Evolution of Self-Incompatibility

Investigating the role of self-incompatibility systems in the prevention of biparental inbreeding

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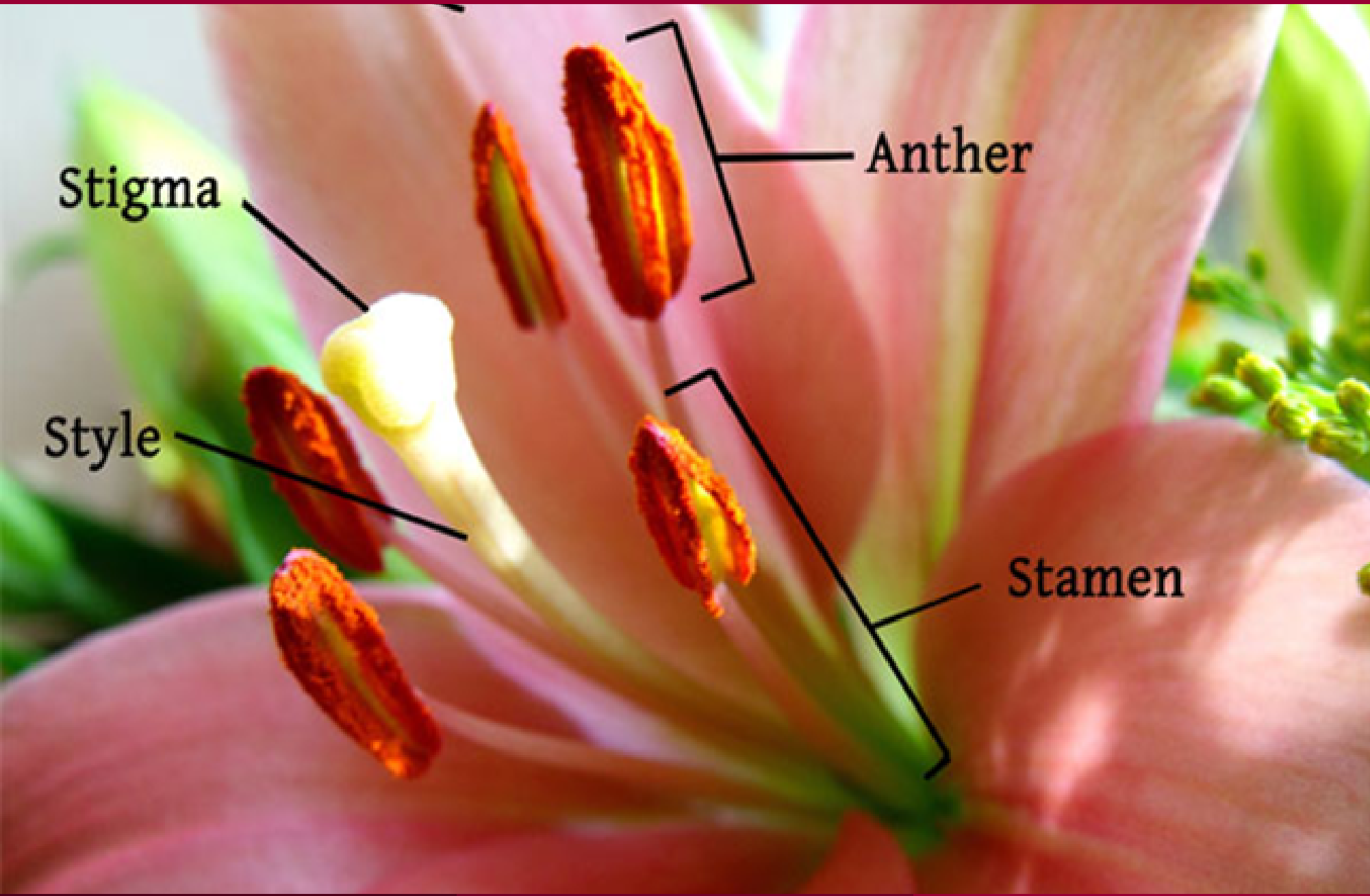
Angiosperms are predominantly hermaphroditic



Self-fertilization

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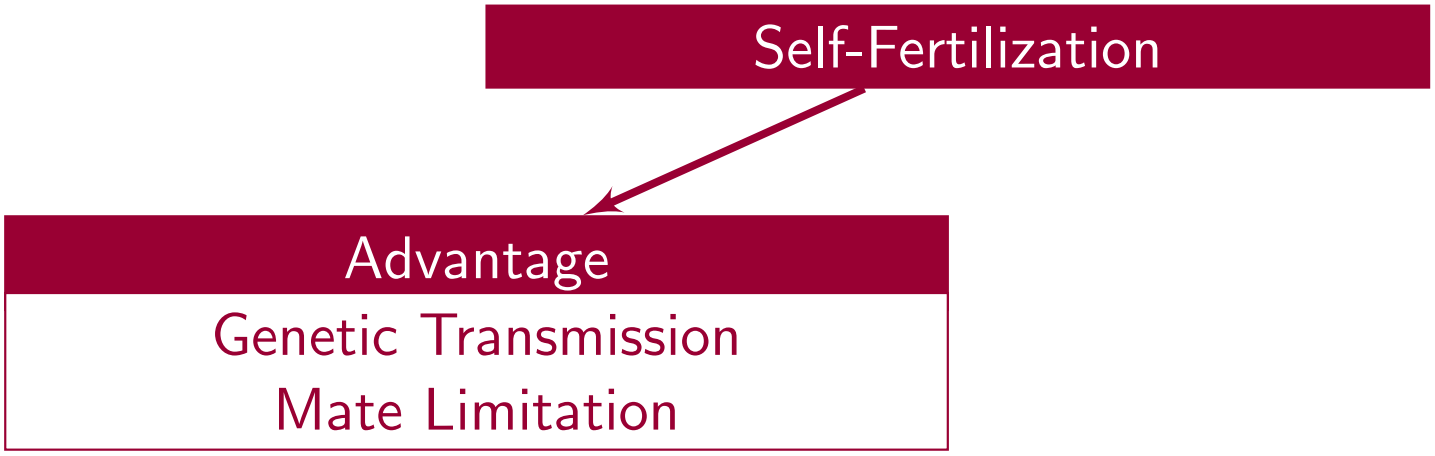

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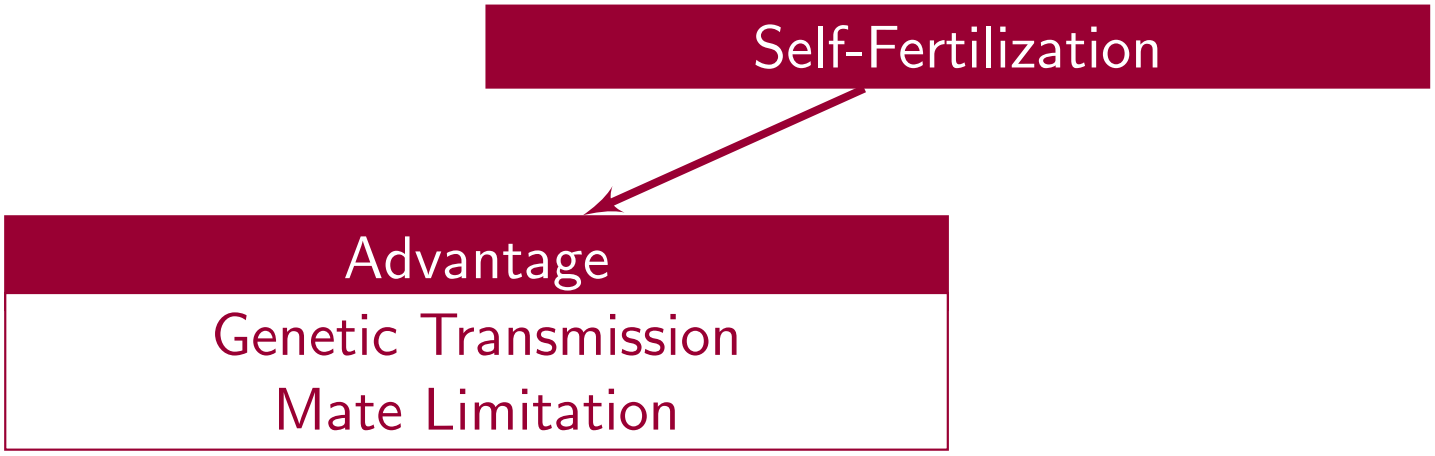

