

LS1101

Introduction to Biology

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Speciation

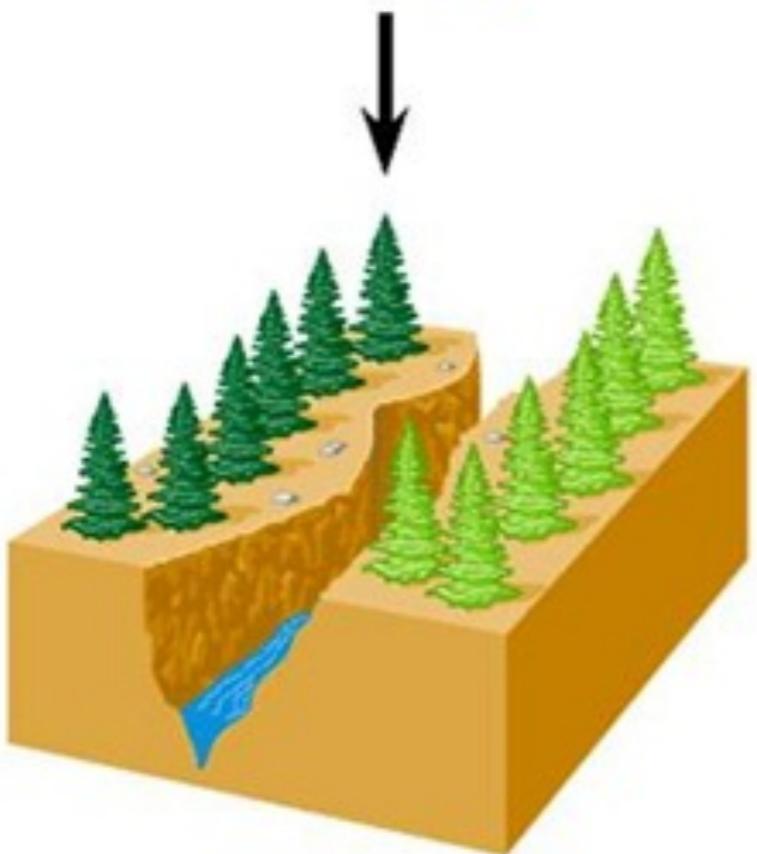
Biological species: a group of populations whose members have the potential to interbreed in nature and produce fertile offspring.

speciation: the process by which one species splits into two or more species.

