- Coevolução de inimigos e vitimas

- Prof. David De Jong
- Depto. de Genética

Wolf and Moose
Buzzle.com

Cheetah and Gazelle

Buzzle.com


African Wild Dog and Zebra
Buzzle.com

A LIVING THING THAT EATS PLANTS

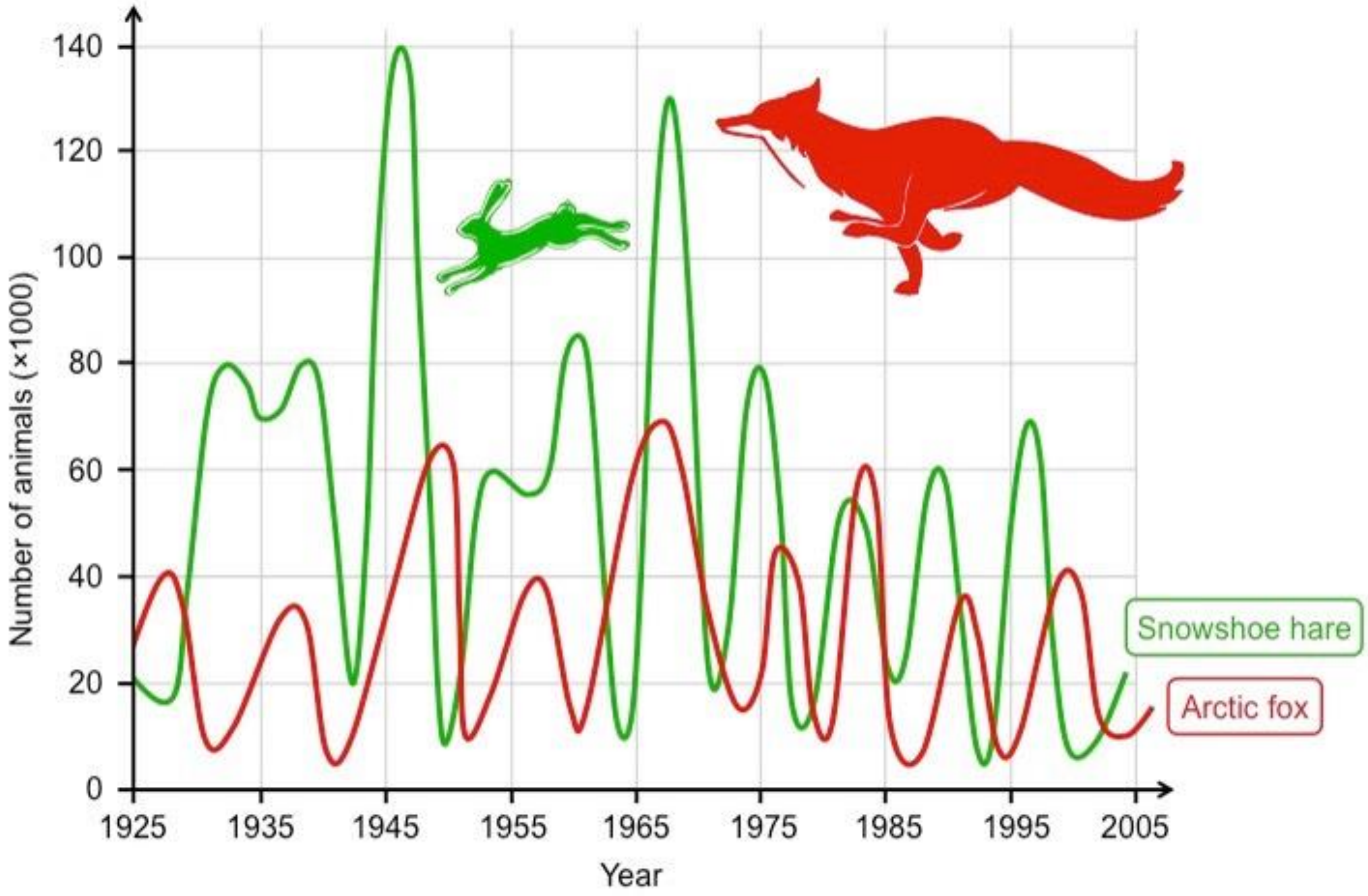
Are these animals predators or prey?

Characteristics of Prey

1. Eyes: Located on the side of the head so they can see if predators are approaching


Lion and Warthog
Buzzle.com


Canadian Lynx and Snowshoe Hare
Buzzle.com



140
120
100
80
60
40
20
0
Number of animals (×1000)
1925
1935
1945
1955
1965
1975
1985
1995
2005
Year
Snowshoe hare
Arctic fox

Coevolução

coevolução**?**

Dois ou mais especies:
1) fazem pressão seletiva um sobre o outro
2) evolvam em resposta uma da outra

Sendo cada espécie esta evoluindo em resposta ao outra
O ambiente seletiva esta em constante mudança

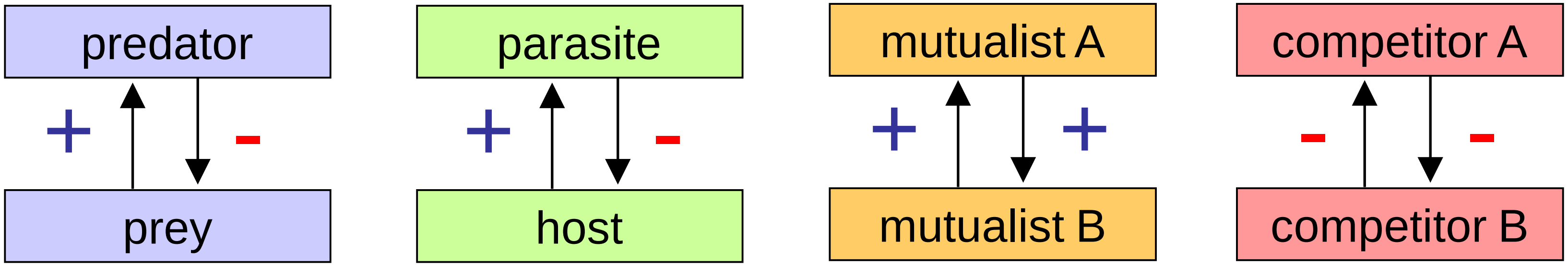
Quando ocorre?

Pressão seletiva maior quando ha uma relação ecológica forte

“relação ecológica forte = geralmente especialistas em vez de generalistas

relações ecológicas que levam a coevolução:

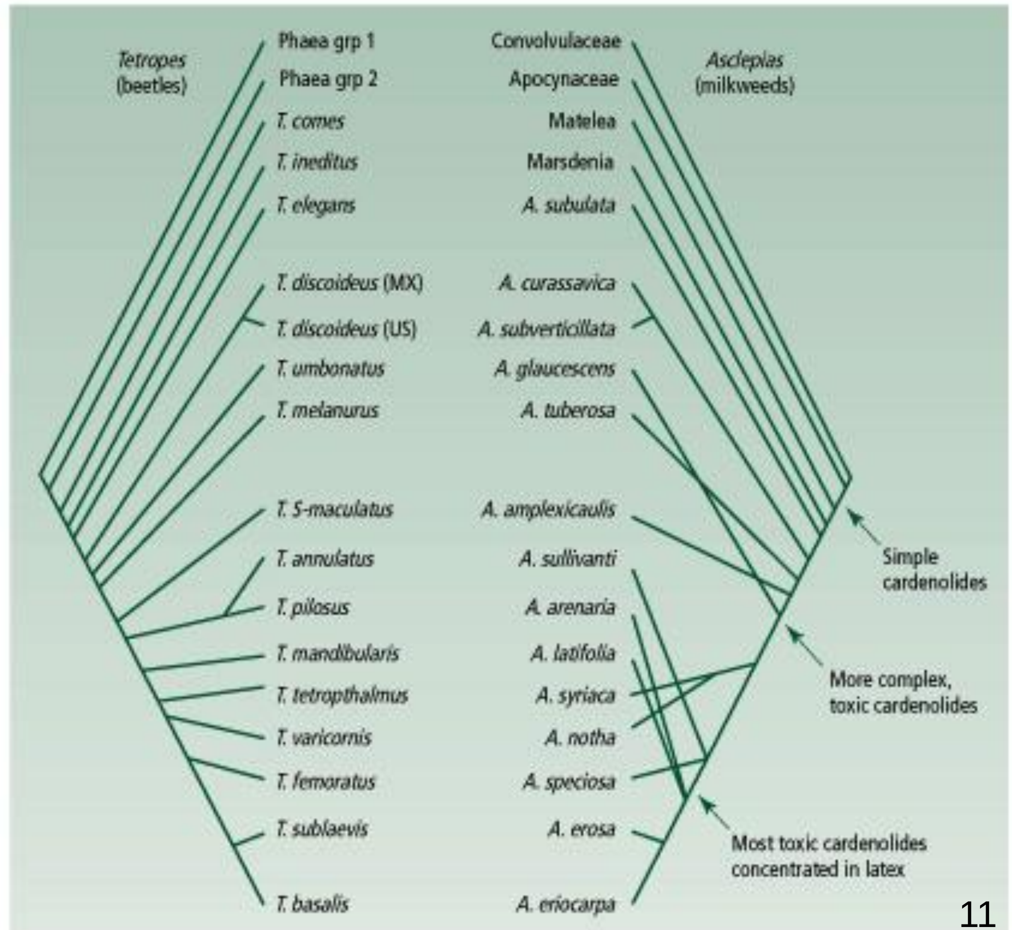
1) predators & prey 2) parasites & hosts 3) mutualists 4) competitors



Plant-insect coevolution

Cospeciation in a plant-herbivore system

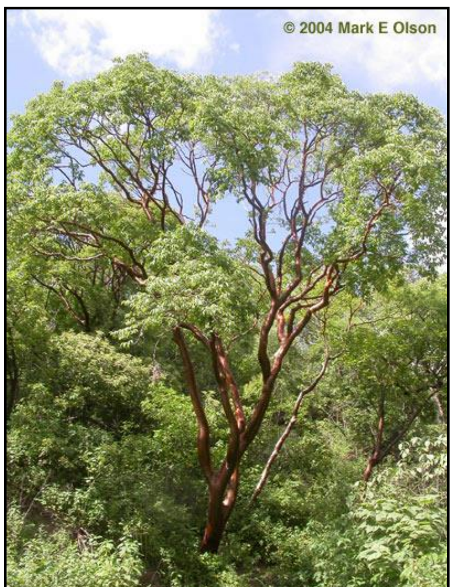
Tetraopes beetles eat milkweed plants in the genus *Asclepias* ➔ **cospeciation**



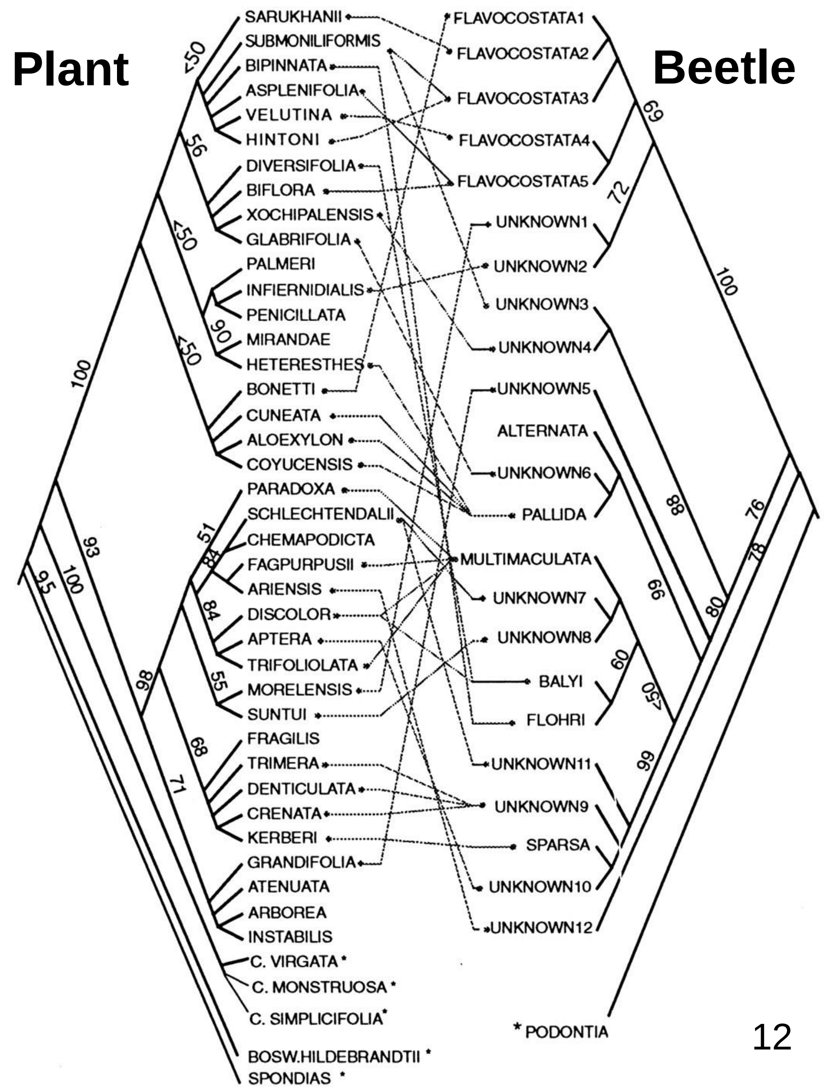
Plant-insect coevolution

Cospeciation in another plant-herbivore system

Blepharida beetles eat *Bursera* plants



Becerra (1997) *Science*



Plant-insect coevolution

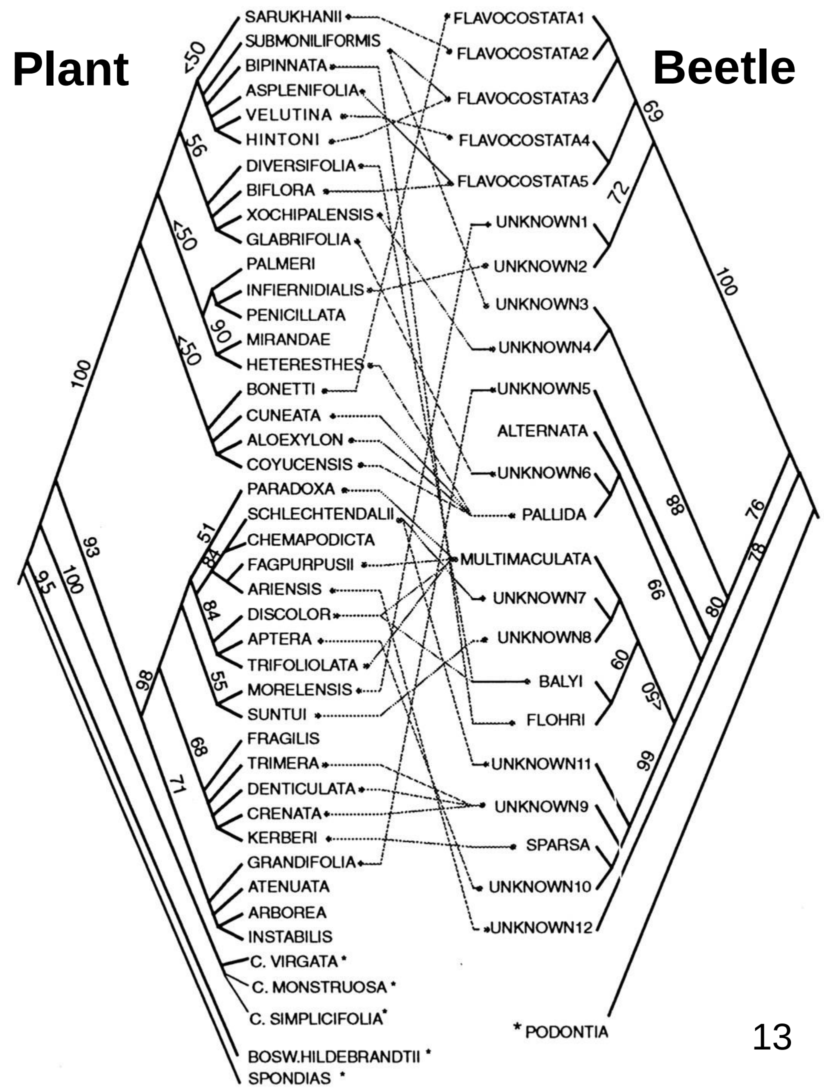
Cospeciation in another plant-herbivore system

Blepharida beetles eat *Bursera* plants

There is a high degree of host-specificity

Then why so much host-jumping?

