The Evolution of Sex

Or, why do we even need males?
Sexual VS Asexual reproduction

**Sexual**
- Fewer offspring/individual
- Only half of genes passed on
- Good genotypes are lost
- Offspring are variable

**Asexual**
- More offspring/individual
- All of genes passed on
- Good genotypes preserved
- Offspring uniform

Asexual would appear to be the winner
Some Factoids

Nearly all organisms have a sexual life stage.
Paramecium have separated sex from reproduction.
Asexual species tend to be evolutionarily young.
Paramecium Life Cycle
An Asexual Lizard

The asexual whiptail species Cnemidophorus neomexicanus (center) with the sexual species that hybridized to form it, C. inornatus (left) and C. tigris (right).
Cnemidophorus Variability

The analysis revealed lower levels of trait variance in asexual species for three traits, but no detectable differences between asexual and sexual species for two other traits. A second analysis examined the influence of each population’s maximum and minimum value on overall population variability, and revealed that the variances of sexual populations were more heavily influenced by outliers than were asexual ones. These results suggest that part of the reason for increased variance in sexual populations may be a greater tendency for these populations to produce extreme phenotypes.

Alistair J. Cullum
Department of Biology
Creighton University
Cnemidophorus Variability
Why Asexual Reproduction

Cost of Meiosis
Preserving genotypes
Cost of Males

Sexual

Asexual
Cyclical Parthenogenesis
Why Sex?

Possible advantages of sex:

• Faster evolution: Sexually reproducing populations will evolve faster than a set of asexual clones, provided that the rate of favorable mutation is high enough.

• Lower extinction rates: The taxonomic distribution of asexual reproduction suggests that asexual forms have a higher extinction rate than sexual forms. Thus sex may be maintained by group selection.

• Deleterious mutations: The large numbers of deleterious mutations are more efficiently removed by sexual than asexual reproduction.

• Host-parasite arms race: The coevolutionary arms race of parasites and hosts produces rapid environmental change, making sexual reproduction advantageous.

Red Queen?
Muller’s Ratchet?
More rapid evolution?
The Red Queen

"Now, here, you see, it takes all the running you can do to keep in the same place"
• Faster evolution: Sexually reproducing populations will evolve faster than a set of asexual clones, provided that the rate of favorable mutation is high enough.
Asexual species tend to be young species

- Lower extinction rates: The taxonomic distribution of asexual reproduction suggests that asexual forms have a higher extinction rate than sexual forms. Thus sex may be maintained by group selection.
Muller’s Ratchet

At the start:

A few generations later:

A few generations later still:
Host Parasite Coevolution

Simian COII gene and simian foamy virus
Cyclical Parthenogens

Cladocera

Rotifers
Sexual reproduction is nearly Universal.

Why remains a bit of a mystery but ultimately there appears to be an advantage to variable offspring.

Cyclical parthenogens reproduce asexually when conditions are good, asexually when conditions are bad.

Large organisms are nearly exclusively sexual.

Asexual lineages are phylogenetically young, and don’t speciate as often.
What is the Optimum Sex Ratio?

Fisher:

In a random mating population the optimal sex ratio is 0.5 (equal numbers of males and females)

Reasoning:

• Mean fitness is maximized by maximizing the mean number of offspring your children will produce

• The rarer sex will produce, on average, more offspring, since each offspring has one mother and one father.

• Parents that produce the rarer sex will have the highest fitness.
What is the Optimum Sex Ratio?

Hamilton:

If there is sib mating then a female biased sex ratio is favored.

Reasoning:

• Mean fitness is maximized by maximizing the mean number of offspring your children will produce.

• Since parents' sons are competing, which one wins does not affect the parents' fitness.

• Grand-offspring numbers are maximized by producing as many females as possible, and just enough males to guarantee fertilization of females.
1 female: lays mostly diploid females, few haploid males. Multiple females: 1/2 diploid females, 1/2 haploid males

Fig wasps