

Biol 418 Evolutionary Ecology

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Web site is www.zoology.ubc.ca/~bio418

Lectures: Tue, Thu 9:30 – 10:30 in Biosciences 1001

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No book for the course. Weekly readings instead.

Midterm: none

50% Assignments up to 5 short essays on discussion topics

40% Final Exam

10% Tutorial discussions

Tutorials involve reading a research article beforehand and contributing to a discussion of an over-arching question.

For example,

"Why manipulate traits in field studies of natural selection?"

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Discussion 1

Allometric Engineering: A Causal Analysis of Natural Selection on Offspring Size

Barry Sinervo, Paul Doughty, Raymond B. Huey, Kelly Zamudio

Techniques of offspring size manipulation, "allometric engineering," were used in combination with studies of natural selection to elucidate the causal relation between egg size and offspring survival of lizards. The results experimentally validate premises underlying theories of optimal egg size: fecundity selection favoring the production of large clutches of small eggs was balanced by survival selection favoring large offspring. However, large hatchlings did not always have the highest survival, contrary to most theoretical expectations. Optimizing selection on offspring size per se was the most common pattern. Moreover, matches between average and optimal egg size were qualitative, not quantitative, perhaps reflecting known functional constraints on the production of large eggs.

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Purpose of discussions:

Opportunity to:

Read the primary literature

Develop and articulate views, however preliminary (you talk)

Recognize and develop improved arguments

Synthesize a logical argument to answer a basic question

Readings provided at the course web site

What is Evolutionary Ecology?

The study of the ecological causes and consequences of evolutionary change, past and present.

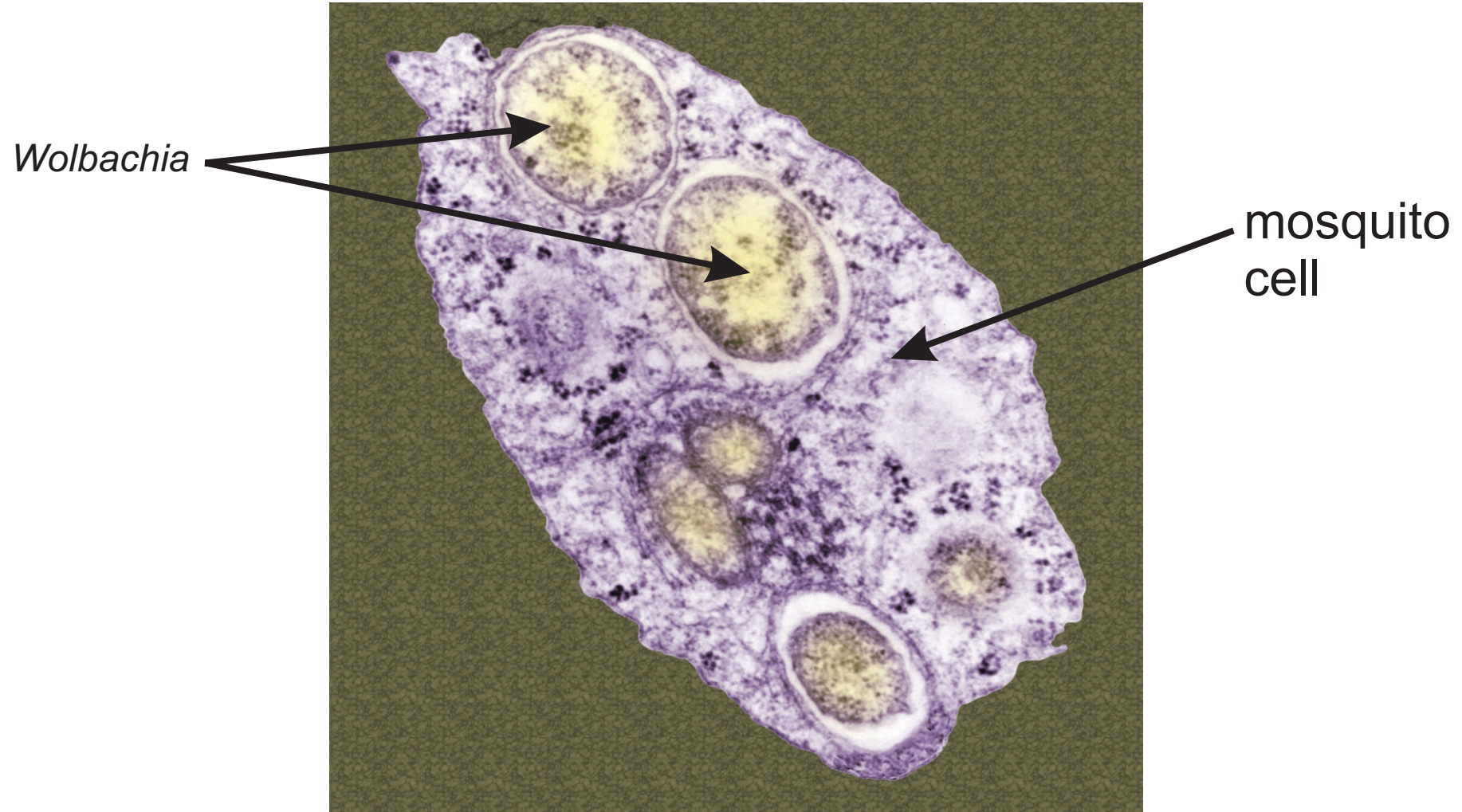
Today's lecture:

An example of an interesting problem in evolutionary ecology:

Intracellular symbionts and their consequences

How an ecological interaction affects evolution, and how evolution might have ecological consequences.

An intracellular symbiont *Wolbachia* bacterium in a mosquito cell

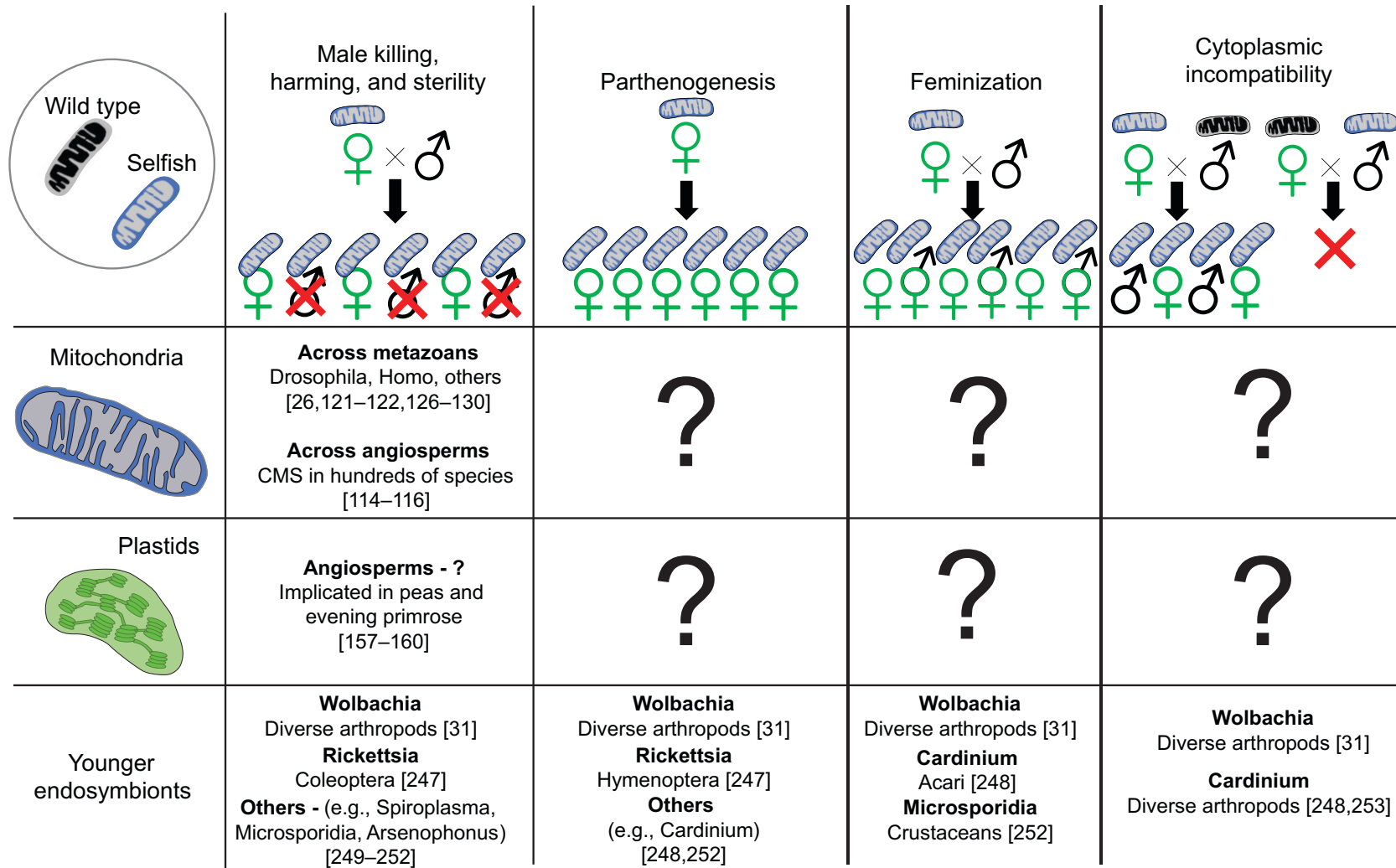


Intracellular symbionts and host sex ratio

Background facts:

- 1) Intracellular symbiont lives inside cells.
- 2) Many examples in nature: rickettsia bacteria, microsporidia, viruses, *Wolbachia* (a bacterium).
- 3) Symbionts may be parasites, commensals, or mutualists (e.g., may be linked to viral resistance in host).
- 4) The usual mode of inheritance is *vertical* (mother to offspring via egg or seed) rather than *horizontal* (via infection)
- 5) Many of these symbionts alter the sex ratio of host individual.

Intracellular symbionts and host sex ratio



Current Biology