Why not cospeciation like in *Tetraoptes* beetles and milkweed plants?



Becerra (1997) *Science*

Plant-insect coevolution

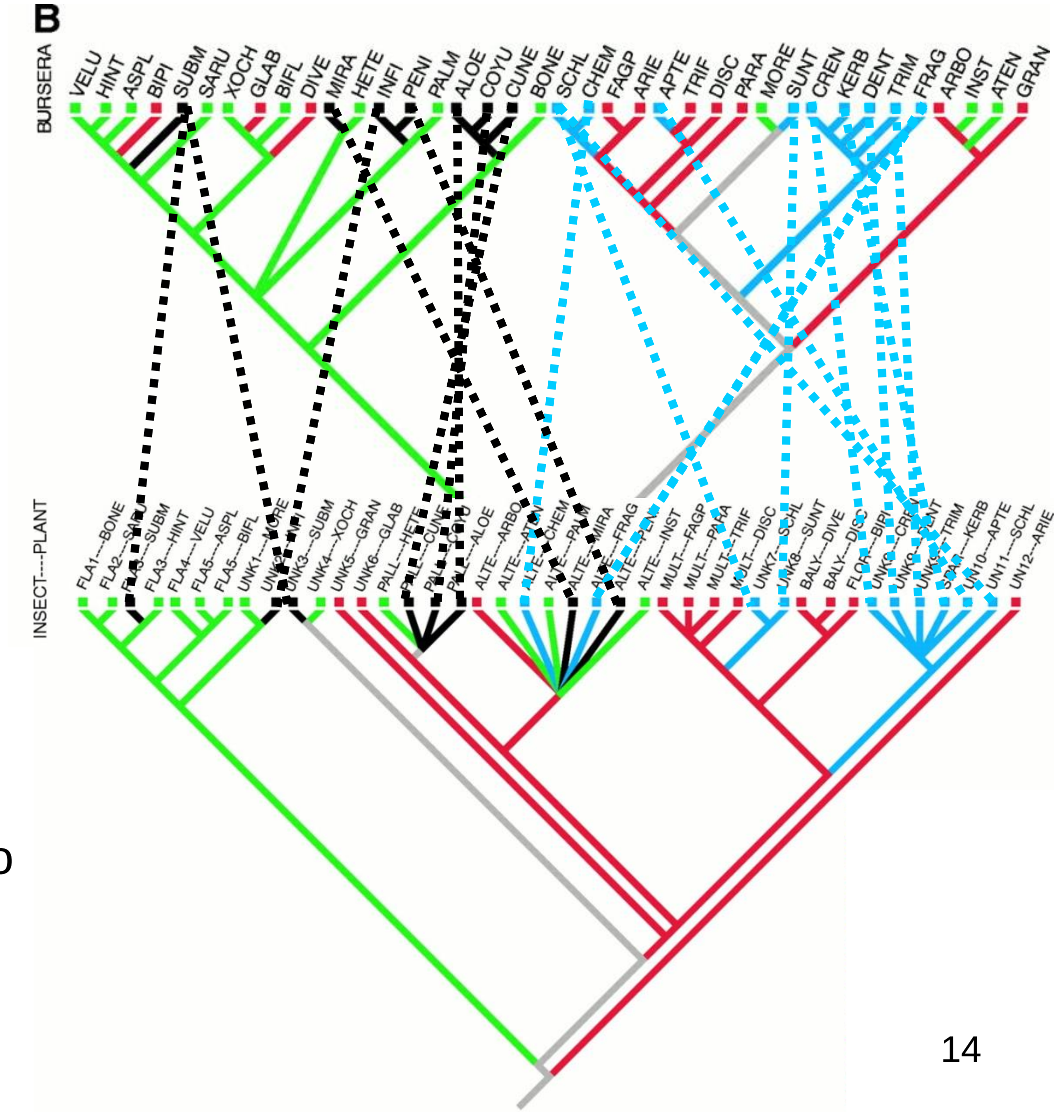
Host specificity is determined by the chemical defenses of the plant

Four major chemical classes of plant defenses against herbivory (indicated by colors)

These chemical classes do not correspond to plant clades (top)

The bottom figure shows beetle phylogeny with branches coded for the chemical type of the host

The phylogenies are incongruent because host switching can occur as long as the beetle switches to a new host with chemical defenses to which it is already adapted



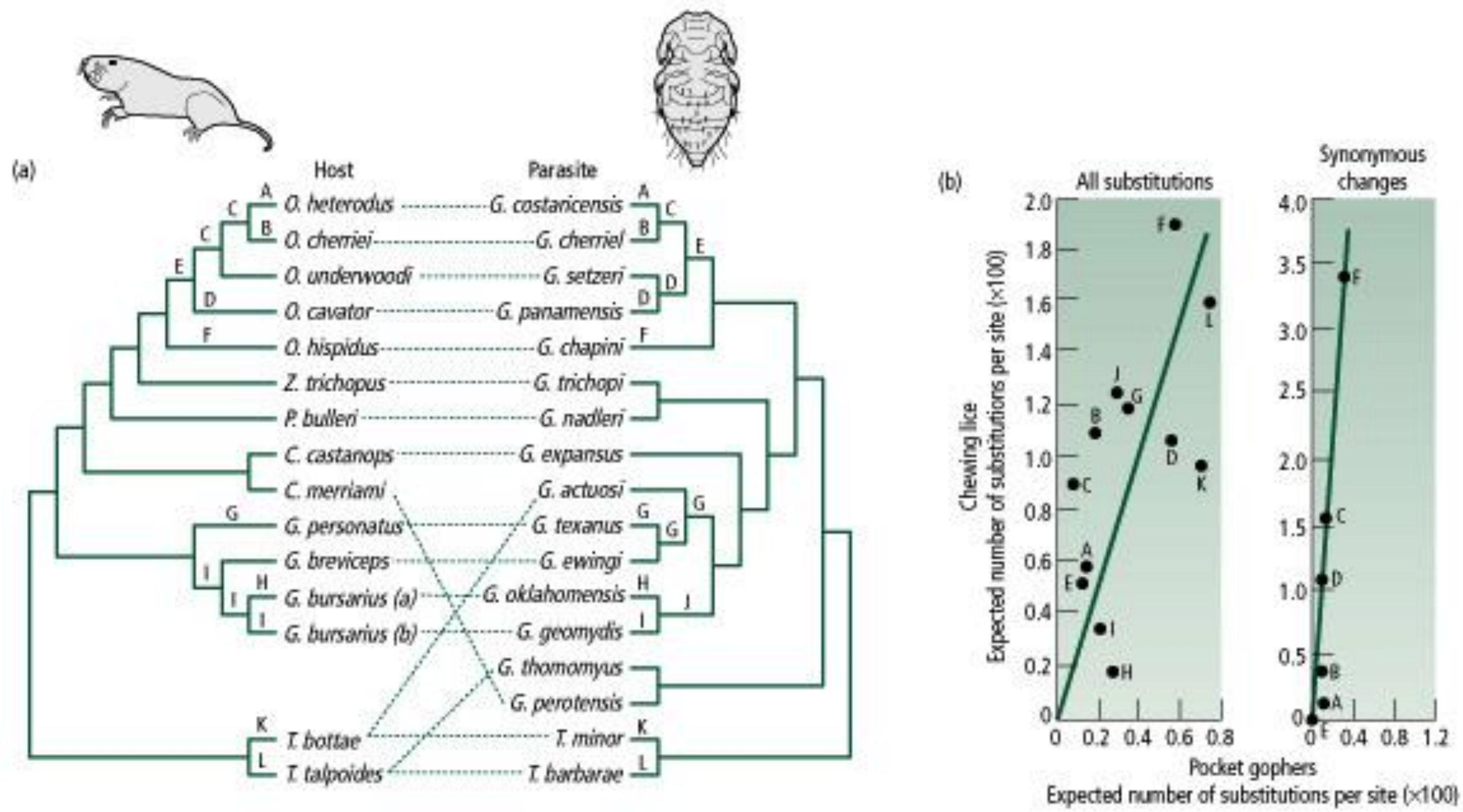
Becerra (1997) *Science*

Host-parasite coevolution

Coevolution – Thus far we have seen examples from mutualism interactions

Pocket gophers (Geomyidae) are are parasitized by lice (Mallophaga)

Clear pattern of cospeciation – this example also shows how rates of evolution can be compared (b) to provide further evidence for coevolution (letters in b = branches in a)



Coevolutionary arms races

“Arms race”

Coevolving species have to constantly “improve” to meet each new adaptation with a “better” adaptation of their own

Escalation

Coadaptations become increasingly powerful, yet species are not any better adapted because the selective landscape is constantly changing

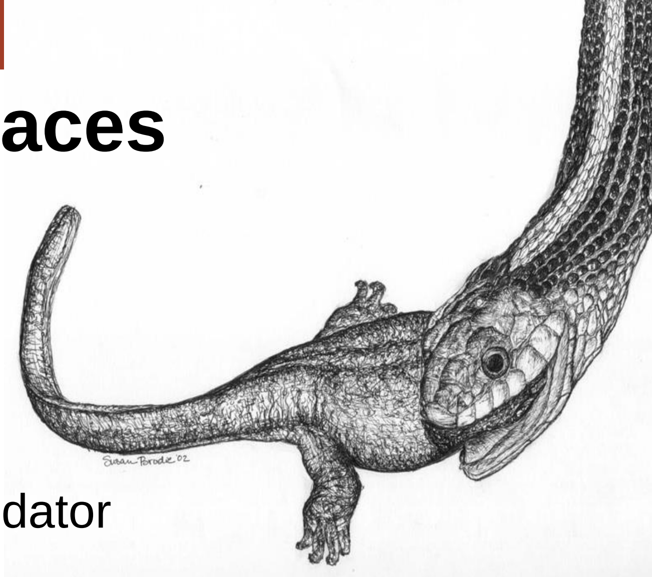
This may sound familiar: it is Van Valen’s **Red Queen Hypothesis:**
- running as fast as possible just to stay in the same place

An inherent feature of coevolution

We often think of “arms races” as occurring between predators and prey, or between parasites and hosts – this makes intuitive sense

But it is not really that different in mutualists – each mutualist will be best adapted when it receives the maximum benefit while paying the minimal cost

Coevolutionary arms races



An arms race in a predator-prey interaction

Taricha granulosa newts have powerful tetrodotoxins (TTX) that are secreted as protection from predators

Thamnophis sirtalis garter snakes are the only major predator of this newt – they have evolved resistance to TTX

Escalation

Toxins produced by newts are hundreds of times more powerful that necessary to kill any other predator (including humans), but snakes are resistant

Can we find evidence for coevolution?

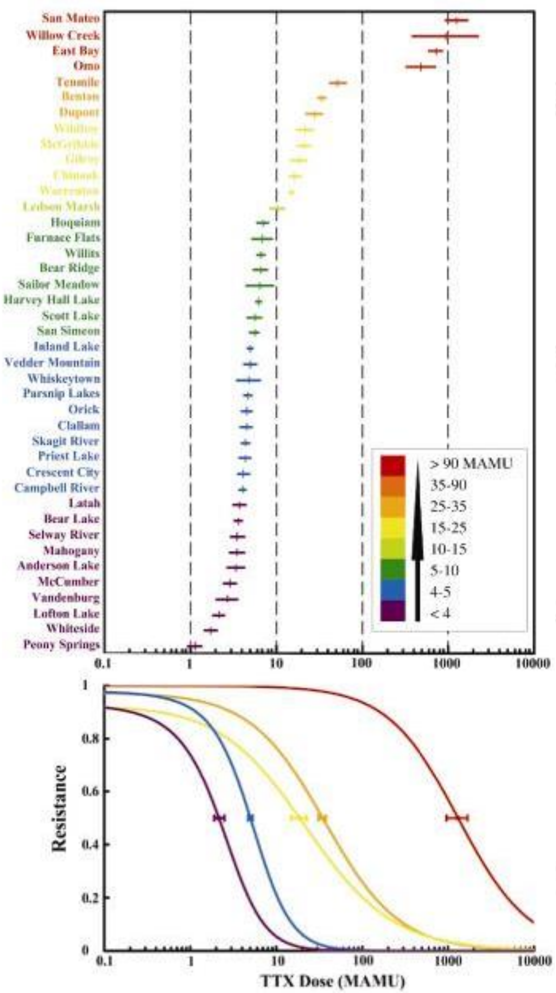
Brodie et al. (2002) Evolution 56:2067-2082

