

# Sexual Reproduction

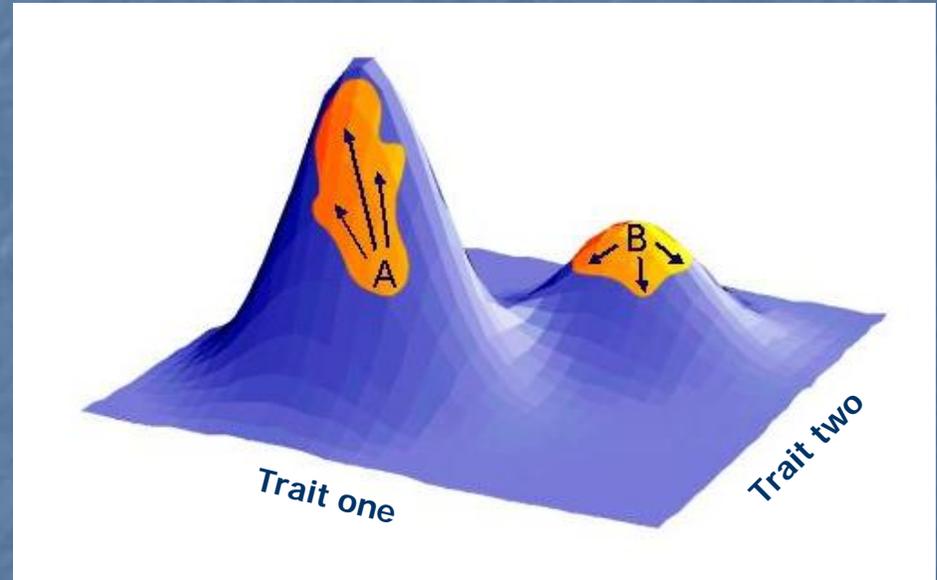
The Evolution of Sex  
Asexual Reproduction

# What is Sex?

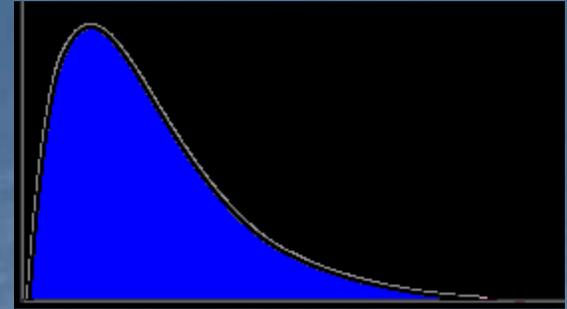
- Recombination.
  - The reshuffling of alleles on a chromosome due to crossing over with homologous chromosomes during meiosis.
    - No recombination during mitosis.
- Segregation.
  - The random assortment of one of each pairs of chromosomes in gametes.
- Syngamy
  - Fusion of gametes from the same or different during fertilization.
- The production of novel genotypes.

# Why is Sex Important

- Alleles do not interact in an “additive” manner.
  - Dominance – interaction among alleles at a single locus.
  - Epistasis – interaction among alleles at separate loci.
- Environmental variation.
  - Adaptive landscapes are not stable over time.



# Why Sex?



- The cost of sex in dioecious species.
  - 2 X reduction in gene transmission.
- The cost of sex in an hermaphrodite.
  - Include male function.
  - 3/2 X advantage for a gene for apomixis.
- Ecological considerations.
  - Spread of a new mutant conferring asexuality in a population.
- The cost of meiosis.
  - Fitness distributions are leptokurtic.
    - A large proportion of sexually reproduced offspring will have low fitness.
  - Hermaphrodites do not experience the “cost of sex” per se, but are subject to the cost of meiosis – the cost of producing a genetically diverse pool of offspring.
- Sexual reproduction “breaks up” advantageous combinations of alleles.
  - Slows the rate of evolution (Williams 1975)?
- In hermaphrodites, reproductive success is always less consistent for one gender function (i.e., male function).

# Why Not Sex?

- Sexual reproduction fuels evolution through the generation of novel allelic combinations.
- Three major advantages to recombination.
  - 1. Higher rates of recombination speed up evolution.
    - Adaptation to changing environments.
    - Populations never sustain fitness peaks because their position keeps shifting.
  - 2. Deleterious mutations accumulate in asexual lineages.
    - Recombination exposes mutations to selection.
  - 3. Novel mutations may confer high levels of fitness only in certain genetic backgrounds.
    - Recombination provides opportunities for “evolutionary experimentation” with new genetic combinations.
- In the evolutionary lottery the dice are loaded.
  - Most genetic combinations are losers, but when there is a rare winner, they really win big.