Figure 3. Mechanisms of reproductive manipulation in cytoplasmic genomes.

Four mechanisms of reproductive parasitism of arthropods have been described in younger endosymbionts

Sex ratio theory

Most organisms have a 50:50 sex ratio at conception. This makes sense for three reasons.

1. Genes residing on chromosomes are transmitted to future generations through both sons and daughters.
2. In each generation, every female must pair with a male to produce offspring.
3. Therefore, if the sex ratio is not 50:50, the rarer sex will on average obtain more matings, and leave more offspring, than the more common sex.
4. Any mutation that causes its bearer to produce more of the rarer sex, and fewer of the commoner sex, will have an evolutionary advantage.
5. This advantage persists until the sex ratio evolves to 50:50.

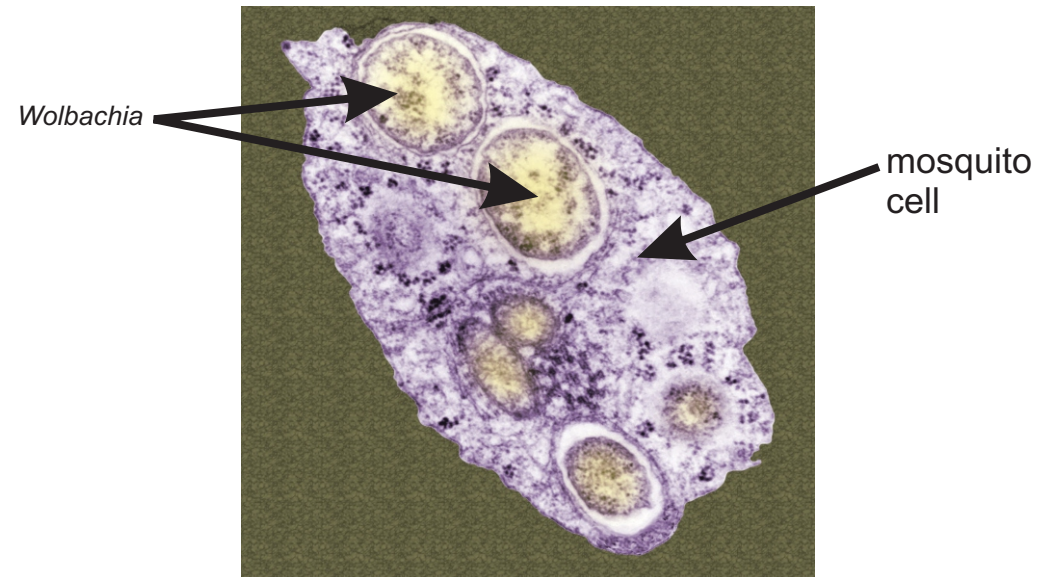
This is the accepted explanation for why so many organisms have a sex ratio close to 50:50.

