Part II. Conserving communities & ecosystems

What forces help to influence and structure biodiversity at levels above the population?

I. How populations work

2: What leads to changes in population genetic structure?
3: How do populations grow and shrink?

II. How communities & ecosystems work

4: What are the possible outcomes of species interactions?
5: What processes help to structure communities?
6: What controls nutrient and energy flow through ecosystems?

Levels in the hierarchy

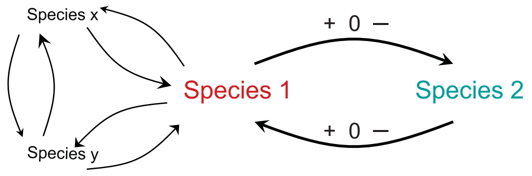
Population: – a group of individuals of one species in an area, potentially interacting (e.g., competition, reproduction)

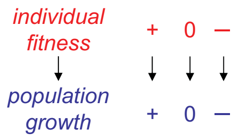
– continuous through time

Community: – a group of *populations of different species* in an area, *potentially interacting*

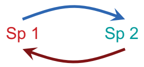
– continuous through time

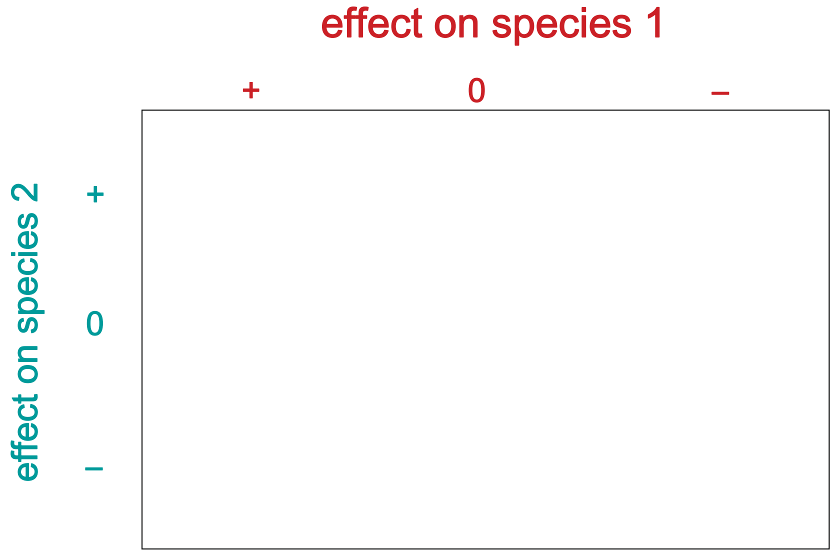
What is the nature of these interactions?





Classes of interspecific interactions





Competition: two species share requirement for limited re$ource

→ reduces *individual fitness* and *population growth* for one or both species


kangaroo rats


deer mice

competition for nutrients

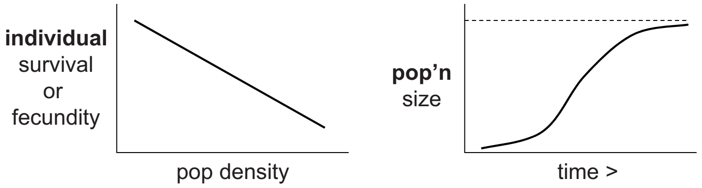

competition for energy


competition for space

Competition: population consequences of individual interactions

***Intra*specific competition**: b/w individuals of the same species

- **Contributes to ΔN through density-dependent effects**



***Inter*specific competition**: b/w individuals of different species

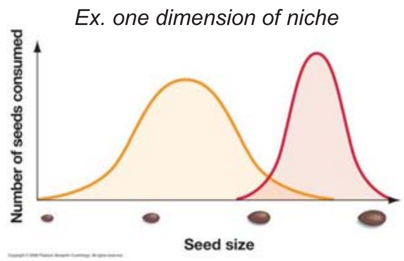
- **How does interspecific competition contribute to ΔN?**
- **How are the effects of interspecific competition studied?**

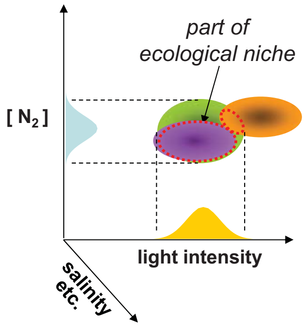
Competition: what is the *ecological niche* of a species? (Grinnell 1927)

combination of conditions (abiotic and biotic)
that can support a stable population

the niche is a "multi-dimensional space" (Hutchinson 1957)
where dimensions are set by limiting resources/conditions

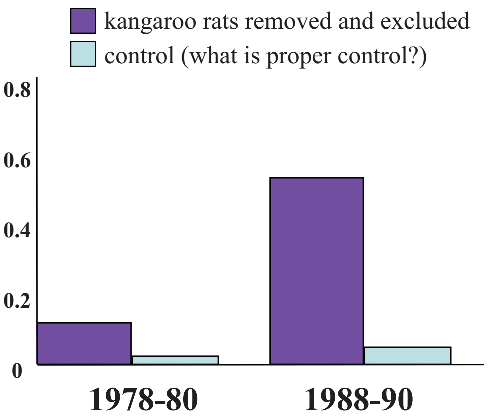
species compete when niches overlap





Q: Does niche overlap determine the outcome of interaction between two granivores?