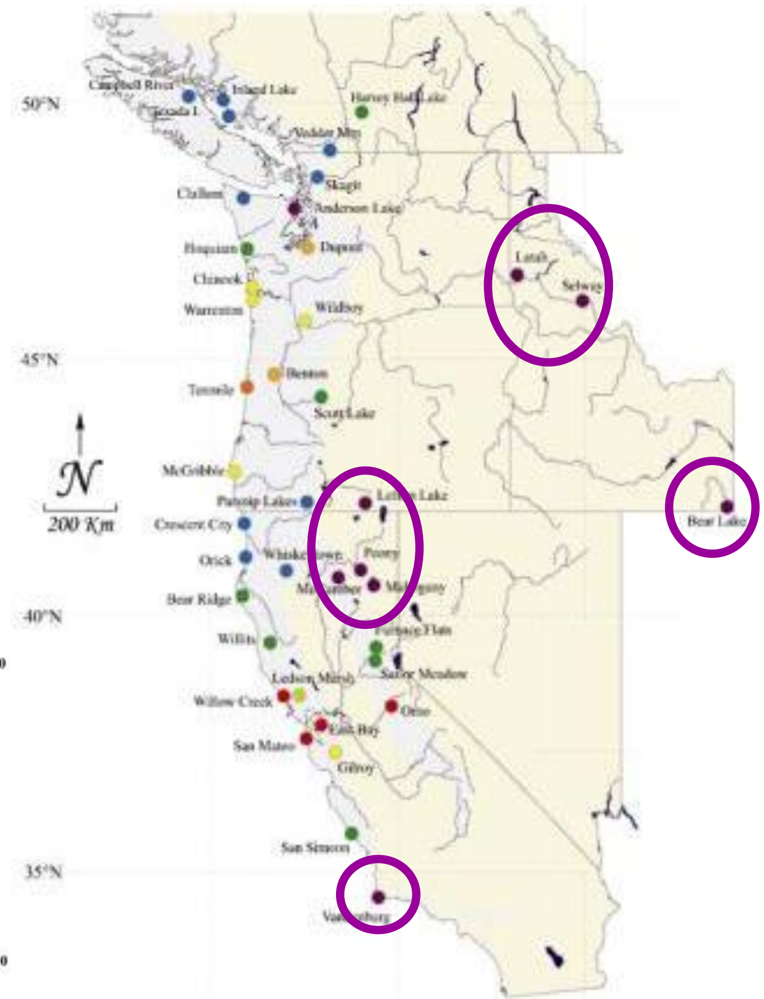
Coevolutionary arms races

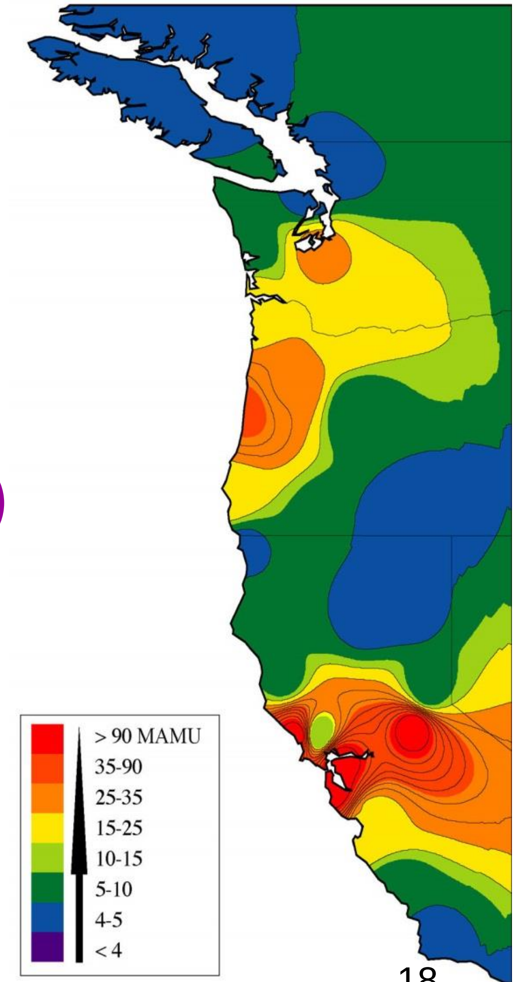
Snake populations vary in resistance to newt toxins

Snake populations outside of newt's range have low resistance

A geographic mosaic with two coevolutionary "hotspots"





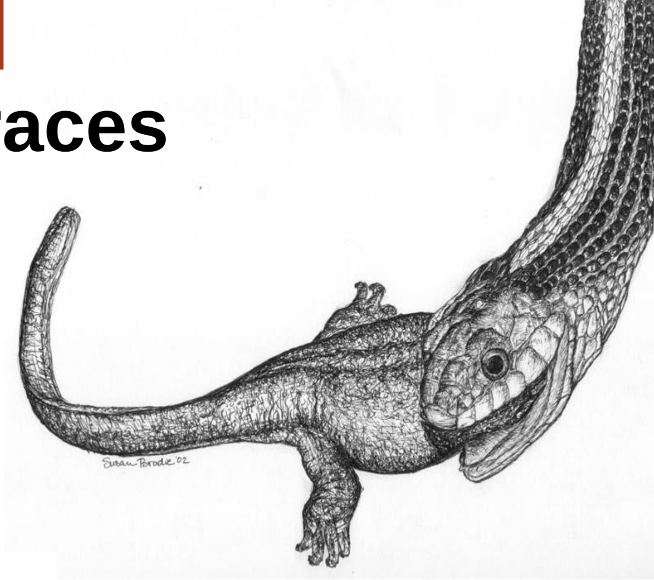


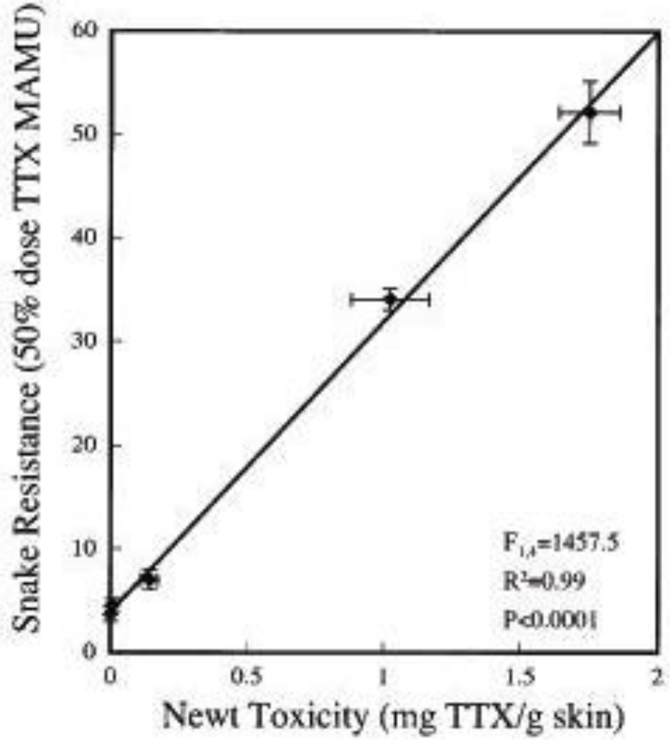
Brodie et al. (2002) Evolution 56:2067-2082

Coevolutionary arms races

An arms race in a predator-prey interaction

The extremely high toxicity of *Taricha granulosa,* which is hundreds of times more toxic than necessary for most predators, is a result of an escalating arms race with one species, *Thamnophis sirtalis*





Snake resistance is predicted by newt toxicity, as expected if these species are coevolving

Brodie et al. (2002) Evolution 56:2067-2082

Evidence for coevolution

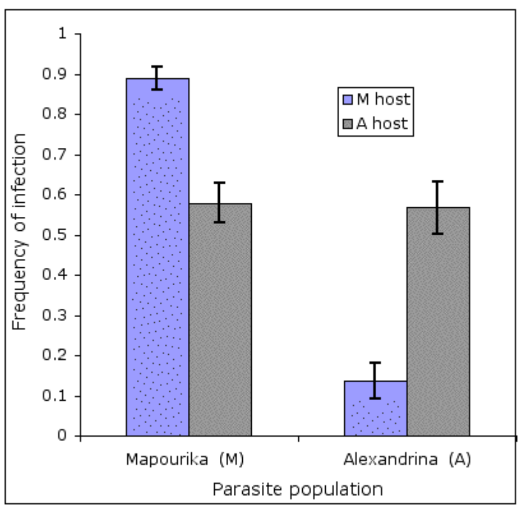
Local coadaptation

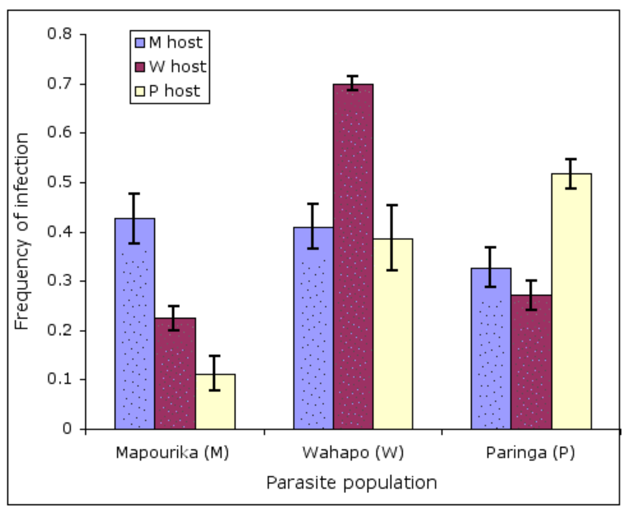
Snakes and newts are locally coadapted:

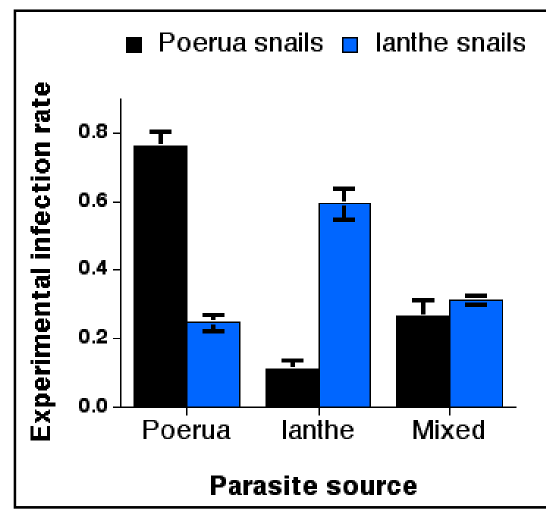
- snakes have not evolved resistance in populations outside of the newt's range
- populations with high newt toxicity have high snake resistance

Snails and their castrating trematode parasites

In three separate studies, parasites were better able to infect snails from their own population than hosts from other populations – parasites are locally coadapted







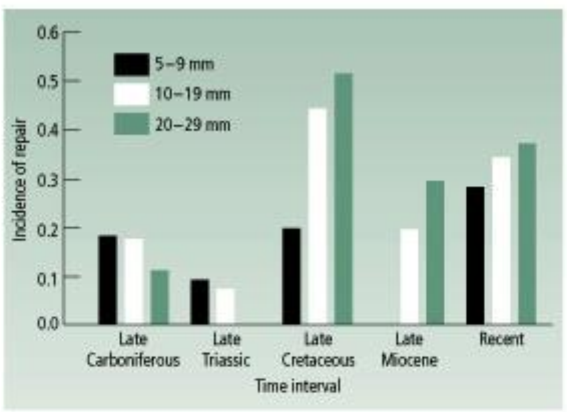
Curt Lively's research: http://www.indiana.edu/~curtweb/Research/local_adaptation.html

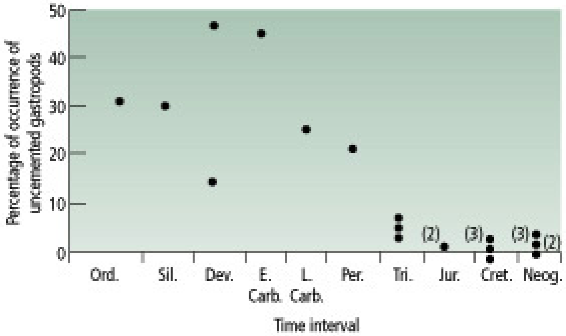
Inferring an arms race from fossils

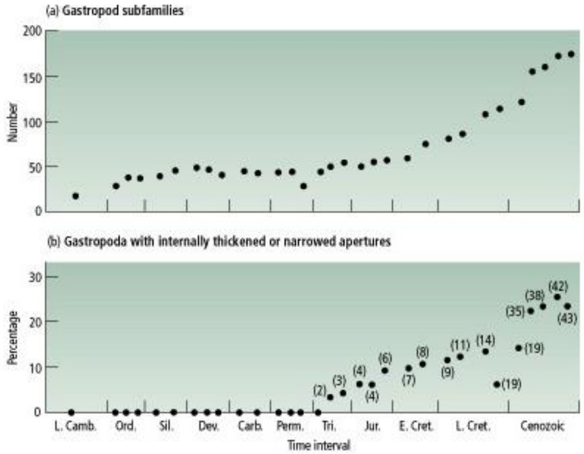
Shells of fossil gastropods

Difficult to infer coadaptation from fossils because we can't <u>observe</u> interactions

But we can use characteristics that reflect predator-prey interactions







When a shell is repaired following a failed predation attempt, it leaves a clear pattern evident in fossils

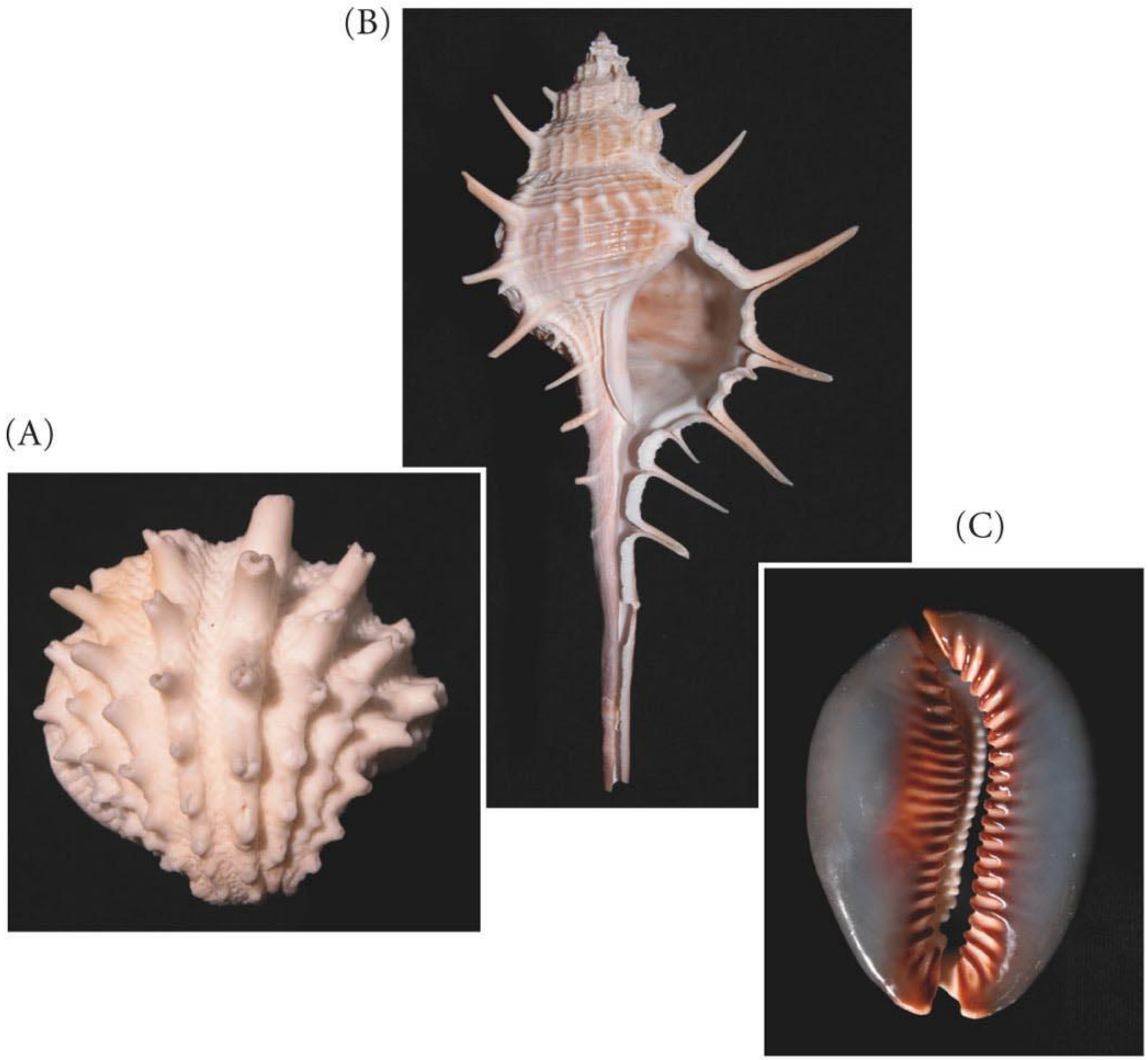
The incidence of shell repair increases through time, suggesting <u>predation is becoming more intense</u>

