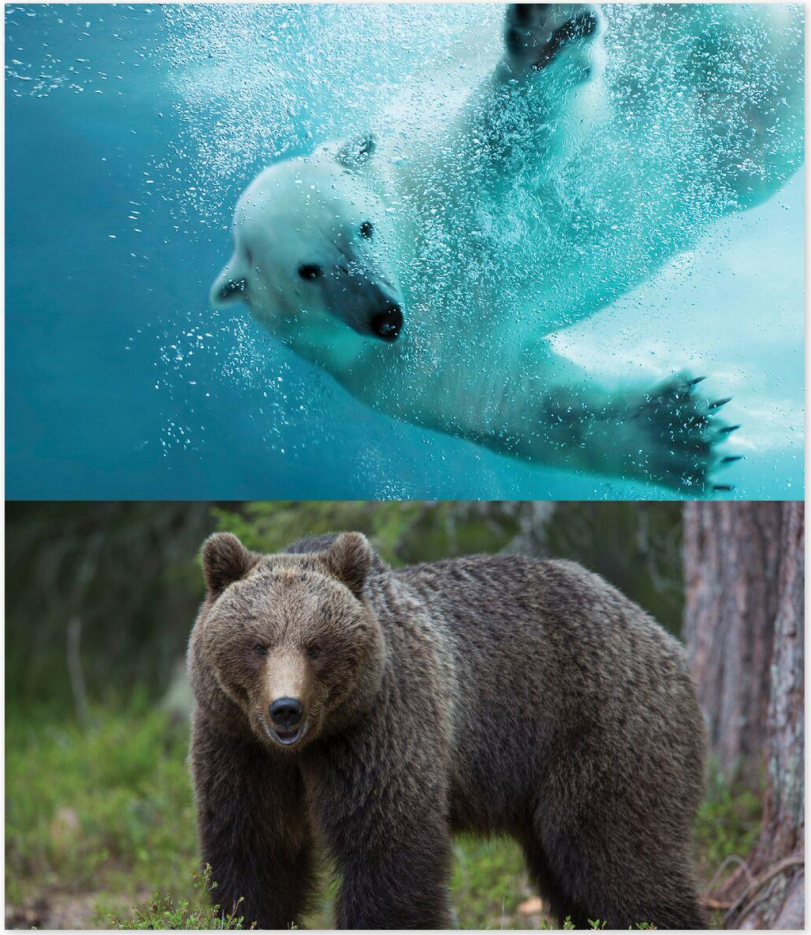
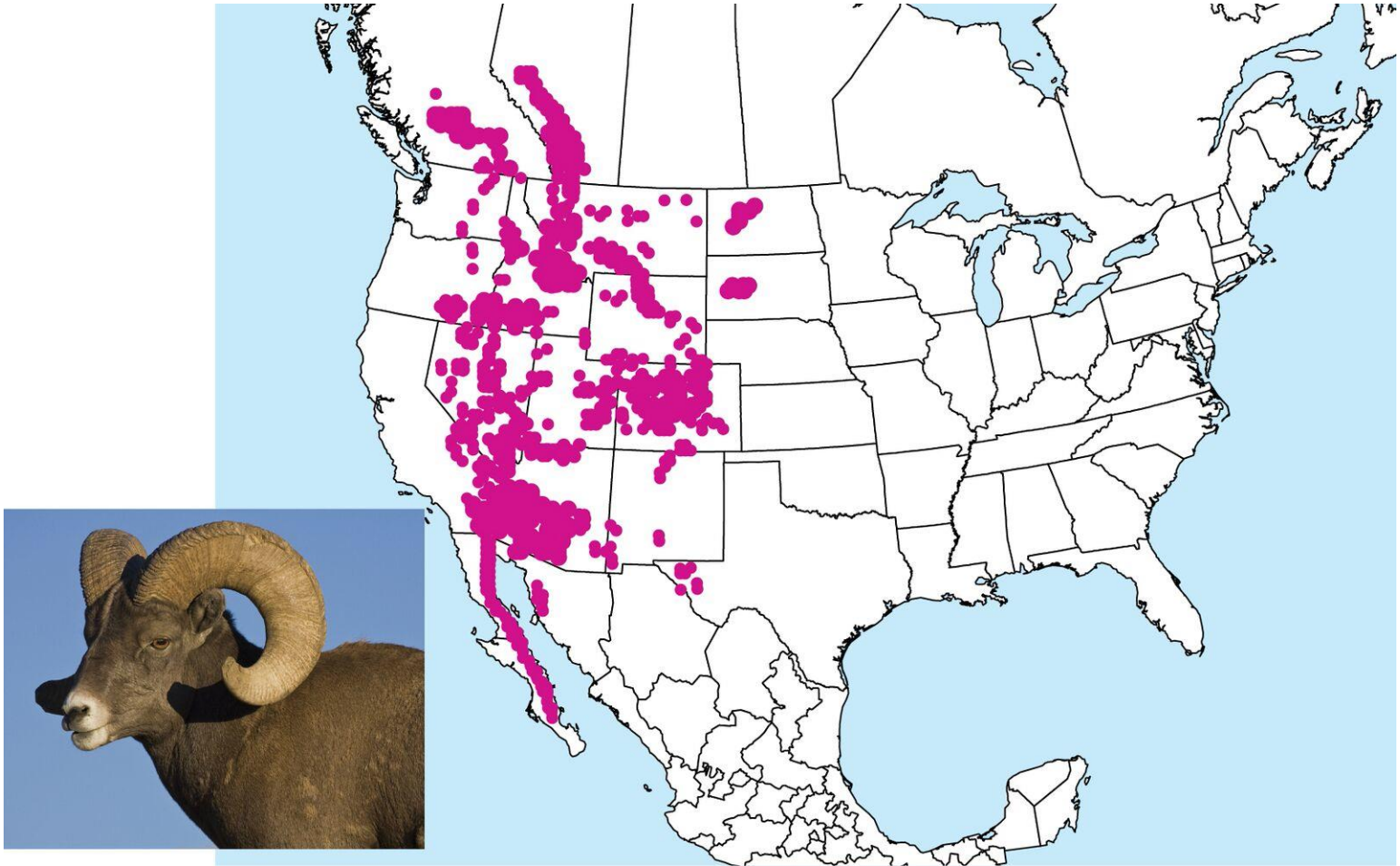
Chapter 13:The origin of species
How do we go about defining a species?
How does one species become two?



This material connects to….

Ex. Bighorn sheep

Which populations would you expect to be genetically different from one another? Which would be similar? Why?



