The Ecology of Sex Part 1: Cost and Consequences

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Biol 417: Evolutionary Ecology

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Overview

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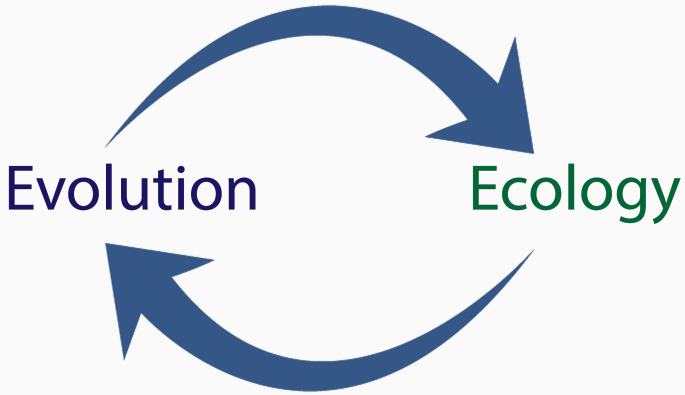


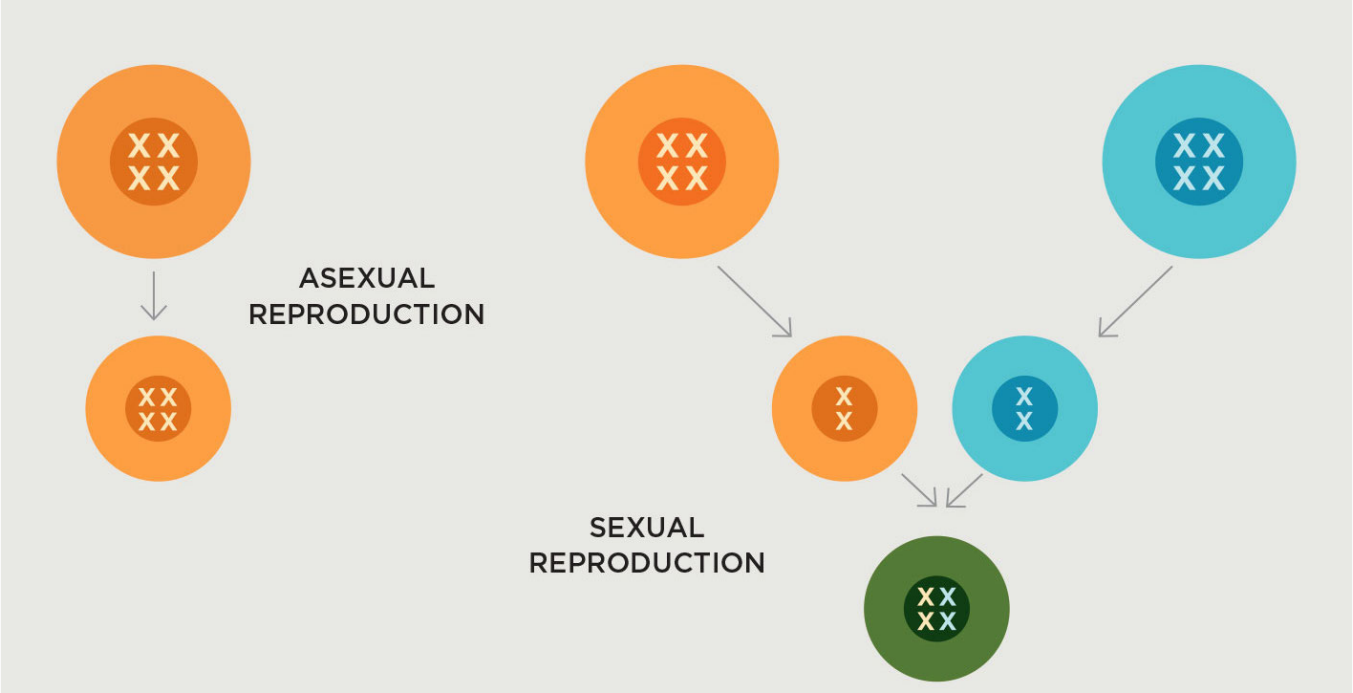
We started this course by discussing how evolutionary ecology is focused on providing answers to "Why?" questions.