# Does Sex Require Group Selection?

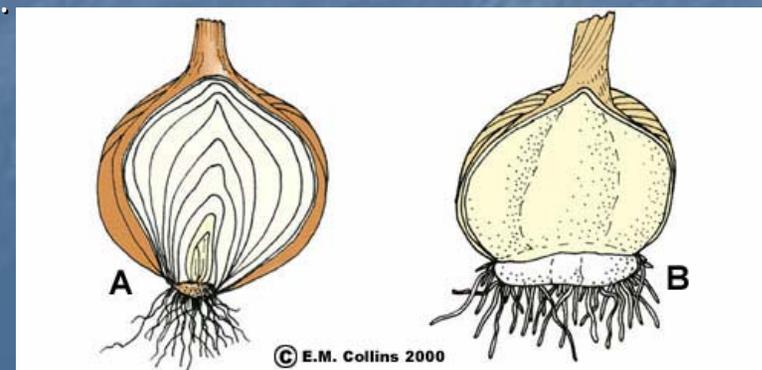
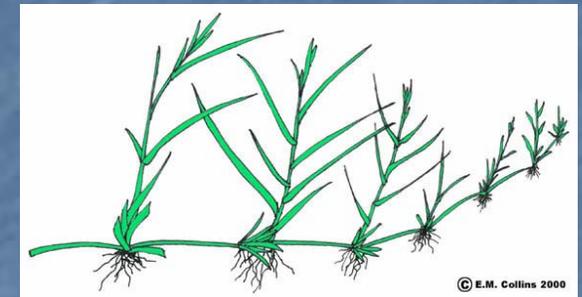
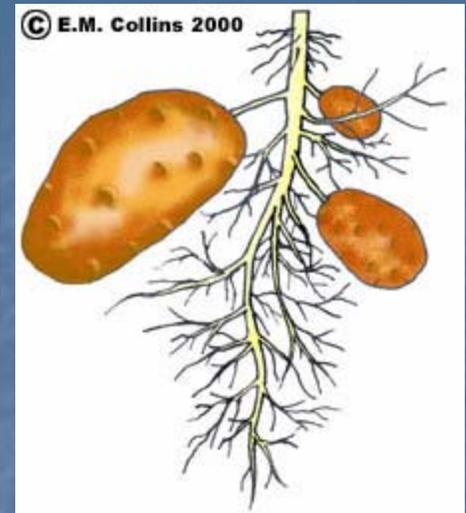
- Group selection.
  - Some groups (populations) grow and spread more than others because of an intrinsic group advantage.
  - Sex has a high cost for an individual, but it might help the population produce those few supper-good genotypes.
- Individual selection.
  - The tangled bank hypothesis (Ghiselin 1974).
    - In a saturated economy, it pays to diversify.
    - Filling those rare "empty niches."
  - The red queen hypothesis (Bell 1982).
    - Sex is necessary because the environment is always changing.

# Sexual and Asexual Reproduction

- Many plants do both.....
  - The “best of both worlds”?
- Modes of asexual reproduction.
  - Vegetative reproduction
    - High survival rates for offspring.
    - Low dispersal ability.
      - Allows dominance in local habitat.
  - Agamospermy
    - Similar survival to sexual reproduction.
    - High dispersal ability.
      - May land in an “inappropriate” habitat.

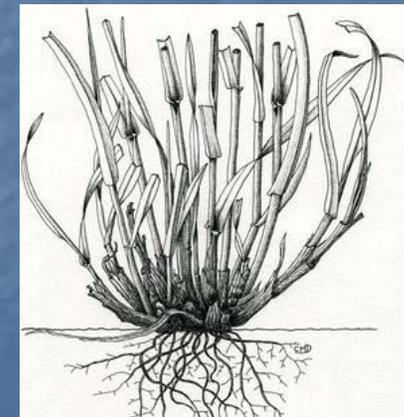
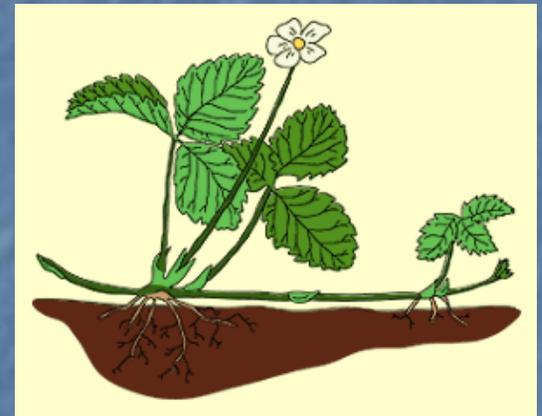
# Vegetative Reproduction

- Stolons
  - Above-ground stems that root at the nodes.
- Rhizomes
  - Below-ground stems that grow horizontally and produce new shoots.
- Tillers
  - Grass shoots that are produced from the lower stem and roots.
- Layering
  - Branches that root as they touch the ground.
- Bulbs (rosette), tubers (stem), and corms (root)
  - Underground storage structures that may split to form new shoots.



# Asexual Reproduction

- Modes of attack:
  - Guerilla strategy
    - Longer dispersal in search of local open sites.
    - Asexual seeds, bulbils, or vegetative reproduction with long internodes.
  - Phalanx strategy
    - Exclusion of other individuals from the local area.
    - Short dispersal of propagules.
    - Tillers, bulbs, short rhizomes, etc.



# Agamospermy (Apomixis)

- Production of fertile seeds in the absence of fertilization.
- At least 400 apomictic taxa.
  - Probably an underestimate.
  - Especially prevalent in the Rosaceae, Asteraceae, and the Poaceae (grasses).
  - Often associated with polyploidy.
- Difficult to detect without careful testing.
  - May require pollination or fusion of pollen nuclei with egg to produce endosperm (pseudogamy).



# Mechanisms of Agamospermy

- Embryos produced by budding.
  - Adventitious embryony or sporohytic apomixis.
- No meiosis – unreduced embryo sac.
  - Gametophytic apomixis.
- Pseudogamy.
  - Pollination and maybe fertilization of endosperm required, but the embryo is a direct sporophytic product of the maternal plant.

# Why be Apomictic?

- Reliable transmission of fit genotypes to the next generation.
  - No cost of sex or outcrossing.
    - transmission of two genome copies per seed.
  - No cost of meiosis.
    - No recombination so advantageous genetic combinations are maintained.
- Dispersal ability.
  - Other modes of asexual reproduction have limited dispersal.
- The ultimate guerilla strategy?