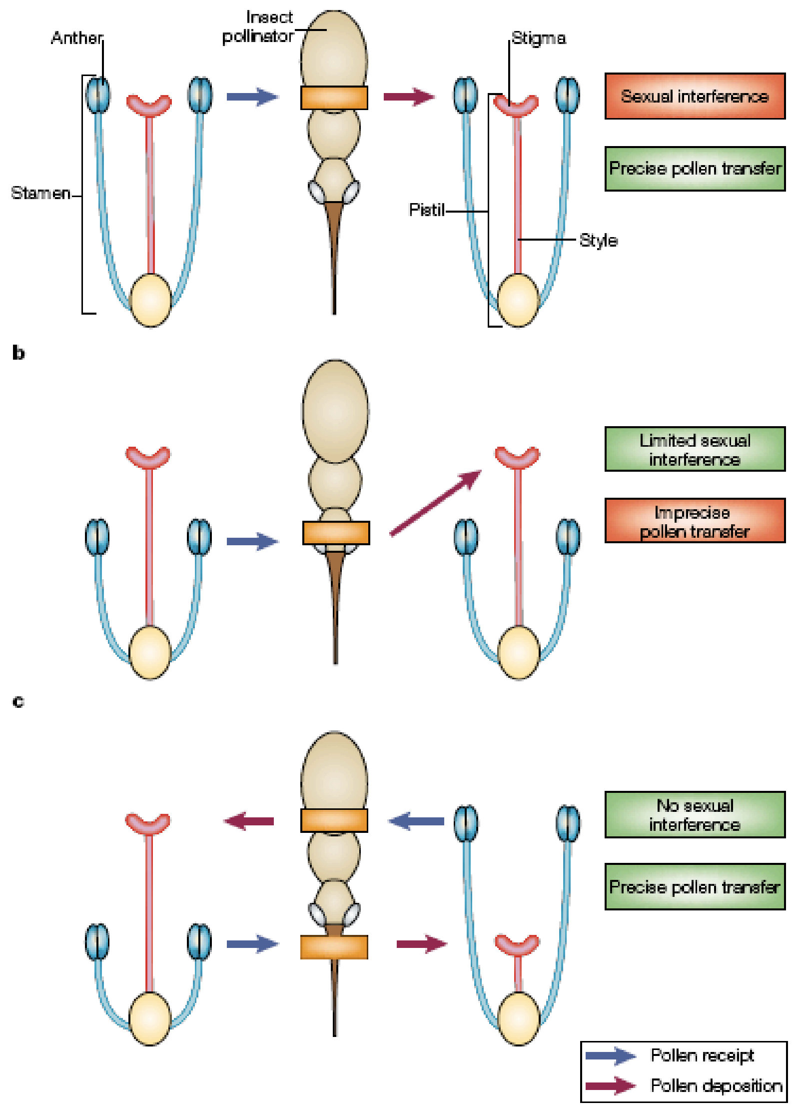
•heteromorphic self-incompatibility (disassortative mating)