Intracellular symbionts and host sex ratio

But what happens if genes residing on chromosomes are NOT transmitted to future generations through both sons and daughters?

Question: How is *Wolbachia* transmitted?

Answer: via daughters of the host species, not via sons.



Intracellular symbionts and host sex ratio

Therefore, a mutation in the symbiont (living in the cytoplasm) that interferes with sex ratio of hosts, causing it to produce more daughters than sons, would have an evolutionary advantage.

It doesn't stop there.

If a female-biased sex ratio should result, then a mutation in the host that counteracts interference by the intracellular symbiont, and restore a 50:50 sex ratio, would have an evolutionary advantage.

Intracellular symbionts and host sex ratio



Example:
Armadillidium vulgare
the pill-bug or woodlouse

http://en.wikipedia.org/wiki/Armadillidium_vulgare

In *Wolbachia*-free populations, males are ZZ, females are ZW.

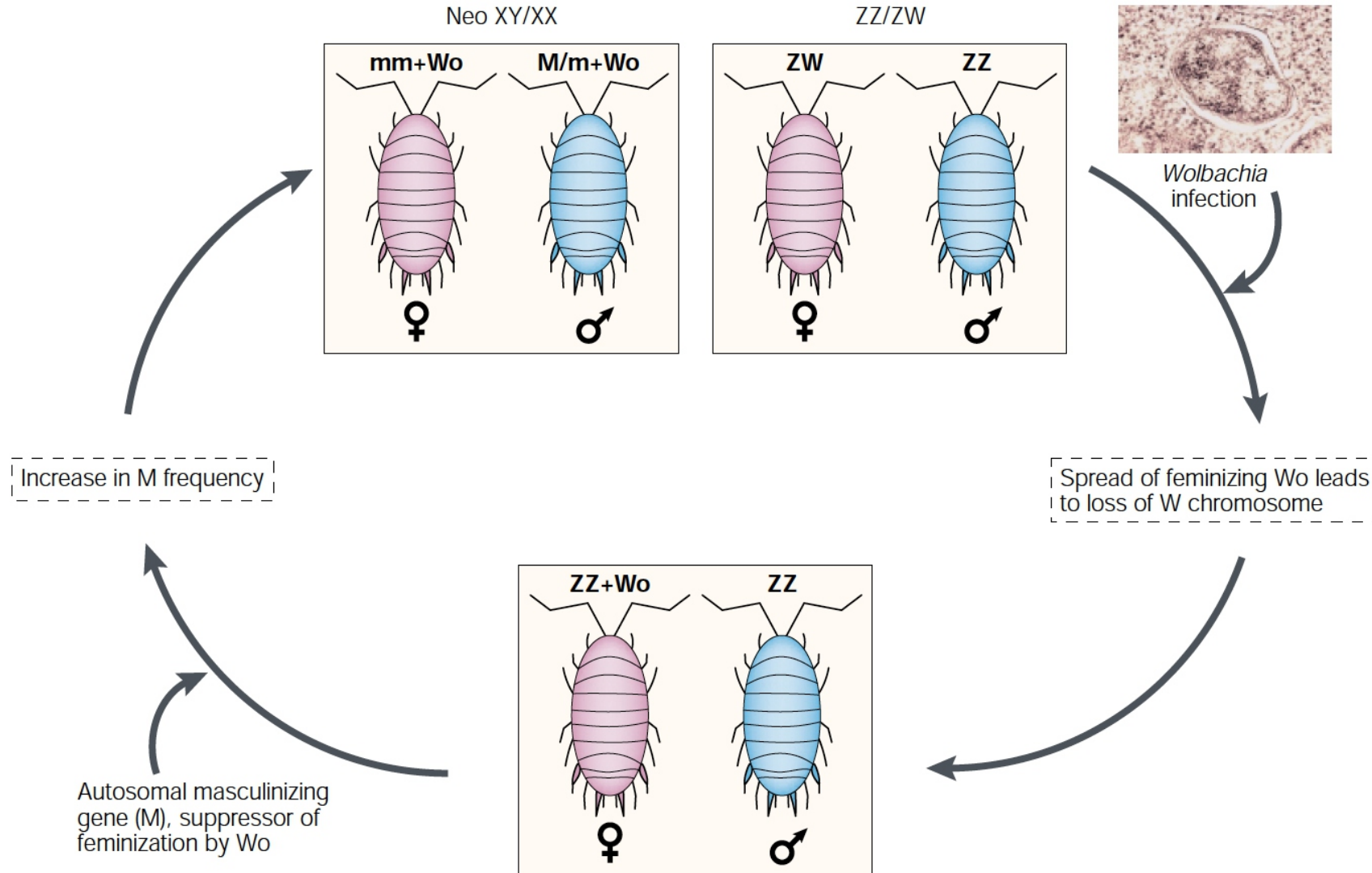
In most populations (*having Wolbachia*), most infected ZZ individuals are *female*. The *Wolbachia* causes feminization.