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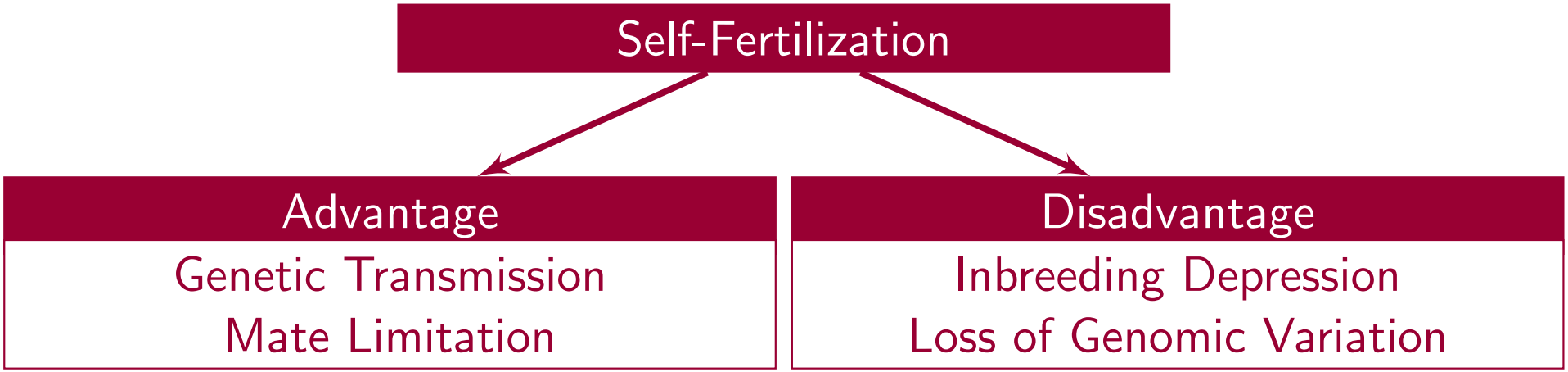

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Biparental Inbreeding

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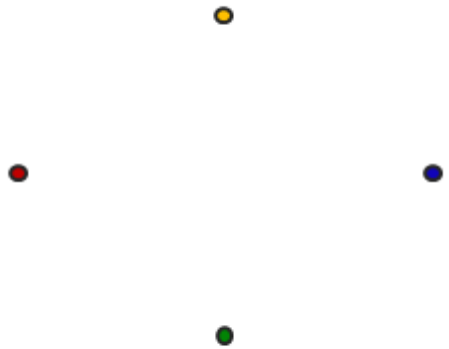

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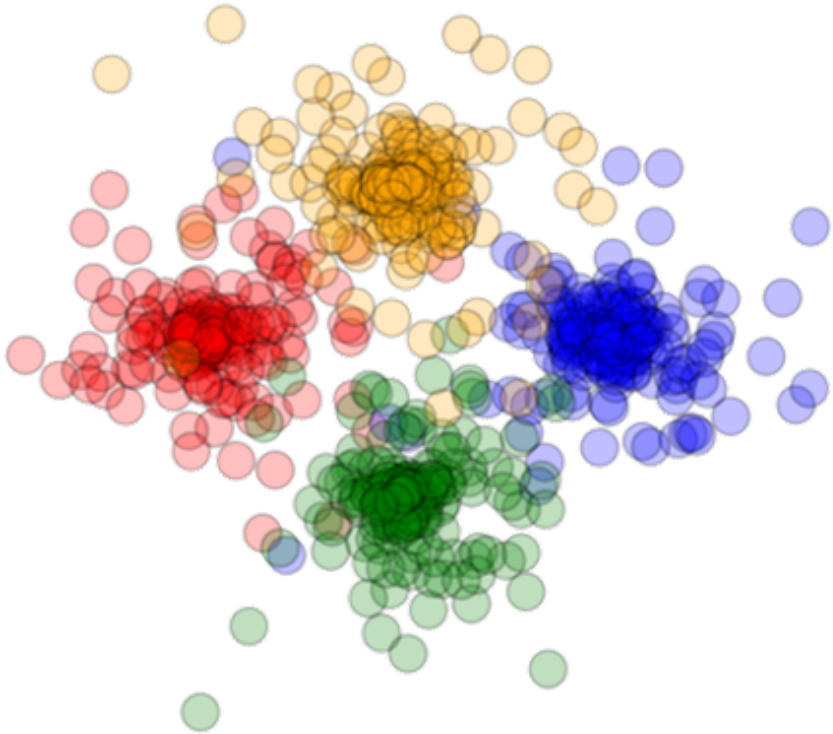


Plants have evolved many systems to avoid self-fertilization

Hermaphroditic

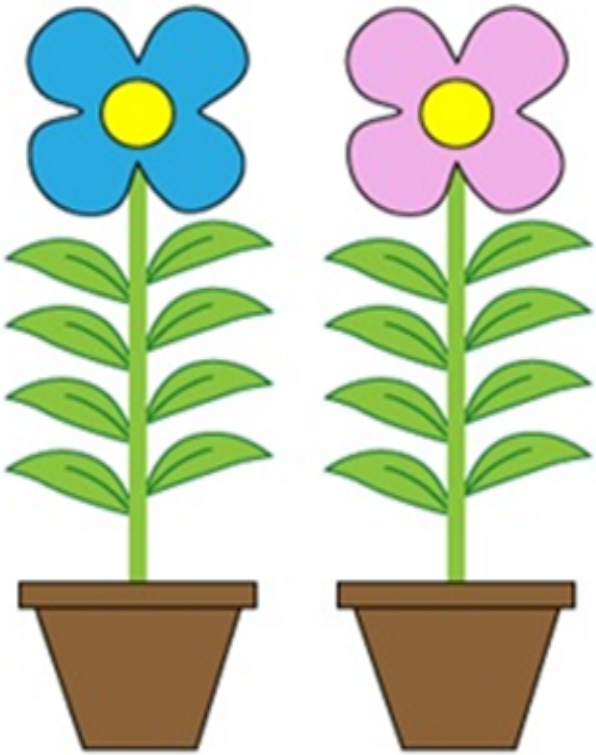
Heterostyly: Spatial separation of male and female parts of the flower
Hercogamy: Temporal separation of male and female maturation