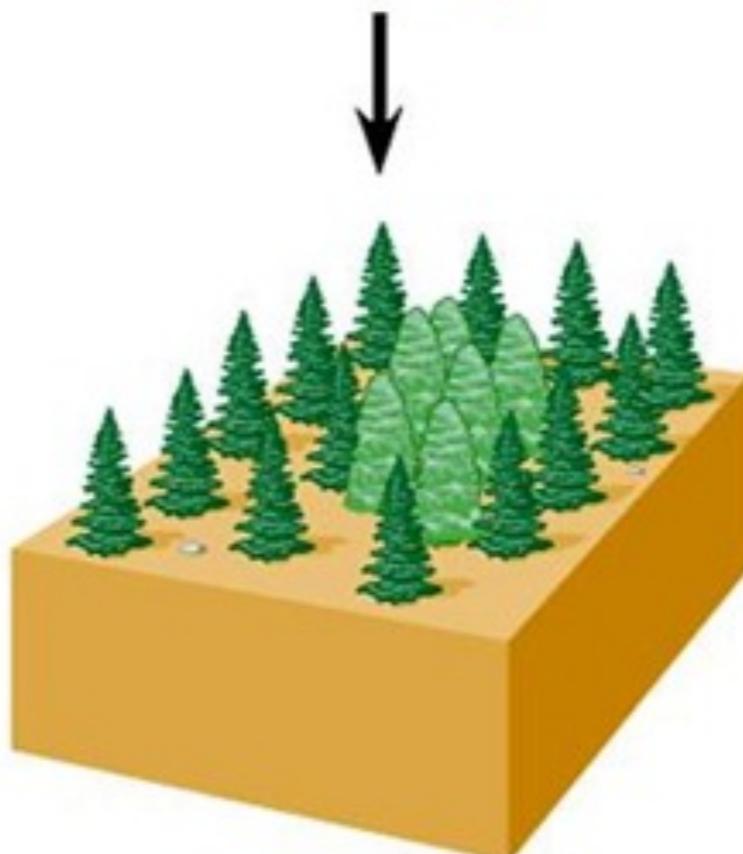


Within one species, there can be high diversity in features

Types of Speciation

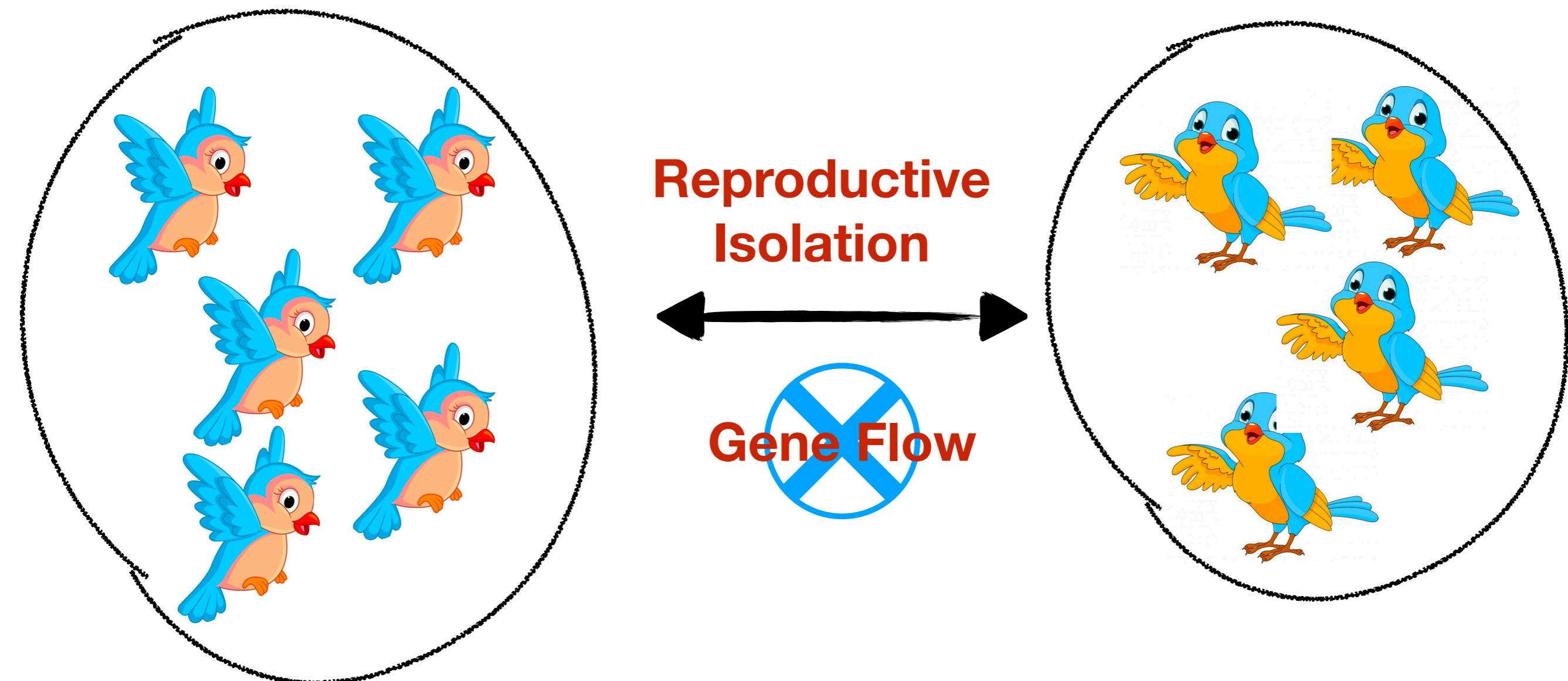


(a) Allopatric speciation

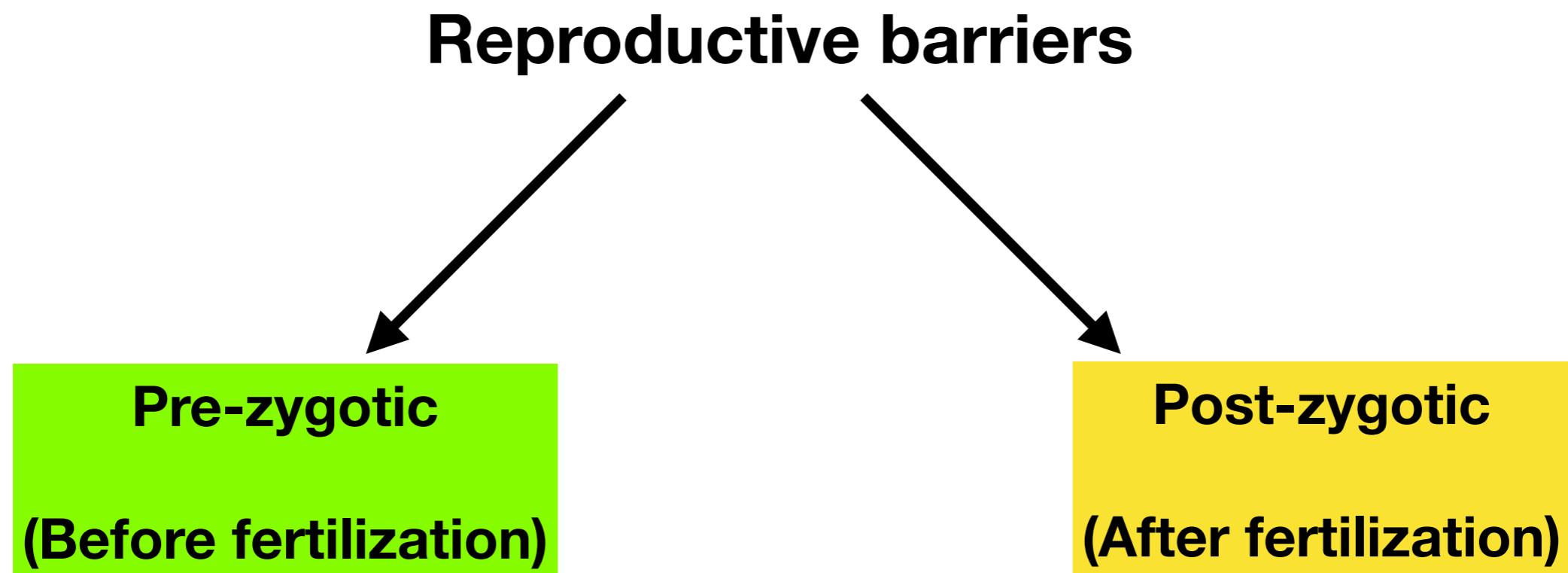


(b) Sympatric speciation

What keeps species separated?



What are the reproductive barriers?



Pre-zygotic (Before fertilization)

1. Habitat: Lives in a different place

The garter snake
Thamnophis atratus
lives mainly in water.



The garter snake
Thamnophis sirtalis
lives on land.

2. Separated by time: Breeding or mating happens at different times

The eastern spotted skunk (*Spilogale putorius*) breeds in late winter.



The western spotted skunk (*Spilogale gracilis*) breeds in the fall.



Magicicada tredecim
Emerges every 13 years



Magicicada septendecim
Emerges every 17 years

3. Mechanical Isolation: Reproductive parts are not compatible



Sinistral Euhadra quaesita

Dextral Euhadra aomoriensis

3. Behavioral Isolation: Inability to send or receive correct signals



Western
Meadow Lark



Eastern
Meadow Lark



PREZYGOTIC BARRIERS

The garter snake
Thamnophis atratus
lives mainly in water.



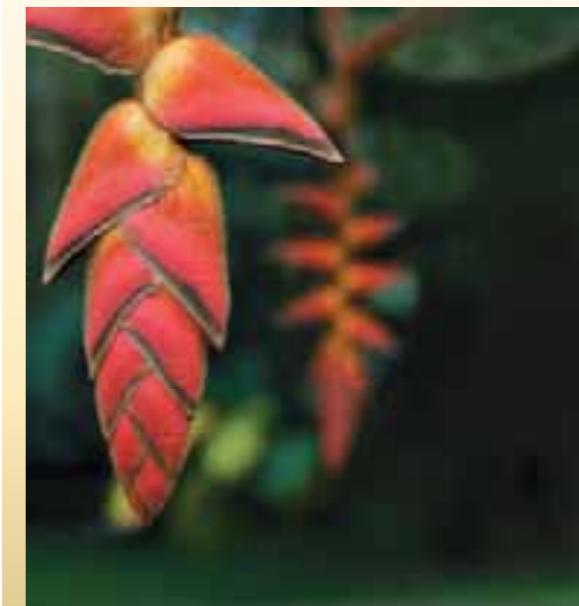
The eastern spotted skunk (*Spilogale putorius*) breeds in late winter.



The blue-footed booby (*Sula nebouxii*) performs an elaborate courtship dance.



Heliconia pogonantha is pollinated by hummingbirds with long, curved bills.



Habitat
Lack of opportunities to encounter each other

Temporal
Breeding at different times or seasons

Behavioral
Failure to send or receive appropriate signals

Mechanical
Physical incompatibility of reproductive parts



The garter snake
Thamnophis sirtalis
lives on land.



The western spotted skunk (*Spilogale gracilis*) breeds in the fall.



The masked booby (*Sula dactylatra*) performs a different courtship ritual.



Heliconia latispatha is pollinated by hummingbirds with short, straight bills.

