Competition

1. What is competition?
2. Intra-specific competition.
    a. Fallacy of group selection
    b. Introduction to principle of allocation, zero-sum games. Circumstances producing intraspecific competition.
3. Inter-specific competition
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    b. Mechanisms of inter-specific competition: Interference vs. exploitation competition
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1. What is competition?

Competition occurs when individuals use a shared resource in short supply: There may not be enough of the resource for any given individual to survive or to reproduce as well as when more resource is present.

Competition does not necessarily involve competitors ever meeting (if the competitors are mobile organisms, such as many animals), or being adjacent to each other (if sessile organisms, such as plants or fungi).

As a result of competition:

- birth rates are lower, death rates higher, or both.
- In ecological terms, population growth rates decrease and population size is lower at equilibrium
- In evolutionary terms, an individual's fitness is lower.

Competition is a ***density dependent effect***. What does this mean?

2. Intra-specific competition

Individuals compete with others of their own kind (that is, members of their own species) when populations grow, and individuals are therefore more closely packed, and/or resources are scarcer. What does the prefix ***intra-*** mean, and what does it refer to in this context?

2a. Fallacy of group selection

- The prevalence of intra-specific competition points out the fallacy of group selection
- *Individuals* (trout, chanterelles, gekkos, mayflies, hemlocks…) are selected to reproduce their genetic makeup as much as possible over their lifetime.
- Those genes that are passed on to the next generation in the greatest numbers are, by definition, the most successful. Individuals who do not reproduce are not (genetically) represented in the next generation. Evolutionarily, these individuals are dead-ends.
- To the extent that an individual’s kin (siblings, cousins, etc.) share some of the genes as he does, he has a shared interest in them also being (reproductively) successful.
- But most individuals in a population are not closely related to one another. (Can you imagine exceptions to this?)

QUESTION: Do individuals benefit (genetically) when unrelated individuals reproduce?

2b. Circumstances producing intra-specific competition: Resource depletion

• ***Effects on Survival***: Individuals starve to death, or poor nutrition makes it more likely they will die of predation, exposure or disease.

> **Principle of allocation**: the more time foraging or more physiological effort invested in growth or resource uptake, the less effort an individual has to devote to other activities, such as defense against predators. Time budget is a ***zero-sum game***.

Other effects?

Circumstances producing intra-specific competition: Space depletion

Other side-effects of space depletion: Increased time in social interaction

Other side-effects of resource or space depletion : Cannibalism or lesser harassment

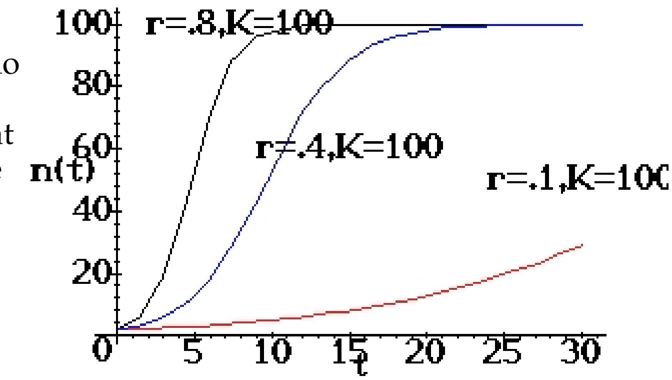
3a. Inter-specific competition: Case study 1: *Paramecium*

Gause (a Russian microbiologist) cultured a single species of *Paramecium* with a finite amount of algae (which the *Paramecium* eat), and got logistic population growth.
Logistic population growth is modulated by three parameters:

N = population size
K = carrying capacity (maximum population size)
r = growth rate of population

Population growth declines as population approaches carrying capacity, and is negative when population size is greater than carrying capacity.

- **dN/dt = rN(1 - N/K):** a differential equation describing logistic growth (for those of you who think in calculus).
- All populations converge on K, but the speed at which populations approach K is related to the growth rate r.
- The 3 lines on the graph represent populations that start with 2 individuals, and grow at rates of 0.1, 0.4 and 0.8 per time interval. All pops have the same carrying capacity (K) of 100 individuals.



Logistic growth assumes that the rate of reproduction is proportional to the amount of available resources. Thus the second term models the competition for available resources, which tends to limit pop growth.

Logistic population growth is too static to accurately reflect how natural populations change (for instance, In reality, K is a fluid parameter that may change with gene flow (migration), season, temperature, etc). But it is still a useful tool.

If $N < K$, the population will increase (positive r)
If $N = K$, the population is at equilibrium. ($r = 0$).
If $N > K$, the population will crash. (negative r)

Gause found that *Paramecium* have logistic pop growth when grown with a finite amount of algae. But when Gause put two species of *Paramecium* in the same culture, both populations experienced lowered growth rates. Ultimately, though, one species (*P. aurelia*) always drove the other (*P. caudatum*) to extinction. Gause therefore proposed the:

> **Competitive Exclusion Principle**: Two species that use resources exactly the same way cannot coexist. One will drive the other to extinction. Extinction by interspecific competition is known as competitive exclusion.

Lesson*: interspecific competition can cause extinction.*

3a. Inter-specific competition, case study 2: bark beetles

Bark beetles eat the phloem of dead and dying trees (as well as attacking live trees under some conditions). There are many communities of bark beetles across the world, including in PNW coniferous forests.

Where closely related species coexist, they do so by segregating themselves spatially within individual trees. In addition, some species segregate themselves with pheromones and timing of reproduction, which are facilitated by various microhabitat and climate conditions. (Ayres et al. 2001. Resource partitioning and overlap in three sympatric species of *Ips* bark beetles (Coleoptera, Scolytidae). Oecologia 128: 443-453.)

- Lesson 1: Ability to compete depends on environmental conditions, which vary over both space & time.
- Lesson 2: Coexistence in nature is possible when individuals of different species use shared resources somewhat differently.

Resource partitioning: differences in how resources are used by individuals of different species. Resource partitioning may help species avoid competitive exclusion.

3a. Interspecific competition, case study 3: salmon

Sockeye salmon *Oncorhynchus nerka* and chum salmon *Oncorhynchus keta* are sympatric in the North Pacific Ocean and have ocean migrations of similar duration. They have responded to this potential for interspecific competition in a variety of ways.

- Chum have a wider range of optimal water temperature than do sockeye
- Chum are superior to sockeye in digestion ability, and this may enable chum to utilize poorly nutritious food organisms such as jellyfish, on which other salmonids seldom feed.

Physiology and anatomy often affect competitive ability, and may change in response to interspecific competition.

3d: Mechanisms of inter-specific competition

Two broad categories are referred to in the literature:

- **Exploitation competition**: If you use a resource, someone else can't, and vice versa. Individuals never need encounter one another to compete. Exploitation competition is over some renewable resource like food or nest sites. Similar to "scramble competition" (from your reading).
- **Interference competition**: Competitors confront one another over resources. Interference competition may be behavioral (e.g. actual fighting over resources), or physiological (e.g. growing over other individuals). Includes: interspecific territoriality, social interactions, chemical competition (which in sessile organisms can be analogous to territoriality). E.g. walnut trees, gymnosperms. Similar to "contest competition."

3e: Synopsis of possible outcomes of inter-specific competition

1. Competitive exclusion = extinction
2. Coexistence:
   a. Resource partitioning (species use resources somewhat differently)
   b. Species settle to different population sizes at equilibrium (different N); and
3. The organisms themselves may change in order to utilize the same niche or resources in different ways.