In some populations, the W chromosome has been lost, so that ZZ are male and ZZ+*Wolbachia* are female.

It doesn't stop there, because additional genetic factors can evolve that affect these dynamics. A genetic factor *M* counteracts the feminizing effects of *Wolbachia*.

Intracellular symbionts and host sex ratio

This could ultimately lead to the evolution of a new mechanism of chromosomal sex determination. Here is a schematic of a proposed evolutionary sequence.



Intracellular symbionts and host sex ratio

Might this evolutionary dynamic have ecological consequences, say on population size?

Perhaps population growth in *Armadillidium vulgare* is faster in those periods or locations where the sex ratio is strongly female-biased.



Lessons for Evolutionary Ecology

- 1) Evolution is a contemporary process. The dichotomy between “ecological time” and “evolutionary time” is blurred. For example, sex ratio can evolve rapidly from year to year.
- 2) This dynamic evolution is happening under the flower pots in your back yard.
- 3) Many phenomena in nature that we take for granted, such as the 50:50 sex ratio, have been moulded by natural selection.
- 4) Ecological interactions between a symbiont and its hosts can have unexpected evolutionary consequences. These consequences may affect ecological dynamics in turn.

Lessons for Evolutionary Ecology

5) The “level” at which natural selection acts can become blurred. In the example of symbionts and sex ratio evolution, natural selection is acting on *individuals* of two distinct species that have conflicting evolutionary “interests”.

But what if cytoplasmic genes causing sex ratio manipulation occur not in a bacterium but instead in the host’s own mitochondria (as is the case in gynodioecy in many species of plants - the pollen sterility factor is in the mitochondria).

At what level is selection acting in this case? Dawkins has argued that the best way to view this is that selection acts on genes not individuals.

6) Genes don’t evolve in a direction that is “good for the species”.

7) These are interesting hypotheses, but how can we test them?

In this course we will investigate such ideas in evolutionary ecology using a combination of *theory* (models of the process, which generate predictions for testing) and *tests* based on experiments and comparative studies.