•genetic polymorphism

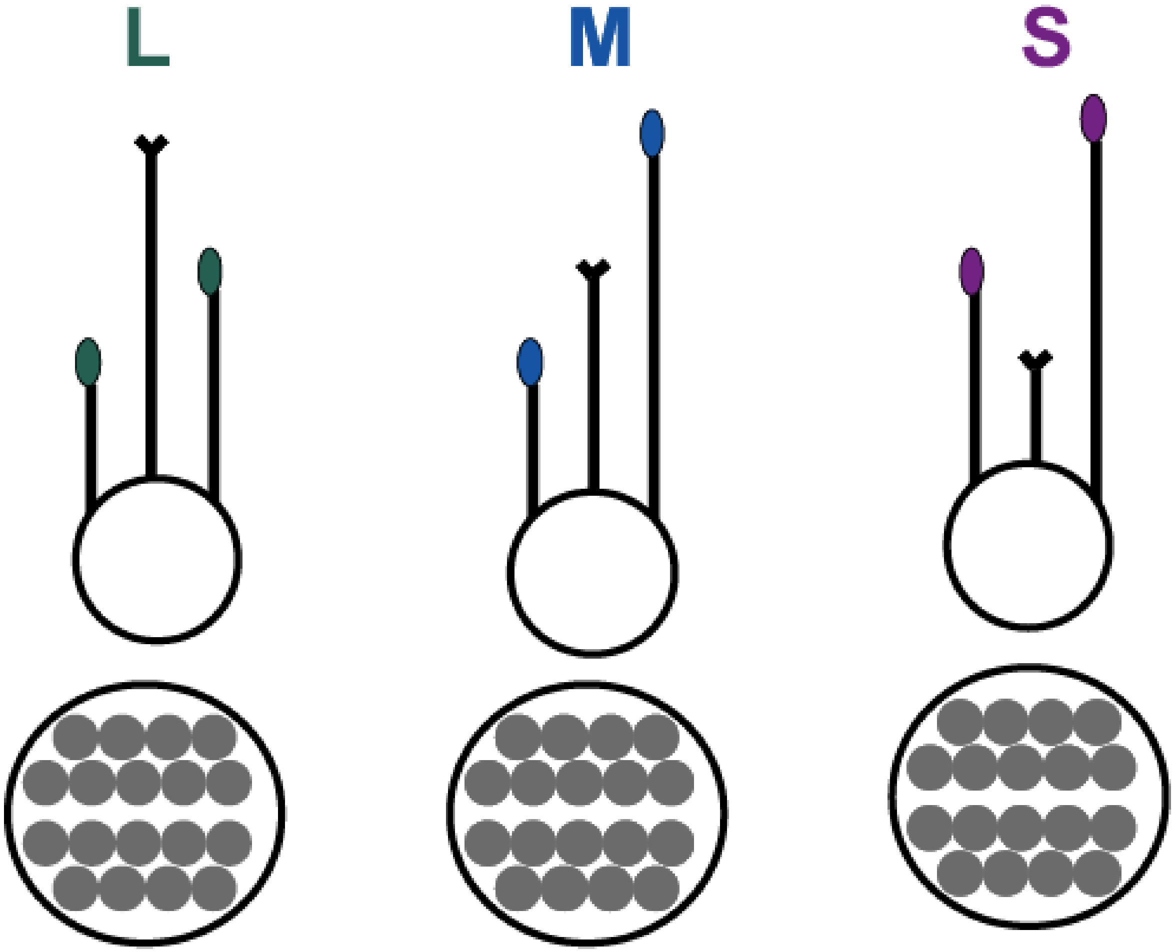




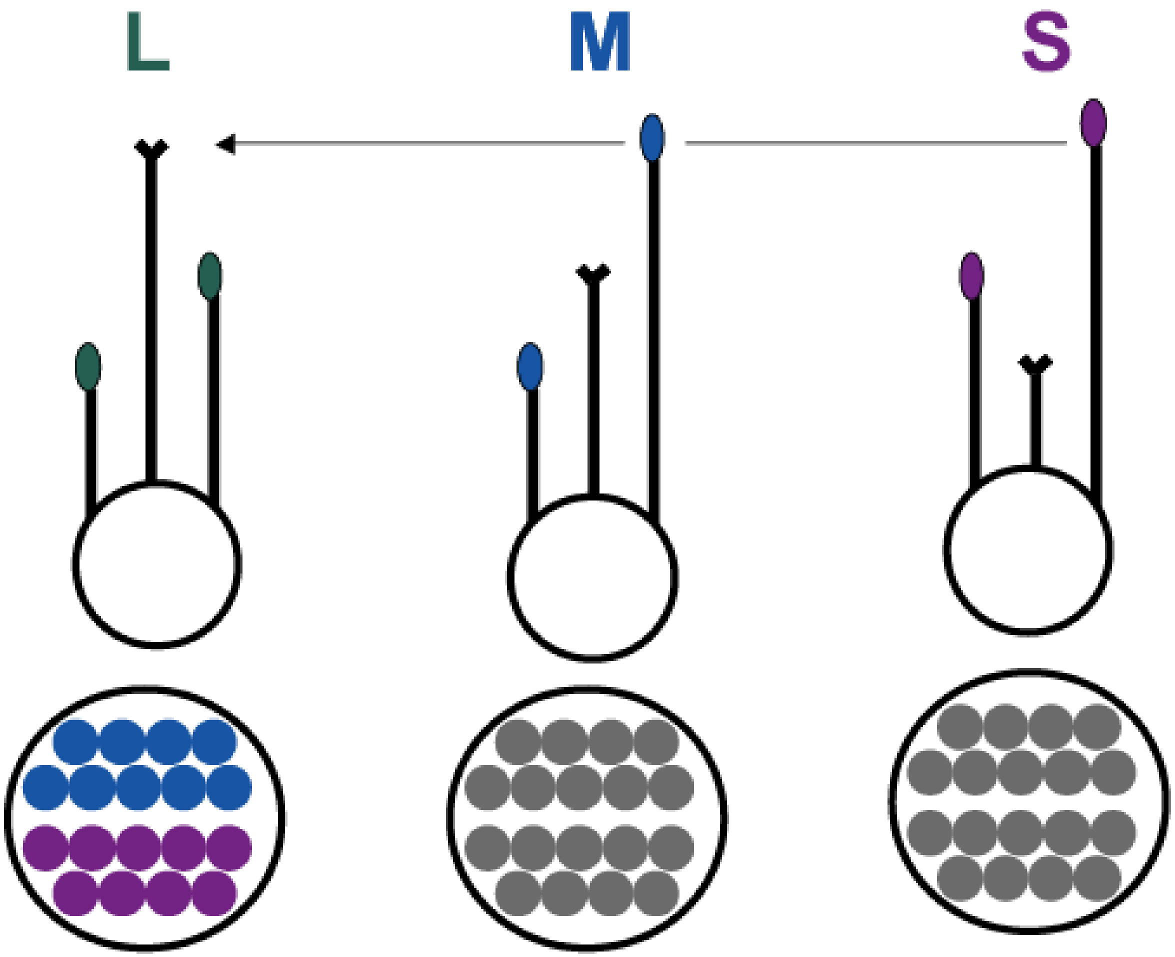