One of those questions was: "Why does sex exists?"

Over the next couple of weeks we will explore this question, the answer, and some of the ecological consequences of sex.

The Cost of Sex

Sexual reproduction



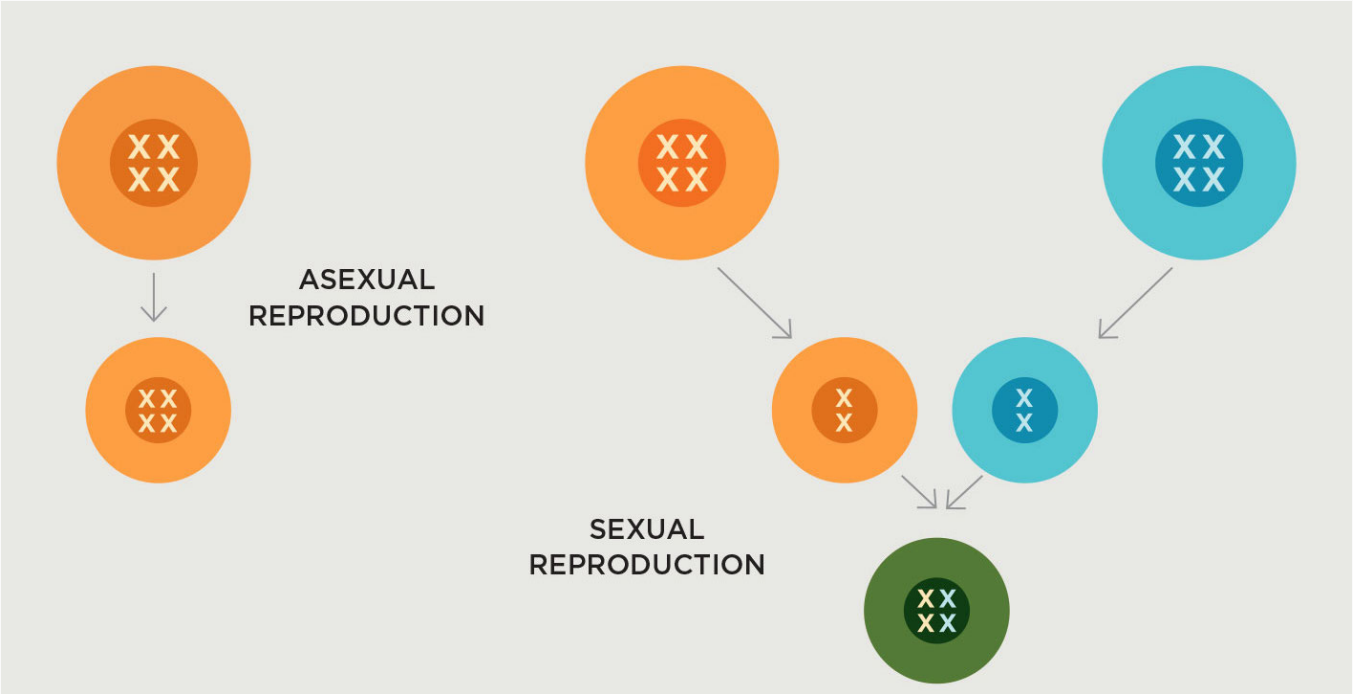
Source: The Scientist

Asexual reproduction: The formation of a new organisms containing genetic material from a single parent.

Sexual reproduction: The formation of a new organisms containing genetic material from two parents.

Sex halves genetic contribution

One of the most important costs of sexual reproduction is that it halves the amount of genetic material that is passed on to progeny.



Source: The Scientist

Sex halves genetic contribution cont.

The rotifer *Brachionus calyciflorus* can reproduce via either sexual or asexual reproduction.

