Mating system = who you mate with

- Outcrossing rate = \( t \)
- Ranges from 0 to 1.0 where 0 is total obligate selfing and 1.0 is obligate outcrossing.
Plant Breeding systems = Attributes of the flowers within an individual that may influence gamete transfer among conspecifics.

Animal Breeding systems ~ tend to use breeding system w/r to crossing programs to acquire particular traits.
Mating system & breeding system differences between plants & animals

Animals

Mobility
Most dioecious
Some hermaphroditic = both sexual functions within a single individual.

Plants

Lack mobility compared to animals
Hermaphroditic
selfing -----> outcrossing -----> dioecy
Gene Flow in Plants

(1) Pollen – deposition and loss (Inouye et al 1994)

(2) Seed Dispersal

   Primary – dehiscent, indehiscent, ballistic, passive

   Secondary – ants, rodents, mammals, humans
Pollen Types & consequences for dispersal

Granular – ex.

Pollinia – ex., orchids
Pollen Dispersal curves

1) Biotic, animal pollination - nearest neighbor on scale of few meters in many instances ~ negative exponential

2) Abiotic, wind pollination ~ negative exponential
Primary Seed Dispersal Curve

http://www.pnas.org/content/102/10/3726/F5.large.jpg
Methods of seed dispersal

Methods of Seed Dispersal

Wind Dispersed

Dandelion

Animal Dispersed

Cranesbill

Water Dispersed

Banana

Coconut

Sedge

http://www.puc.edu/Faculty/Gilbert_Muth/art0071.jpg
Primary and Secondary seed dispersal

**Figure 1** – Seed dispersal of *Ricinus communis* in secondary growth vegetation of Brazil. The ballistic curve represents the distance of each seed from the nearest adult individual (considered as parental) before ant removal. Myrmecochory represents the distance of seed removal by ants, and total dispersal represents the distance of each seed from the assumed parental individual after ant removal.

**Figura 1** – Dispersão de sementes de *Ricinus communis* em vegetação secundária no Brasil. A curva balística representa a distância de cada semente ao indivíduo adulto mais próximo (considerado como parental) antes da remoção por formigas. Mirmecocoria representa a distância de remoção de sementes por formigas e a dispersão total representa a distância de cada semente ao indivíduo parental presumido após a remoção por formigas.

Mechanisms thought to aid gamete transfer:

- **Autogamy** – repro. assurance
- **Cleistogamy** – repro. assurance
- **Geitonogamy** – within plant selfing (between flowers of same indiv.)
- **Dichogamy** – temporal separation of male and female function, promote outx, gamete transfer
- **Herkogamy** – spatial separation of male and female function, promote outx, gamete transfer
- **Protandry** - hermaphrodite exhibits male fn before female fn
- **Protogyny** – hermaphrodite exhibits female fn before male fn
- **Self–incompatibility** – similar S alleles, promote outx by preventing selfing and related individual matings
Chasmogamy and Cleistogamy:

violets

*Specularia biflora*
Specularia biflora (Campanulaceae) – hermaphroditic and protandrous

1st Male phase flower

2nd Female phase flower
Monoecy: Begonias

Begonias are monoecious.

Female flower

Male flowers
Dioecy: willow tree and many animals
Tristyly – legitimate vs. illegitimate crossing
(Darwin 1876)
## Types of self incompatibility

<table>
<thead>
<tr>
<th>Gametophytic</th>
<th>Sporophytic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rxn determined by pollen genotype</td>
<td>Rxn determined by sporophyte genotype</td>
</tr>
<tr>
<td>Stylar inhibition</td>
<td>Stigmatic inhibition</td>
</tr>
<tr>
<td>Binucelate pollen grains</td>
<td>Trinucleate pollen grains</td>
</tr>
</tbody>
</table>

**Ex.** Legumes, Roses, Lily, tomatoes

**Ex.** Asteraceae (composites~ sunflowers and daisy), Brassicaceae (crucifers)-many crop plants

Stamen = anther + filament

Pistil = stigma + style + ovary
Some interesting observations....

- Temporal separation between male and female function (dichogamy) appears to be better than physical separation between male and female function (herkogamy) in avoiding within flower selfing when both nectar and pollen are rewards.

- If pollen the only reward, then....floral blooms are more likely to be herkogamous than dichogamous...
Why one species has both mechanisms?

• Prevent within flower selfing

• Increase efficiency of gamete transfer through preventing interference between male and female sexual function

• Pollen limitation in many systems – variable and limits female reproductive success (Dudash 1991; Dudash and Fenster 1997; NCEAS working group: Ashman et al 2004.; Knight et al. 2005)

• Separate Functions:
  – Pollen presentation
  – Pollen receipt
Animal issues

Most dioecious, but some exhibit other breeding systems

Inbreeding in animals
- Biparental inbreeding (loss of heterozygosity not as severe as when plants self-pollinate and they decrease het. by 50% each generation).

How do animals attain gene flow?
THE INBREEDING COEFFICIENT \((F)\)

The inbreeding coefficient of an individual refers to how closely related its parents are. When parents are unrelated, offspring \(F = 0\), for completely inbred individuals \(F = 1\).