Post-zygotic (After fertilization)

Zygote Mortality: Gametic isolation

Purple sea urchin
(*Strongylocentrotus purpuratus*)

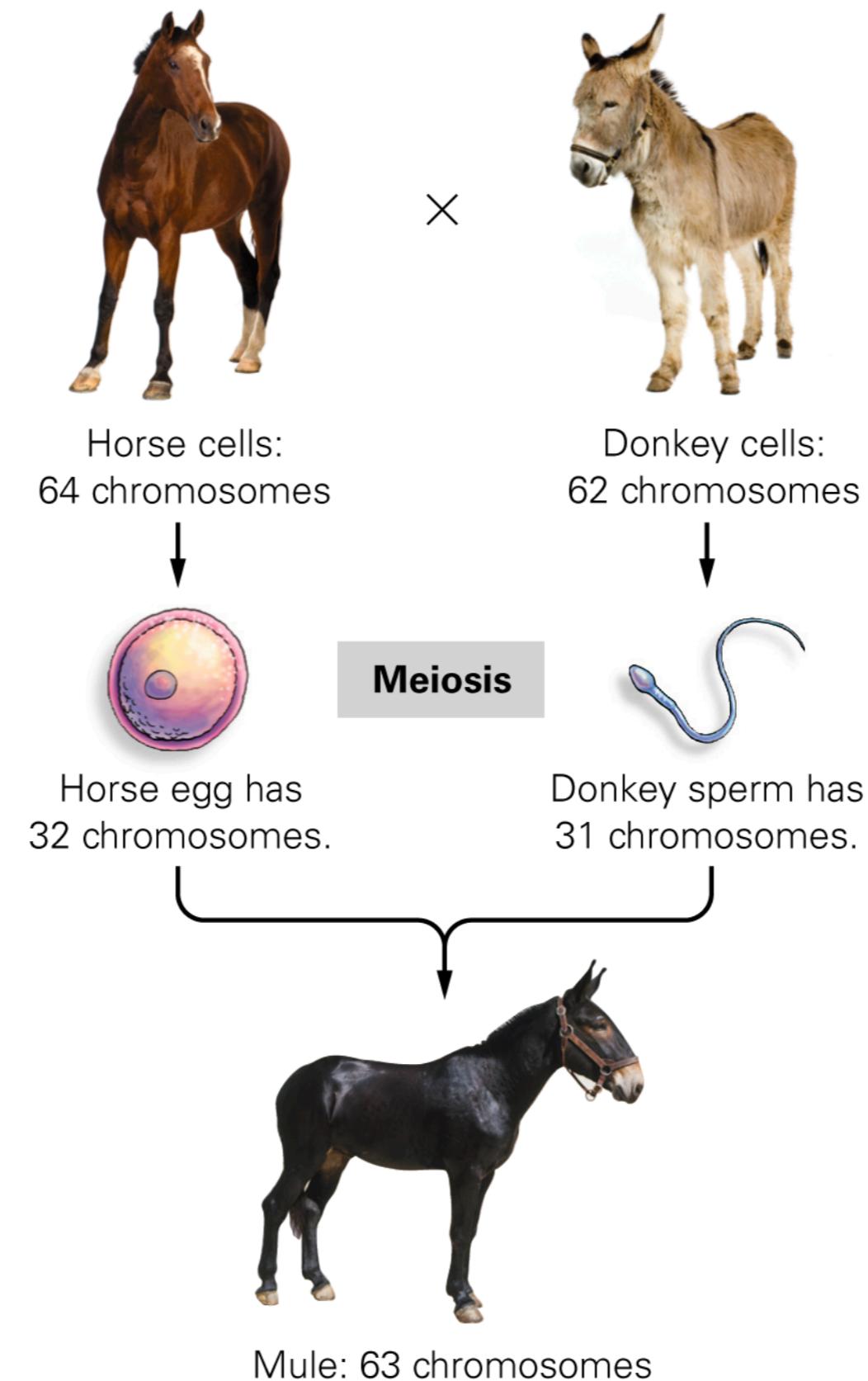


Red sea urchin
(*Strongylocentrotus franciscanus*)

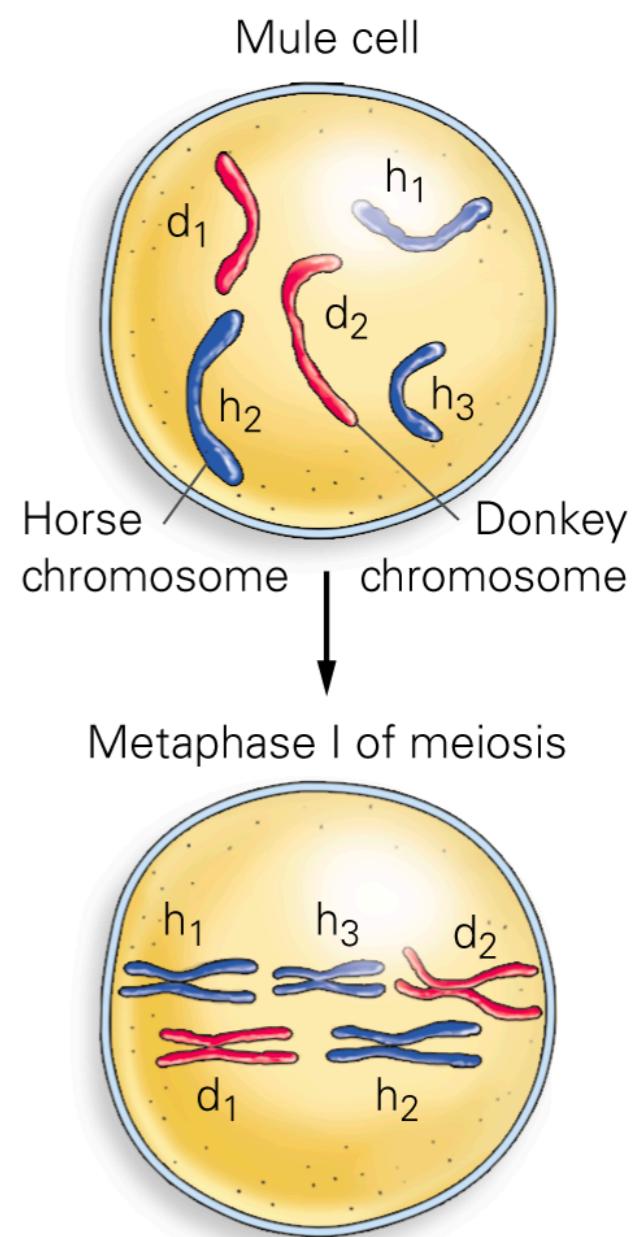
Due to molecular incompatibility, zygote mortality occurs.

Hybrid Sterility

(a) A mule results from the mating of a horse and a donkey.