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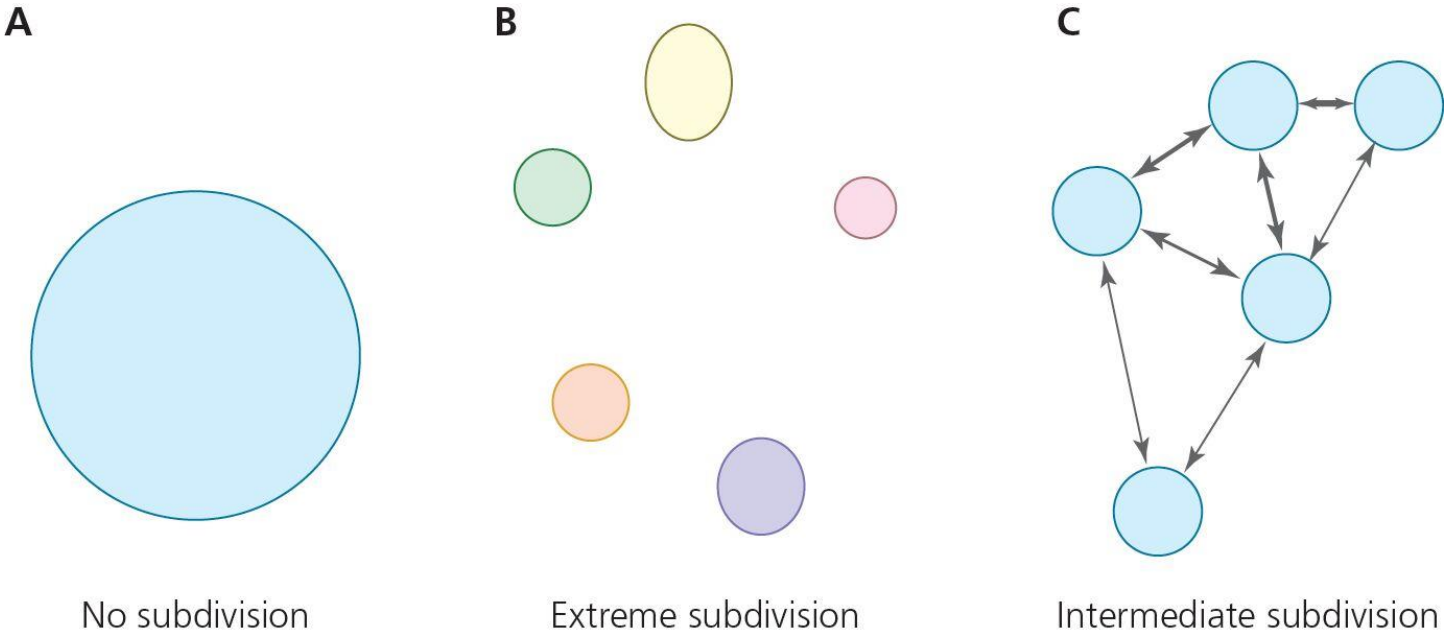
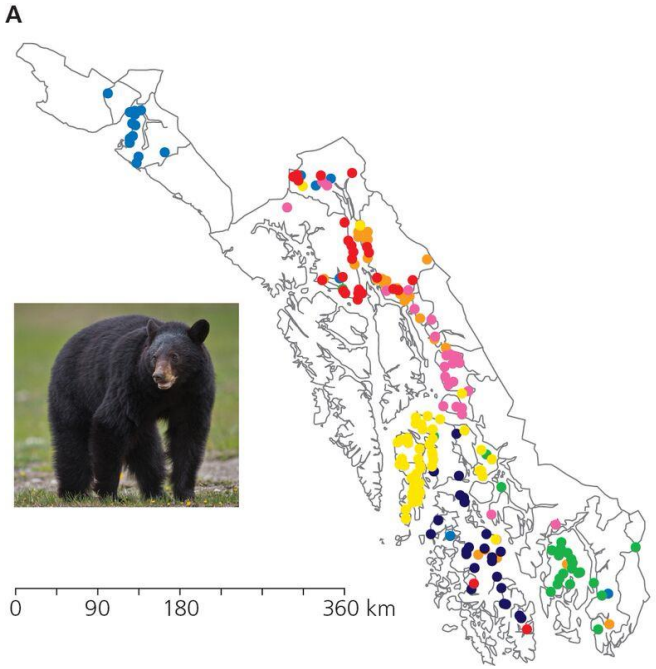
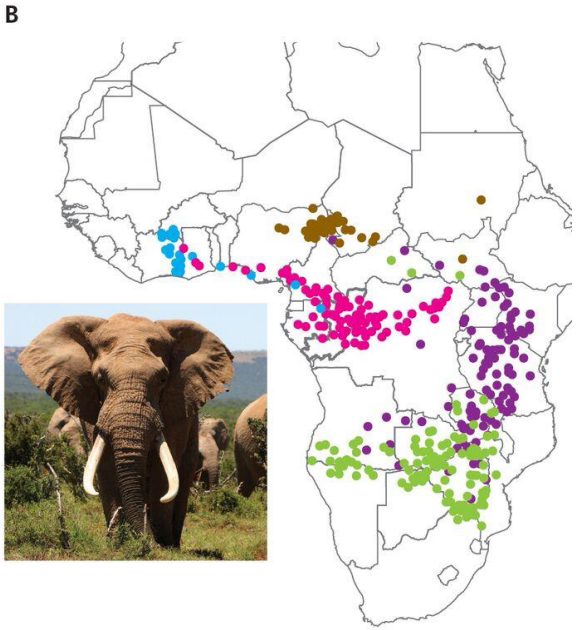