Approach: exclusion experiment
24 "selectively fenced" plots, started in 1976



Granivorous rodents

kangaroo rats

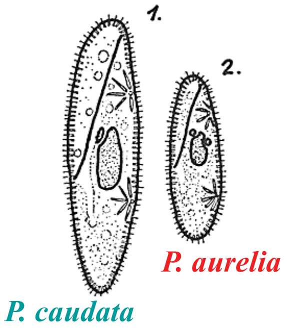
deer mice

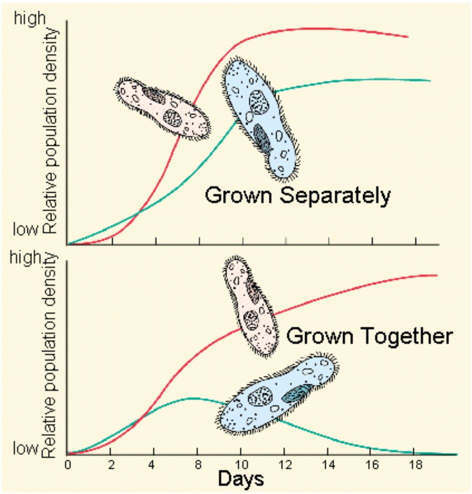
Conclusions:
- **kangaroo rats *competitively exclude* deer mice**
- **these species share critical aspect of ecological niche**

(Heske, Brown, and Mistry 1994)

Competitive exclusion principle: if two species share the same niche, the weaker competitor will be eliminated (Gause 1934)

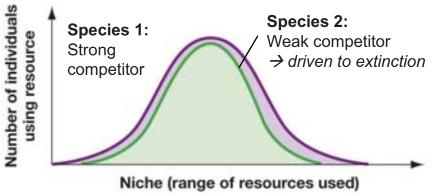
two species of *Paramecium*





Competitive exclusion principle: if two species share the same niche, the weaker competitor will be eliminated (Gause 1934)

- ➢ *one species dominant competitor*
- ➢ *niches overlap completely*



⬇

***Complete* competitors cannot coexist.**

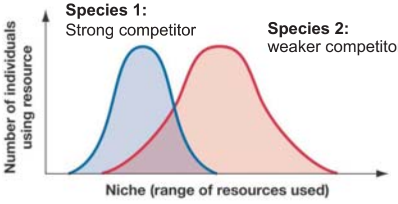
Ex. Kangaroo rats exclude deer mice…

Q: What would ultimately happen if you added more seeds to the environment?

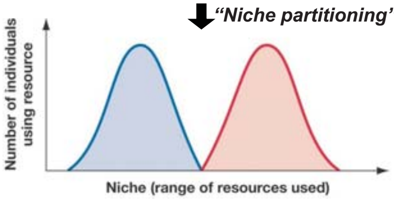
- ***A) deer mice ↑***
- ***B) kangaroo rats ↑***
- ***C) both ↑***
- ***D) neither ↑***

Q: What if you added a <u>different</u> resource?

- ➢ *one species dominant competitor*
- ➢ *niches overlap partially*



⬇*"Niche partitioning"*



Q: How do species come to partition niches?

Q: Has the niche of species 2 changed?

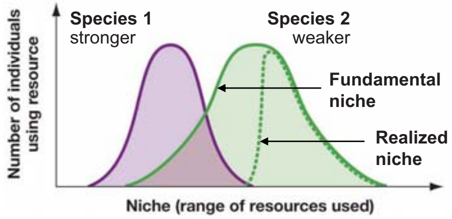
Competition: what is the *ecological niche* of a species? (Grinnell 1927)

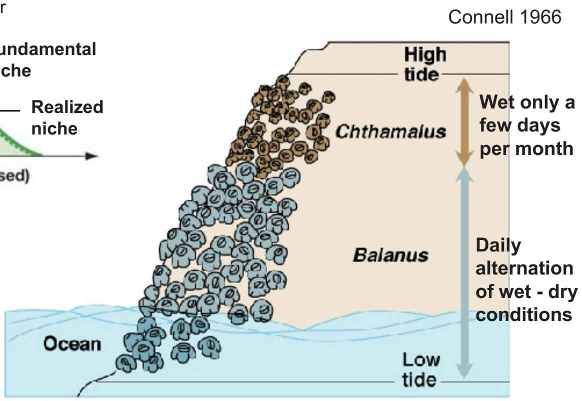
Fundamental niche – widest set of usable conditions

- ➢ depends on resources, physical conditions, behavior, etc.