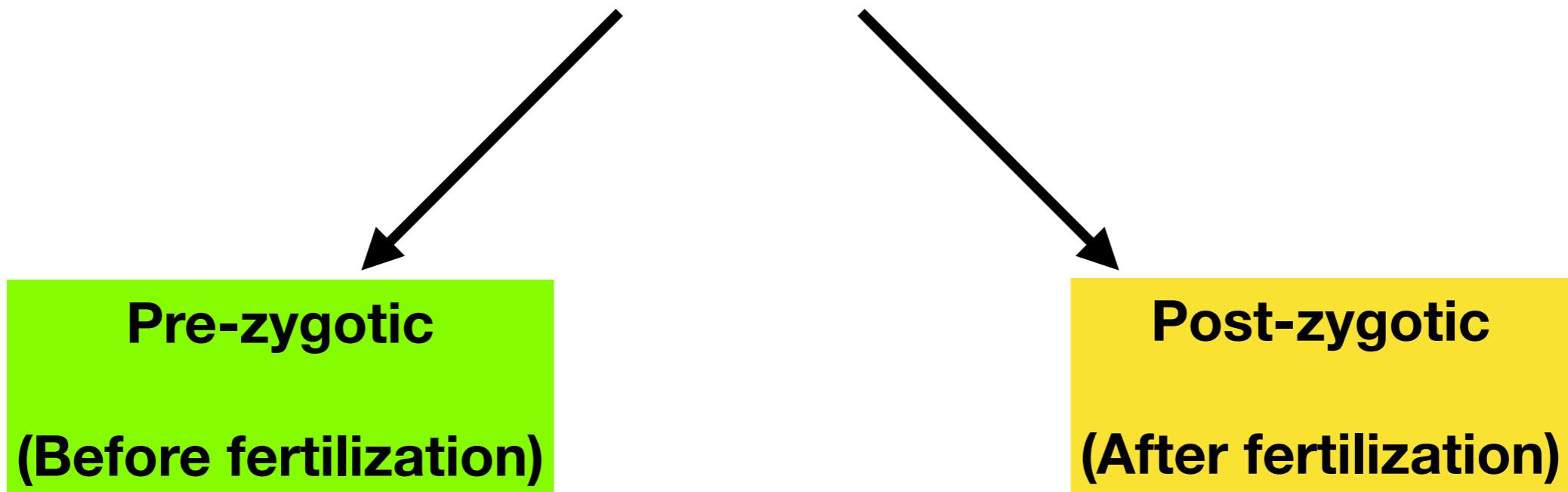


(b) Why mules are sterile



The chromosomes are from different species with different numbers of chromosomes, so they are unable to pair during the first part of meiosis.

Reproductive barriers



- Habitat
- Temporal
- Mechanical
- Behavioural

- Gametic
- Hybrid

Can you Answer?

**Two closely related fish live in the same lake,
but one feeds along the shoreline and the other
is a bottom feeder in deep water.**

What type of isolation: Pre-zygotic (habitat)

Hybrid zones provide opportunities to study reproductive isolation

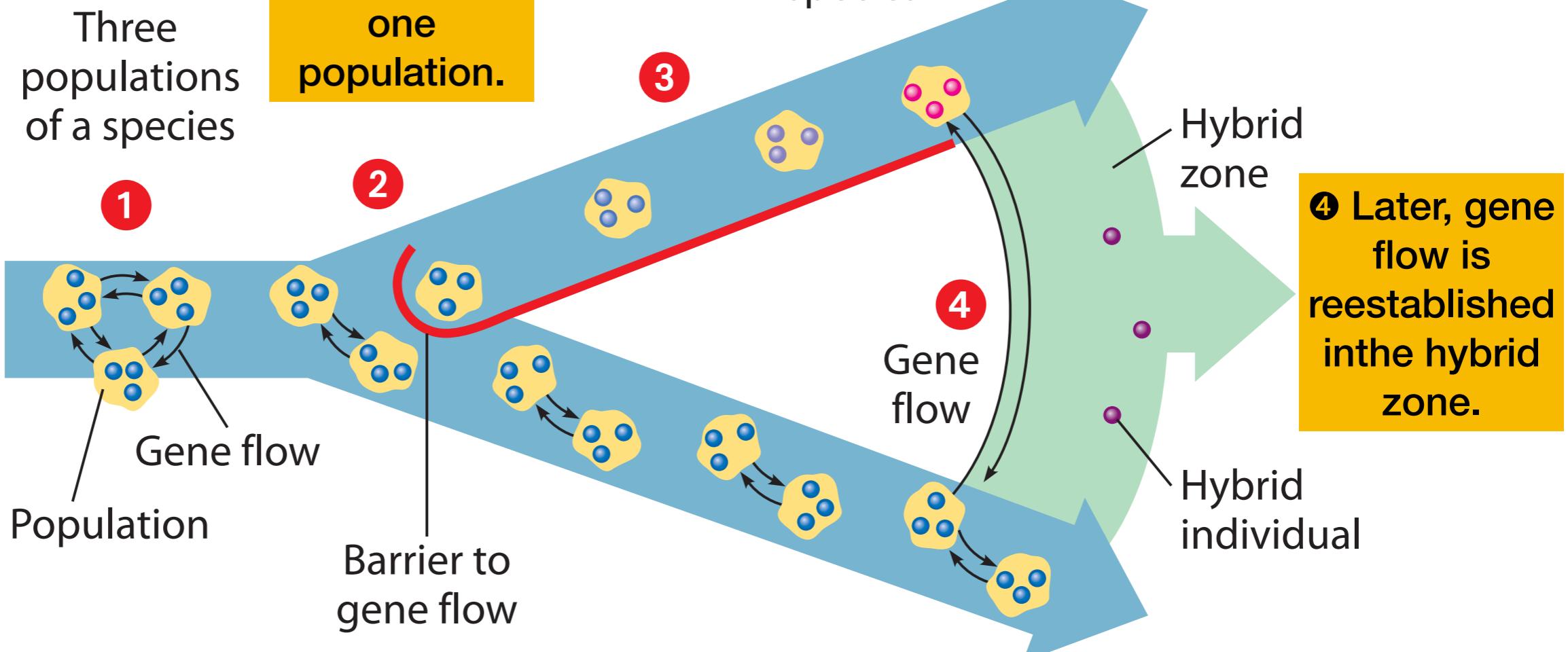
What happens when separated populations of closely related species come back into contact with one another? Will reproductive barriers be strong enough to keep the species separate? Or will the two species interbreed and become one? Biologists attempt to answer such questions by studying **hybrid zones**.

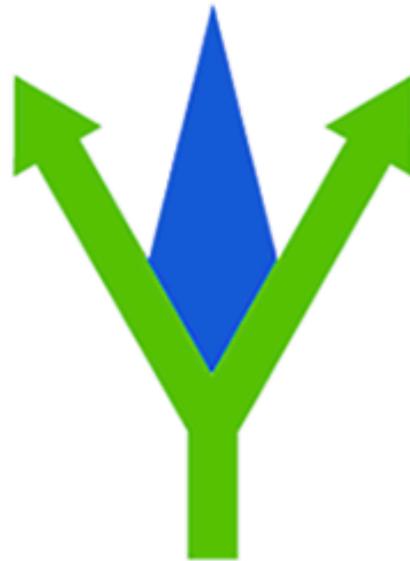
Hybrid Zone: Regions in which members of different species meet and mate, producing at least some hybrid offspring.

① Three populations are connected by gene flow.

② A barrier to gene flow separates one population.

