# *Definitions*

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## *What are ecology and evolution?*

### *ecology*

"the study of the processes determining the distribution and abundance of organisms" (Krebs) or of "the interaction among organisms and between organisms and their environment" (Poulin)

In infectious disease (ID) context: **incidence** (number of new infections per unit time) and **prevalence** (number of infected individuals in the population). We may also be interested in the **parasite burden** or **intensity** of infection: how many bugs/host on average?

How do we get this information?

- case reports
- proxies (deaths, hospitalizations, wills)
- **serosurveys**
- counting eggs in feces, or worms in gut contents
- viral titers (e.g. by quantitative PCR)
- population genetic methods (Volz et al. 2009)

### *evolution*

"changes in gene frequency in a population between generations" - due to **mutation**, **selection**, **drift**, etc. - or more broadly, the change in characteristics of organisms over time due to genetic change.

In ID context, we will be interested in the evolution of pathogens, of hosts, and the **coevolution** of pathogens and their hosts.

How do we find out about evolution?

- experiments (*in vitro*)
- changes in phenotype frequencies (e.g. parasite strains)
- measuring **serotype** frequency
- detection of ancient DNA
- detection by sequencing (e.g. S-gene target failure)
- genome sequencing
- inferring **selective sweeps** from
- phylogenetic reconstruction (time to **most recent common ancestor**, relationships)
- inference about phenotypes by modelling protein structures

*What is an infectious disease?*

- **disease**: departure of an organism from its "normal" functioning (genetic, environmental, ...). An **infectious disease** is a disease that can be transmitted (**horizontally**) among organisms.
- **symbiont**: an organism that lives in close association with its host, in contrast with **free-living** organisms ($\neq$ "mutualist")
- **parasite**: an organism that *lives in close association with its* **host** and *harms its host* (reduces **fitness** but doesn't kill)
- **pathogen**: "a microorganism that causes disease" (Oxford English Dictionary).
- **natural enemy**: any organism that benefits (increase in fitness) from association with its victim (loss of fitness)

| | **kills** | **harms** | **no effect** | **benefits** |
|---|---|---|---|---|
| **close** | parasitoid | parasite | commensal | symbiotic mutualist |
| **not close** | predator | grazer | | mutualist |

- **Biochemical** parasites: prions (chronic wasting disease, scrapie, bovine spongiform encephalopathy), transposable elements, cancer (including *transmissible* (Wikipedia) cancers, e.g. Tasmanian devil facial tumour disease)
- **Biochemically obligate** parasites: phages, viruses
- Other **microparasites**: bacteria, fungi, protozoans
- Classical **macroparasites** (nematodes, schistosomes, trematodes, acanthocephalans, molluscs ...)
- **Ectoparasites**/grazers (leeches, fleas)
- **Phytophagous insects** (aphids, *Lepidoptera* etc.)
- **Behavioral** parasites ("scroungers"): brood parasites (intraspecific and cuckoos) and kleptoparasites (skuas)
- **Cheaters** in animal societies (e.g. reproducing worker bees)
- **Cheaters** in mutualisms (ant-plant scroungers)

*Why do we care?*

Because close association qualitatively changes the ecological/evolutionary relationship between host and parasite to a chronic, biochemically

mediated arms race. We will expect the evolutionary trajectories of parasites, parasitoids, and predators to be extremely different (cf. anthrax and tuberculosis).

*Why are we talking about parasites in general when this course is about infectious disease?*

1. parasites have a major impact on **morbidity** (disease) and **mortality**, albeit mostly in less-developed countries (should we care less?) (2) thinking about
2. understanding parasitism in general gives a broader scope for understanding biological interactions involved in disease
3. parasites are really neat

*microparasites and macroparasites*

- **microparasite** (**intensity-independent** parasite): typically, a parasitic microorganism (virus/bacterium/protozoan/fungus) but more generally a parasite where we count hosts as uninfected/infected. (Counterexample: viral load)
- **macroparasite** (**intensity-dependent** parasite): typically, a metazoan parasite (cestode/nematode/copepod/insect) but more generally a parasite where we track the intensity of infection per host

**Why do we care?** Because we have to think differently about the interaction

## *Origins of parasitism*

Why be a parasite?

The **biotic** environment of a parasite may seem ideal (the host maintains **homeostasis** and provides resources), but the biotic environment is *actively hostile*, unlike the **abiotic** environment of free-living organisms

- Did symbionts become enemies, or enemies become symbionts?
- How easy is it to switch between (1) **free-living** and **symbiotic** lifestyles or between (2) mutualism and parasitism?
- **Comparative analysis** tries to answer such questions by looking at organismal traits in a **phylogenetic** context.
- **phoresis**: the use of a (**phoretic**) host for transport (or a stable environment) only (e.g. mites, nematodes)
- Combes describes the progressive intensification of parasitism in 12 species of prosobranch molluscs

- Moran and Wernegreen (2000): chronic (**obligate**) symbionts are stuck, but **opportunistic** symbionts can easily flip between commensalism and parasitism (cf. **plasmids**, **quorum sensing**)

*References*

Moran, Nancy A., and Jennifer J. Wernegreen. 2000. "Lifestyle Evolution in Symbiotic Bacteria: Insights from Genomics." *Trends in Ecology & Evolution* 15 (8): 321–26. https://doi.org/%7B10.1016/S0169-5347(00)01902-9%7D.

Volz, Erik M, Sergei L Kosakovsky Pond, Melissa J Ward, Andrew J Leigh Brown, and Simon D W Frost. 2009. "Phylodynamics of Infectious Disease Epidemics." *Genetics* 183 (4): 1421–30. https://doi.org/10.1534/genetics.109.106021.