Realized niche – set of conditions *actually* used

- ➢ depends on resources, physical conditions, behavior, etc. **<u>and</u>** species interactions

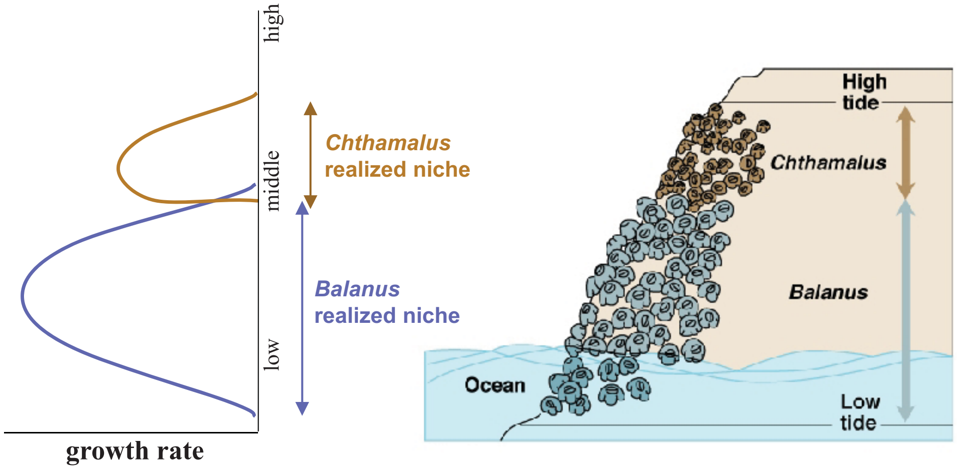




What is the ***realized niche*** of each?
What is the ***fundamental niche***?

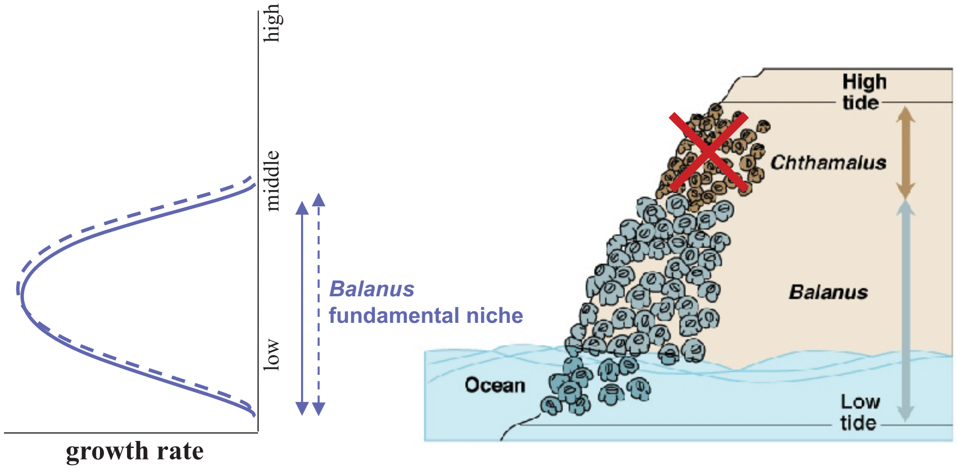
How do we determine the <u>realized niche</u> of each species?

Q_r: Where do individuals grow when allowed to compete?



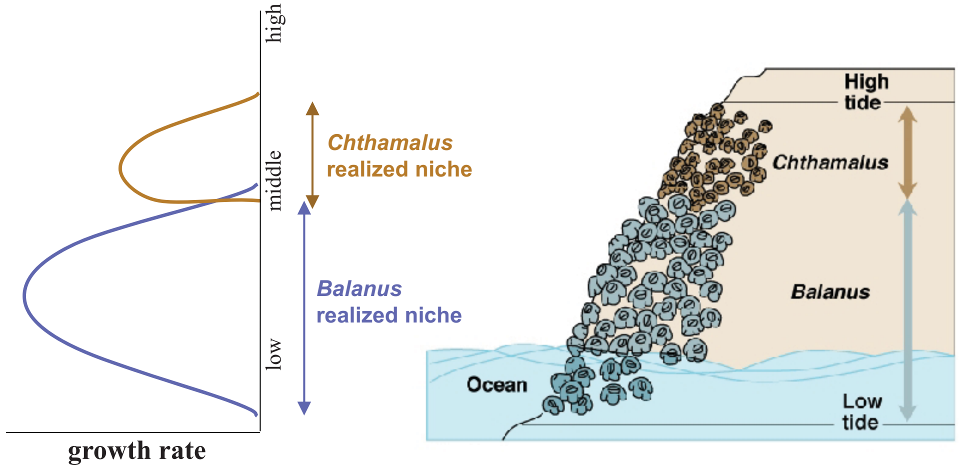
How do we determine the <u>fundamental niche</u> of each species?

Q_f: Where do individuals grow when competition is absent?