Floral design and pollen transfer



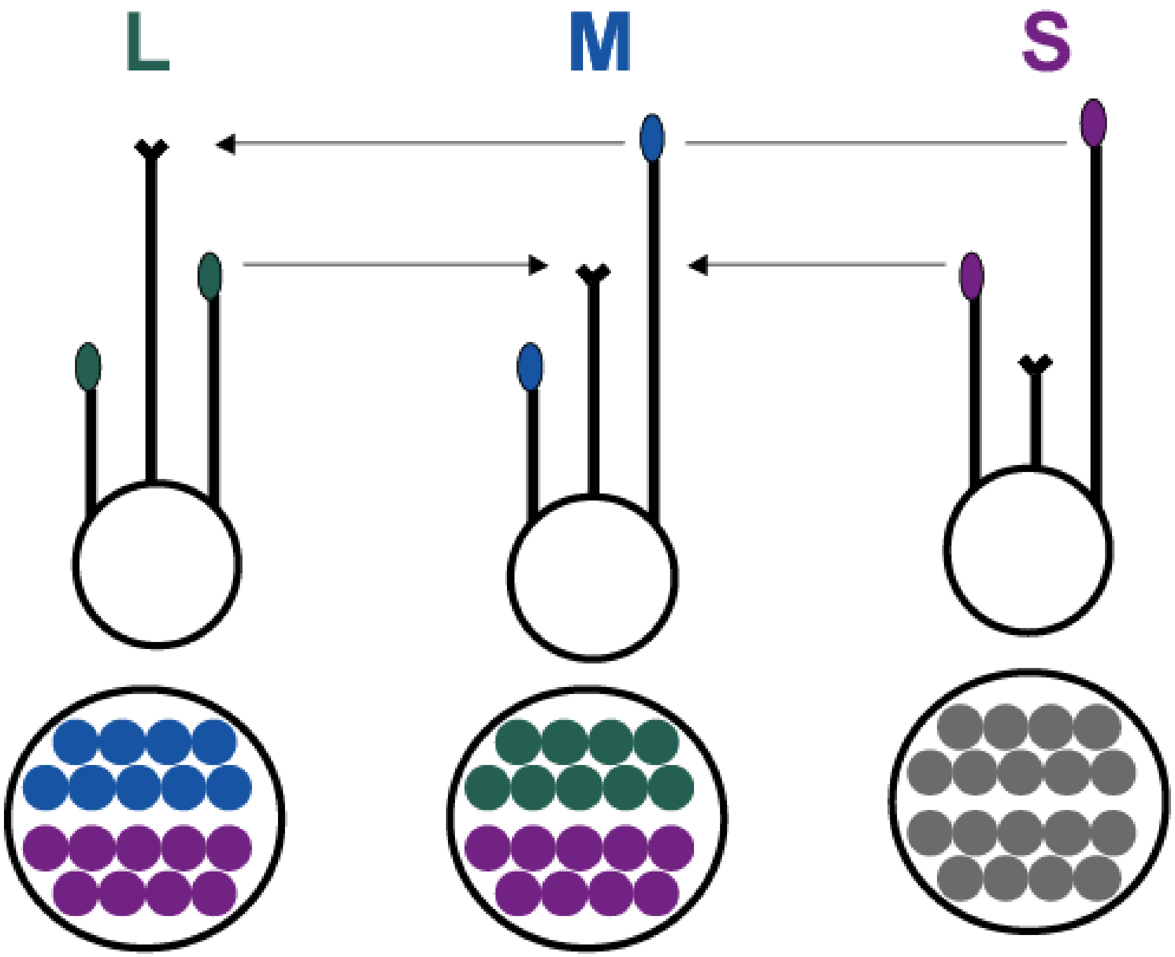
Pollen transfer and equilibrium morph ratios in typical tristyly