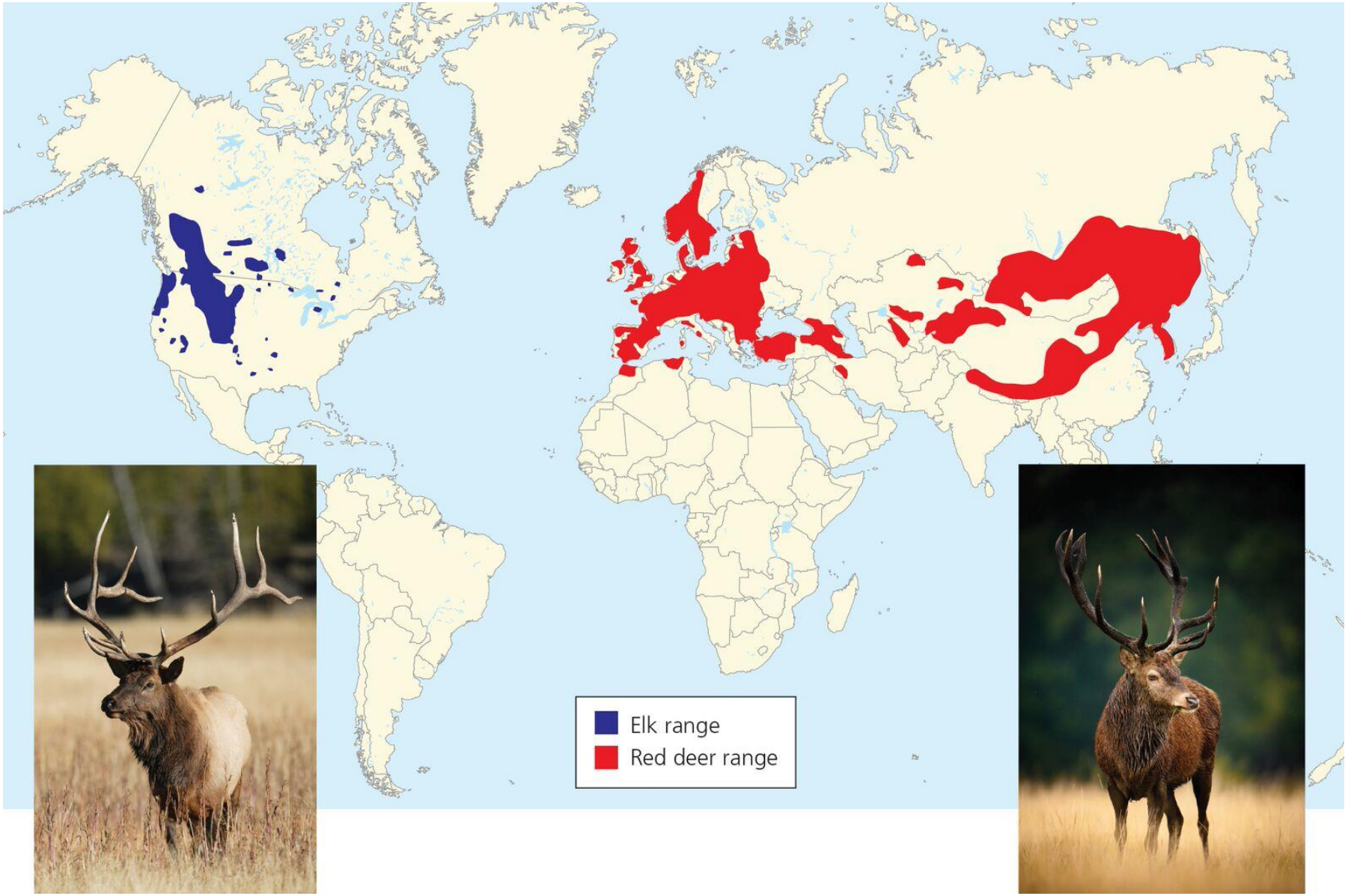




Topics for this Chapter

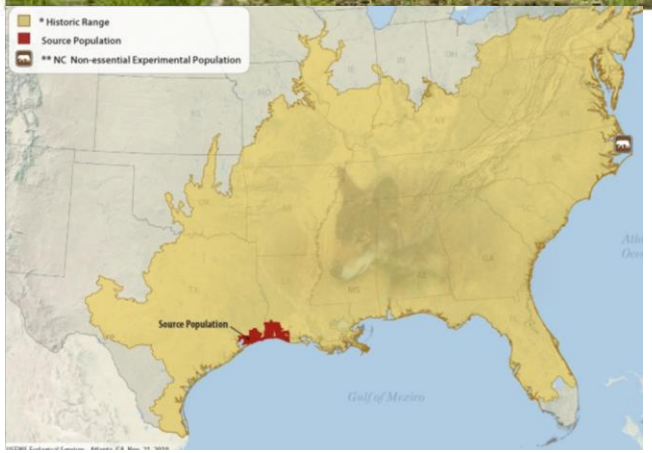
- **How do we define species?**
- How do new species form?
- Fate of hybrid zones
- Reproductive barriers
- Problems with bacteria
- Bears, bears, bears

North American elk and European red deer: One or two species? (in text)



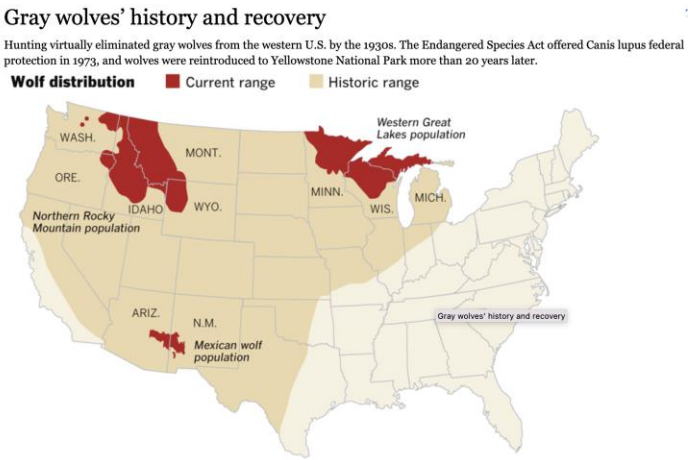
North American wolves, one or two species?

What would you want to know/measure?



http://www.fws.gov/redwolf/aboutredwolf.html

- https://graphics.latimes.com/towergraphic-la-me-wolves/
- https://www.fws.gov/project/red-wolf-recovery-program



IMPORTANT for - ESA

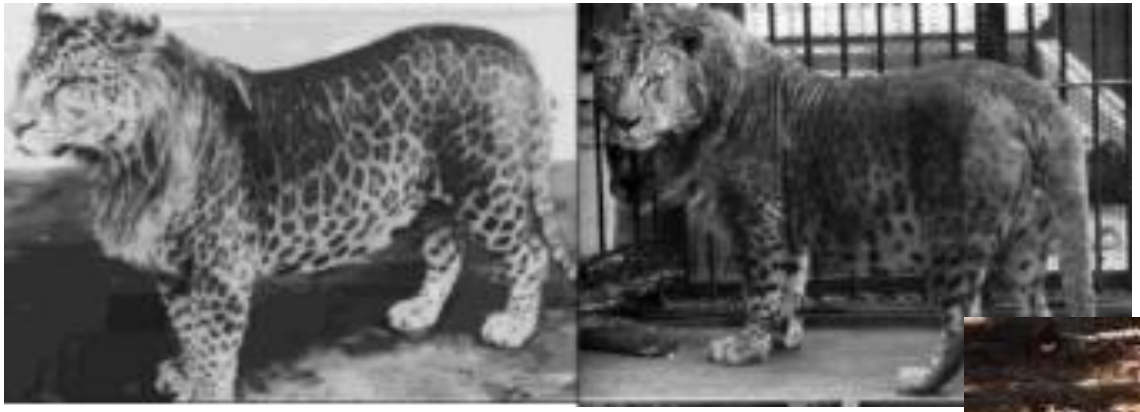
1st we had Biological Species Concept (Mayr)

Do they interbreed and produce fertile offspring?

Advantages?