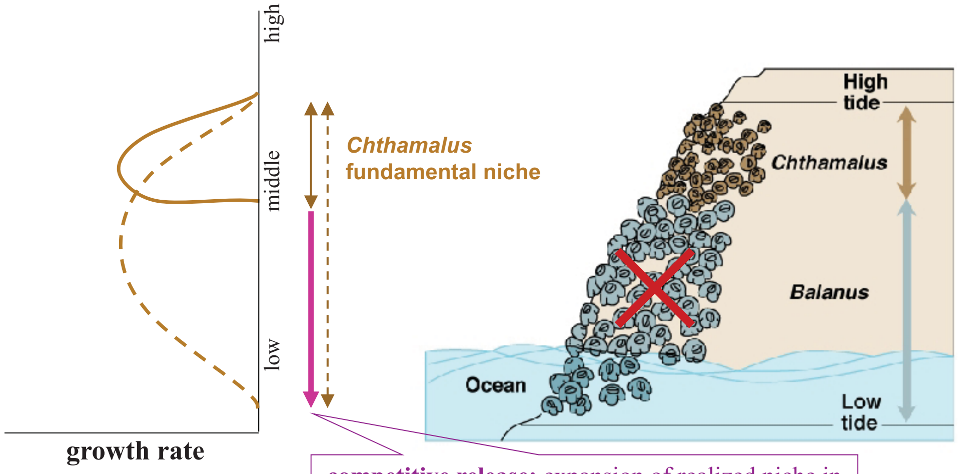
How do we determine the <u>realized niche</u> of each species?

Q_r: Where do individuals grow when allowed to compete?



How do we determine the <u>fundamental niche</u> of each species?

Q_f: Where do individuals grow when competition is absent?



competitive release: expansion of <u>realized</u> niche in absence of competitively-superior species

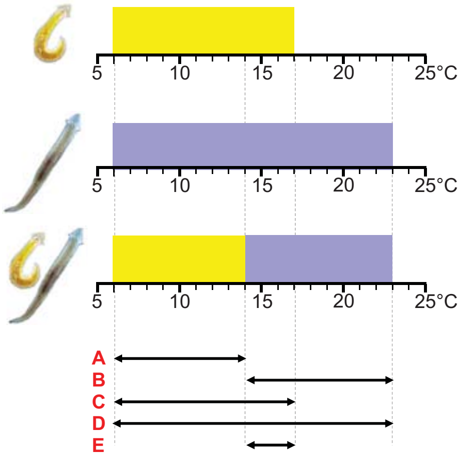
Outcomes of competition:
Niche partitioning

Ex. Two species of planarian flatworms that live in streams
(*Planaria montenegrina* and *P. gonocephala*)
Beauchamp & Ullyett, 1932

Streams with species 1
(in allopatry)

Streams with species 2
(in allopatry)

Streams with species 1 & 2
(in sympatry)



Q1: What is the <u>fundamental</u> niche of species <u>1</u>?

A B C D E

Q2: What is the <u>realized</u> niche of species <u>2</u>?

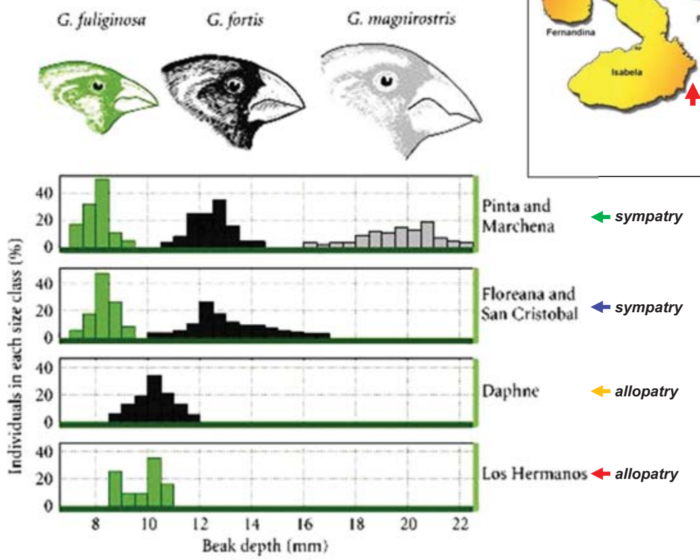
A B C D E

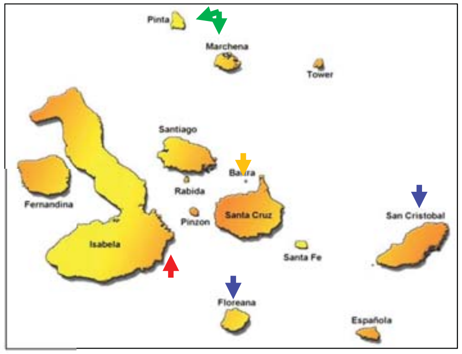
Q3: Which is the stronger competitor?

- *A. species 1*
- *B. species 2*
- *C. about equally competitive*
- *D. cannot tell*

Outcomes of competition:
Character displacement

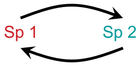
Ex. Darwin's finches in the Galapagos
(Grant and Grant)





Galapagos Islands

Classes of interspecific interactions



effect on species 1

effect on species 2	+	0	–
+			**consumption** predation herbivory parasitism
0			competition
–	**consumption** predation herbivory parasitism	competition	**competition**

Consumption: one species uses another as a re$ource

→ reduces fitness of consumed but enhances fitness of consumer (- / +)