Plants have evolved many systems to avoid self-fertilization

Monoecy

Separate male and female flowers on the same plant

Plants have evolved many systems to avoid self-fertilization



Dioecy

Separate male and female plants

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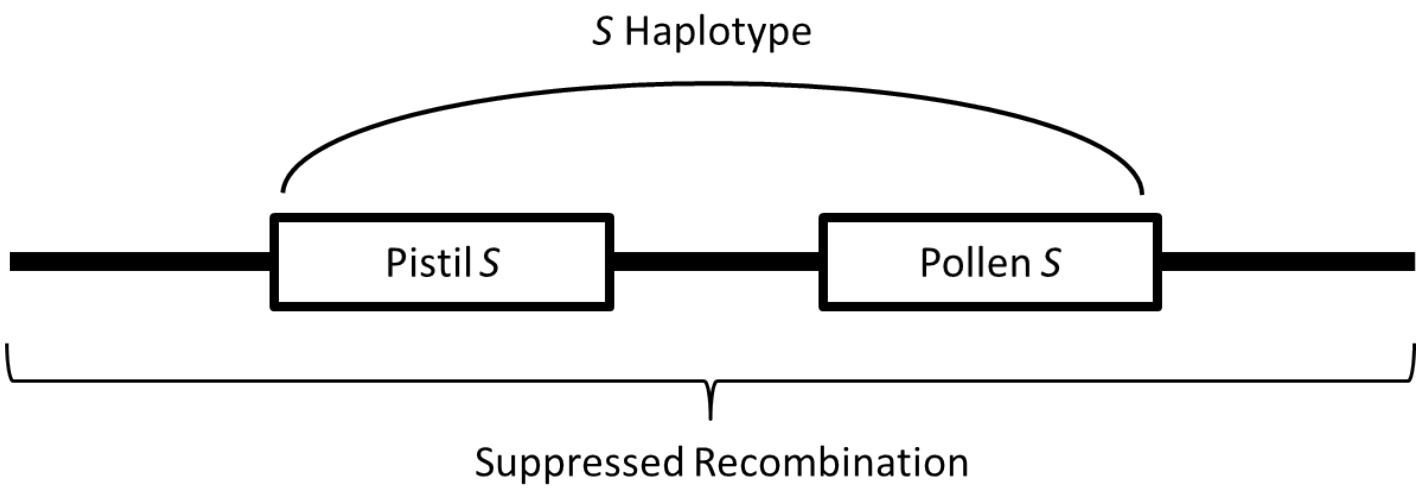
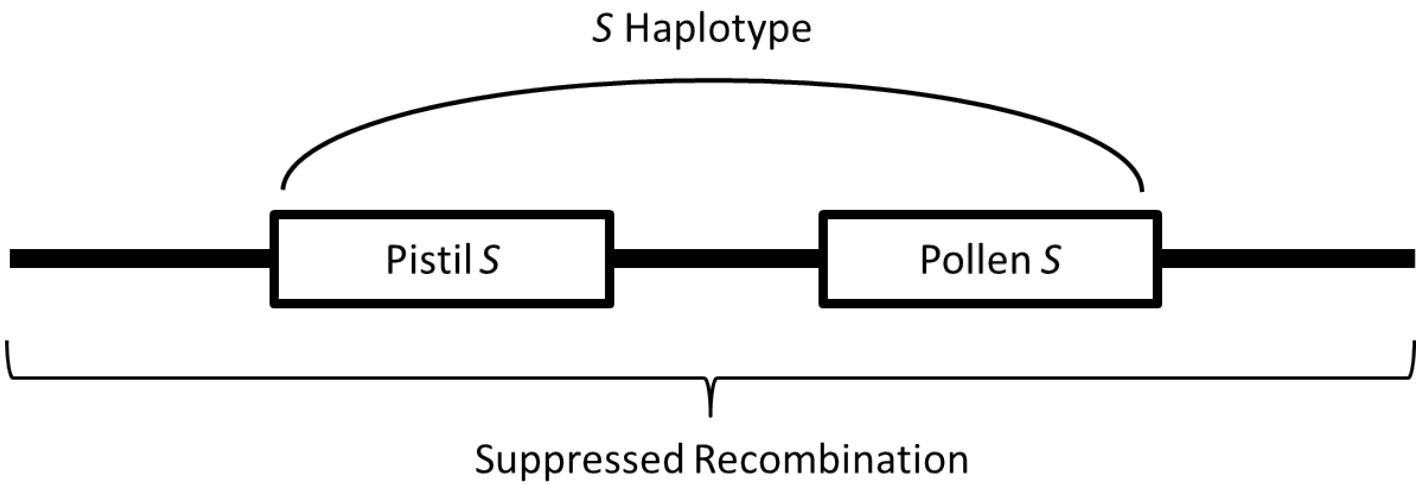


The female and male recognition determinants are tightly linked due to physical proximity and suppressed recombination.

Homomorphic Genetic Self-Incompatibility

- 70% of angiosperms have some form of genetic self-incompatibility
- Genetically similar pollen is rejected based on alleles at the S-locus.
- Self-incompatibility (SI) eliminates self-fertilization and reduces mating between related individuals.



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Evolution of Self-incompatibility

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- Inbreeding depression is caused by both self-fertilization and biparental inbreeding.
- Self-incompatible taxa are very effective at reducing inbreeding due to self-fertilization.
- **Do self-incompatible taxa also benefit from reduced biparental inbreeding?**

Modeling self-incompatible plant populations

- The plant population exists on a geographically continuous surface

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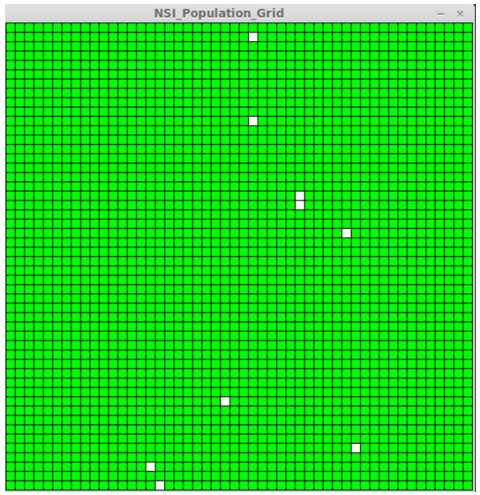
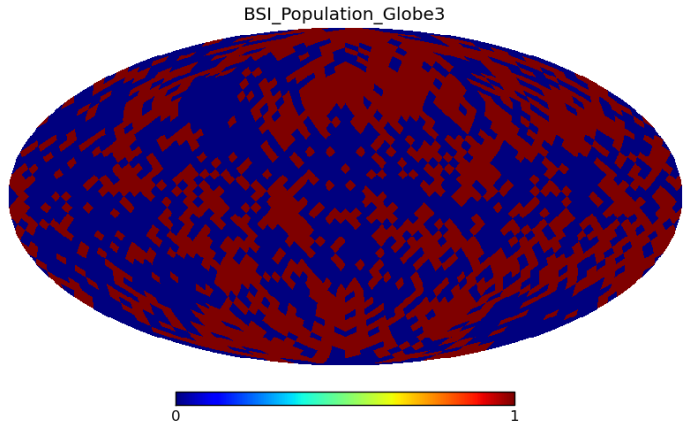
NxN Rectangular Lattice



Hierarchical Equal Area isoLatitude Pixelisation (HEALPix)



Modeling self-incompatible plant populations

- The plant population exists on a geographically continuous surface
- Generations are non-overlapping
- Each cell represents a single individual

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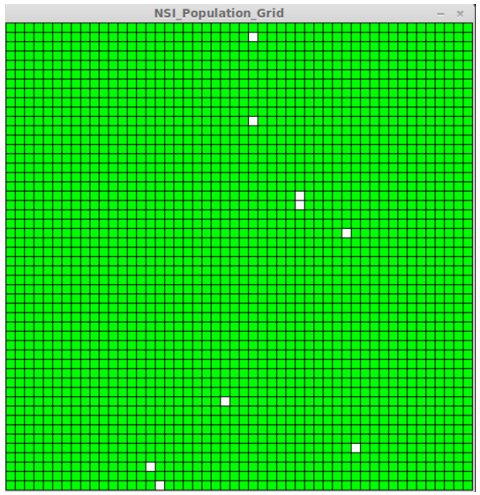