Gastropods "cement" themselves to the substrate as an adaptation against predators

The incidence of mobile gastropods that lack a means of attachment decreases over time

Gastropods with thickened or narrowed apertures are better able to survive predation events

The incidence of thickened or narrowed apertures increases over time



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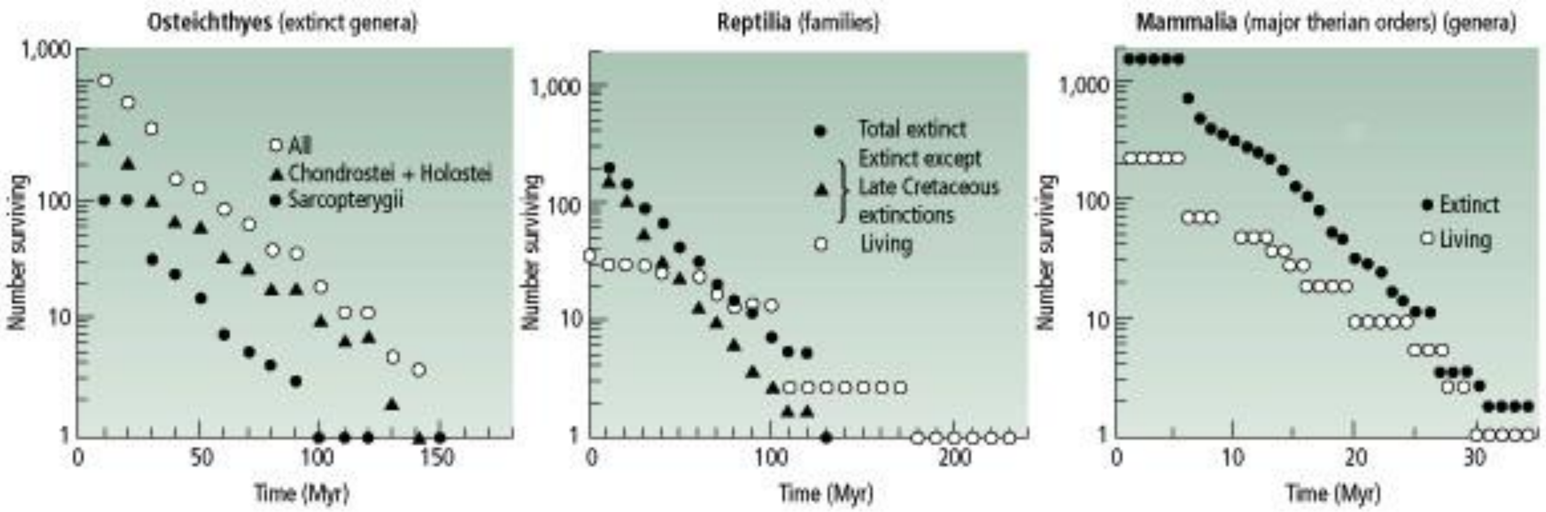
Fossils and the Red Queen

Probability of extinction

The fossil record also supports another important theoretical point:

Probability of extinction is constant through the course of evolution



Why is this important?

It shows that evolution is not progressive – taxa that have been around longer have not become "better adapted" and thus better able to avoid extinction

Supports the Red Queen model and implicates coevolution as a major force:
Organisms have to keep running (evolving) just to stay in place (avoid extinction)

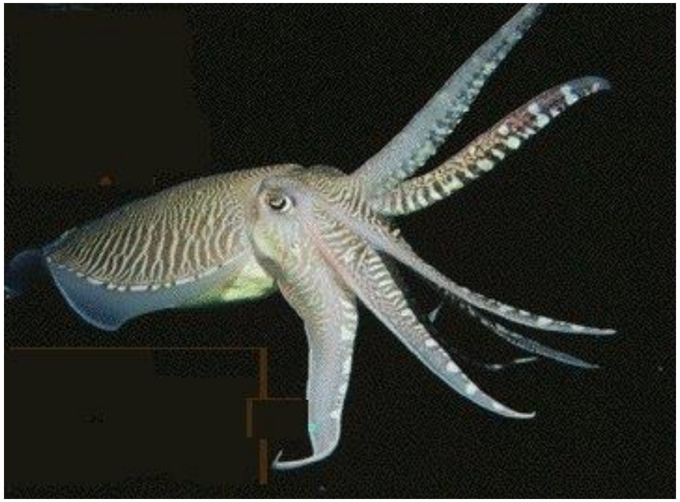
Coevolution: A Langohrfledermaus Bat Hunting a Moth

© Brooks/Cole, Cengage Learning

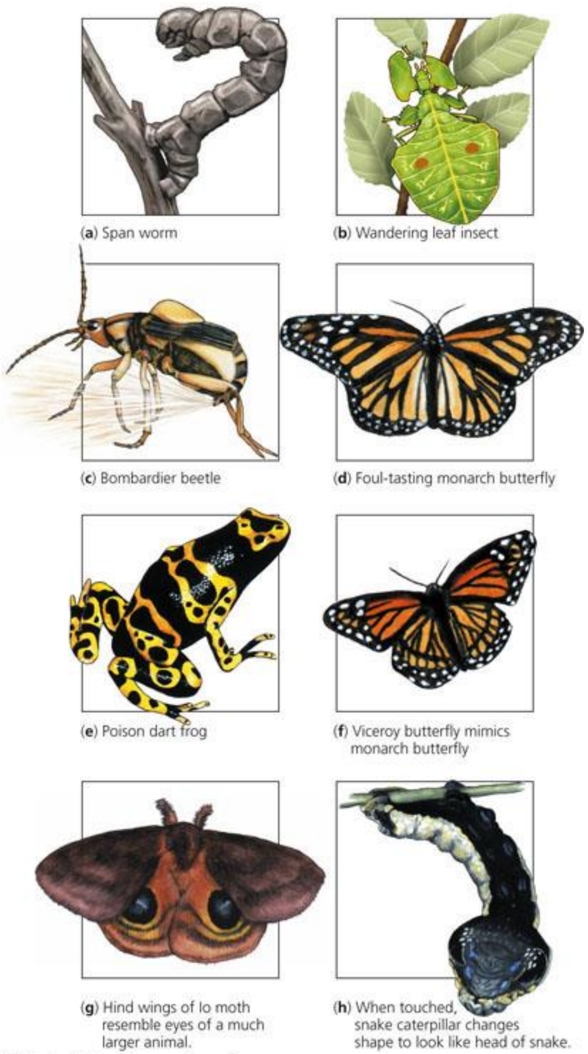
- Interspecific Competition
- Predation
- Parasitism
- Mutualism
- Commensalism

- Predation – act of one organism eating another organism
  - **Predator** – organism that does the eating
  - **Prey** – organism that gets eaten

- **Predators** may capture prey by:
  - Walking
  - Swimming
  - Flying
  - Pursuit and ambush
  - Camouflage
  - Chemical warfare



- **Prey** may avoid capture by
  - Camouflage
  - Chemical warfare
  - Warning coloration
  - Mimicry
  - Deceptive looks
  - Deceptive behavior



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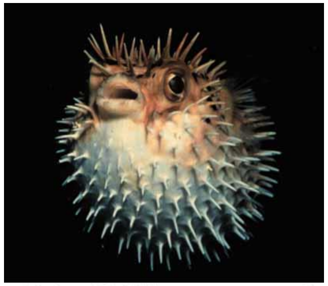
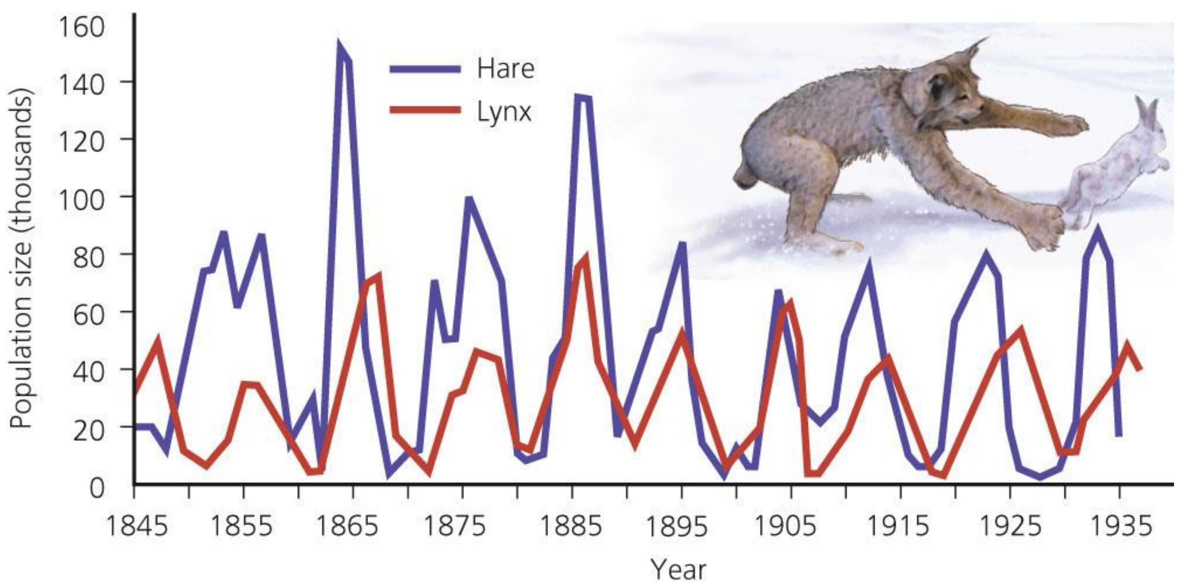
- If an organism is small and beautiful… it is probably poisonous.



Bridled Burrfish (Chilomycterus antennatus)

- If it is strikingly beautiful and easy to catch…it is probably deadly.

- **Cyclic fluctuations, boom-and-bust cycles**
  - Top-down population regulation
    - Controlled by predation
  - Bottom-up population regulation
    - Controlled by scarcity of one or more resources



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Mutualism: Oxpeckers Clean Rhinoceros; Anemones Protect and Feed Clownfish

(a) Oxpeckers and black rhinoceros

(b) Clownfish and sea anemone

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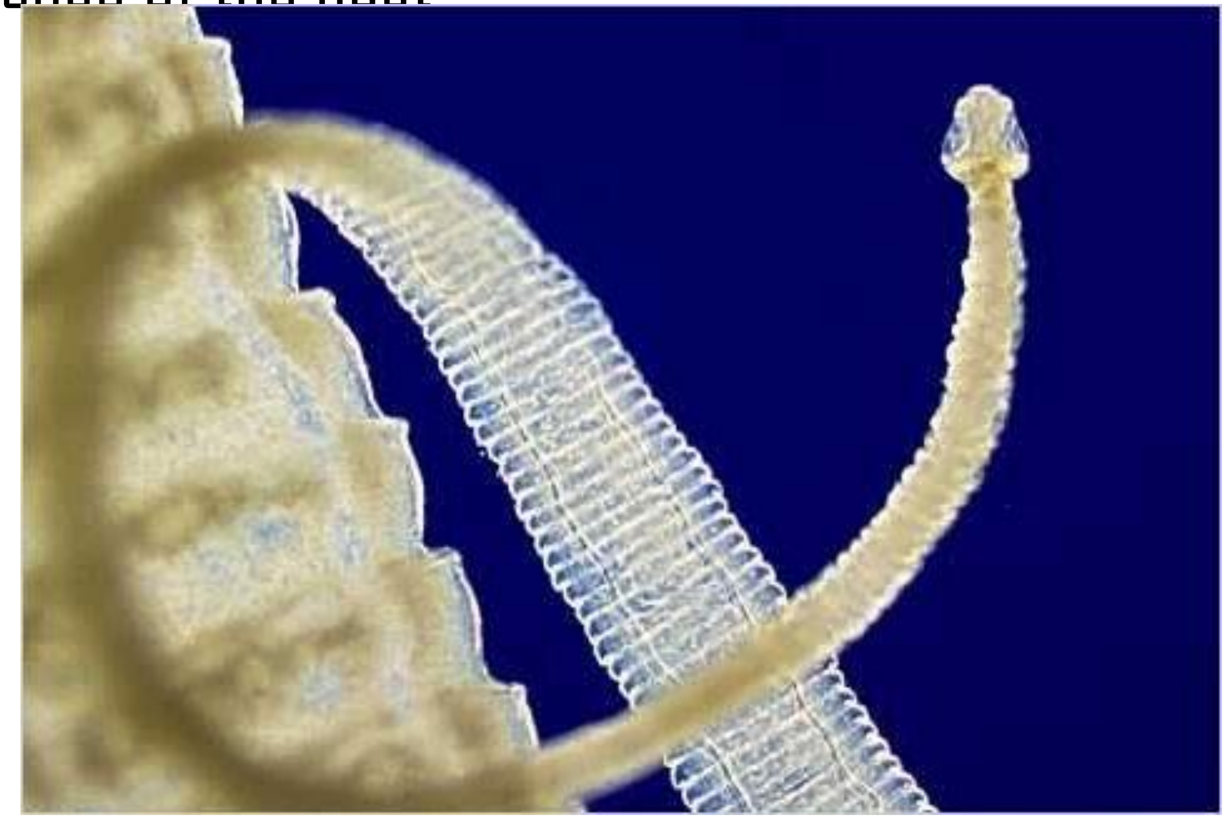
Parasitism: Tapeworm and Humans