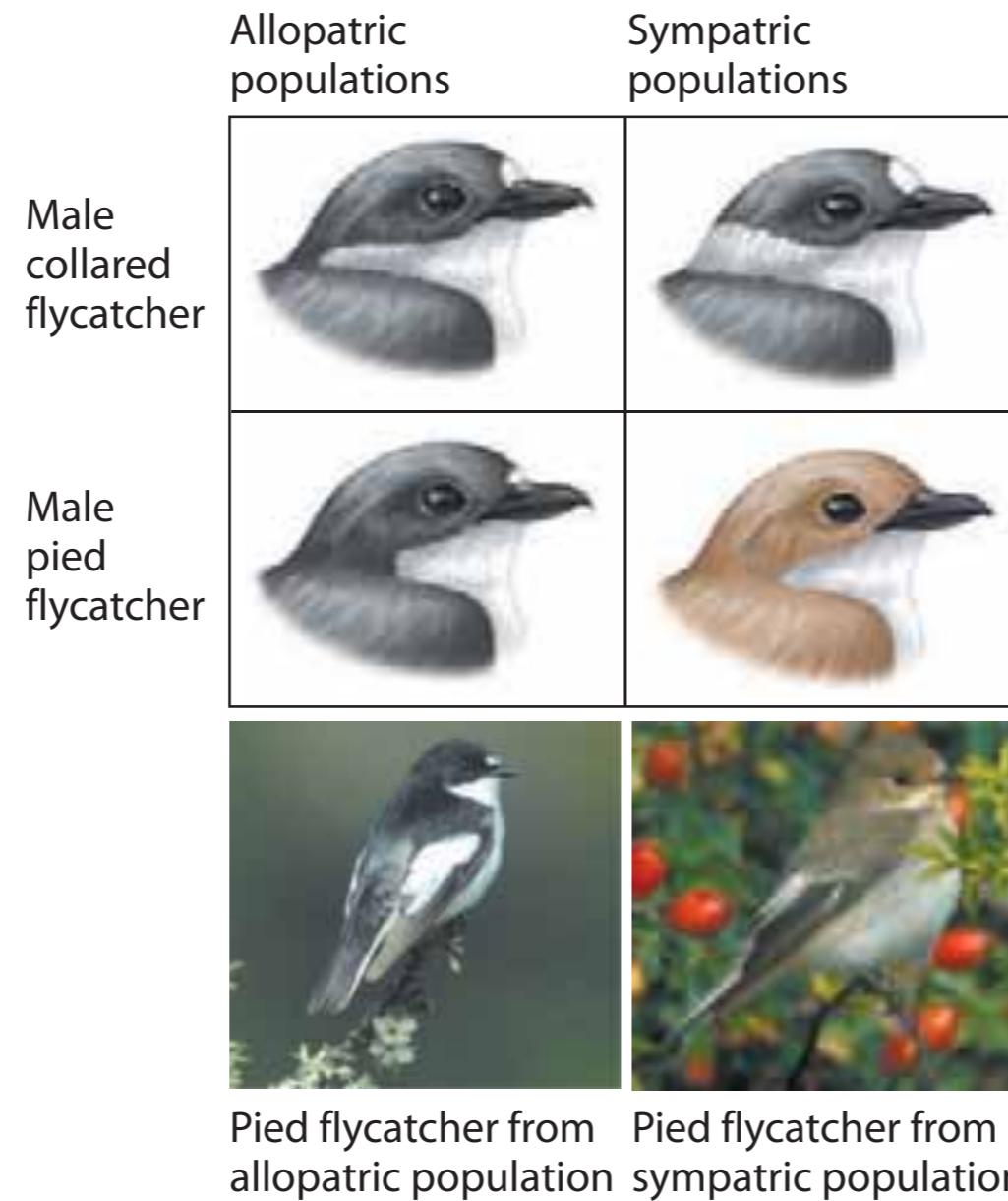
③ Over time, this population diverges from the other two.





When hybrid offspring are less fit than members of both parent species, we might expect natural selection to strengthen, or *reinforce*, reproductive barriers

Reinforcement:
Hybrids are less fit than either purebred species. The species continue to diverge until hybridization can no longer occur.



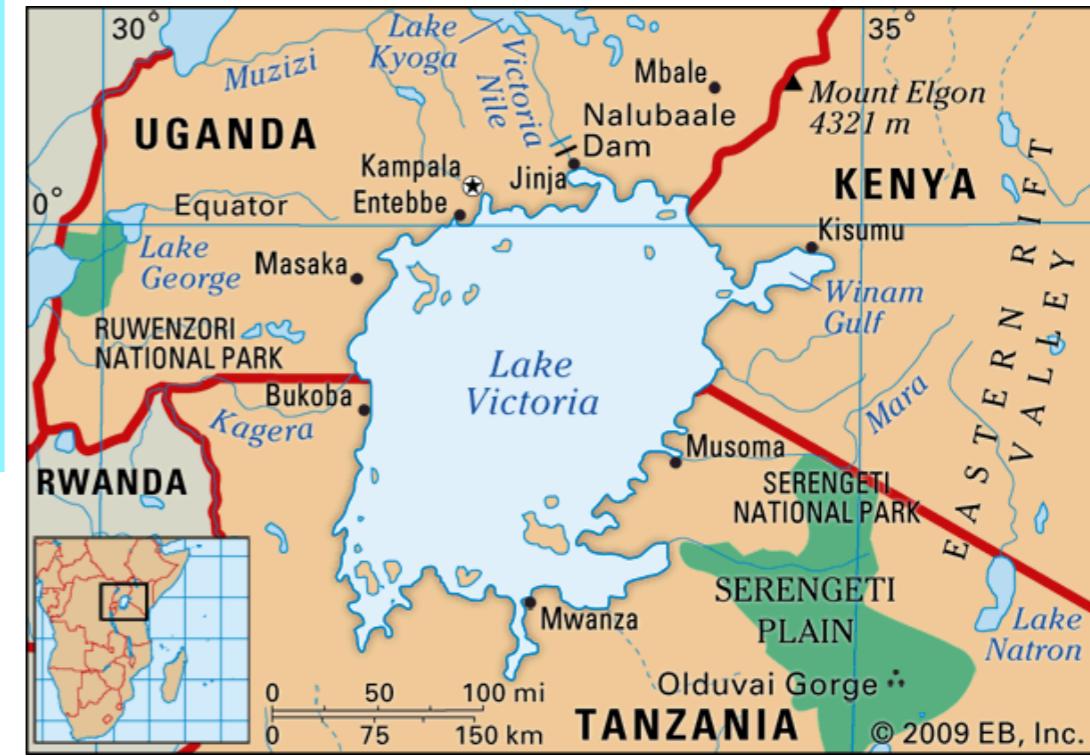
When populations of these two species do not overlap (that is, when they are allopatric), males closely resemble each other, with similar black and white coloration. IN sympatric populations, males are different coloured.

Reproductive barrier reinforced where species overlap is more.



When reproductive barriers are not strong enough, gene flow may occur. The speciation process reverses, causing the two hybridizing species to fuse into one.

Fusion:
Reproductive barriers weaken until the two species become one.



What happens when *P. nyererei* or *P. pundamilia* females can't tell red males from blue males? The behavioral barrier crumbles. Many viable hybrid offspring are produced by inter-breeding, and the once isolated gene pools of the parent species are combining – two species fusing into a single hybrid species.