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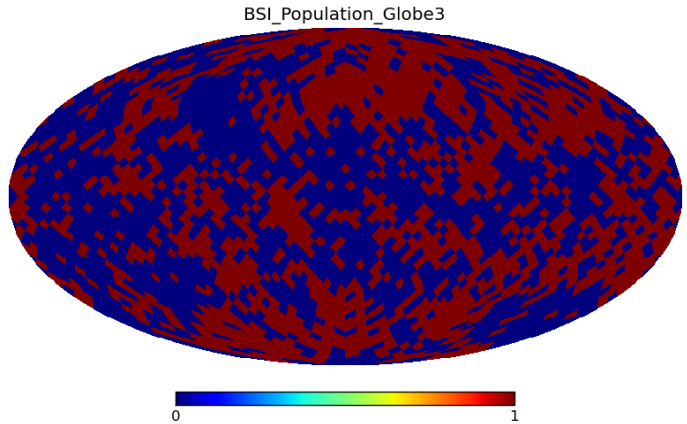

Plants

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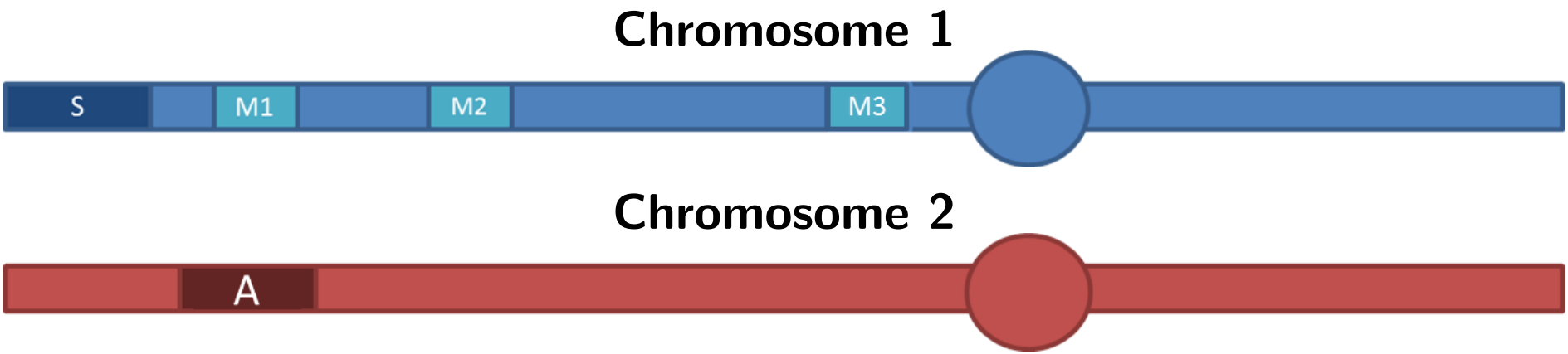
- Two chromosomes per haploid set $(2n = 4)$



Mating Systems

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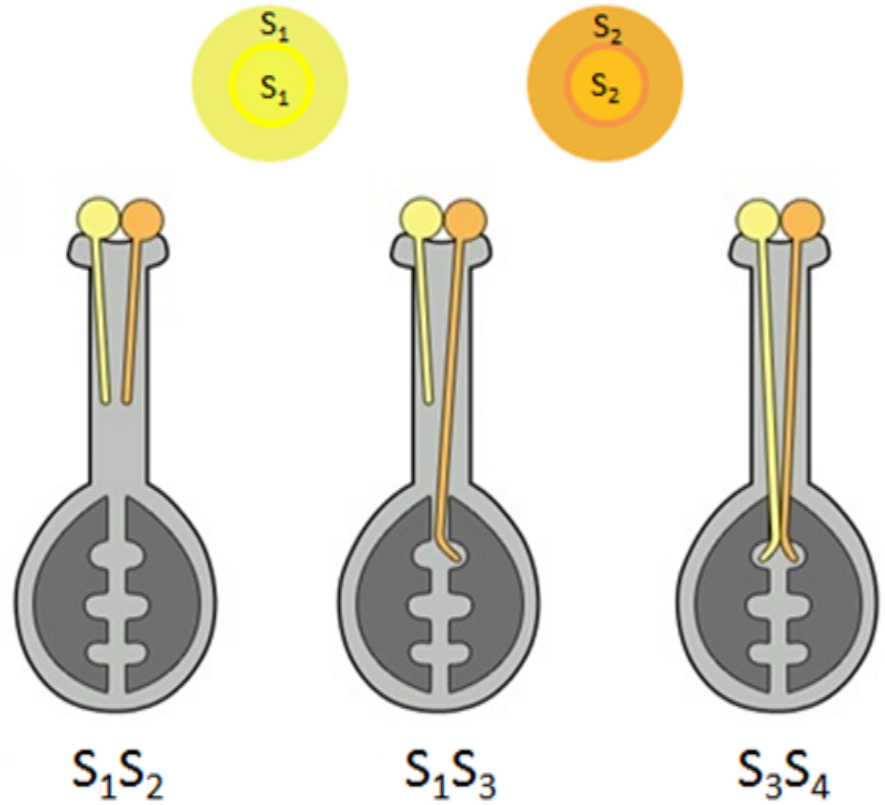

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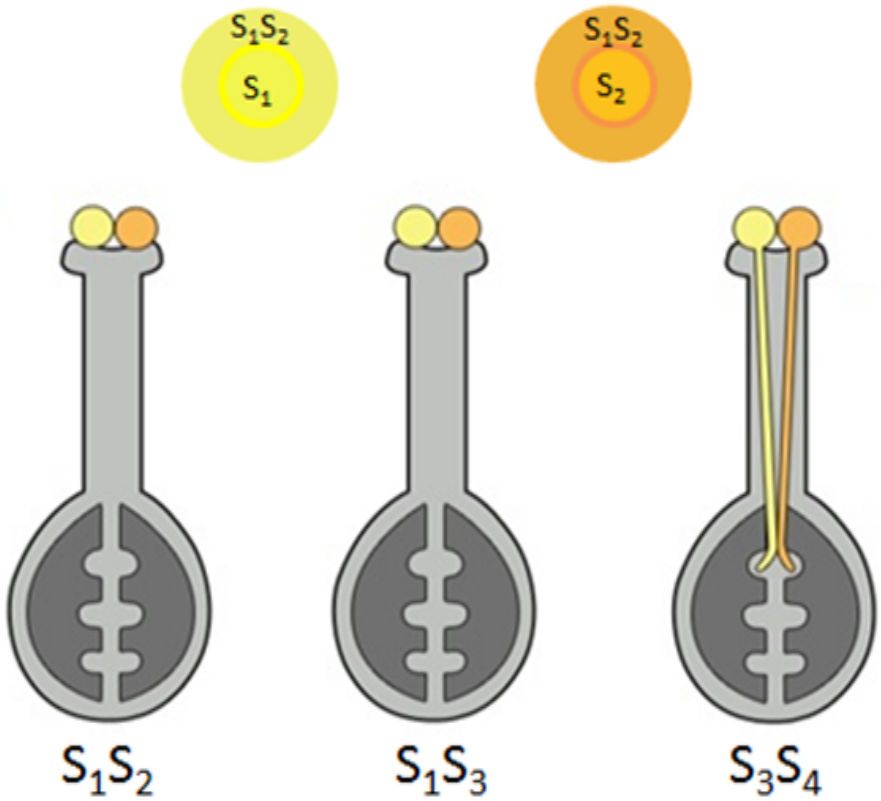
- **Sporophytic Self-Incompatibility Dominant (BSI):**
  - The SI phenotype of the pollen is determined by the diploid genotype of the sporophyte. Dominance relationships exist between S-alleles in pollen.