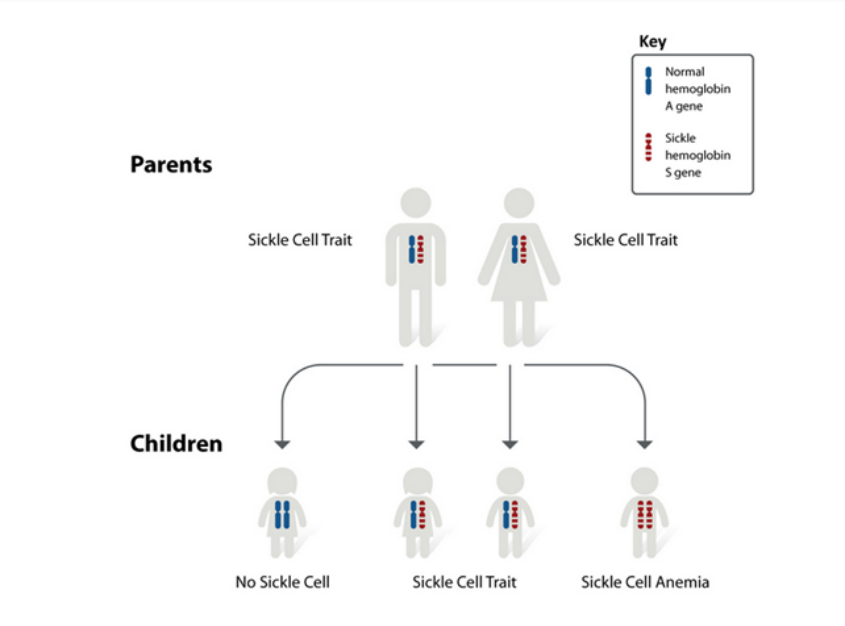
Over short timescales, asexuals outcompete sexuals because sex results in diapausing eggs and male/female phenotypes which slows population growth (Stelzer, 2011).

... but we'll come back to this study later.

Sex breaks up linkage

Sex involves meiosis (divison of cells and genetic material) and syngamy (fusion of cells and genetic material), generating segregation and recombination.

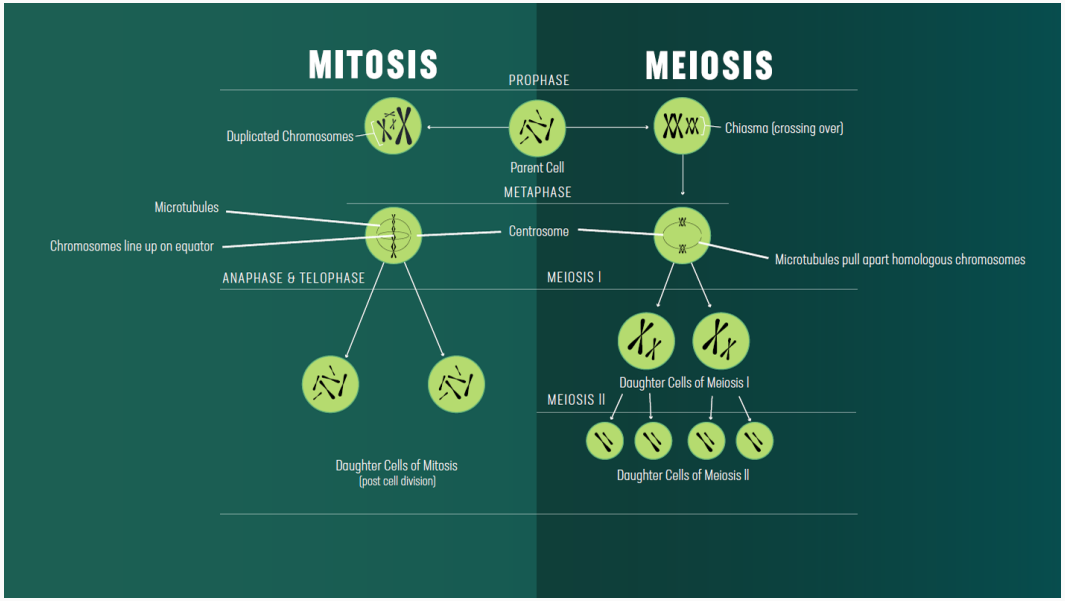
Recombination breaks up favourable gene combinations (e.g., sickle cell trait would be best maintained by asexual reproduction).



Source: Pixabay

Meiosis is slow

Meiosis and syngamy are slower than double mitosis, with meiosis estimated as taking 5 to 100 times longer than mitosis for unicellular organisms (Lewis Jr, 1983).



Source: Technology Networks

Sex slows down reproduction and population growth rate (extremely important for small/single celled organisms).