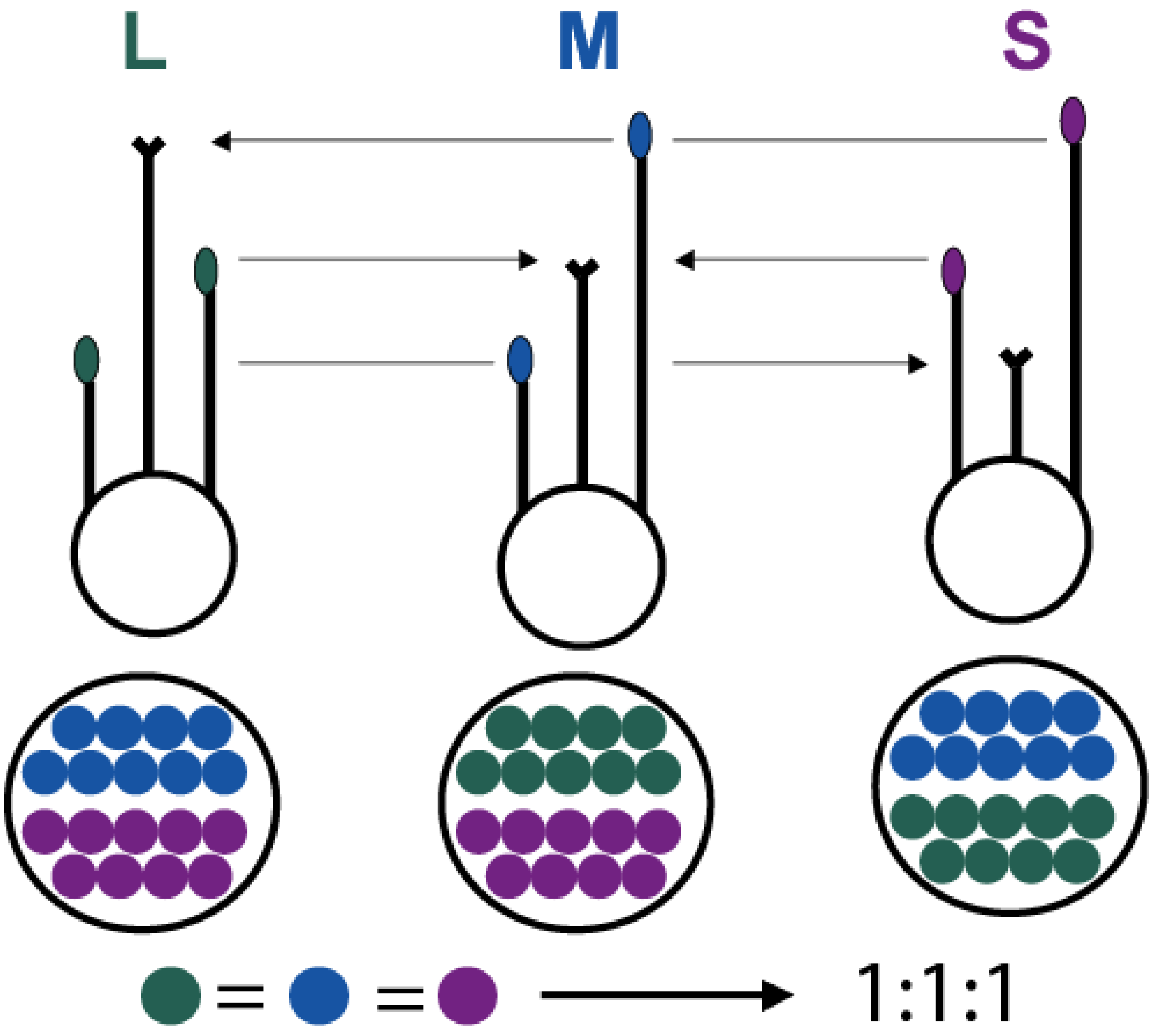
Pollen transfer and equilibrium morph ratios in typical tristyly