Sporophytic Self-Incompatibility (SSI)

Genetically, the rejection of the pollen is determined by the diploid genotype of the sporophyte (the pollen parent plant).



Sporophytic Self-Incompatibility (SSI)

Different dominance relationships exist between alleles in SSI systems.

	Pollen Phenotype
SSI Codominance (SSI)	All alleles are codominant
SSI Dominance (BSI)	Some alleles will be dominant over others

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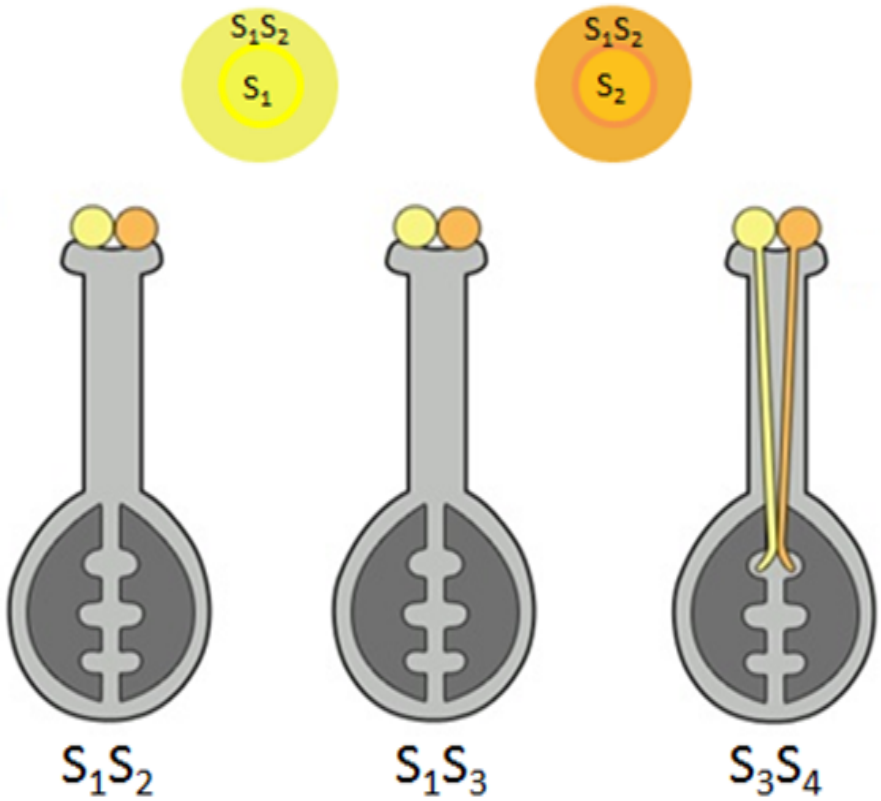

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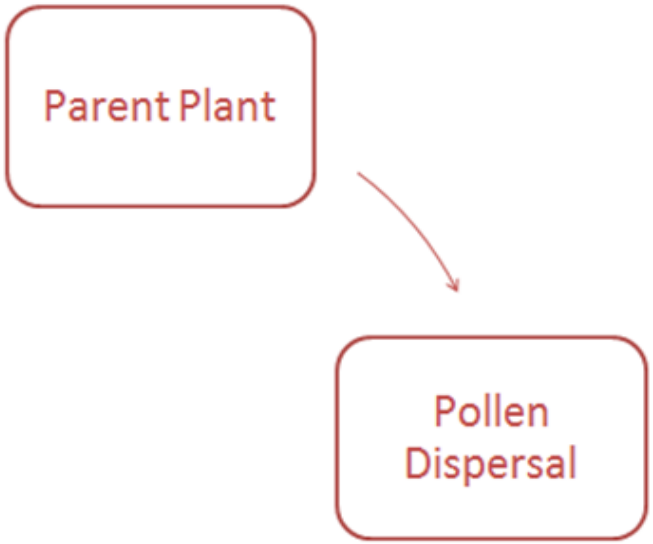

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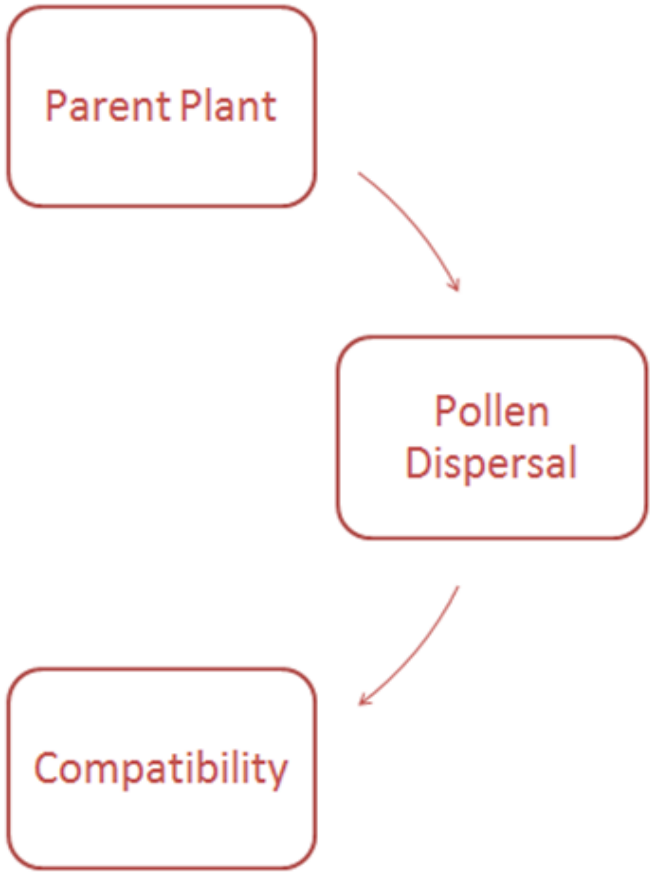