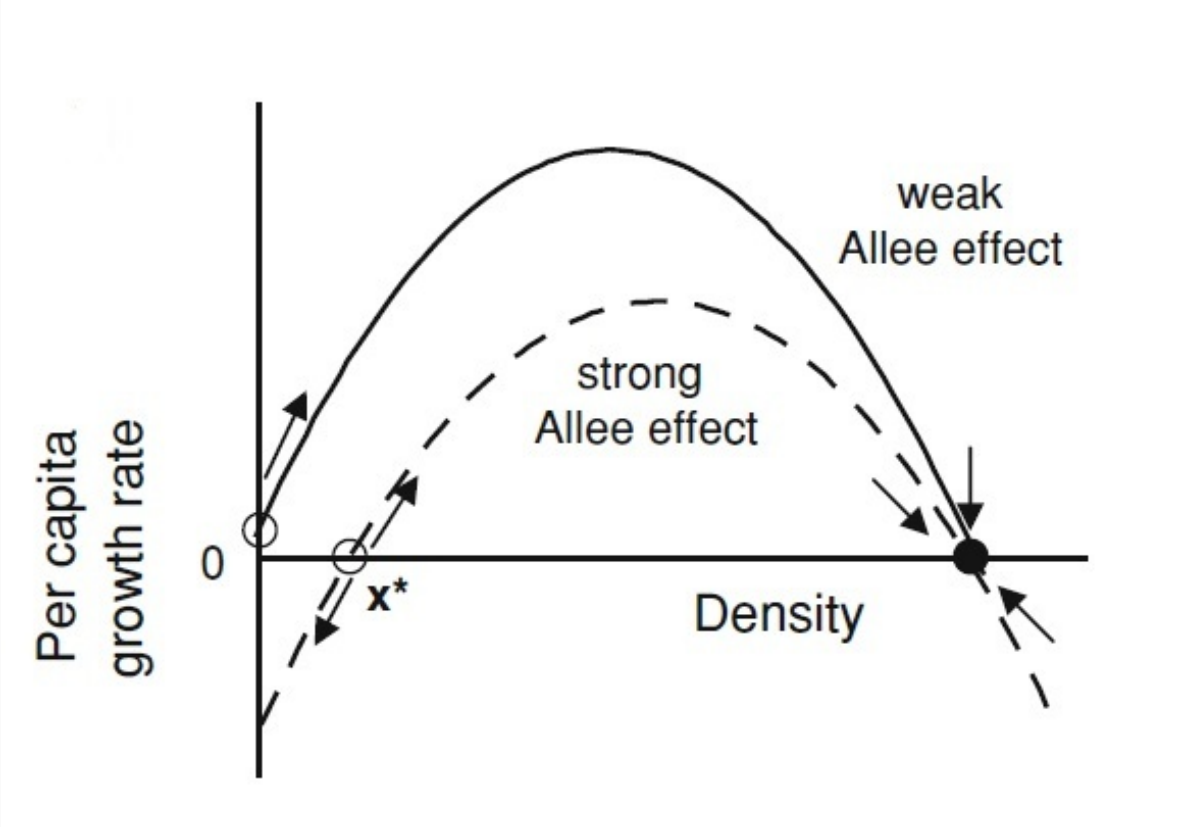
Sex requires a mate

Sexual reproduction requires that compatible gametes encounter each other (means investing time, energy, and resources into finding a mate).

Rhainds (2010) found that in 100 species of insects, failure to find a suitable mate is one of the primary sources of breeding failure.

Sex requires a mate cont.

Because sexual reproduction requires that compatible gametes encounter each other, small populations are prone to extinction (Allee effect).



In contrast, asexual reproduction is always possible.

Fertilization is unpredictable

In many plant species, sexual reproduction requires intermediary species (e.g., pollinators) for successful fertilisation.

Source: ISTOCK

Source: Wikipedia

Source: Wikipedia

Tying reproduction to the population dynamics of another species is extremely risky.

Sex is dangerous

Competing for access to mates can be lethal. Wounds can also become infected, decreasing survival.