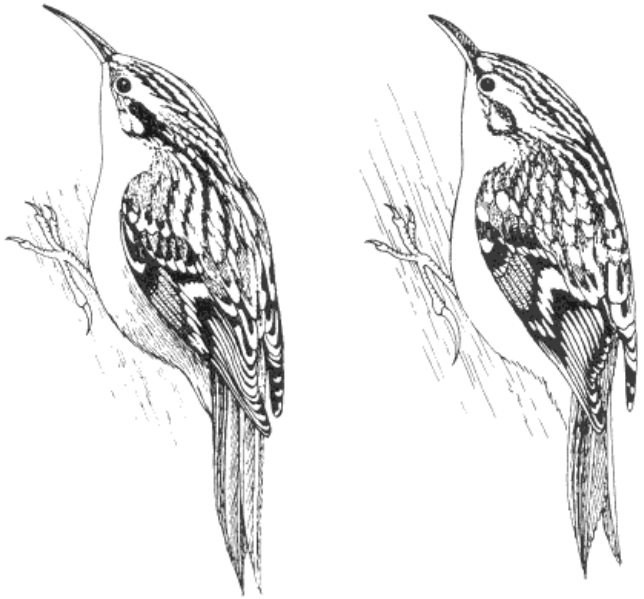
Problems?

1. Asexual species…
2. Fossils
3. Geographically separated
4. Hybridizers
5. Do we really do this?



Hybrids occur and it doesn't mean the two interbreeding are the same species.

Morphological Species Concept



Do they look the same?

Advantages?

Works well for fossils!

Problems?

How different is different?

Ex. Short-toed treecreeper (*Certhia brachydactyla*) (left) differs subtly from the common treecreeper (*C. familiaris*) (right) (www.mun.ca/biology/scarr/Fut_15_03_treecreepe...)

Often the first thing you do…until time or $$$ to …..

Phylogenetic or Evolutionary Species Concept

How long have these two groups been on separate evolutionary paths?

Reconstruct evolutionary history of populations

(often but not always infer through molecular genetic info)

EX. Shiitake Mushrooms (Donohue and Hibbett ’96)

Ranges from Japan, Thailand, Borneo, New Zealand and Tasmania

Widely cultivated

Threatened due to….

Researchers used all three

“species concepts”

- All are **reproductively compatible** (what does that mean)
- Morphological measurements clustered in 3 groups
- ribosomal RNA-4 distinct groups
- Basically there are **cryptic species** here

Lets apply our 3 concepts to our wolves

Can interbreed?
Yes! many *Canids* do!

Morphology?
Look different-RW is smaller, with longer ears and legs relative to body size, color different

Phylogenetic (genetic) analysis
examined 48,000 single nucleotide polymorphisms (SNPs) of red wolf, wolves from NE, our MN gray wolf, coyotes and dogs

Red wolves were 76-80 % coyote and 20-24 % gray wolf…

USFWS is a species

Whatever it is … considered extinct in the wild by 1980.

Captured individuals in ‘70s were combined with zoo populations to start a captive breeding program with **14** individuals….

Have introduced some back into wild.

Today 220 in captivity but only a small number have persisted in wild….about 100?

FYI..Mexican gray wolf is a subspecies

Canis lupus baileyi

http://www.fws.gov/species/species_accounts/bio_rwol.h

U.S. Fish & Wildlife Service

Red Wolf Recovery Program

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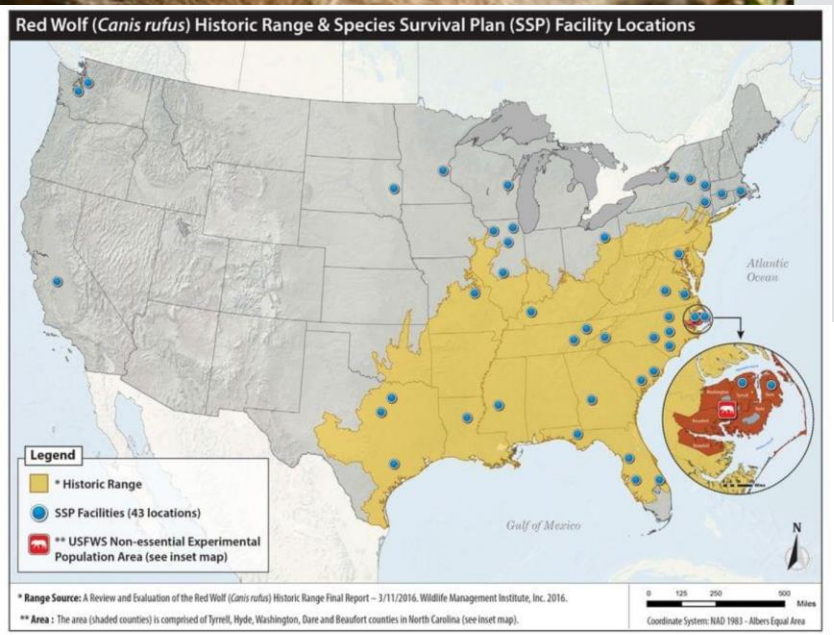
Wild by the Numbers

90-110

Estimated Population



Red wolf historic range with species survival plan facility locations. Map by Jose Barrios, USFWS.

Updated March 31, 2014

Table 1. Causes of mortality in wild red wolves (*Canis rufus*) 2011-2014.

Cause of Death	# of Total Mortalities 2011	# of Total Mortalities 2012	# of Total Mortalities 2013	# of Total Mortalities 2014
Natural				
Health-related	2	1		
Intraspecific competition	0	0		
Human-related				
Management-related actions	0	2		
Non-management-related actions	2	0	1	1
Vehicle strike	3	3	3	
Suspected or confirmed gunshot	7	8	9	2
Poison				
Unknown				
Lack of biomaterial	5	4		
Suspected illegal take	2	1	2	
Pending necropsies	0	0		1
Total Mortalities	21	19	15	4
Population Estimates				
Known wild red wolves (End of Year)	66	65	66	62
Estimated total wild red wolves	90-110	100-120	90-110	90-110

Status review shows the red wolf remains endangered

Work continues on future management of Eastern North Carolina experimental population

https://www.fws.gov/southeast/pdf/five-year-reviews/red-wolf-2018.pdf

April 24, 2018

The U.S. Fish and Wildlife Service today released a five-year status review and Species Status Assessment outlining the latest science and data supporting its recommendation for no change in the red wolf's overall status as endangered under the Endangered Species Act. The status review is required every five years and is based on the latest science and data included in a Species Status Assessment (SSA) that serves as the foundation for the recommendation.

Red Wolf Origin and Taxonomy

The red wolf (*C. rufus*) has generally been accepted as the valid designation for wolves in the southeastern United States; however, there is a lack of consensus among the scientific community regarding the taxonomy and genetic ancestry of the red wolf. For more than 30 years, various studies have reached conflicting conclusions as to the origin, and therefore, the correct taxonomic status of the red wolf. Since the 2007 5-year review, additional morphological and genetic studies have become available, all of which continue to reach conflicting conclusions.

Following slides are from that review mentioned…..