Carnivores
- kill single prey during a brief attack, usually larger

Herbivores
- remove parts of many prey, rarely lethal

Parasites
- consume parts of one-few prey, rarely lethal, usually smaller

Parasitoids
- kill single prey during prolonged attack, usually smaller

Evidence that *consumption* has influenced trait evolution

➢***Constitutive*** *defenses*

Physical



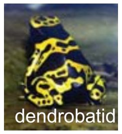

Chemical



Coloration and form

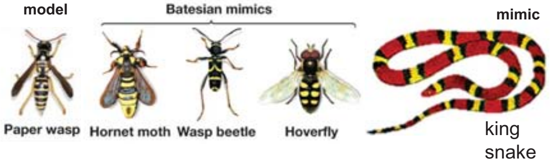
– matching objects or backgrounds

aposematic coloration – warning



model

mimicry – resemblance to aposematic model

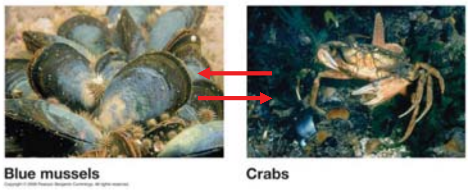


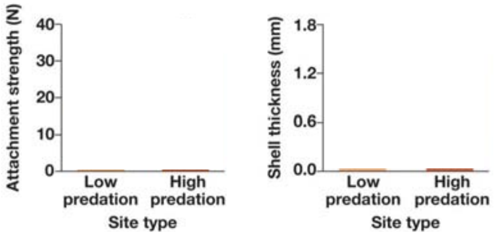
Evidence that *consumption* has influenced trait evolution

➢***Inducible*** *defenses*

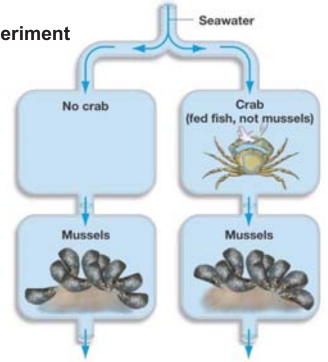
Anti-predator defense in an intertidal mussel (Leonard et al. 1999)

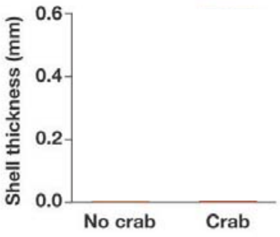
Field observations





Lab experiment





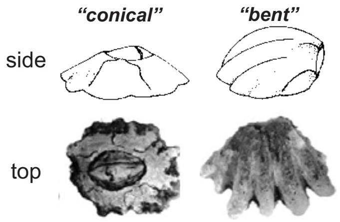
Q: What 3 hypotheses (processes) could explain this pattern?

Evidence that *consumption* has influenced trait evolution

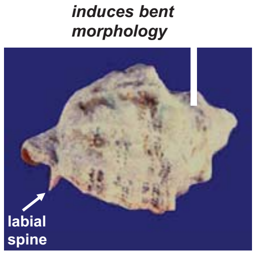
➢***Inducible*** *defenses*

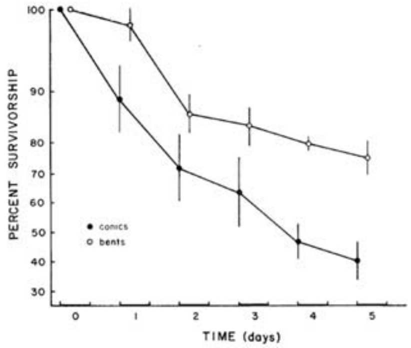
Anti-predator defense in an intertidal barnacle (Lively 1986)

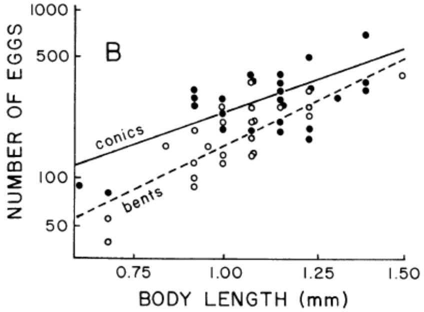
Acorn barnacle
Chthamalus anisopoma



Predatory snail
Acanthina angelica







Indirect effects: predation + competition

"The enemy of my enemy is my friend"

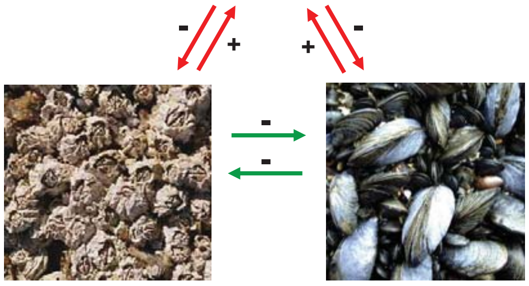
predator

Seastar
Pisaster

Q: What is the effect of a predator on the interaction between competing prey?