Pundamilia nyererei



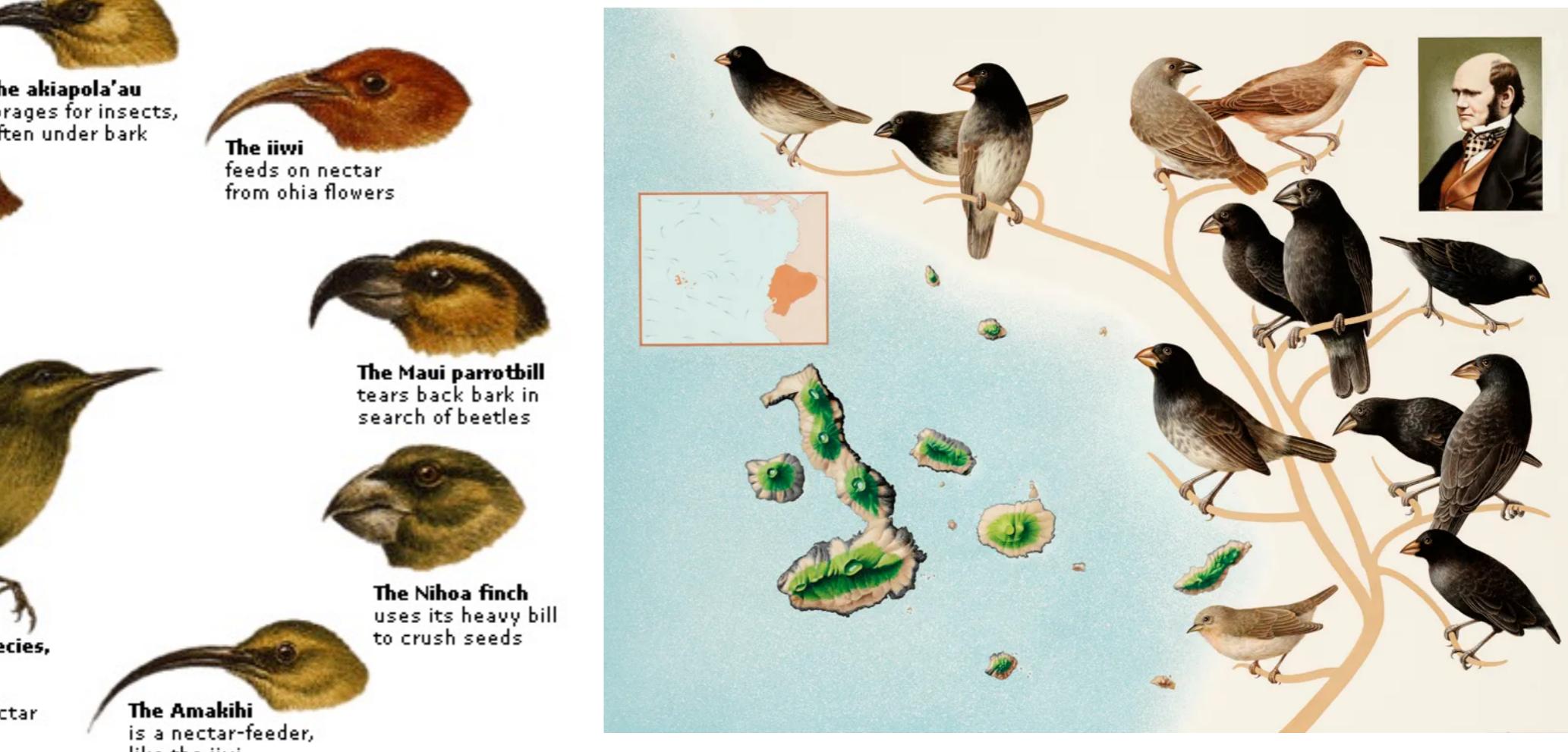
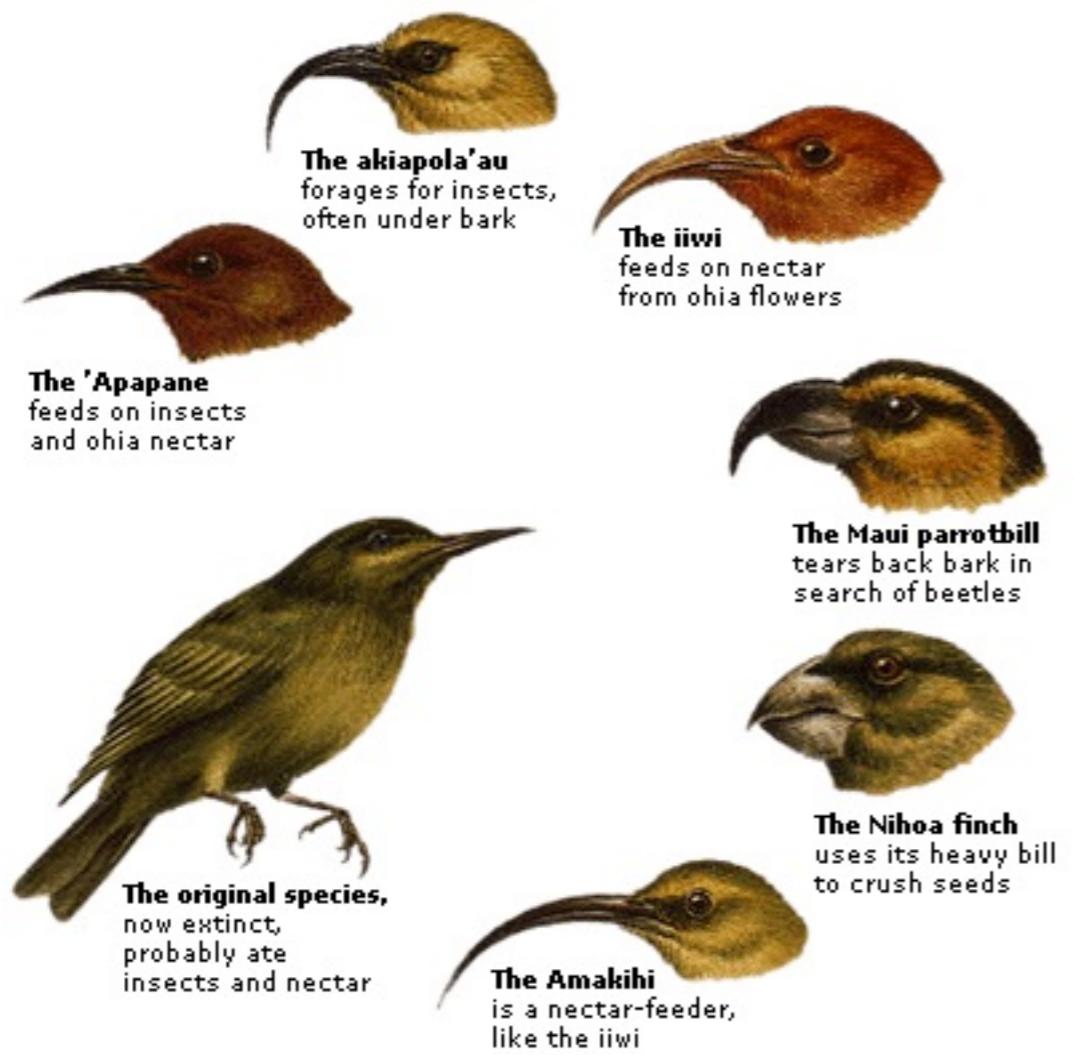
Pundamilia pundamilia



Hybrid: *Pundamilia* "turbid water"