“In 2016, an expert workshop was convened to investigate and address key questions related to uncertainty surrounding hybridization and the potential increase in introgression with coyotes and challenges to survival of red wolves. **The main contribution of the workshop was the evaluation of competing evolutionary origin hypotheses for the red wolf, specifically whether the red wolf is a listable entity under the ESA (Pacifi and Mills 2016, p. 13). Although the attending experts did not reach consensus on a hypothesis**, they did agree that there was a logical and valid path to make a determination that the red wolf is a listable entity under the ESA either as a species (*C. rufus*), a subspecies or distinct population segment (DPS) of eastern wolf (*C. lycaon*), or a subspecies or DPS of gray wolf (*C. lupus*) (Pacifi and Mills 2016, p. 16). However, even with this conclusion, the Service must ensure the red wolf meets the definition of species under the ESA. **The term “species” under the ESA includes any subspecies of fish or wildlife or plants, and any DPS of any species of vertebrate fish or wildlife which interbreeds when mature. “**

“Genetic studies present conflicting interpretations and offer various theories on the origin of the red wolf and recommendations on the correct taxonomic status. **There are three main theories on the origin of the red wolf: (1) the red wolf originated from ancient hybridization between gray wolves and coyotes, (2) the red wolf originated from recent (post European colonization) hybridization between gray wolves and coyotes, and (3) the red wolf evolved from a common ancestor with the coyote, but is of a lineage divergent from coyotes.** Additionally, one of the mammal taxonomy authorities (Wilson and Reeder, Mammal Species of the World Third Edition 2005) **does not recognize the red wolf as a distinct species, but does recognize it as a subspecies of gray wolf.** Given the fact that the scientific community is not in agreement on the question of red wolf taxonomy, in 2017, the USFWS conducted a review of all the evidence related to red wolf taxonomy. **The most recent scientific publications continue to provide conflicting interpretations and support for different theories of origin, specifically theories 2 and 3 above; therefore, USFWS continues to recognize the red wolf as the species *Canis rufus*.”**

2025

BMOLS Research Presentations

REGENTS 4TH FLOOR ATRIUM

ALL ARE INVITED TO ATTEND THE POSTER PRESENTATIONS, LEARN ABOUT BIOMOLECULAR SCIENCE RESEARCH OPPORTUNITIES, AND CELEBRATE OUR SENIORS.

MONDAY

APRIL 28

4-5 PM

SNACKS AND CAKE WILL BE SERVED

Topics for this Chapter

- How do we define species?
- **How do new species form?**
- Fate of hybrid zones
- Reproductive barriers
- Problems with bacteria
- Bears, bears, bears

How do new species form? (speciation)

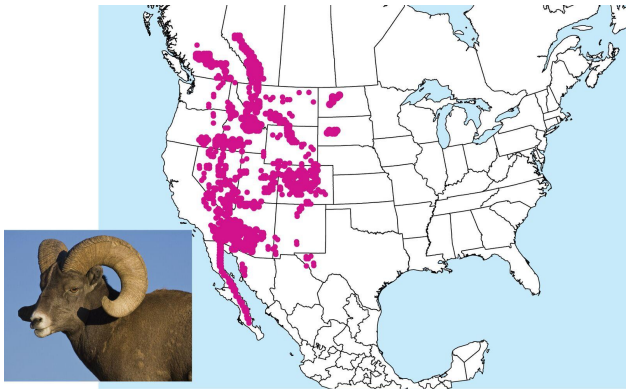
Two step process..

1. Must become separated, isolated or cut off from other populations…

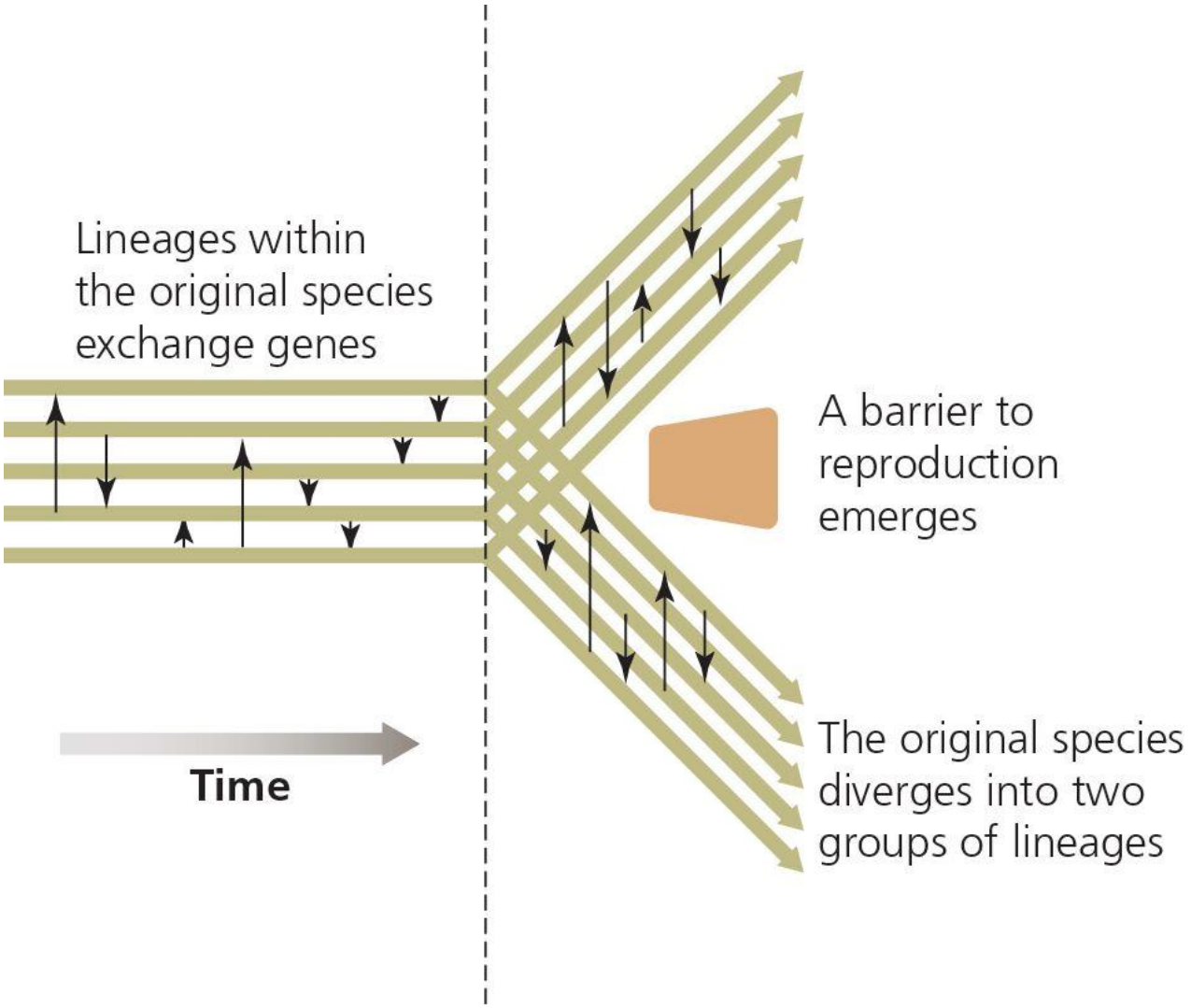
Genes must stop flowing
Populations must become reproductively isolated