Approach: exclusion experiment (Paine 1966)

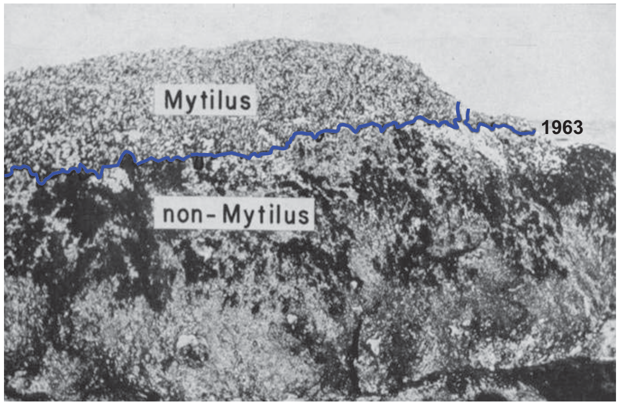
competitors



Barnacles
Balanus

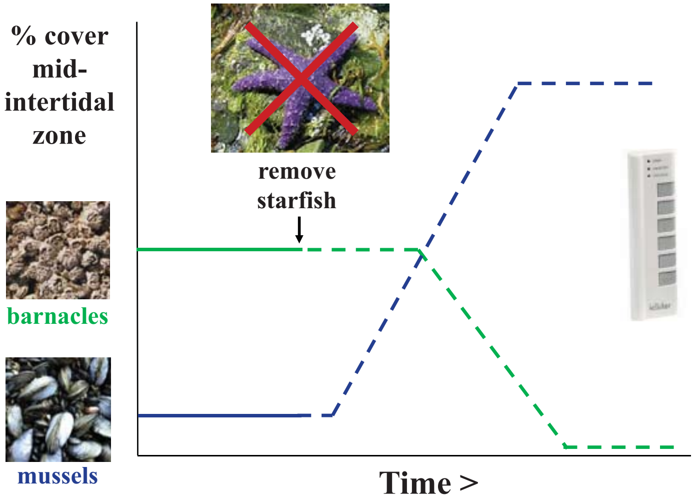
Mussels
Mytilus

Paine (1974)
effects of seastar removal on the diversity of a rocky intertidal community



Indirect effects: predation + competition

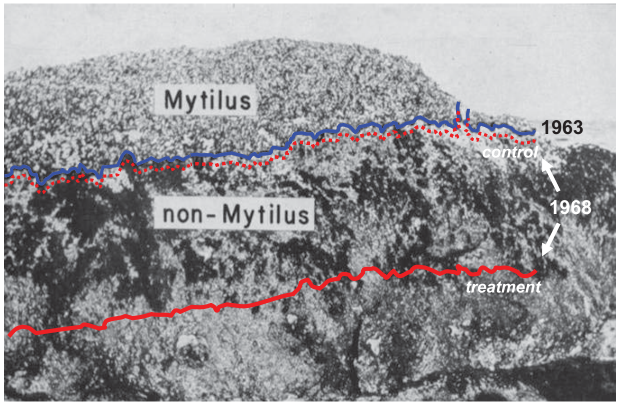
"The enemy of my enemy is my friend"



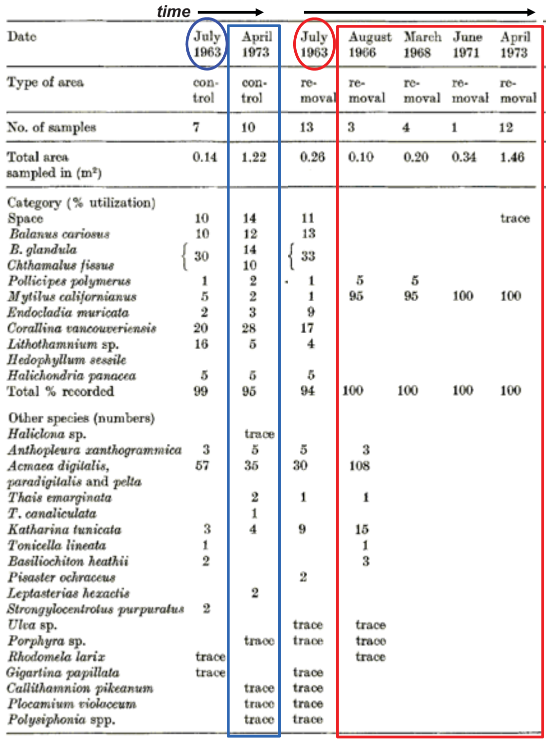
A) mussels ↑
B) barnacles ↑
C) both ↑
D) neither ↑

Q: Which must be the dominant competitor?

Paine (1974)
effects of seastar removal on the diversity of a rocky intertidal community



Paine (1974)
effects of seastar removal on the diversity of a rocky intertidal community



Date	July 1963	April 1973	July 1963	August 1966	March 1968	June 1971	April 1973
Type of area	con-trol	con-trol	re-moval	re-moval	re-moval	re-moval	re-moval
No. of samples	7	10	13	3	4	1	12
Total area sampled in (m²)	0.14	1.22	0.26	0.10	0.20	0.34	1.46
Category (% utilization)							
Space	10	14	11				trace
Balanus cariosus	10	12	13				
B. glandula	30	14	33				
Chthamalus fissus		10					
Pollicipes polymerus	1	2	1	5	5		
Mytilus californianus	5	2	1	95	95	100	100
Endocladia muricata	2	3	9				
Corallina vancouveriensis	20	28	17				
Lithothamnium sp.	16	5	4				
Hedophyllum sessile							
Halichondria panacea	5	5	5				
Total % recorded	99	95	94	100	100	100	100
Other species (numbers)							
Haliclona sp.		trace					
Anthopleura xanthogrammica	3	5	5	3			
Acmaea digitalis, paradigitalis and *pelta*	57	35	30	108			
Thais emarginata		2	1	1			
T. canaliculata		1					
Katharina tunicata	3	4	9	15			
Tonicella lineata	1			1			
Basiliochiton heathii	2			3			
Pisaster ochraceus			2				
Leptasterias hexactis		2					
Strongylocentrotus purpuratus	2						
Ulva sp.			trace	trace			
Porphyra sp.		trace	trace	trace			
Rhodomela larix	trace			trace			
Gigartina papillata	trace		trace				
Callithamnion pikeanum		trace	trace				
Plocamium violaceum		trace	trace				
Polysiphonia spp.		trace	trace				