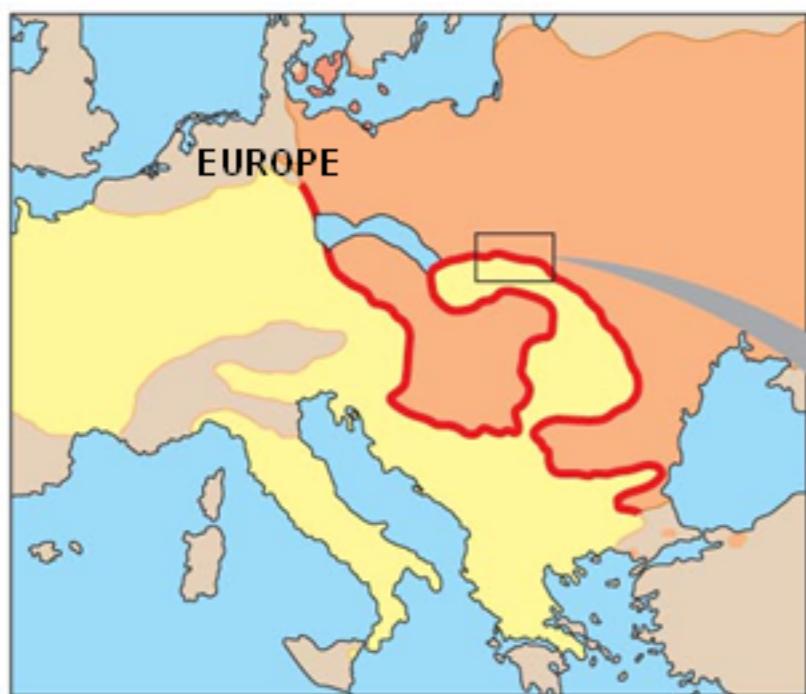


Stability:
Fit hybrids continue
to be produced.

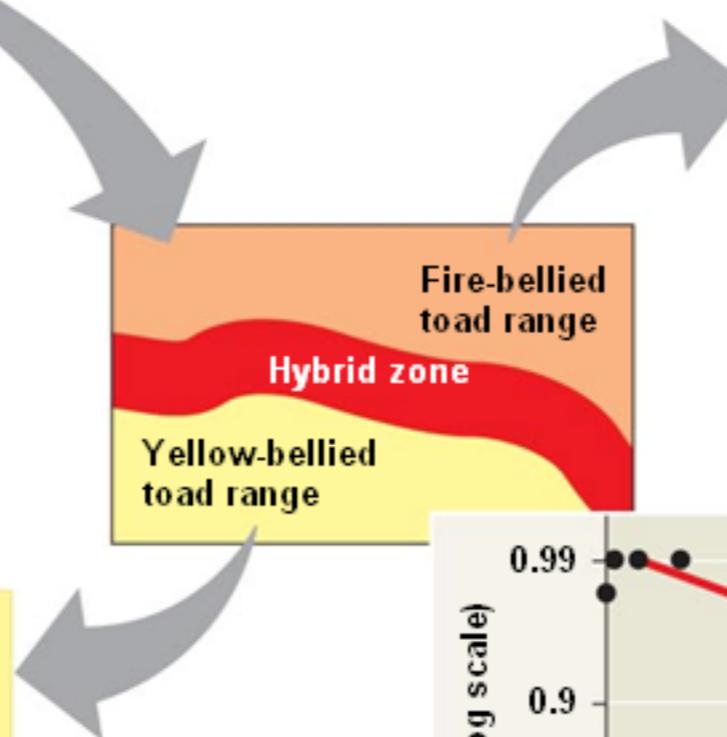


Many hybrid zones are fairly stable, and hybrids continue to be produced. Although these hybrids allow for some gene flow between populations, each species maintains its own integrity. The island inhabited by two finch species that occasionally interbreed is an example of a stable hybrid zone.

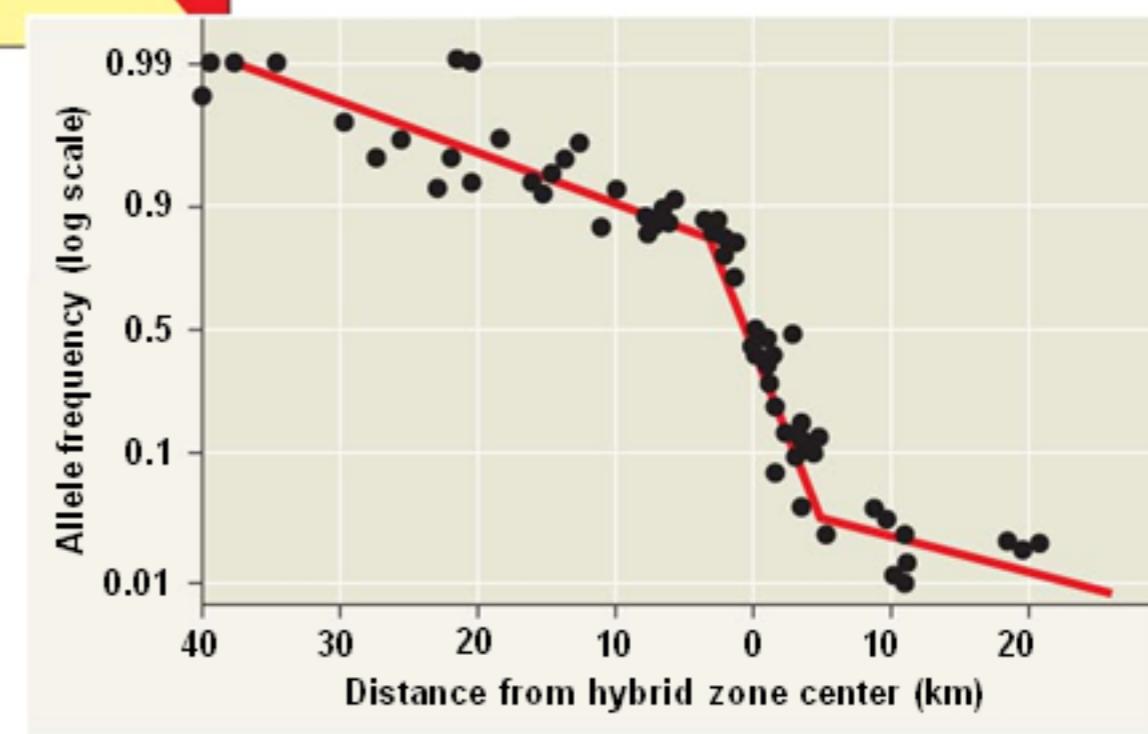
Hybrid Zones



Yellow-bellied toad,
Bombina variegata



Fire-bellied toad,
Bombina bombina





Corvus corone

Corvus cornix



Carrion Crow x Hooded Crow hybrid

Due to sexual preferences, the hybrid zones are still stable (~10000 years).

“These concepts are human inventions and only invented because of our anthropogenic desire to put everything into a neatly organized system. For birds themselves (or any other organisms) this does not matter.”