2. Once reproductively isolated may see differences accumulate.

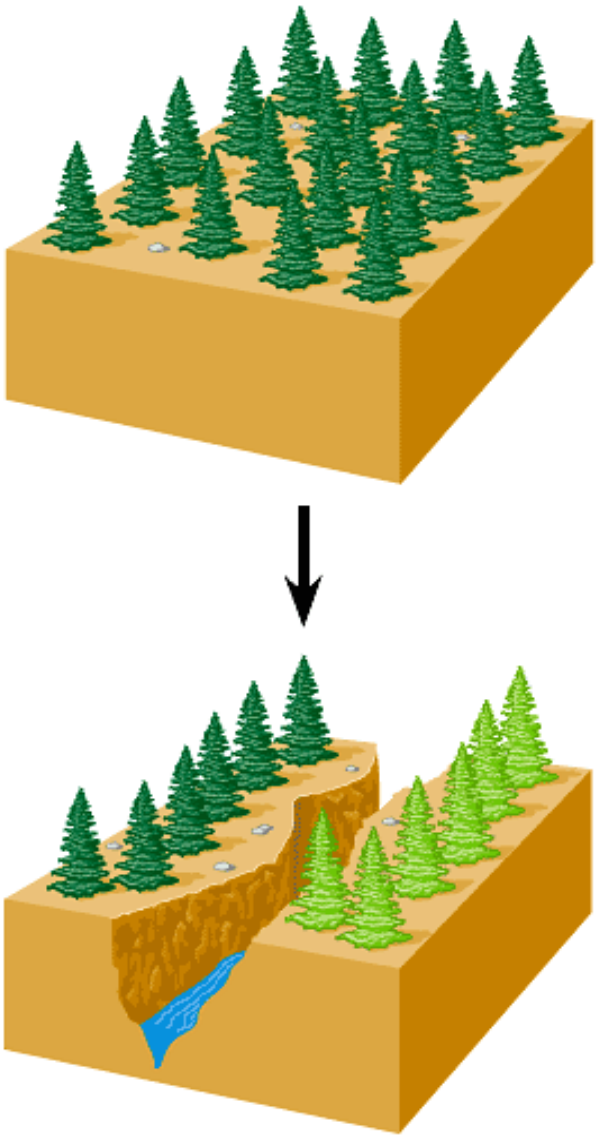
What factors or forces might drive two populations to accumulate differences over time?



River of Genes (concept introduce by Dawkins)



Different ways of isolating or separating a population…

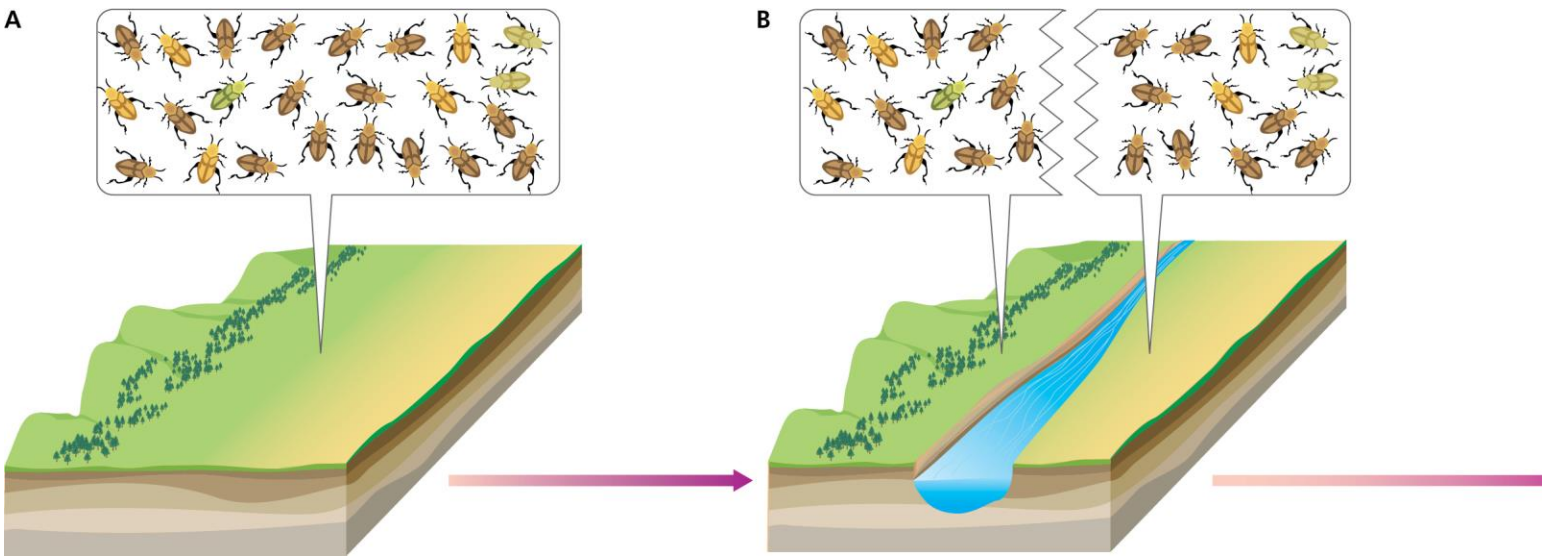


(a) Allopatric speciation

What happened here?