Table 5. Composition of quadrats on control and experimental sides of the *Pisaster* removal area, Mukkaw Bay, July 1963-April 1973

Q: How do starfish promote coexistence and diversity?

Seastar
Pisaster

KEY
➡ **strong direct effect**
→ **weak direct effect**
⇢ **indirect effect**

Barnacles
Balanus

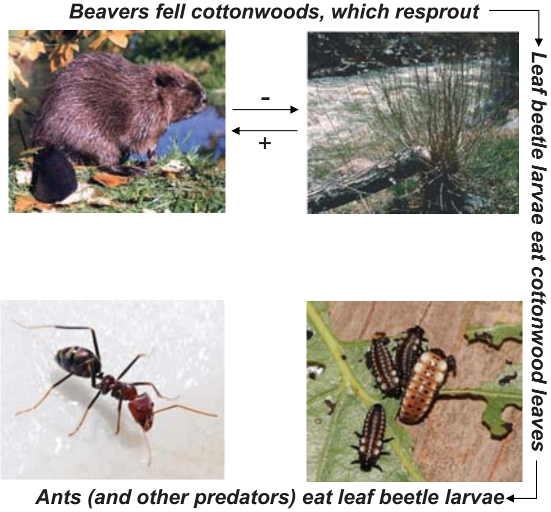
Mussels
Mytilus

Preferred prey
Dominant competitor

Conclusions:
1) **Indirect effect**: starfish allow coexistence by depleting stronger competitors
2) **Keystone species:** ecological effects out of proportion with numerical abundance

Q: What if starfish preferred barnacles?

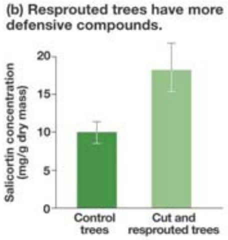
An indirect effect involving an inducible defense

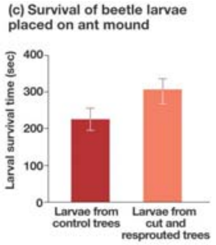


Beavers fell cottonwoods, which resprout

Leaf beetle larvae eat cottonwood leaves

Ants (and other predators) eat leaf beetle larvae

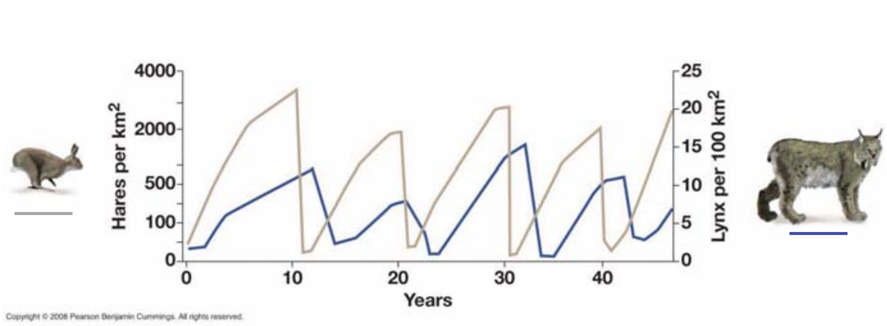




Assignment:
- Use solid arrows and (+/0/-) signs to indicate direct effects
- Use dashed arrows and (+/0/-) signs to indicate indirect effects

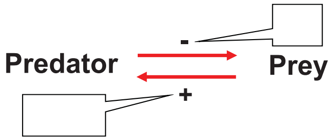
Coupling of predator-prey population dynamics (in special cases)

Ex. snowshoe hare & arctic lynx
late 19th c. fur trade



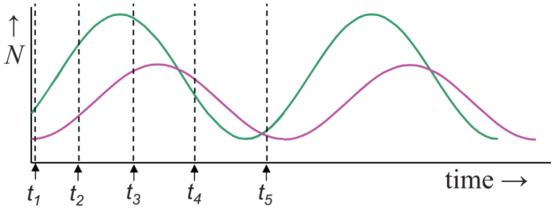
Q: Is the lynx a generalist or a specialist in its diet?