GENETICS

How carrion and hooded crows defeat Linnaeus's curse

How two crow species maintain their identity raises questions about species concepts



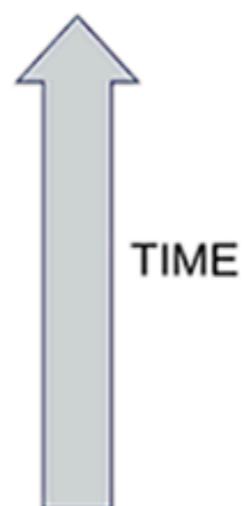
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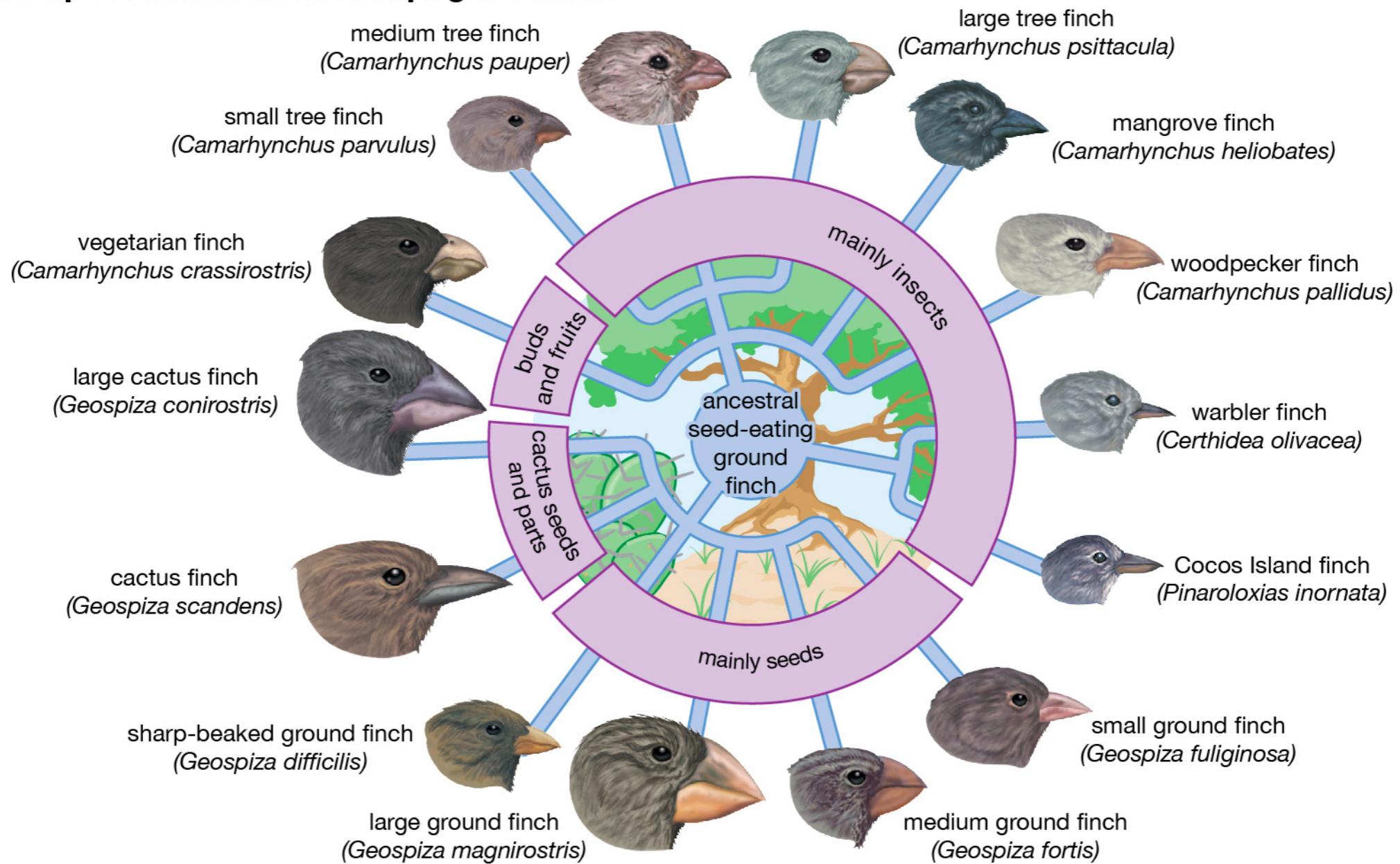
Hybrid Speciation
Hybrids become reproductively isolated from both parent species, but can interbreed among themselves



Adaptive Radiation

An adaptive radiation occurs when a single lineage produces many ecologically diverse descendant species in a relatively short period of time.

Adaptive radiation in Galapagos finches

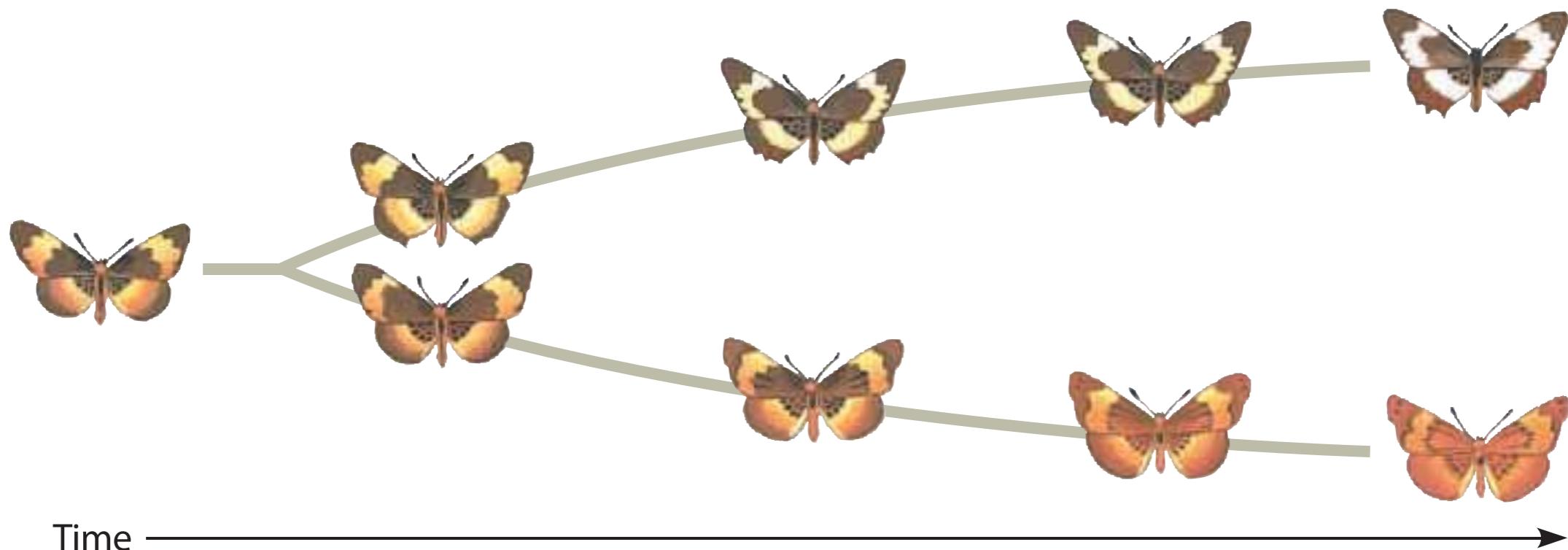


Speciation might take few hundreds to thousands of years.

Punctuated pattern



Gradual pattern



Time →

Gradual speciation is most likely to occur in large populations that live in a stable environment, while the punctuation equilibrium model is more likely to occur in a small population with rapid environmental change.