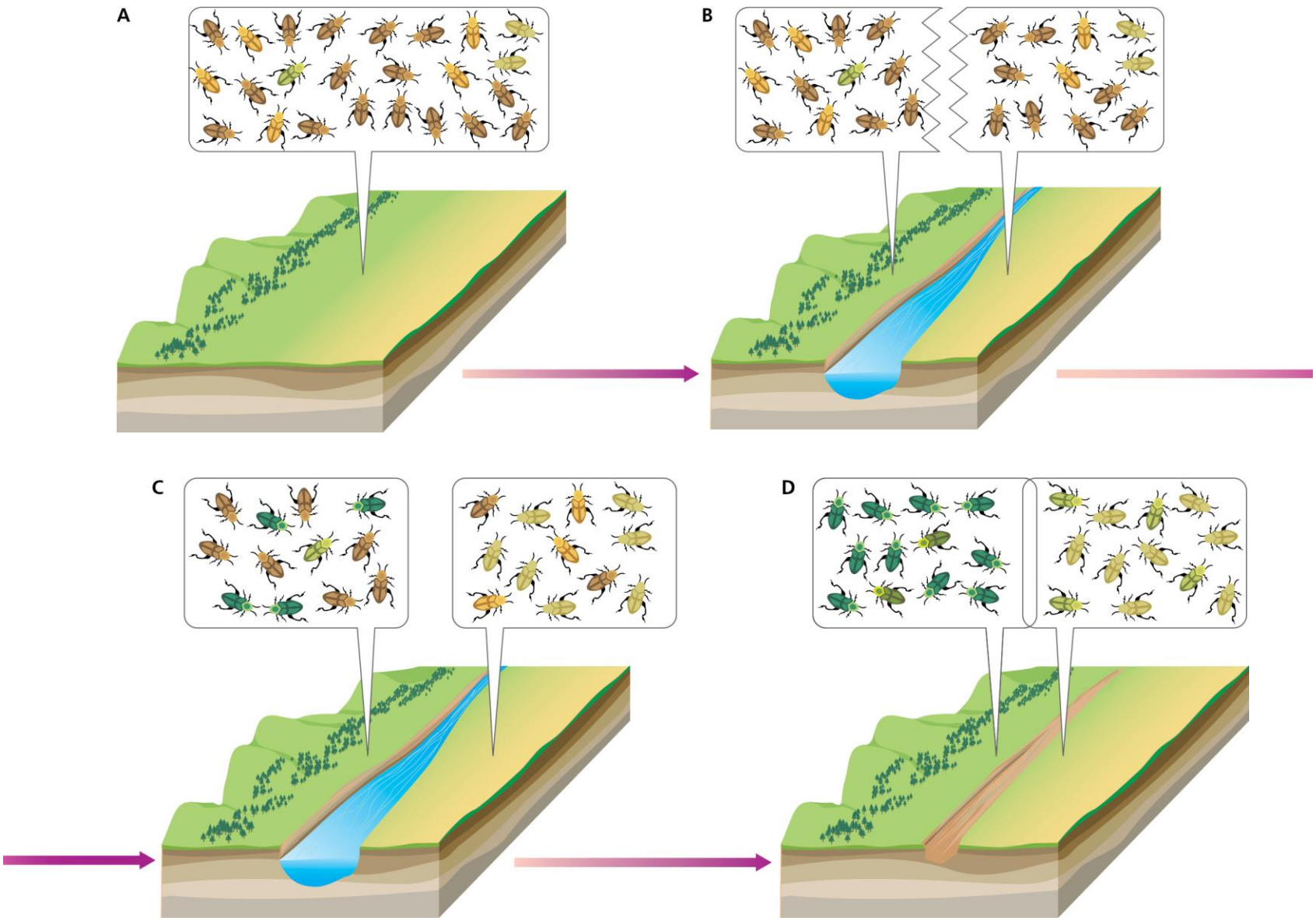
First way of isolating a population is through Allopatry-we call this Allopatric speciation.

Allopatric speciation



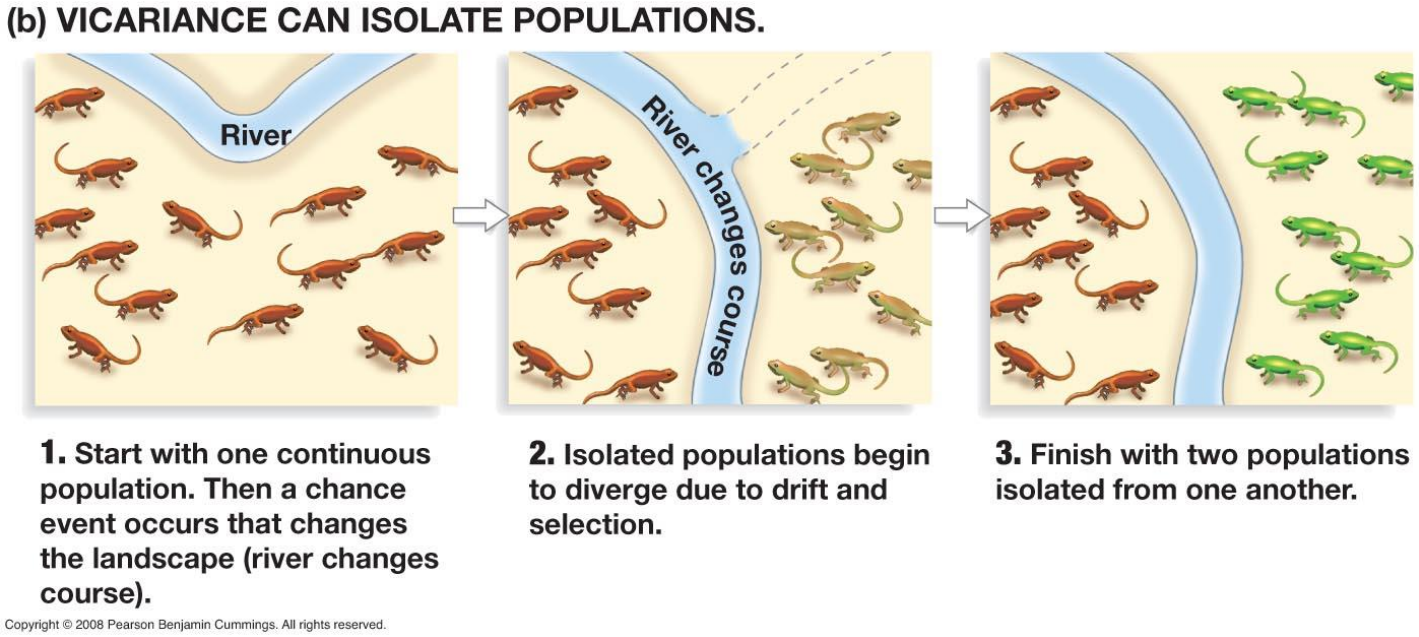
Then over time…

Allopatric speciation



Two kinds of Allopatric
(your text does not distinguish between these)