Simulation

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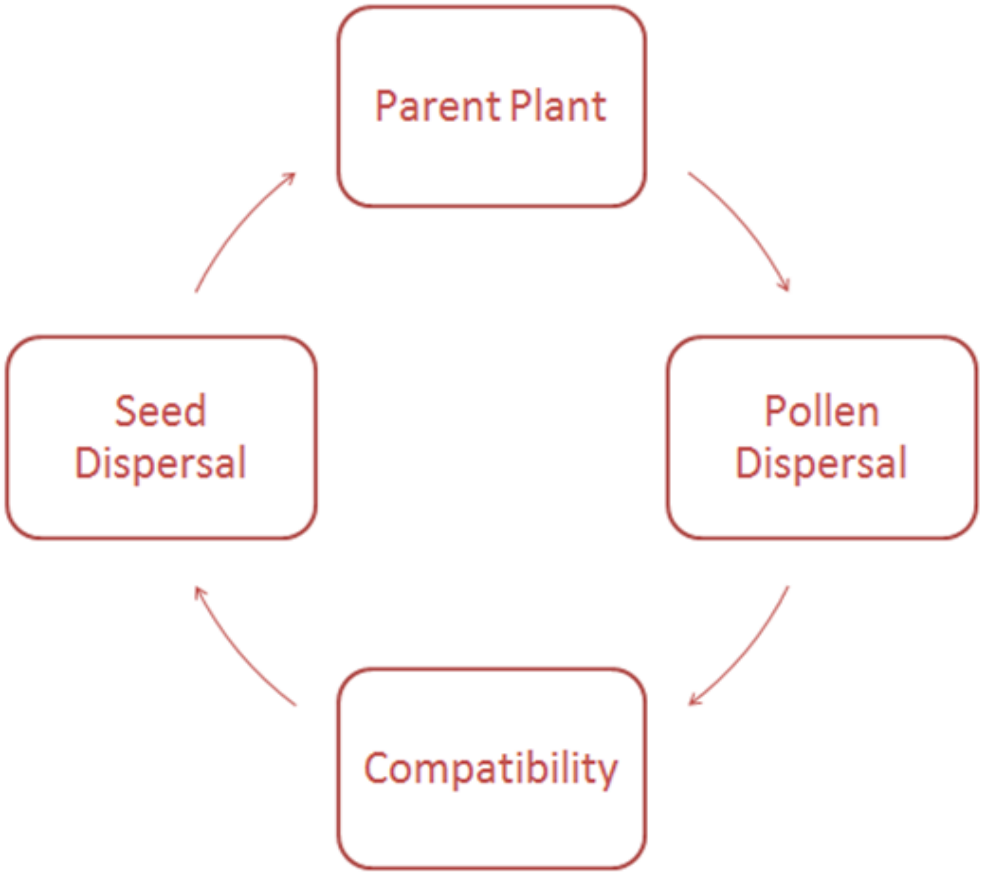
- Seeds will produce plants which replace previous generation.



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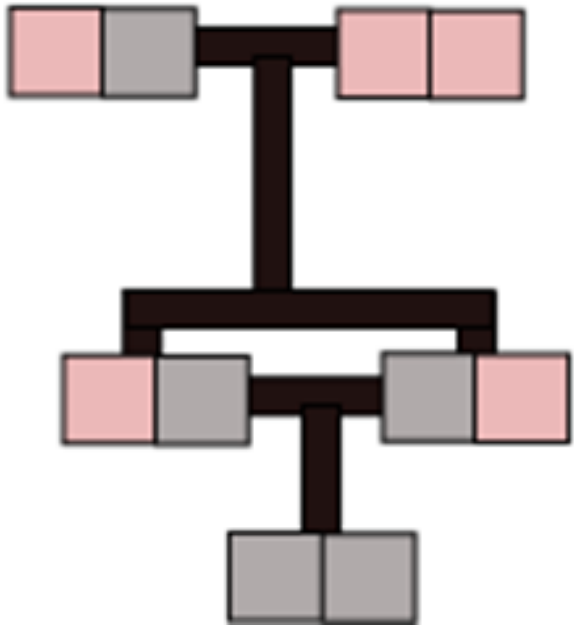

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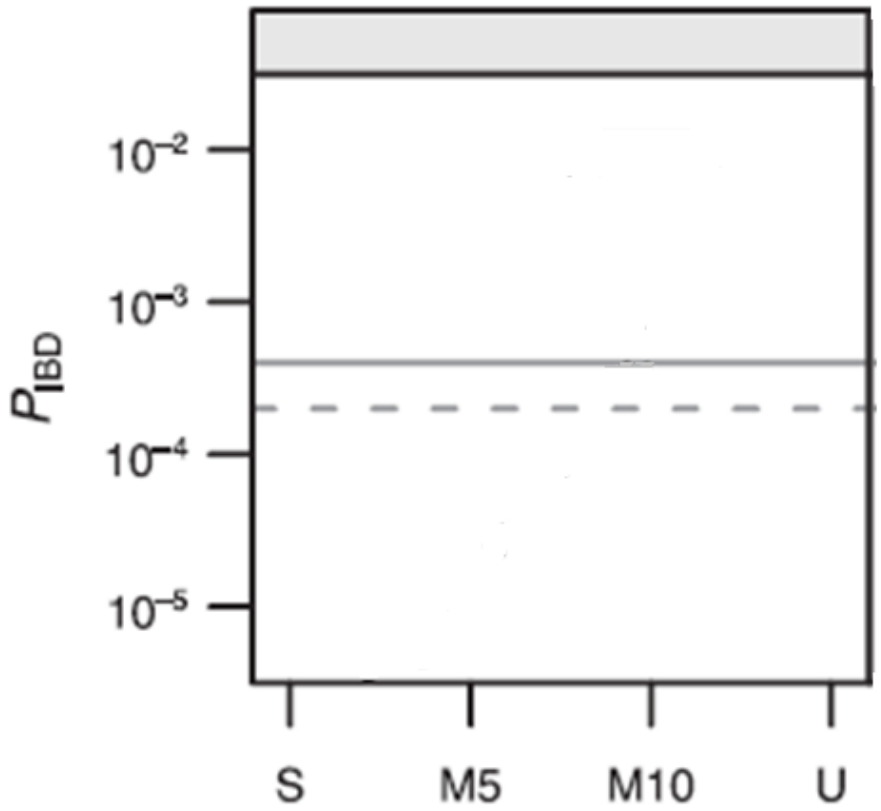
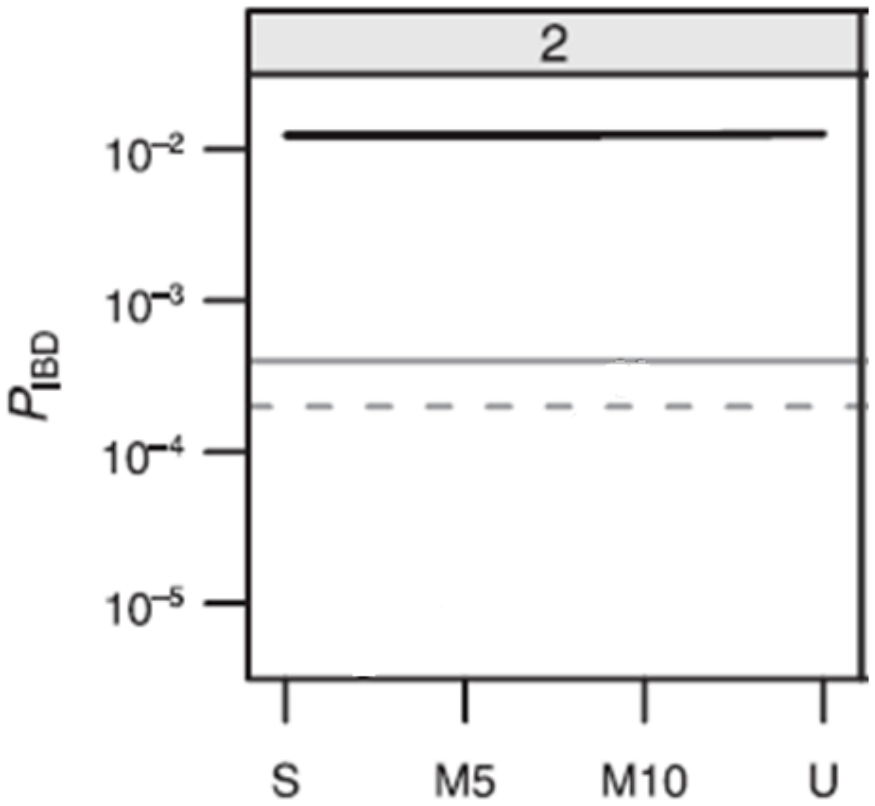
R. Cartwright, *Molecular Ecology*, 2009