- Parasite lives on or in the host and benefits at the expense of the host



Parasitism: Tree with Parasitic Mistletoe, Trout with Blood-Sucking Sea Lampreys

© Brooks/Cole, Cengage Learning

© Brooks/Cole, Cengage Learning

Commensalism: Flatworms and horseshoe crabs

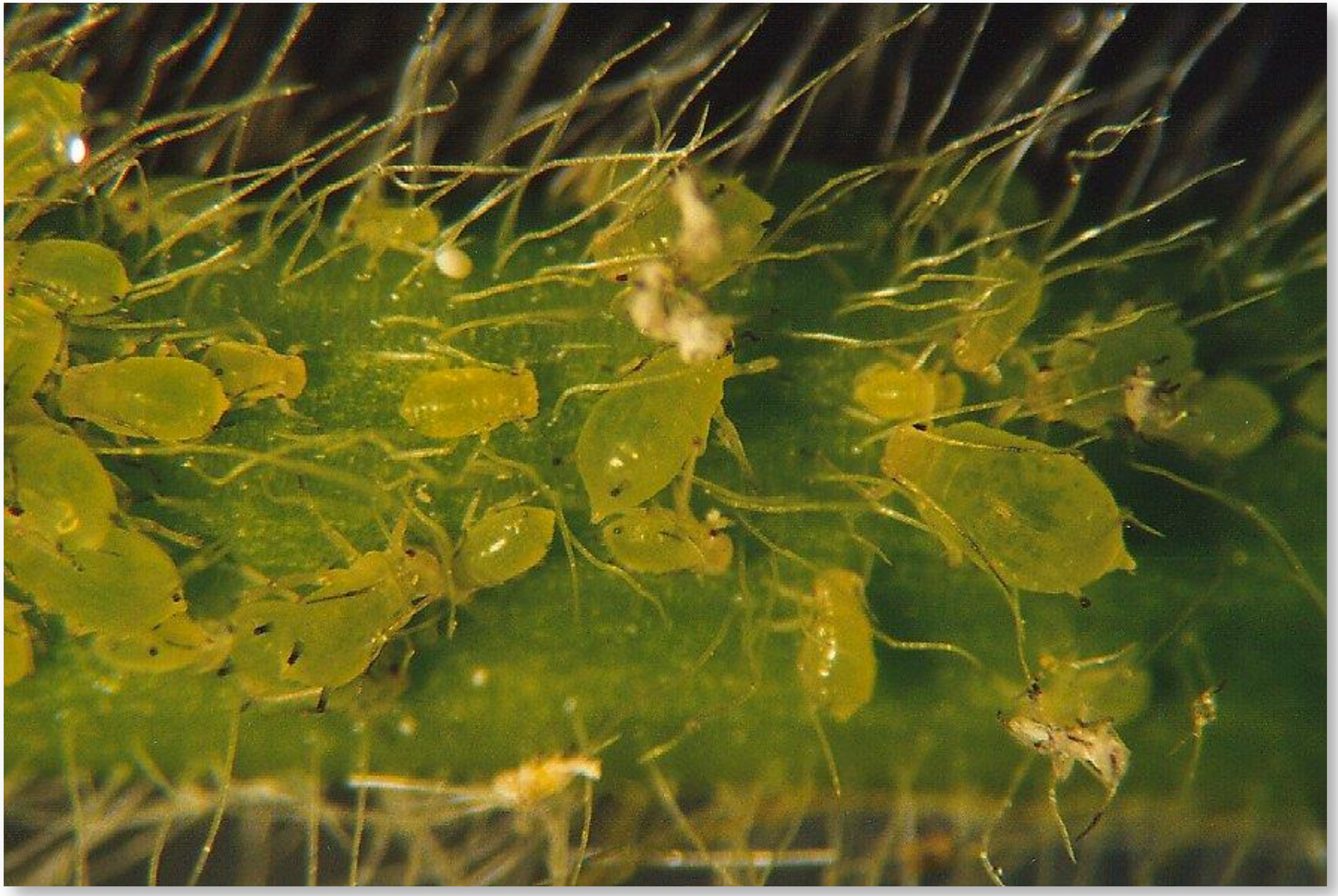
- Only one member benefits
  - sharing space, defense, shelter, food
- Flatworms that live on the gills of horseshoe crabs obtain food from the host, but do not negatively affect the host

Commensalism: Bromiliad Roots on Tree Trunk Without Harming Tree

© Brooks/Cole, Cengage Learning

Case Study: Expl ... U.S.

- 1900: deer habitat destruction and uncontrolled hunting
- 1920s–1930s: laws to protect the deer
- Current population explosion for deer
  - Lyme disease
  - Deer-vehicle accidents
  - Eating garden plants and shrubs
- Ways to control the deer population

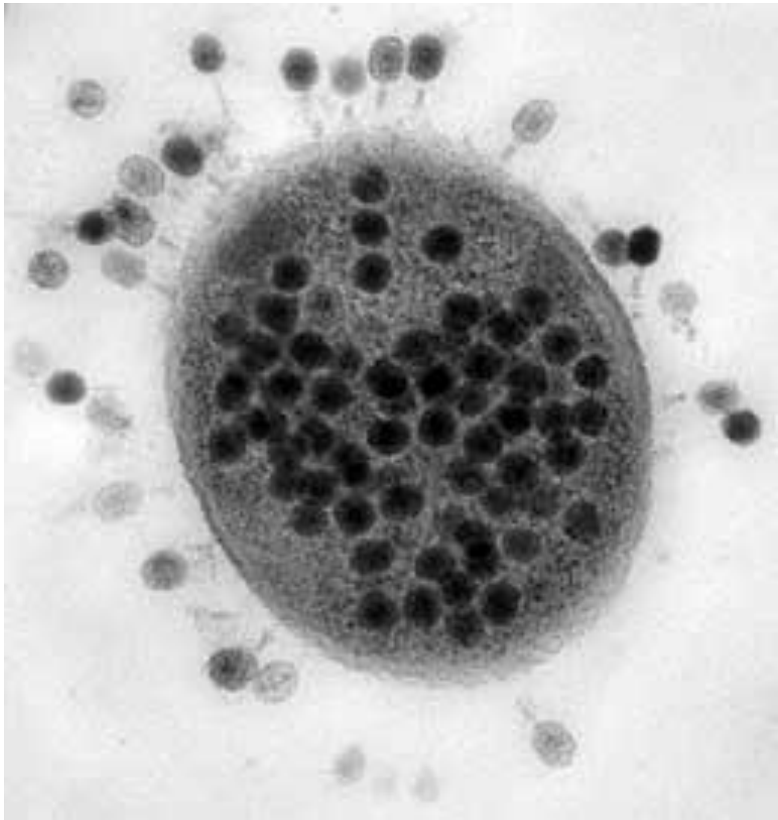


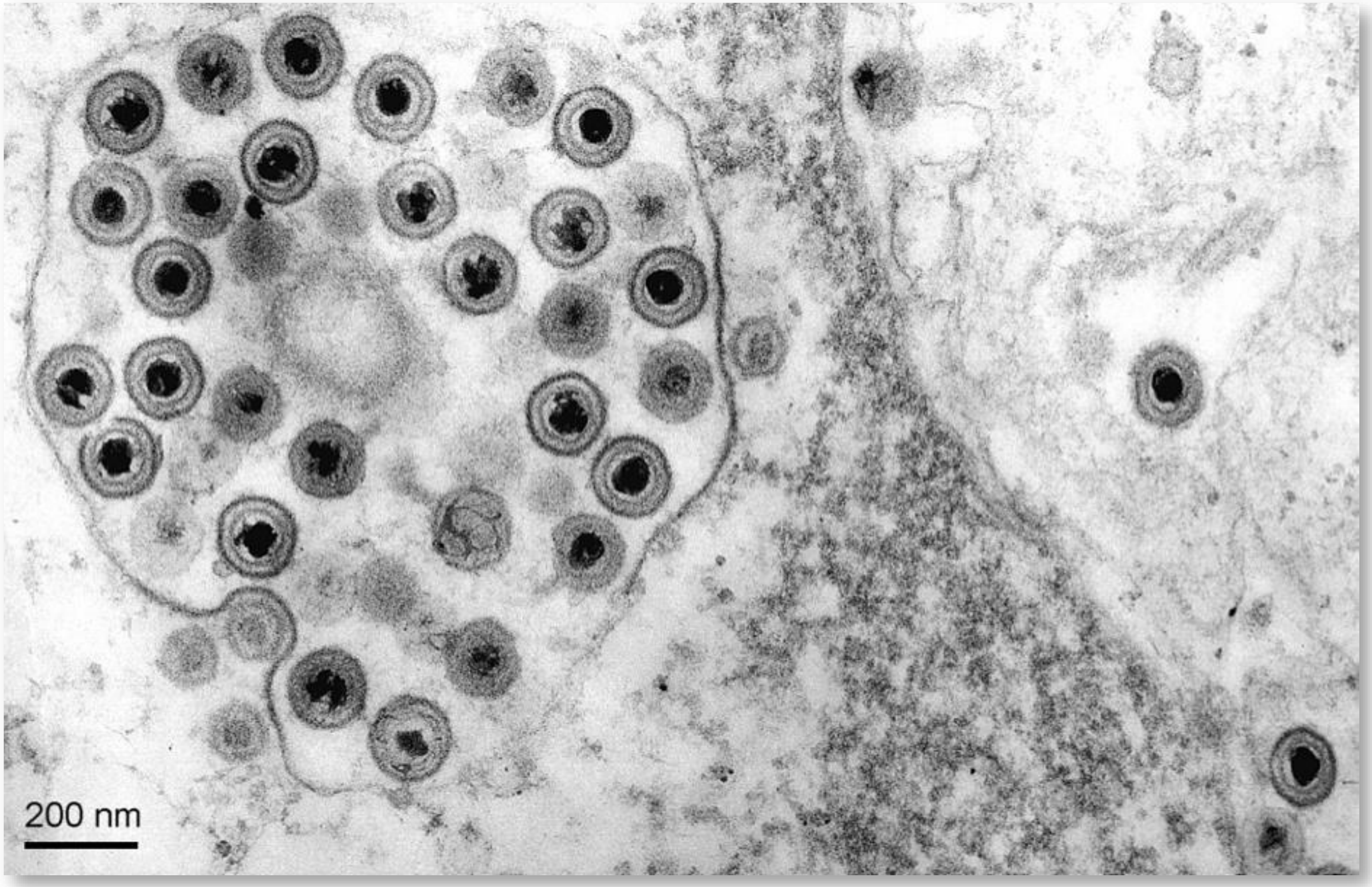
parasitic wasps typically lay eggs into larvae of other species (here flour moth) which the parasitic larvae then gradually consume from inside

Not all animals that live in close association with a host are parasites...

eyelash mite – commensal
(lives with about 1/3 of humans)

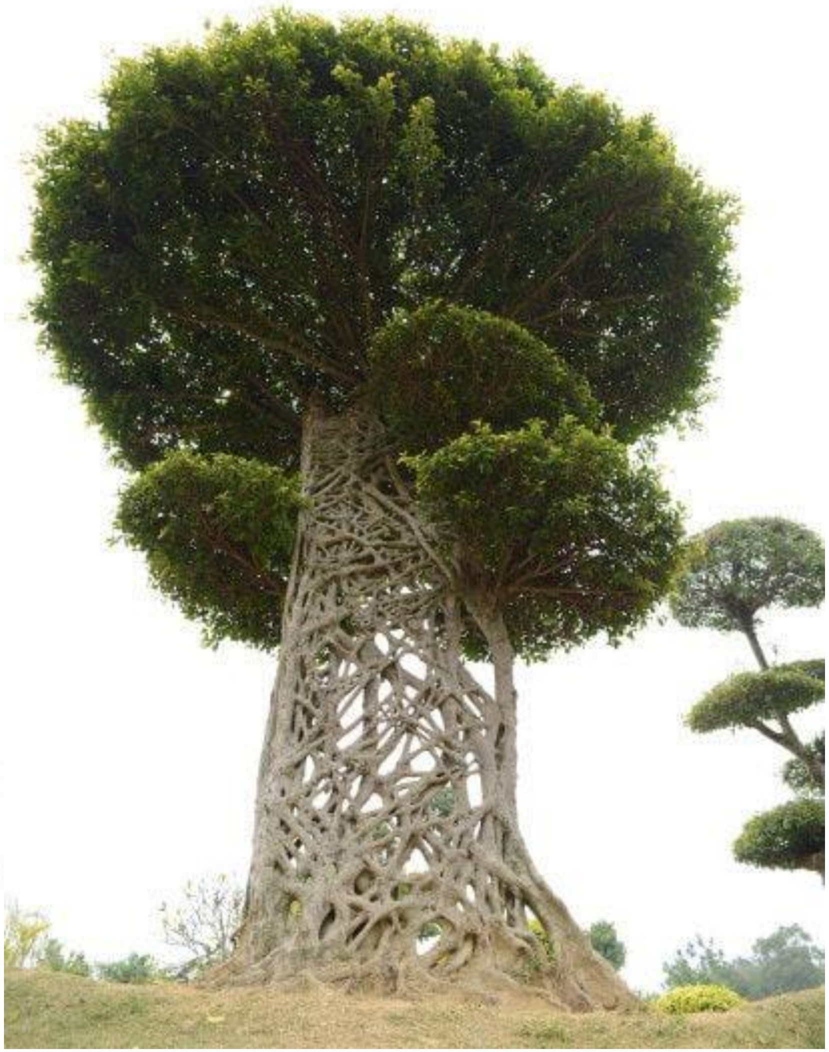
Even bacteria have "parasites"



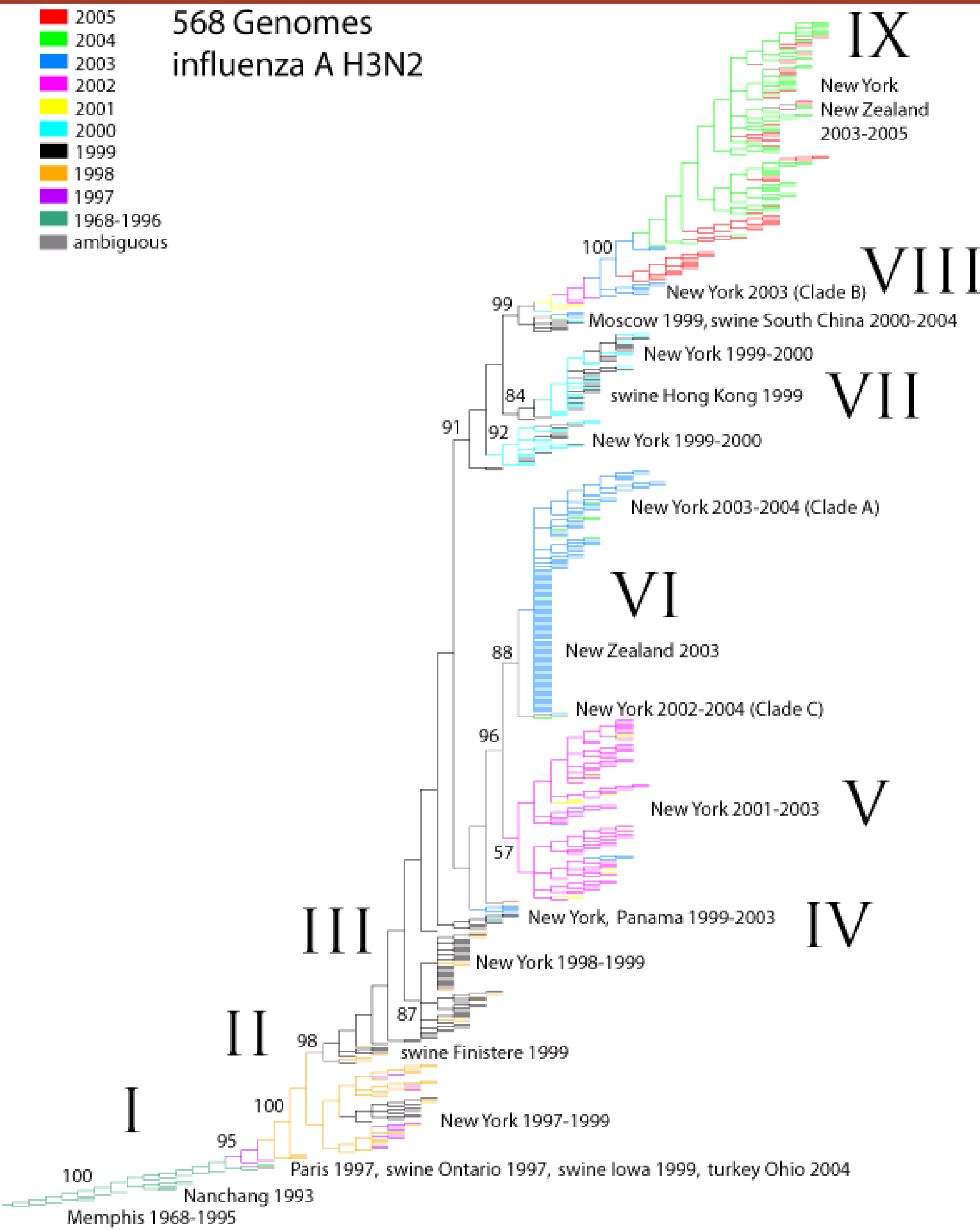


Herpes simplex virus

Plants can parasitise other plants



- Influenza virus:
- Immunity is determined by two antigens, HA and NA.
- “Antigenic drift” leads to new strains with different HA or NA antigens, that are able to infect people who are resistant to other strains
- This is why we see periodic epidemics of influenza when new strains emerge and are strongly selected for.