Source: Stephen Underwood/Sun

Source: Roaring Earth

Source: Joseph Witkowski/Caters News

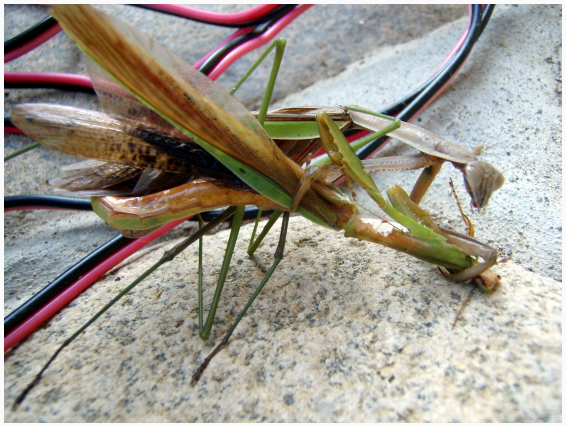
Sex is dangerous cont.

Sexual displays can increase the risk of predation.

Source: Wikipedia

Sex is dangerous cont.

Copulation and insemination can be physically damaging or even lethal in many species.



Source: Wikipedia

Source: Wikipedia

Source: Wikipedia

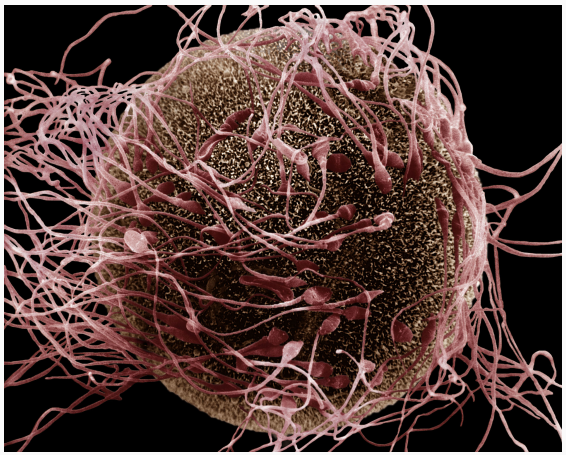
Sex is dangerous cont.

Sex exposes individuals to the risk of sexually transmitted infections.

Source: Wikipedia

Sex is wasteful

Sexual reproduction results in the waste of any unfertilised gametes.



Energy invested into the production of unfertilised gametes is wasted, increasing the net cost of reproduction.

Prevalence of sex

Despite the many costs of sex, more than 99 percent of multicellular eukaryotes reproduce sexually.

Organisms have evolved elaborate adaptations to facilitate costly sexual reproduction, including:

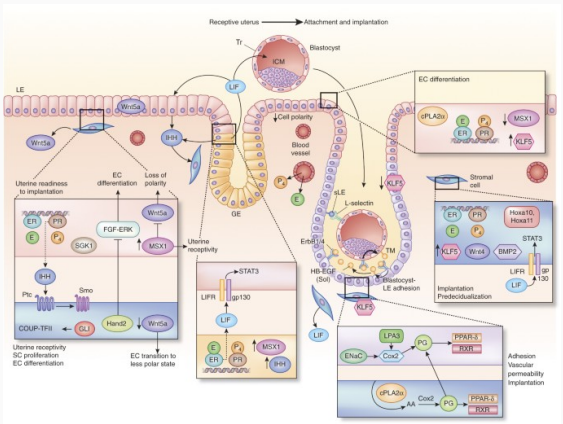
Behavioural

Satin bowerbird (*P. violaceus*)

Source: Luke Shelley/Shutterstock

Physiological

Humans (*Homo sapiens*)



Source: (Cha *et al.*, 2012)