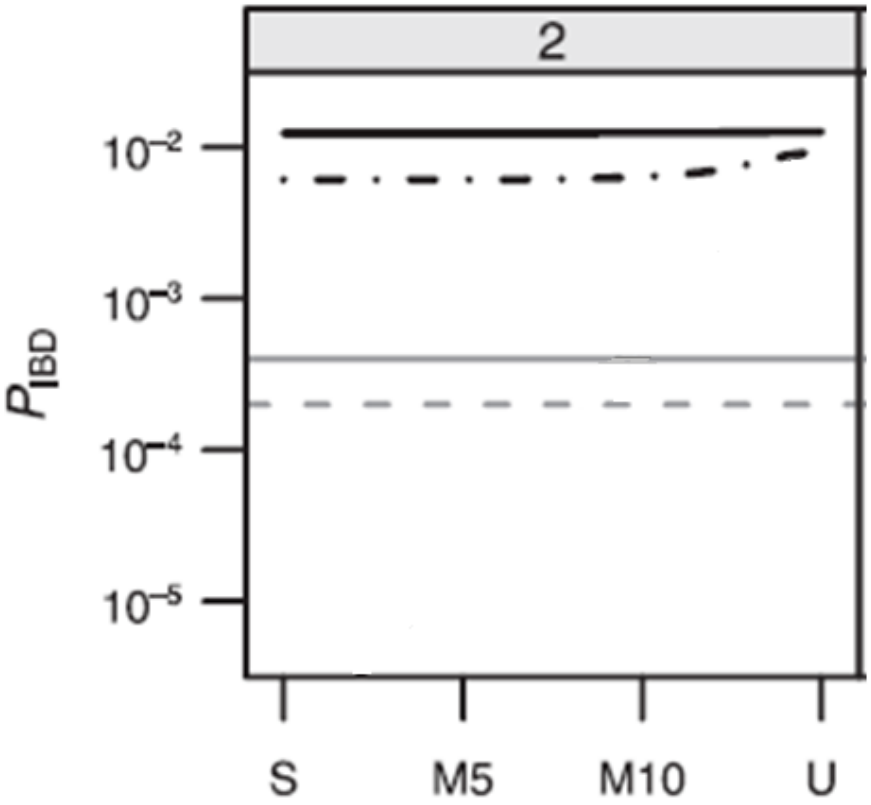
Solid line is the expected level under random mating
Dashed line is the expected level if selfing were prohibited.

Physical Self-Incompatibility



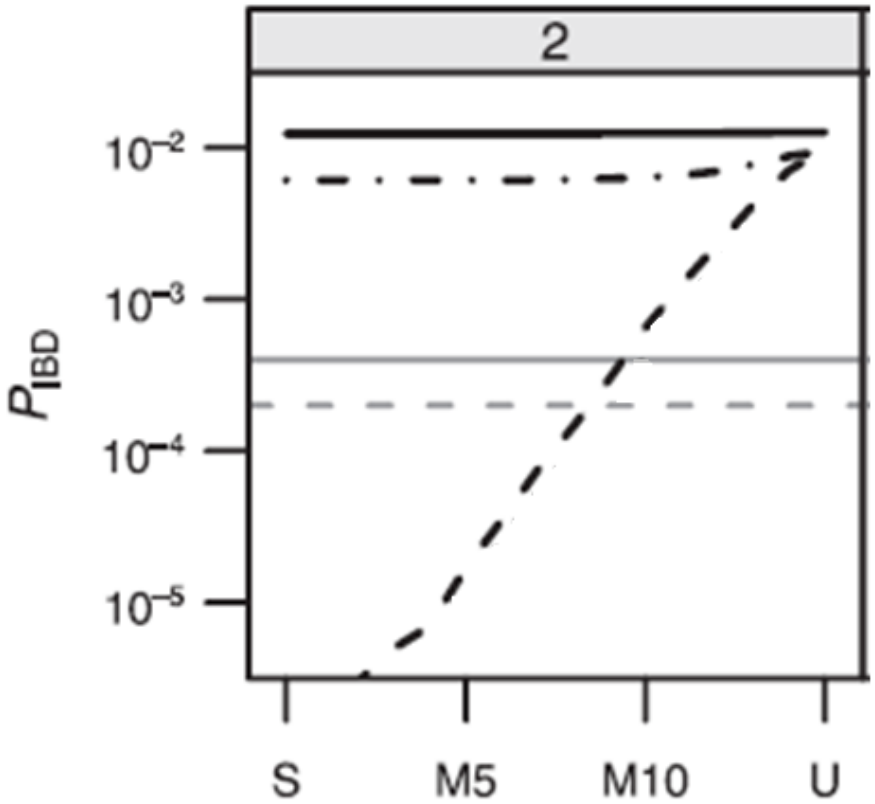
This represents the level of inbreeding when only selfing is prohibited.

Dominant Sporophytic Self-Incompatibility



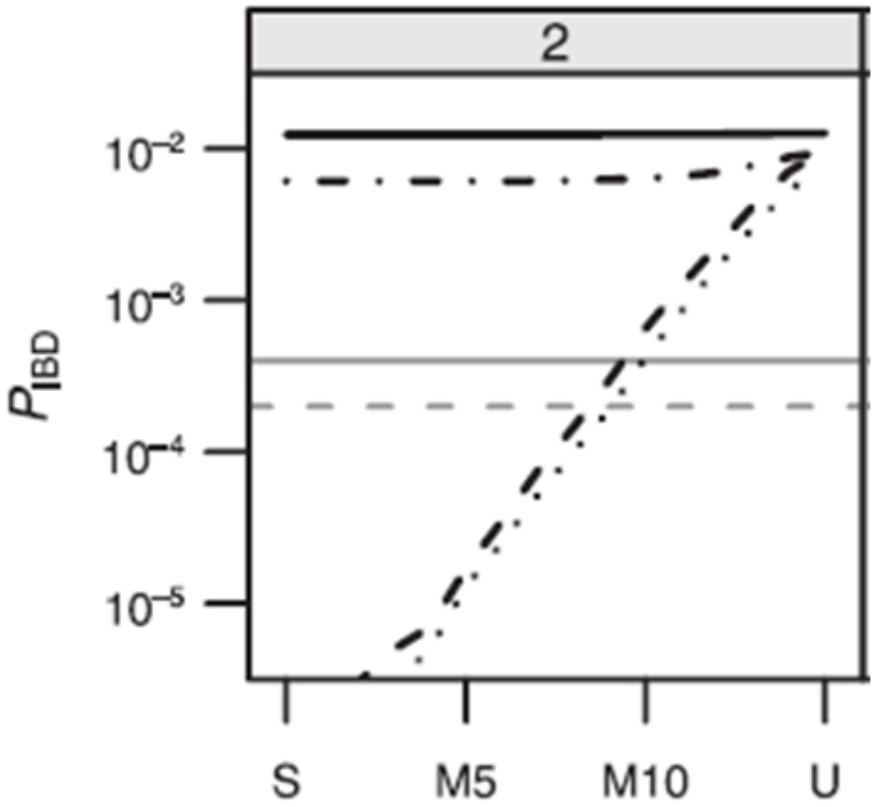
Least stringent form of SI behaves similarly to PSI.