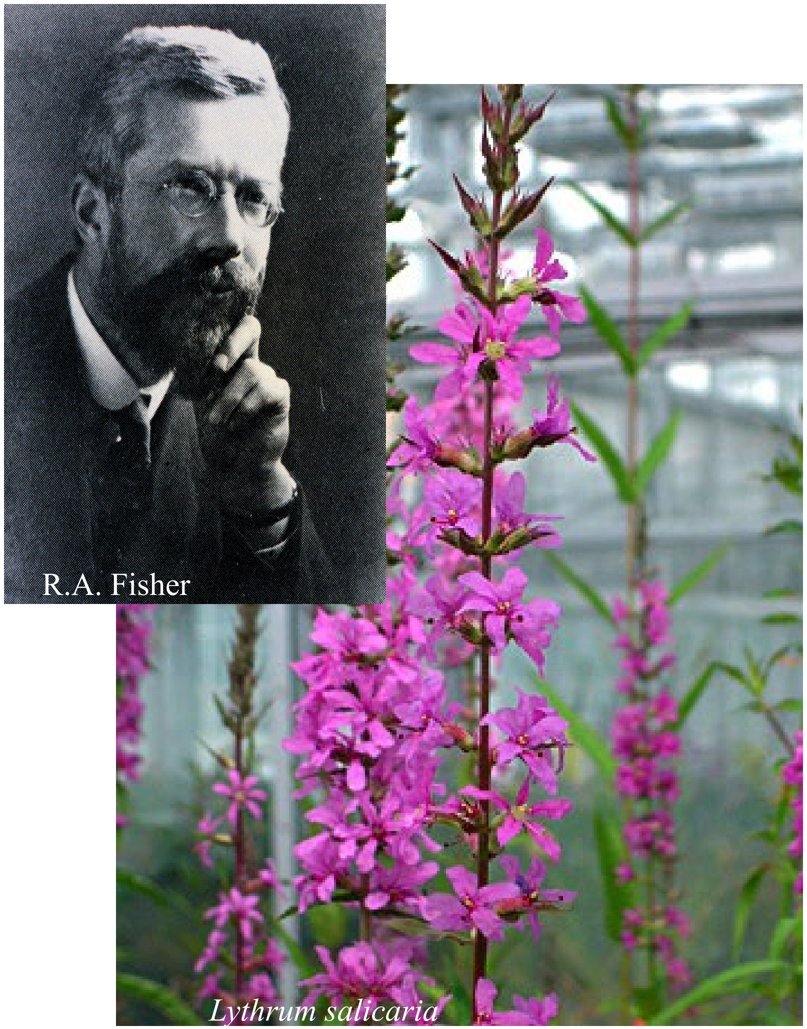
Pollen transfer and equilibrium morph ratios in typical tristyly