- This is a phylogeny of influenza A virus over an extended period
- Note that there is continual replacement of one strain by another, and that old strains go extinct

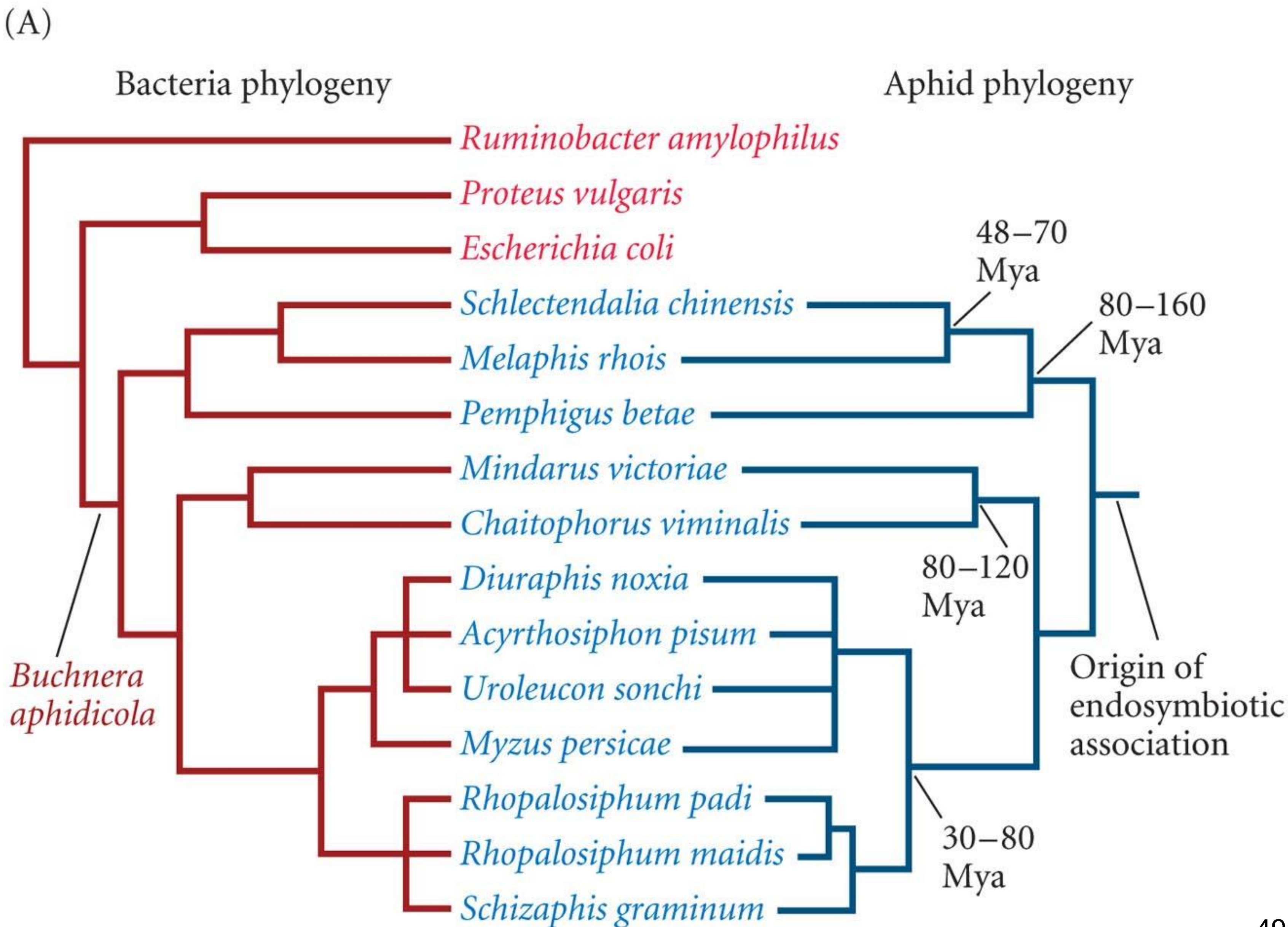
- In the same way that parasites are constantly evolving to overcome host defences,
- Host organisms will be constantly evolving to resist parasitic infection
- This will lead to *Frequency dependent selection*, locking hosts and parasites into endless coevolutionary cycles
- This is what is often called the "Red Queen Effect"

"Now here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that"

from *Through the Looking Glass,* by Lewis Carroll

- The evolution of sexual reproduction is a big puzzle in biology
- One possibility is that sexual reproduction benefits an organism by increasing the variability of the organism's offspring
- This only gives a big fitness advantage when the environment changes very rapidly
- One aspect of the environment that does change fast enough is the parasites that

- Very hard to test experimentally
- One noteworthy study by Curtis Lively and coworkers
- *Potomopyrgus antipodiarum -* freshwater snail with both sexually and asexually reproducing individuals
- The proportion of asexually reproducing individuals is related to the amount of parasitism a population experiences
- More parasitism leads to more sexually reproducing snails



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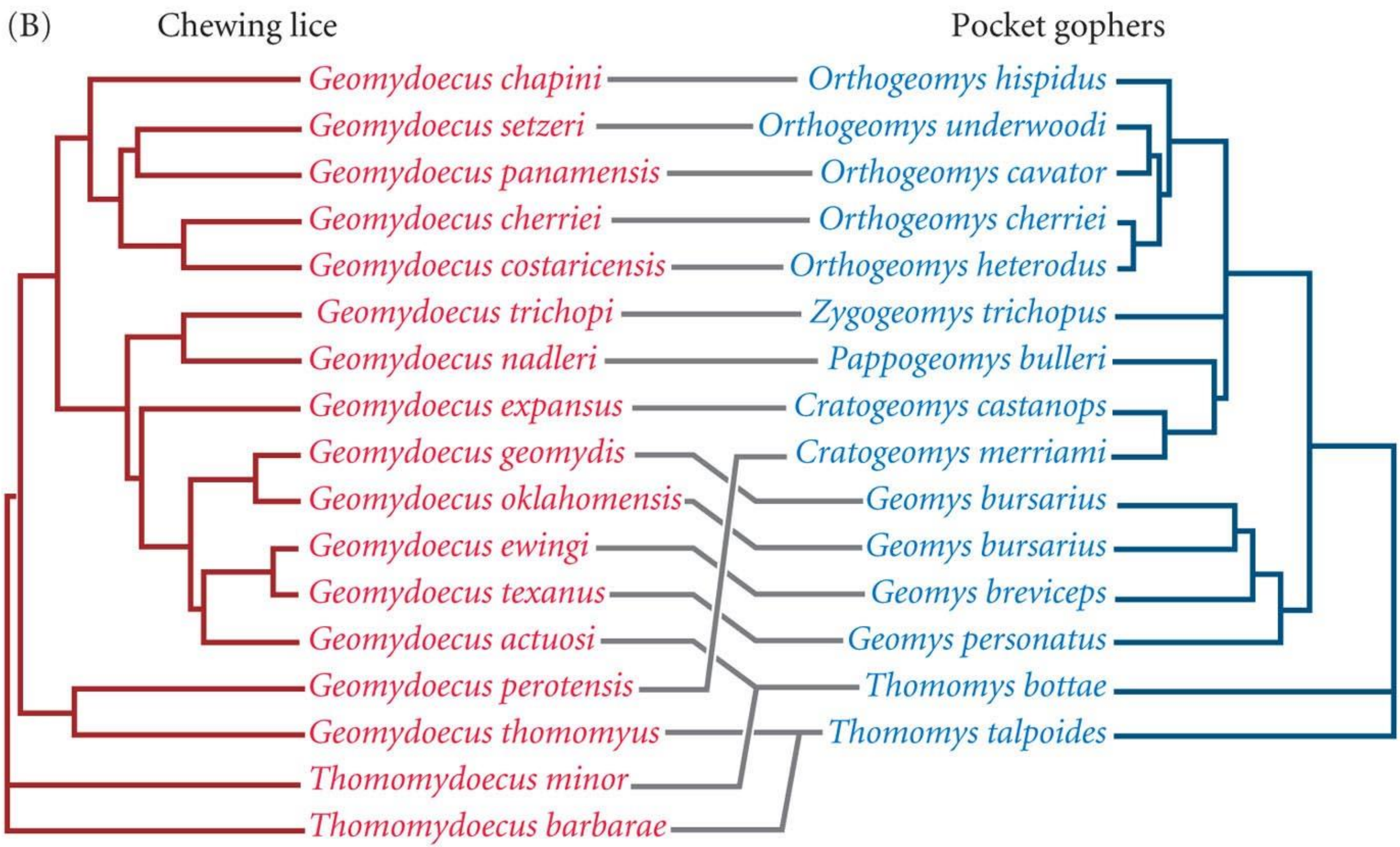

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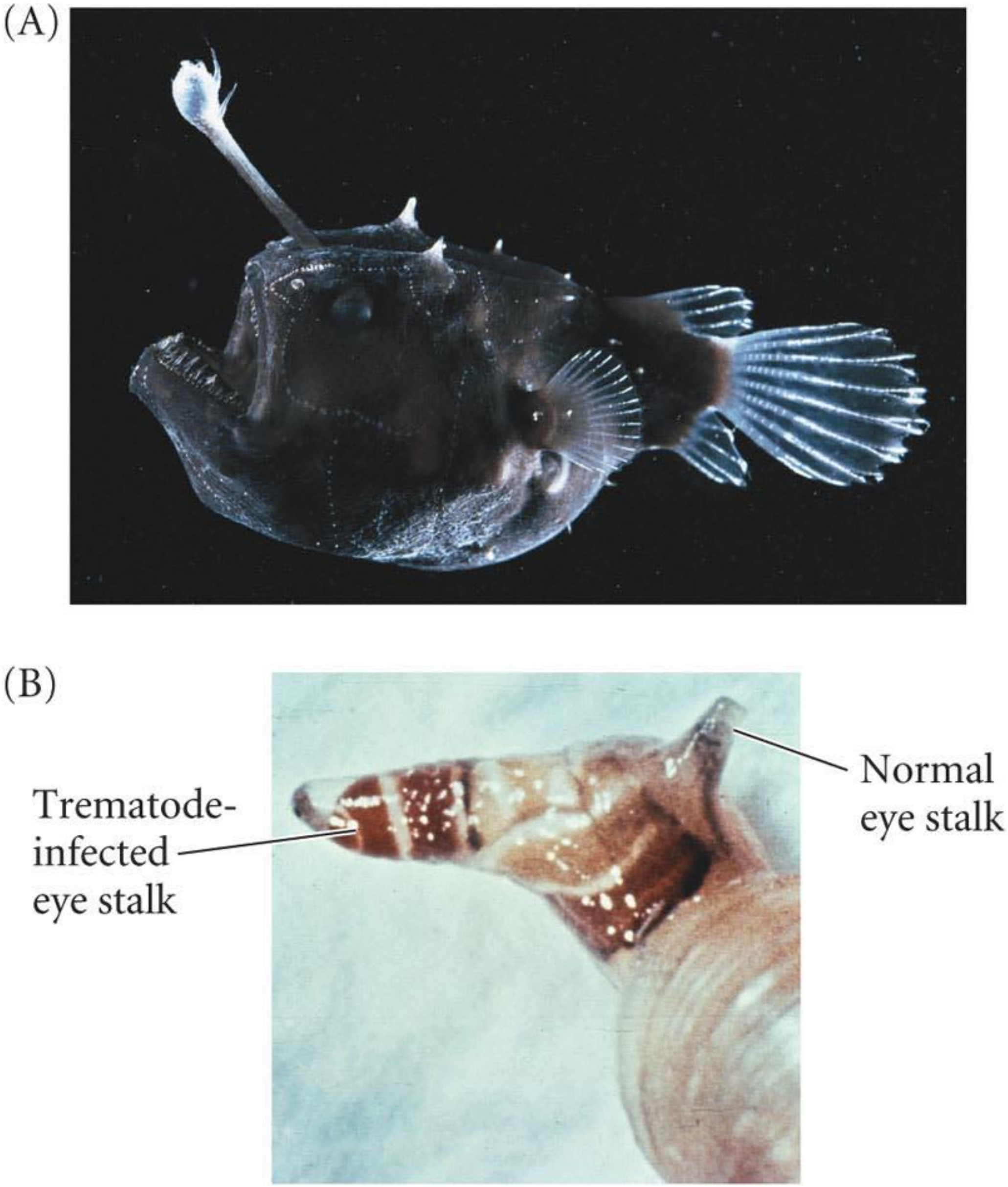