Coupling of predator-prey population dynamics (in special cases)



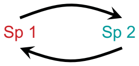
Recall:

$$\Delta N/\Delta t = bN - dN$$
$$= rN$$



t_1: with few predators, prey population grows (*d*)
t_2: with increasing prey, predator population grows (*b*)
t_3: with increasing predator, prey population starts to decline (*d*   *b*)
t_4: with decreasing prey, predator population starts to decline (*d*   *b*)
t_5: with few predators, prey population grows (*d*   *b*)

Classes of interspecific interactions



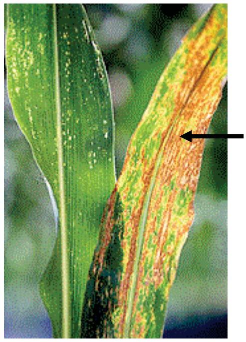
effect on species 1

effect on species 2	+	0	–
+			consumption predation herbivory parasitism
0			competition
–	consumption predation herbivory parasitism	competition	competition

Parasitism: Why is genetic diversity so important?

A lesson in evolutionary biology

1. In 1970, a single genotype of hybrid corn (with excellent growth characteristics) was planted throughout the southeastern U.S.



2. A new strain of southern corn blight evolved.

3. Most of the corn crop in the southeast US was **destroyed**, at a loss of $4 billion!

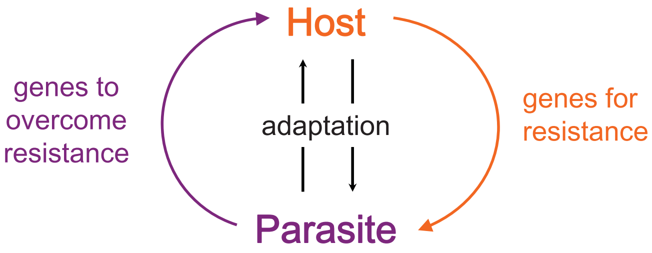
Parasitism: Why is genetic diversity so important?

A lesson in evolutionary biology

The corn blight example:
Some host individuals must have genes for resistance to respond to evolution in the parasite.

"It takes all the running you can do, just to keep in the same place."

The "Red Queen" Effect



Host

genes to overcome resistance

adaptation

genes for resistance

Parasite

Genetic diversity is necessary!
Monoculture is risky!

Parasitism: why are parasites so effective at overcoming host resistance?

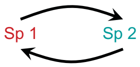
Parasites can evolve ways to overcome resistance faster than hosts can evolve new types of resistance. *Why?*

1) Parasites have bigger population sizes than hosts…
…more individuals in which mutations can occur

2) Parasites have shorter generation time than hosts…
…more chances for mutation in same time interval
…more generations to undergo natural selection

So, how do host populations survive?

Classes of interspecific interactions



effect on species 1

effect on species 2

	+	0	–
+	**mutualism**		**consumption** predation herbivory parasitism
0			competition
–	**consumption** predation herbivory parasitism	competition	competition

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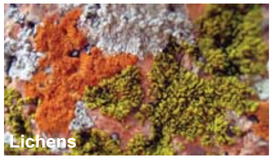
Mutualism: two species each provide re$ources or services

→ enhances fitness of individuals of both species (- / +)

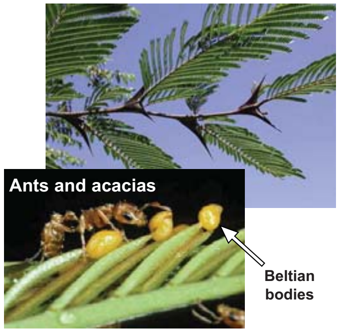
Nutrition …and Protection

Rhizobium on legume roots

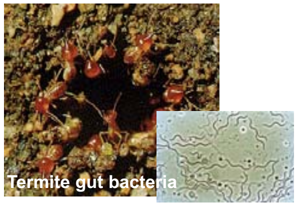


Lichens

Coral endosymbionts



Ants and acacias



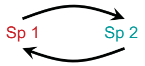
Termite gut bacteria

…and Transport

Seed dispersal

Pollination

Classes of interspecific interactions

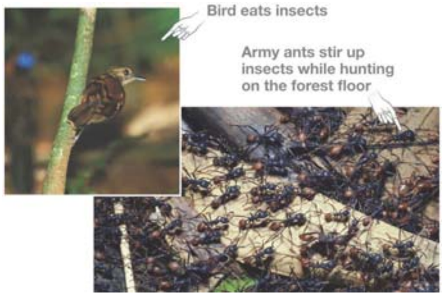


		effect on species 1		
		+	0	–
effect on species 2	+	**mutualism**	commensalism	consumption predation herbivory parasitism
	0	commensalism		competition
	–	consumption predation herbivory parasitism	competition	competition

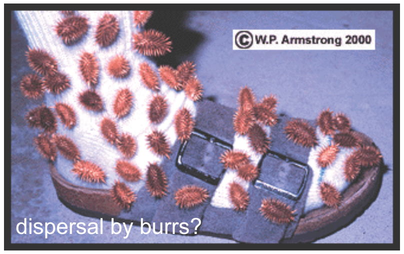
Commensalism: one species benefits, without (apparent) cost to the other

→ enhances fitness of individuals for one species


epiphytes growing on tree limb?



Q: Commensalism (or indirect effect?



dispersal by burrs?


hitchhiking by remoras?

Q: Is the relationship mutualistic, parasitic or commensal?

Symbiosis ("living together"): two species live in contact

→ can involve parasitism, mutualism, or commensalism


bird louse & bird


corals & endosymbionts


trees & epiphytes


fungus & corn


rhizobium & legume


remoras & rays