Biochemical

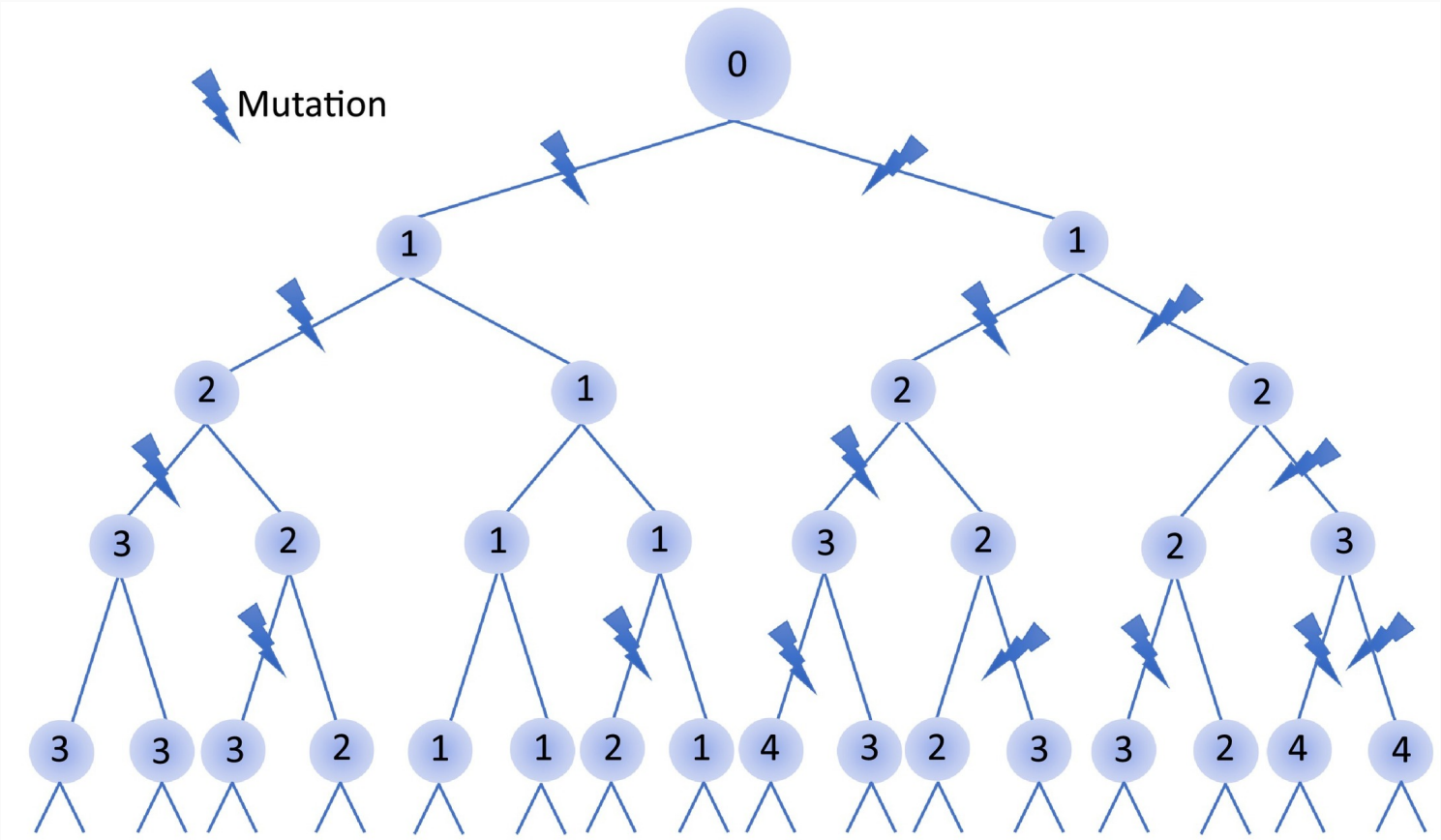
Silkworm (*Bombyx mori*)

Source: reddit

The Benefits of Sex

Sex and Muller's Ratchet

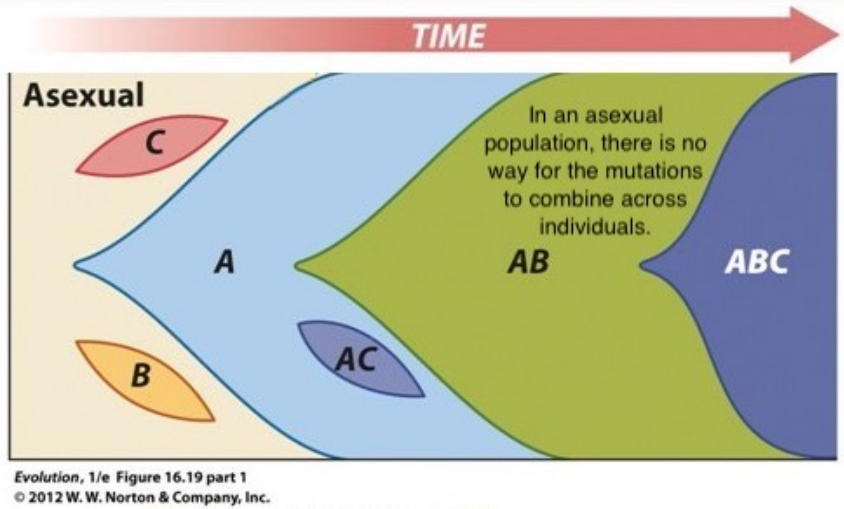
Sexual reproduction exposes recessive and/or deleterious alleles to selection, preventing deleterious mutations from being locked in (i.e., Muller's Ratchet).