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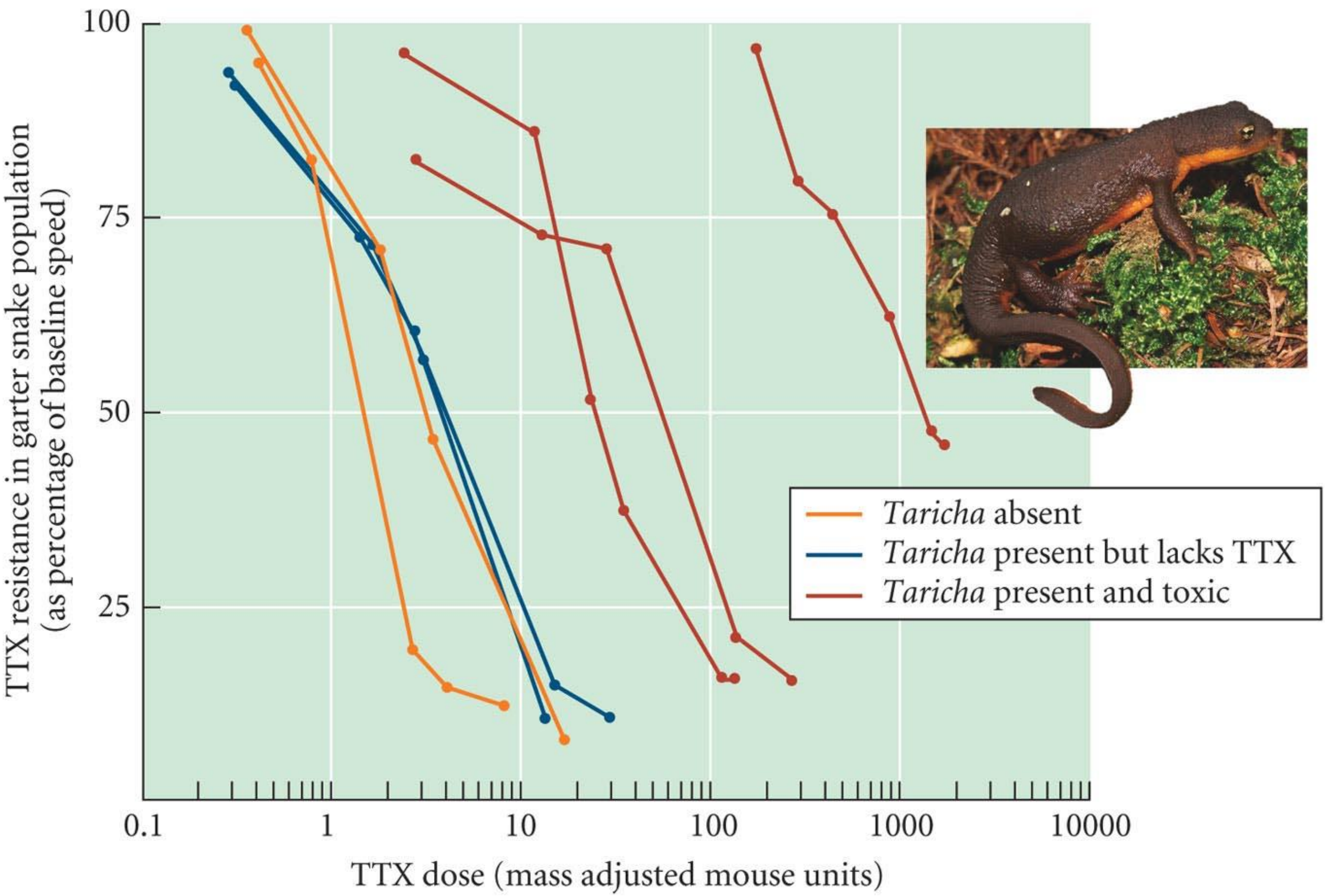
(A)

(B)

EVOLUTION, **Figure 18.5** © 2005 Sinauer Associates, Inc.



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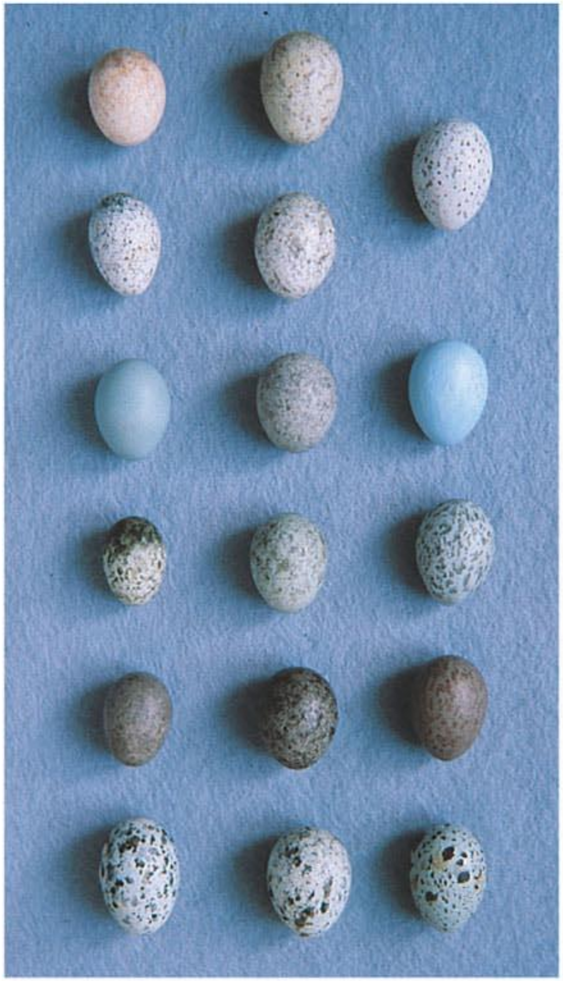
18.11 (A) A fledgling European cuckoo being fed by its foster parent, (B) Mimetic egg polymorphism

(A)

(B)



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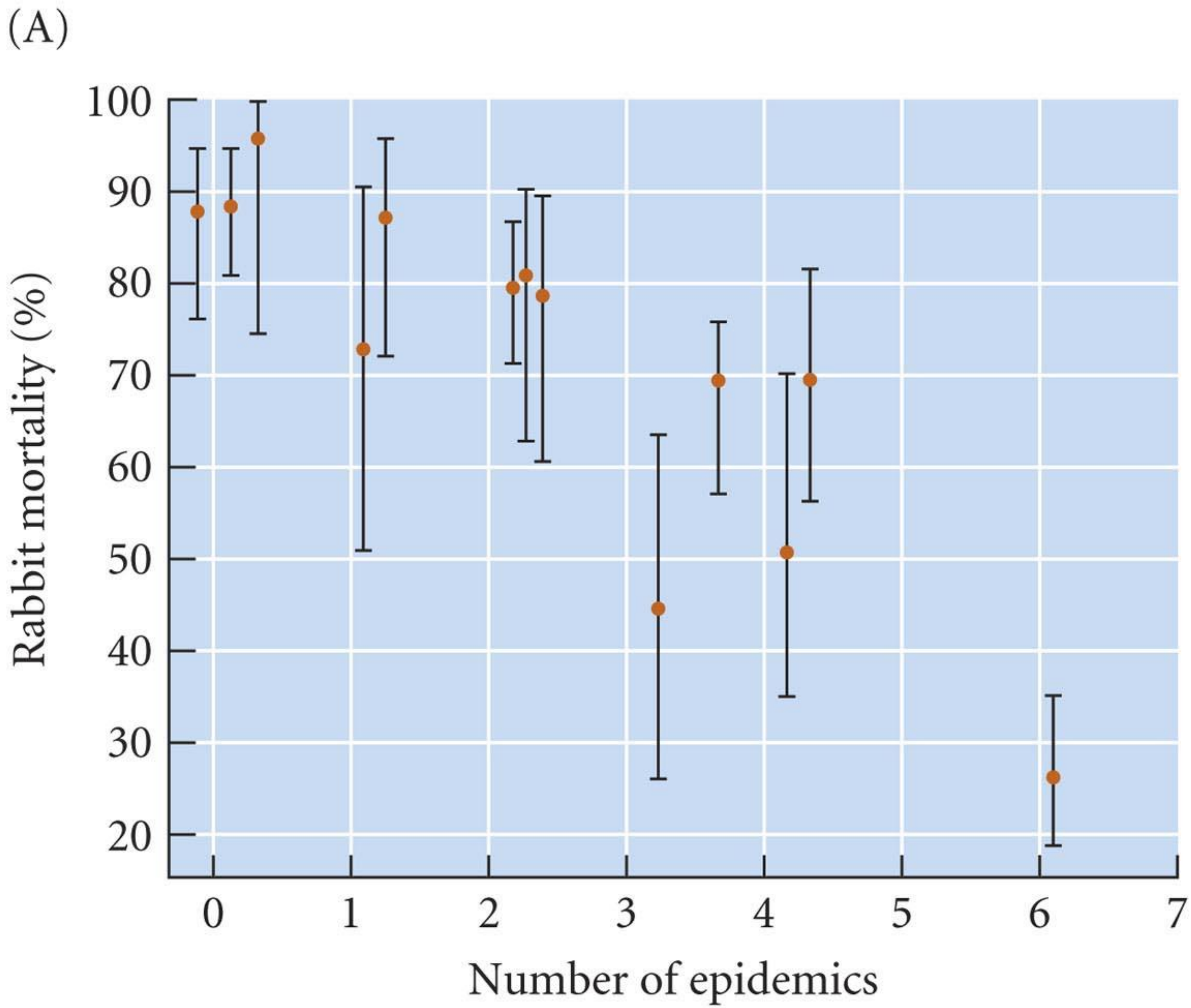

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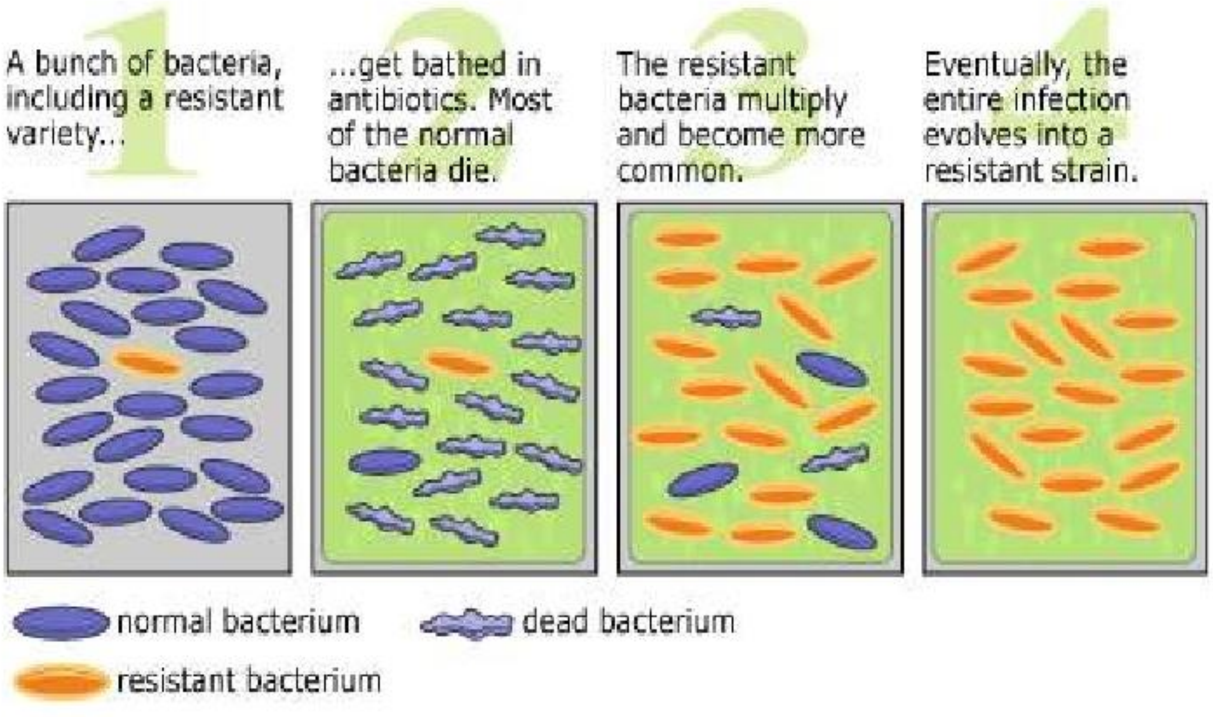
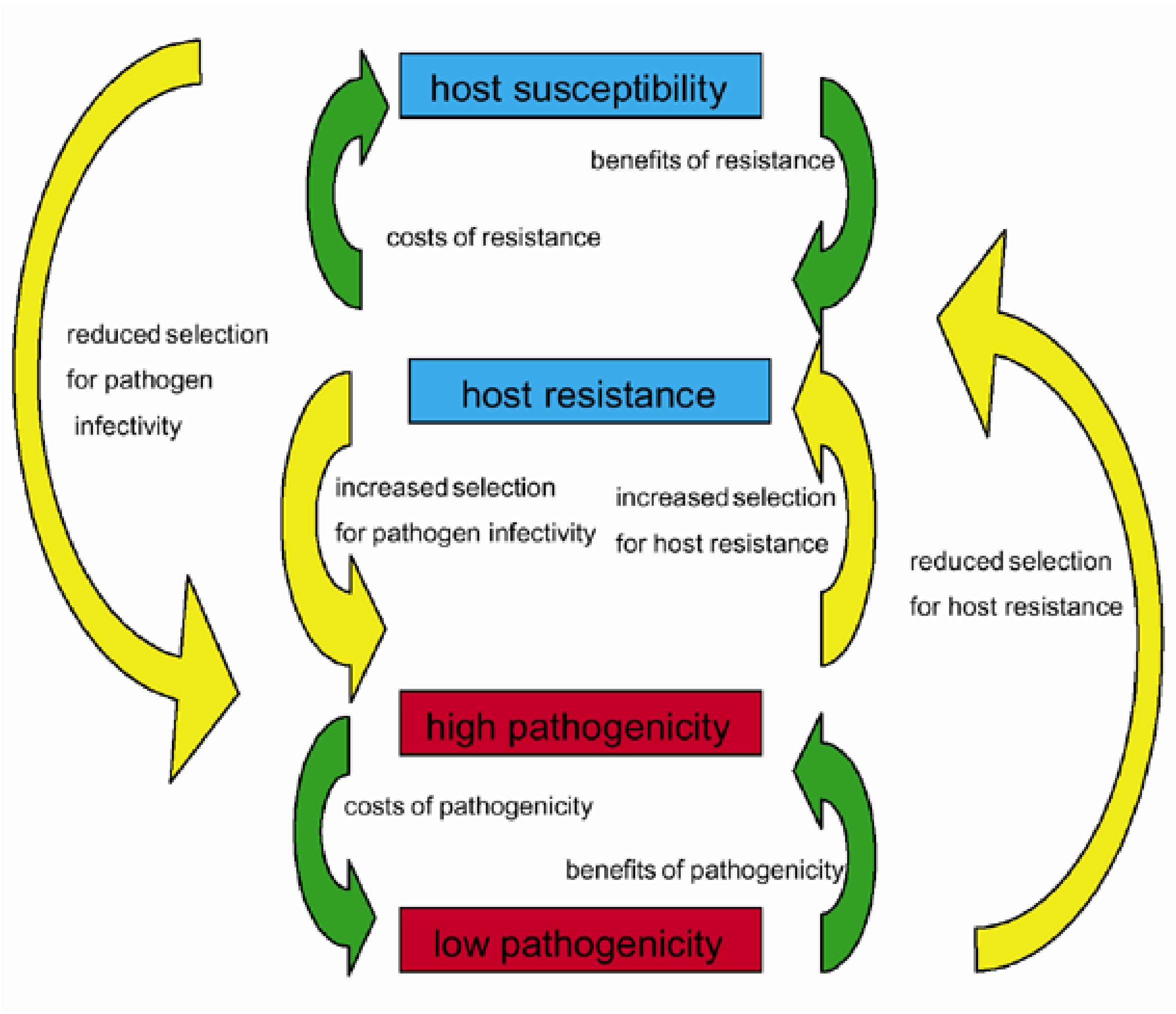
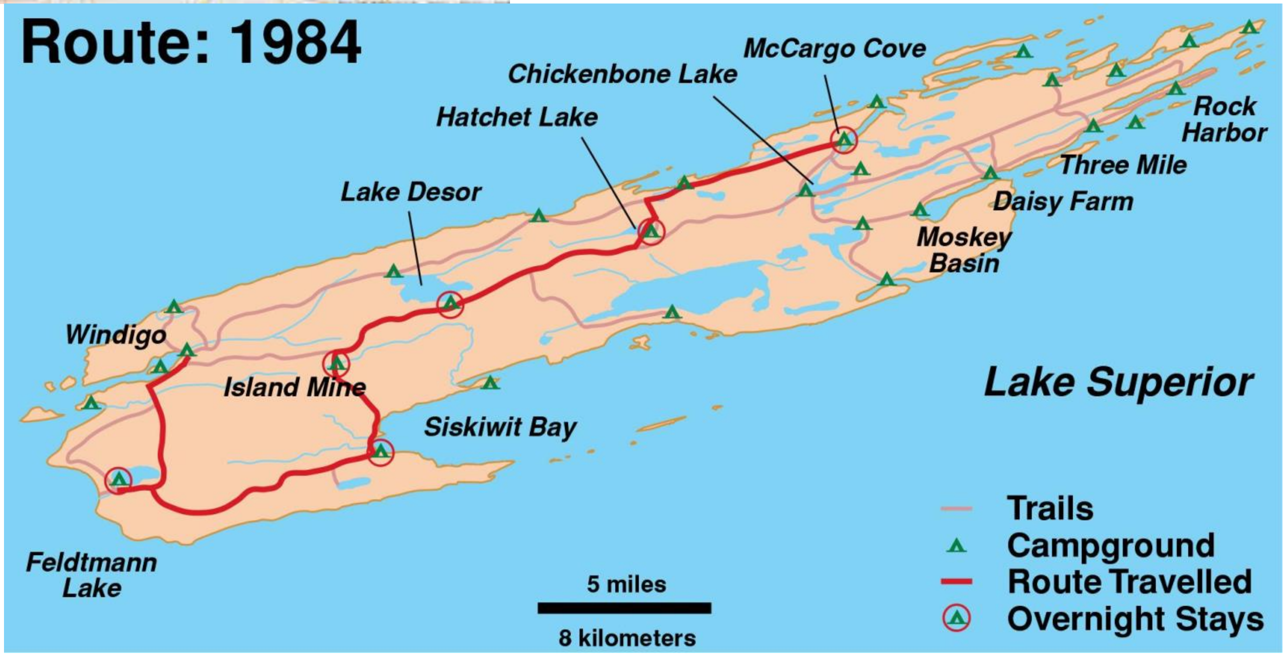
Examples of "fitness"