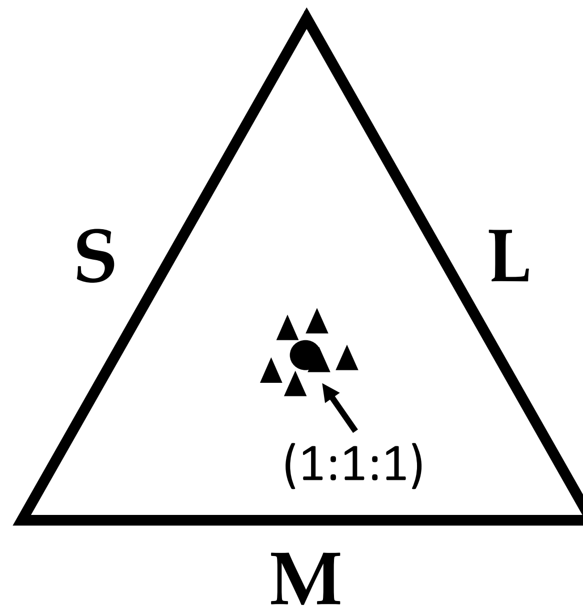
Pollen transfer and equilibrium morph ratios in typical tristyly



Equilibrium morph frequencies

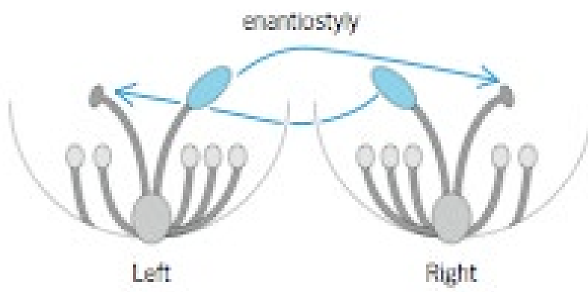


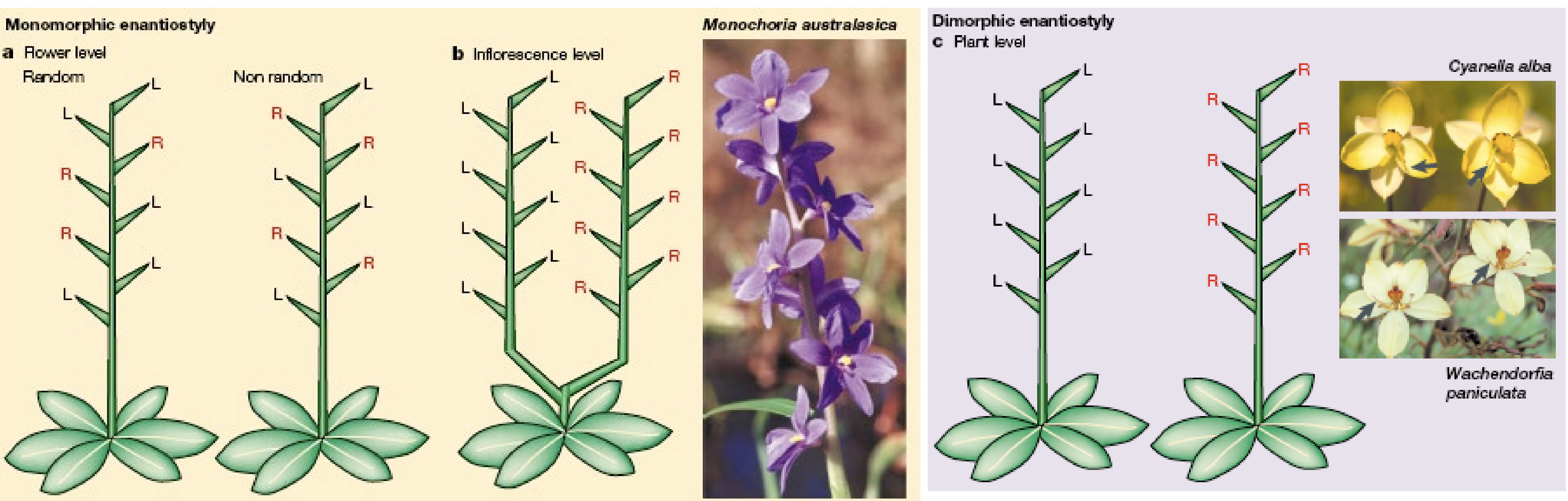
- Disassortative mating results in negative frequency-dependent selectio
- Equal morph ratios are predicted
- 1:1:1 found in many tristylous populations