Gametophytic Self-Incompatibility



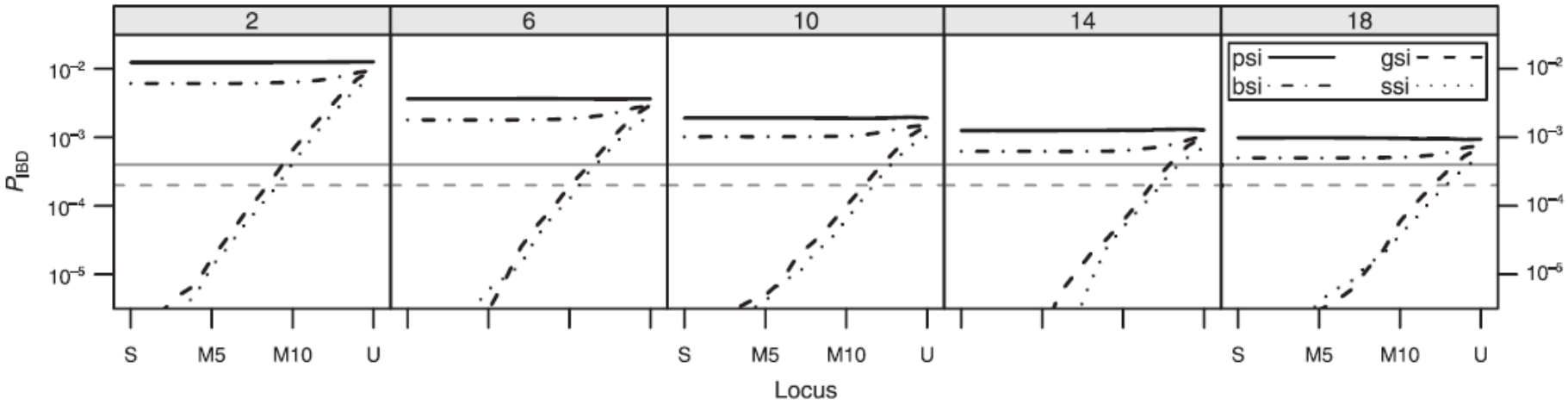
Loci linked to S show a large reduction in identity by descent which increases as linkage decreases.

Codominant Sporophytic Self-Incompatibility



Most stringent form of SI. Shows a similar pattern as GSI.

R. Cartwright, *Molecular Ecology*, 2009



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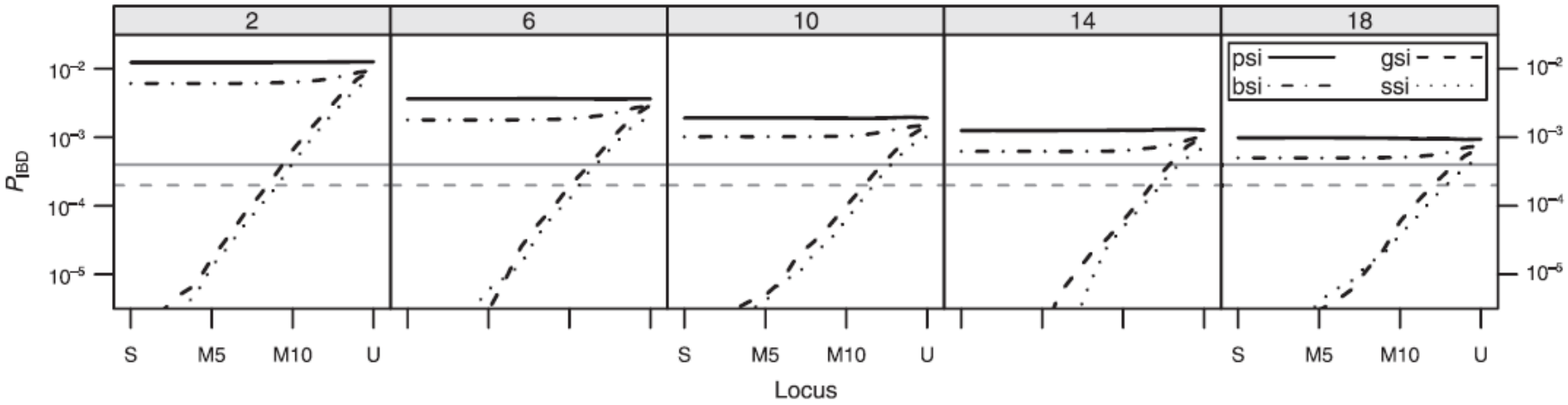

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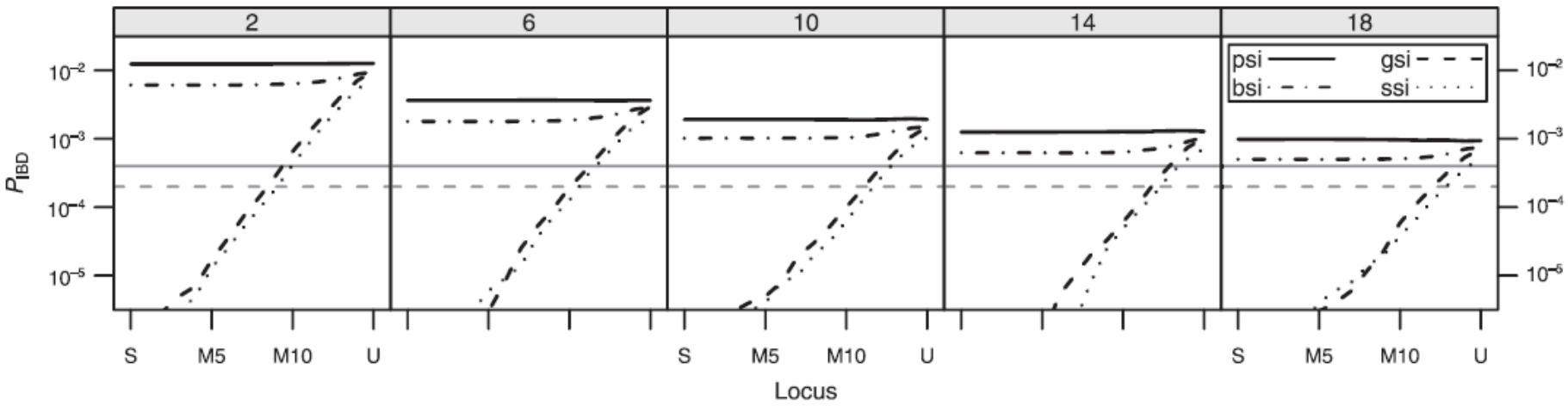

- At unlinked loci, the genetic self-incompatibility systems are only slightly more effective at reducing inbreeding than physical self-incompatibility.
- However, this model did not include inbreeding depression which would provide a selective advantage for avoiding inbreeding.

Modeling Inbreeding Depression

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- Ovules will abort if they carry two mutated copies of the A locus.

Expected Results

Is biparental inbreeding reduced in self-incompatible plant populations experiencing inbreeding depression?

- If PSI shows similar levels of inbreeding as the genetic forms of SI that will suggest that SI systems do not prevent biparental inbreeding.

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Is biparental inbreeding reduced in self-incompatible plant populations experiencing inbreeding depression?

- If PSI shows similar levels of inbreeding as the genetic forms of SI that will suggest that SI systems do not prevent biparental inbreeding.
- A reduction in inbreeding below the level of PSI would indicate that genetic SI reduces biparental inbreeding.

Conclusion

- It is commonly assumed that self-incompatibility systems evolved in response to selective pressures to avoid inbreeding.

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- It is commonly assumed that self-incompatibility systems evolved in response to selective pressures to avoid inbreeding.
- Using a population simulation I will theoretically determine if the success of genetic self-incompatibility is mainly due to the prevention of selfing or if it can be extended to the prevention of biparental inbreeding.

Acknowledgments

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Committee

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