- Bacterial resistance to antibiotics

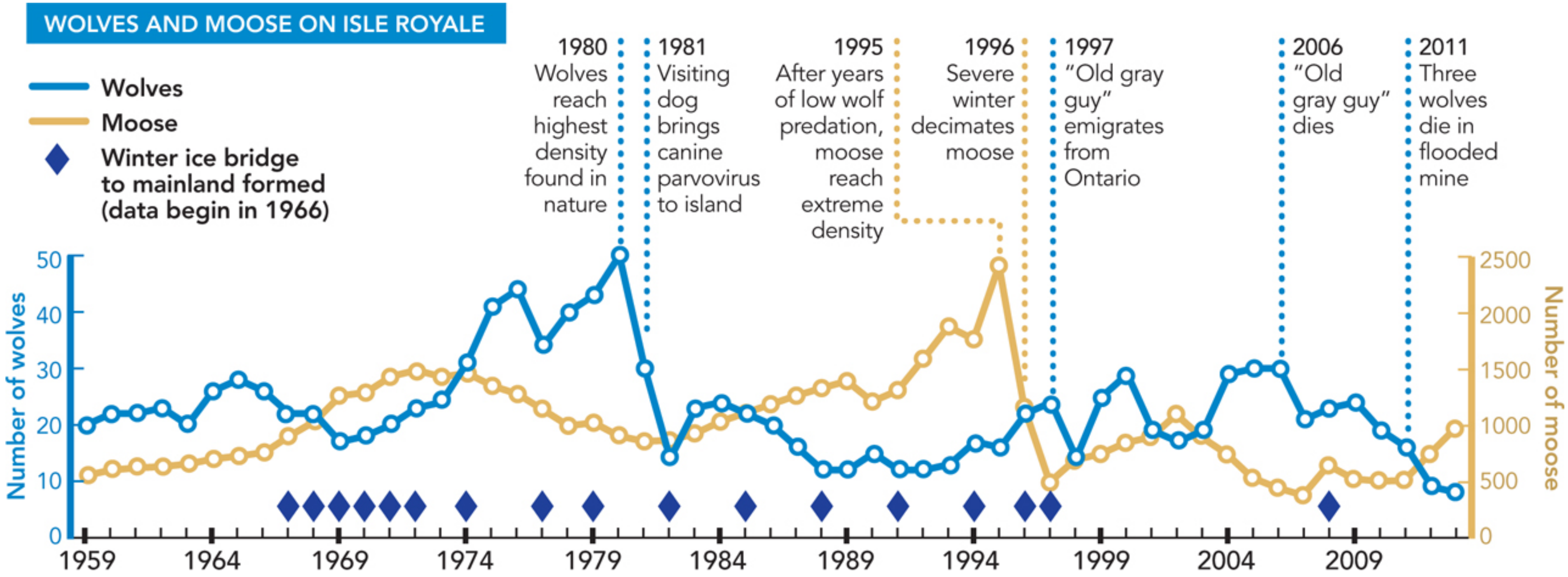



host susceptibility
benefits of resistance
costs of resistance
reduced selection
for pathogen
infectivity
host resistance
increased selection
for pathogen infectivity
increased selection
for host resistance
reduced selection
for host resistance
high pathogenicity
costs of pathogenicity
benefits of pathogenicity
low pathogenicity



535,4 km²

24 km da costa


WOLVES AND MOOSE ON ISLE ROYALE
Wolves
Moose
Winter ice bridge to mainland formed (data begin in 1966)
1980 Wolves reach highest density found in nature
1981 Visiting dog brings canine parvovirus to island
1995 After years of low wolf predation, moose reach extreme density
1996 Severe winter decimates moose
1997 "Old gray guy" emigrates from Ontario
2006 "Old gray guy" dies
2011 Three wolves die in flooded mine
Number of wolves
0
10
20
30
40
50
Number of moose
0
500
1000
1500
2000
2500
1959
1964
1969
1974
1979
1984
1989
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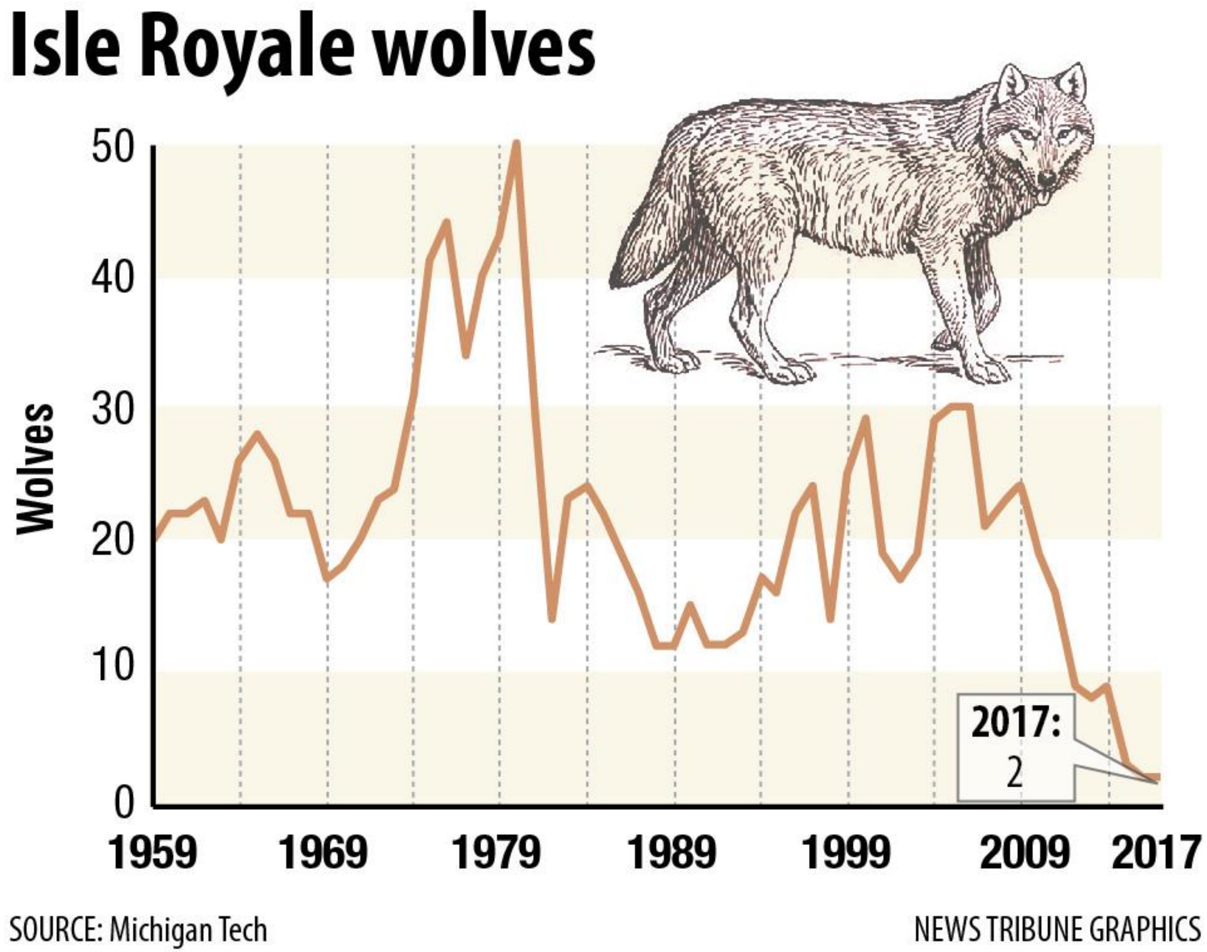
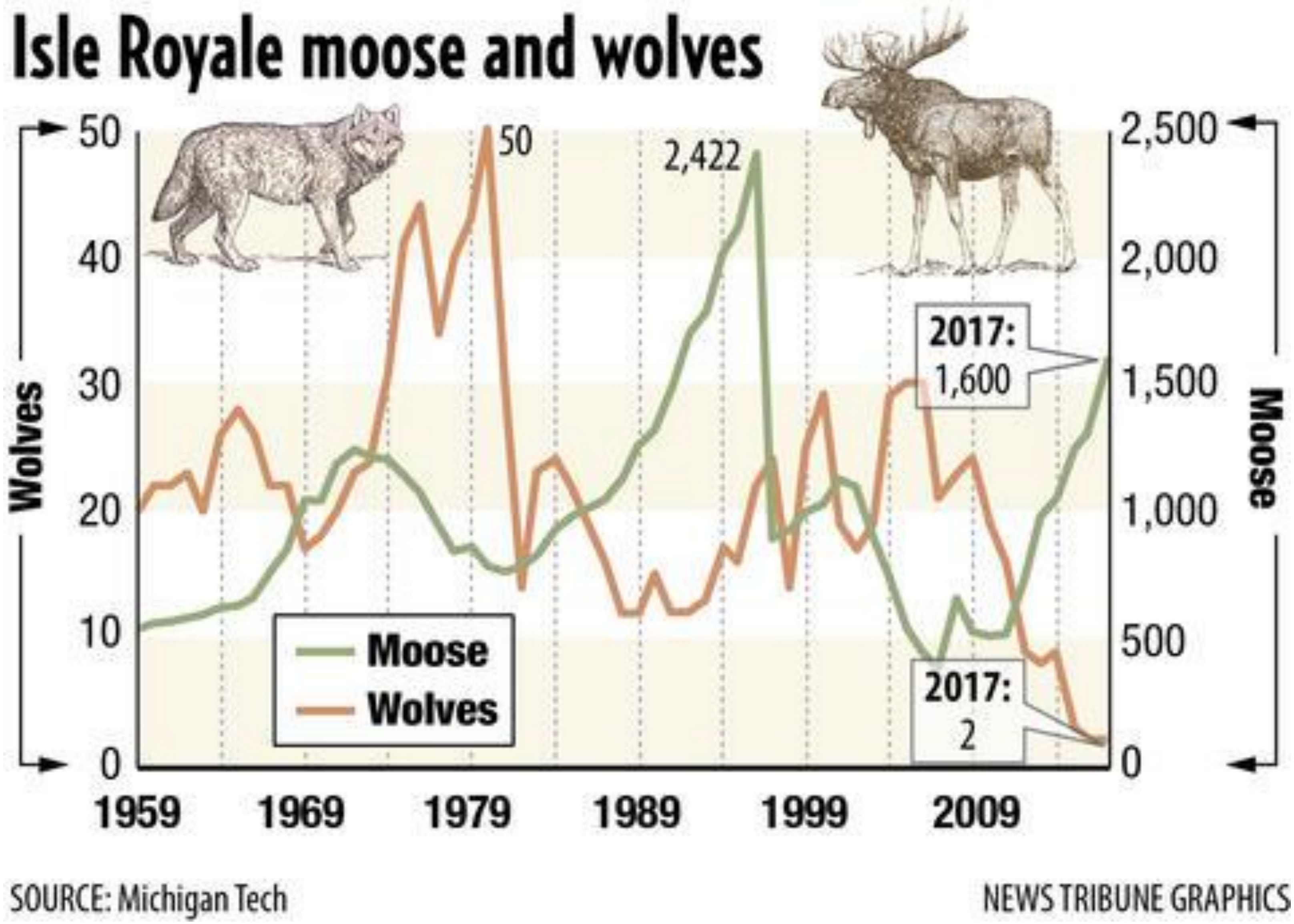
2004
2009


Isle Royale wolves
Wolves
50
40
30
20
10
0
1959
1969
1979
1989
1999
2009
2017
2017:
2
SOURCE: Michigan Tech
NEWS TRIBUNE GRAPHICS


Isle Royale moose and wolves
Wolves
Moose
50
40
30
20
10
0
2,500
2,000
1,500
1,000
500
0
50
2,422
2017:
1,600
2017:
2
Moose
Wolves
1959
1969
1979
1989
1999
2009
SOURCE: Michigan Tech
NEWS TRIBUNE GRAPHICS