Levels of inbreeding in offspring for different kinds of relationships among parents are:

<table>
<thead>
<tr>
<th>Parents</th>
<th>Offspring (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrelated</td>
<td>0</td>
</tr>
<tr>
<td>Brother-sister, mother-son, or father-daughter</td>
<td>0.25</td>
</tr>
<tr>
<td>Half brother-half-sister (half sibs)</td>
<td>0.125</td>
</tr>
<tr>
<td>First-cousins</td>
<td>0.0625</td>
</tr>
<tr>
<td>Second-cousins</td>
<td>0.0156</td>
</tr>
<tr>
<td>Self-fertilization</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Types of mating systems:

1) **Asexual ~ Vegetative** (offspring sprout from body of adult and then separate) – stolons-plants, budding-animals via fission (mitosis)

2) **Parthenogenesis** – animal young produced without meiosis (unfertilized egg develops into an adult animal)

  **Apomixis** = seed production in plants without meiosis (unfertilized ovules develop into a diploid seed and then plant)

3) **Change/switch sex** – often dependent on some resource ex.,

  *Issues of internal vs. external fertilization and parental care*
Asexual or Parthenogenetic Reproduction:

- Ubiquitous
- Frequently much rarer than sexual reproduction
- Syngamy or fertilization does not occur
- **Definition**: production of offspring which are identical to the parents.
Ode to an Apomict: The Dandelion

Daughters have I many
Yet husband and father none
A perfect matriarchy
I sit here in the sun
And send my plumed children
Floating one by one
Parthenogenesis: aphids, lizards, *Daphnia*, and boa
Sex switchers: jack in the pulpit & some fish species

Jack in the pulpit

Rainbow trout

Clown fish
Types of mating systems:

4) sexual repro. without partner - hermaphrodite

5) Polygamy – one male and many females

6) Polyandry – one female and many males

7) Monogamy – partners for life
Hermaphroditic flower:

http://upload.wikimedia.org/wikipedia/commons/4/4e/Tulip_Tulipa_clusiana_%27Lady_Jane%27_Rock_Ledge_Flower_Closeup_3008px.jpg
Hermaphroditic Animals: snails, worms
Polygamy: one male & many females (harem)
Polyandry: much rarer mating system

- Jacanas, one female brightly colored & many males

What other females practice a form of polyandry?
Monogamy:
Evolution of Sex: Why Sex?

- Age old question………….
- Really talking about the act of fusing (SYNGAMY) genetic material from two parents into a single offspring. In diploid organisms, gametes are produced by the act is meiosis.

- Sex is ubiquitous – from viruses to animals

- “It’s here to stay.” quote from Marilyn Monroe

- Really a continuum from isogamy --> anisogamy
An OVERVIEW of the comparison of mitosis and meiosis

**Mitosis**

- **Prophase**: Chromosome replication, Duplicated chromosome (with sister chromatids), Parent cell (before chromosome replication)
- **Metaphase**: Chromosomes align at the metaphase plate, Sister chromatids separate during anaphase
- **Daughter cells of mitosis**: $2n$ to $2n$

**Meiosis**

- **Prophase I**: Chiasma (site of crossing over), Tetrad formed by synopsis of homologous chromosomes, Parent cell (before chromosome replication)
- **Metaphase I**: Tetrads align at the metaphase plate, Homologous chromosomes separate during anaphase I; sister chromatids remain together, Daughter cells of meiosis I: $n$, $n$ to $n$ $n$
- **Meiosis II**: No further chromosomal replication; sister chromatids separate during anaphase II, Daughter cells of meiosis II: $n$, $n$ to $n$ $n$
Sex:

- Really a continuum from isogamy ---> anisogamy

- Isogamy = gametes of equal size

- Anisogamy = gametes of unequal size where one smaller mobile gamete and one larger less mobile gamete fuse.
Figure 23.15  The two-fold disadvantage of sex
Why Sex?

Disadvantages of Sex or (cost of sex or meiosis) 1/2:

1) Pass on only $\frac{1}{2}$ of your genes in comparison to asexual reproduction where you pass on 100% of your genes.

2) Two fold cost may explain why asexual reproduction has evolved repeatedly in the plant and animal kingdom.

3) Parental care may decrease cost of sex, with increased probability of young surviving
Disadvantages of Sex or (cost of sex or meiosis) 2/2:

4) Meiosis takes more time than mitosis

5) Cost of attracting mates

6) Potential breakdown of favorable gene combinations.
Why Sex?

Advantages of Sex:

1) Able to get rid of deleterious mutations (minimize accumulation of deleterious mutations). Ex., Muller’s Ratchet.

Muller’s Ratchet = deleterious mutations will increase in a population without recombination.

2) Bring together favorable gene combinations. Recombination more frequent than mutations!
Muller’s Ratchet: with only asexual reproduction

Number of deleterious mutations

Frequency of Deleterious Mutations
With Recombination:

\[ \text{mutation} \]

\[ \text{mutation} \]
3) Sex may have evolved as a DNA repair mechanism.

4) Produces greater genetic variation.

5) Greater genetic variation allows for a greater potential response to variable selection pressures.
Highlights/Questions?

• Great variation in breeding/mating systems for both plants and animals

• Plants have gone to great lengths to direct their gametes to conspecifics

• Animal mating behaviors achieve many of these same goals: such as mating between unrelated conspecifics

• Even though there are transmission costs associated with sex (~ genetic recombination), sex is crucial to maintaining genetic variation to allow populations to respond to novel conditions