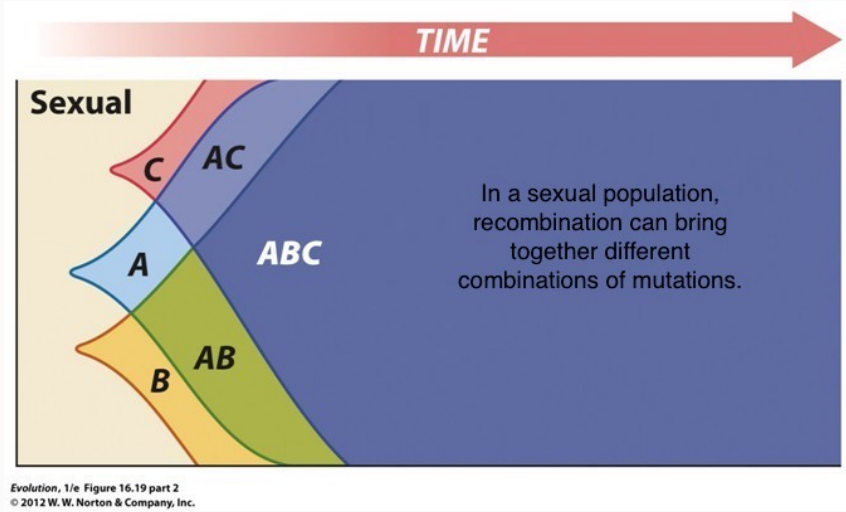


Modified from: (Govindaraju *et al.*, 2020)

Sex increases rate of transfer

Recombination increases the rate at which mutations are transferred across a population (Fisher-Muller Hypothesis).





Corollary: exposing recessive and/or deleterious alleles to selection increases homozygosity.

Consequences of sex

Sex involves meiosis (divison of cells and genetic material) and syngamy (fusion of cells and genetic material), generating segregation and recombination.

	Progeny Genomes		
	Diversity	**Heterozygosity**	**Costliness**
Asexual	Low	Very High	Low
Sexual			
Self-fertilization	Intermediate	Low	Minimal
Sex	Very High	High	Very High

Source: (Bell, 2019)

Costs vs. Benefits

For sexual reproduction to persist the costs need to outweigh the benefits.

Costs of sex

- Half of genes passed on
- Slow
- Dangerous
- Wasteful
- Unpredictable
- Requires a compatible mate
- Breaks up linkages
- Small pops. are prone to extinction

Benefits of sex

- Increases variability
- Prevents buildup of deleterious mutations

Costs vs. Benefits

On paper, sexual reproduction is extremely costly and the main benefits are that sex increases genetic variability and prevents buildup of deleterious mutations.

How did the costly practice of sex become so prevalent across the kingdom of life?

The ecological context of sexual reproduction is everything.

... we will continue with this next lecture.

References

Bell, G. (2019). *The masterpiece of nature: the evolution and genetics of sexuality*. Routledge.

Cha, J., Sun, X. & Dey, S.K. (2012). Mechanisms of implantation: strategies for successful pregnancy. *Nature medicine*, 18, 1754–1767.

Govindaraju, D.R., Innan, H. & Veitia, R.A. (2020). The muller's ratchet and aging. *Trends in Genetics*, 36, 395–402.

Lewis Jr, W.M. (1983). Interruption of synthesis as a cost of sex in small organisms. *The American Naturalist*, 121, 825–833.

Rhainds, M. (2010). Female mating failures in insects. *Entomologia Experimentalis et Applicata*, 136, 211–226.

Stelzer, C.P. (2011). The cost of sex and competition between cyclical and obligate parthenogenetic rotifers. *The American Naturalist*, 177, E43–E53.