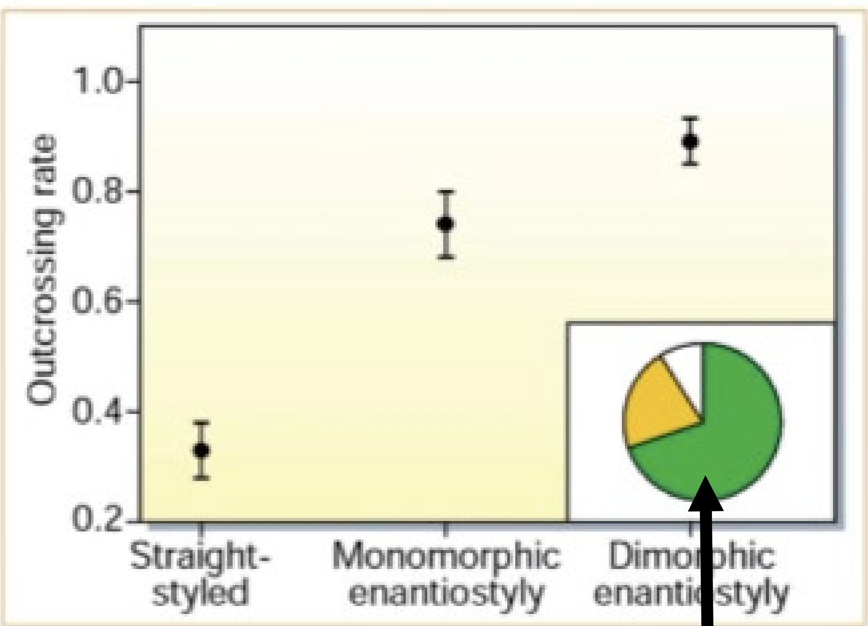
Floral design and pollen transfer: enantiostyly

Enantiostyly: mirror image flowers in which the style bends either to the left or the right side of the floral axis-deposits pollen on the left or right side of the bee.
Function: promotes cross pollination





Floral design and pollen transfer



Jesson and Barrett 2002 Nature

Inter-morph mating

- Created straight styled, monomorphic and dimorphic arrays from *Solanum rostratum* (monomorphic)
- Highest outcrossing rate in dimorphic arrays
- Most of the mating was intermorph in the dimorphic array (negative frequency dependent selection)

Floral design and pollen transfer

•Herkogamy reduces self pollination (and other forms of sexual interference)

•Separation reduces precision of cross pollination (lower male and female fitness-pollen wastage and pollen limitation)

•Reciprocal herkogamy improves pollen transfer efficiency

•Polymorphisms is generally maintained by disassortative mating at equal frequency

Unanswered Questions

- Why do dioecious plants have low diversification rates?
- Is the transition from cosexuals to dioecy unidirectional?
- What is the genetic basis of different floral designs such as heterostyly or enantiostyly? Are they controlled by supergenes? Is there evidence of balancing selection such as that found at SI loci?