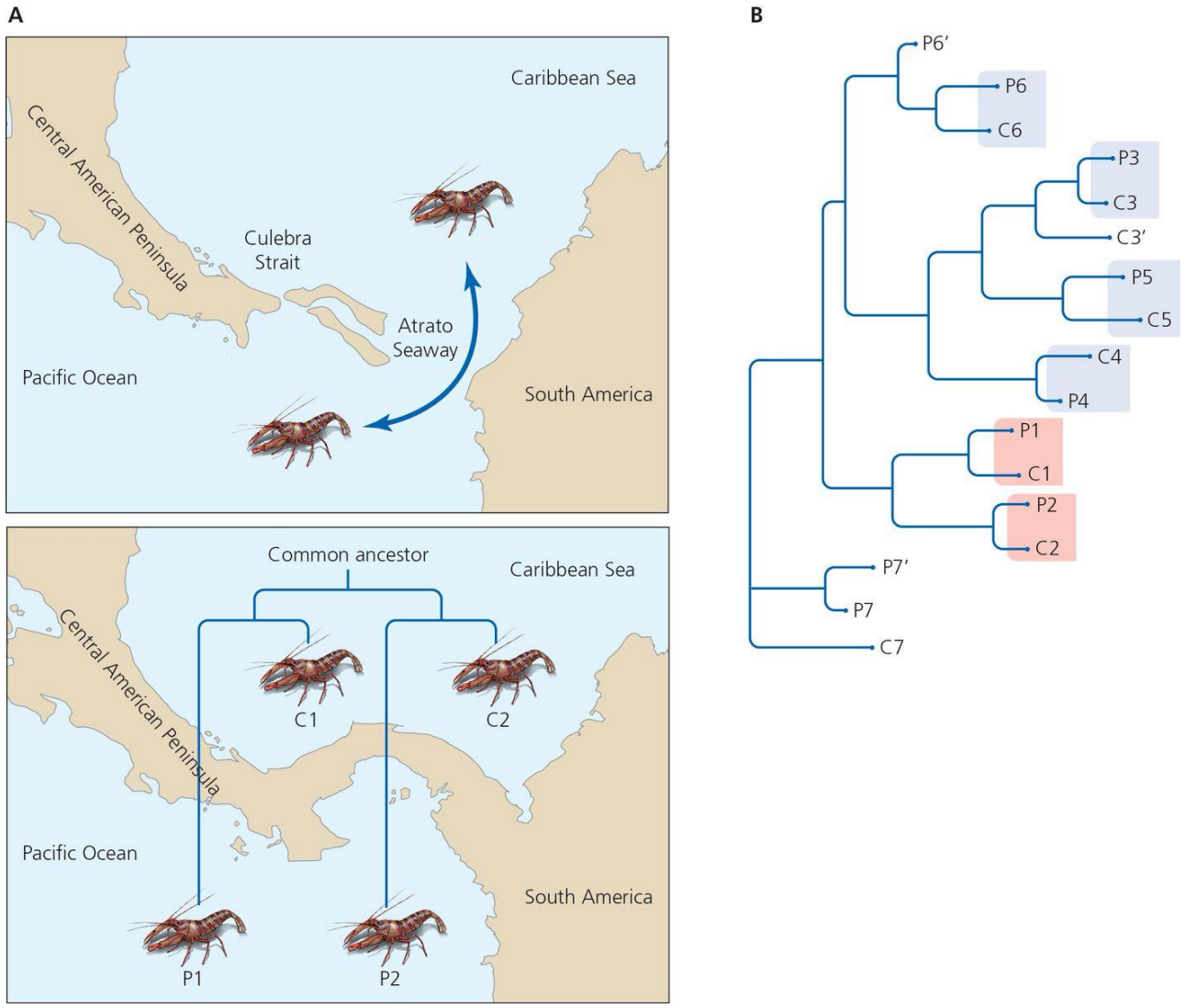
1. Vicariance events- pop is split into two or more parts



What is with the color change??

Ex. Shrimp in Pacific and Caribbean p428

Phylogenetic evidence for allopatric speciation



EX. Grand Canyon.. Antelope squirrels

Other vicariance events

(rivers and canyons are not the only landscape features that divide or generate barriers between populations…glaciers do this too)

EX. Orioles-east and west populations separated by glaciers until 15,000yrs ago

The Bullock's Oriole (left) and Baltimore Oriole (right) were once lumped together as one species, the Northern Oriole, because they can mate and produce viable offspring. *Photos by Brian Small.*

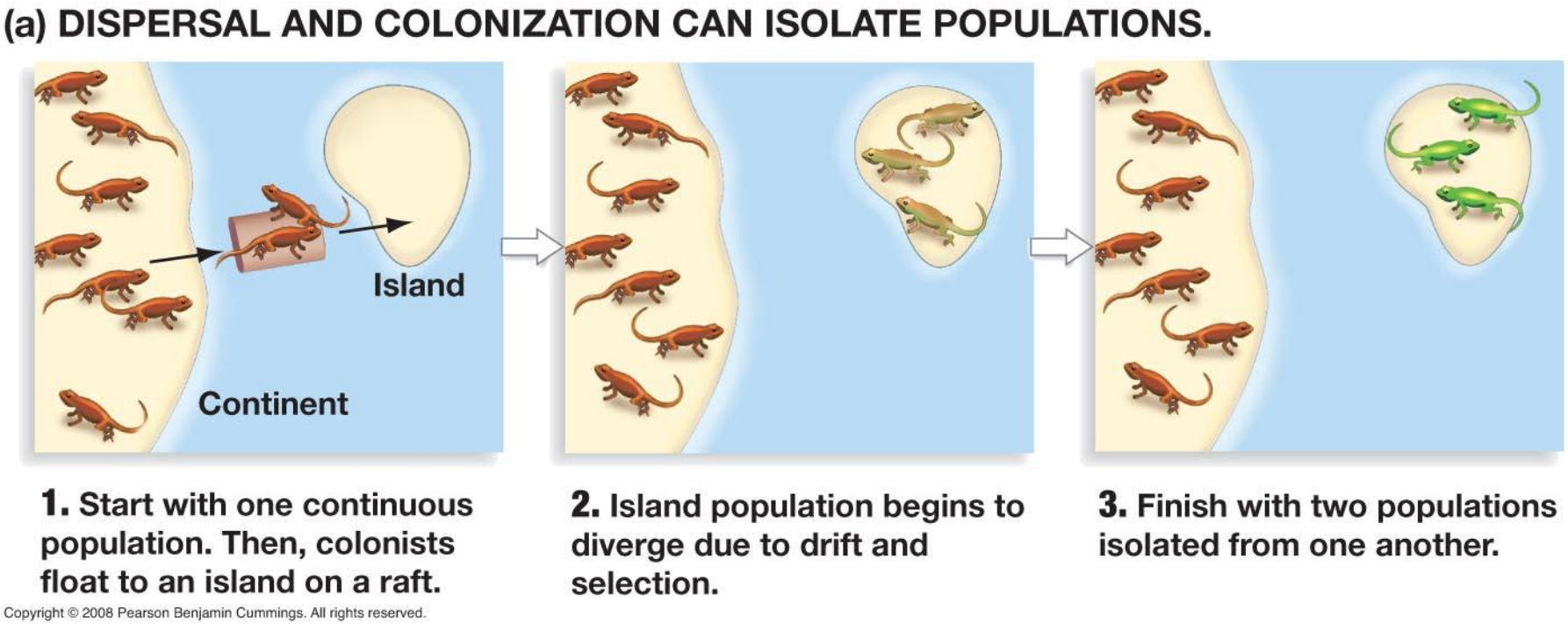
https://www.allaboutbirds.org/news/whats-in-a-name-how-genome-mapping-can-make-it-harder-to-tell-species-apart/

Allopatric Speciation

1. Vicariance events

2. Founder events

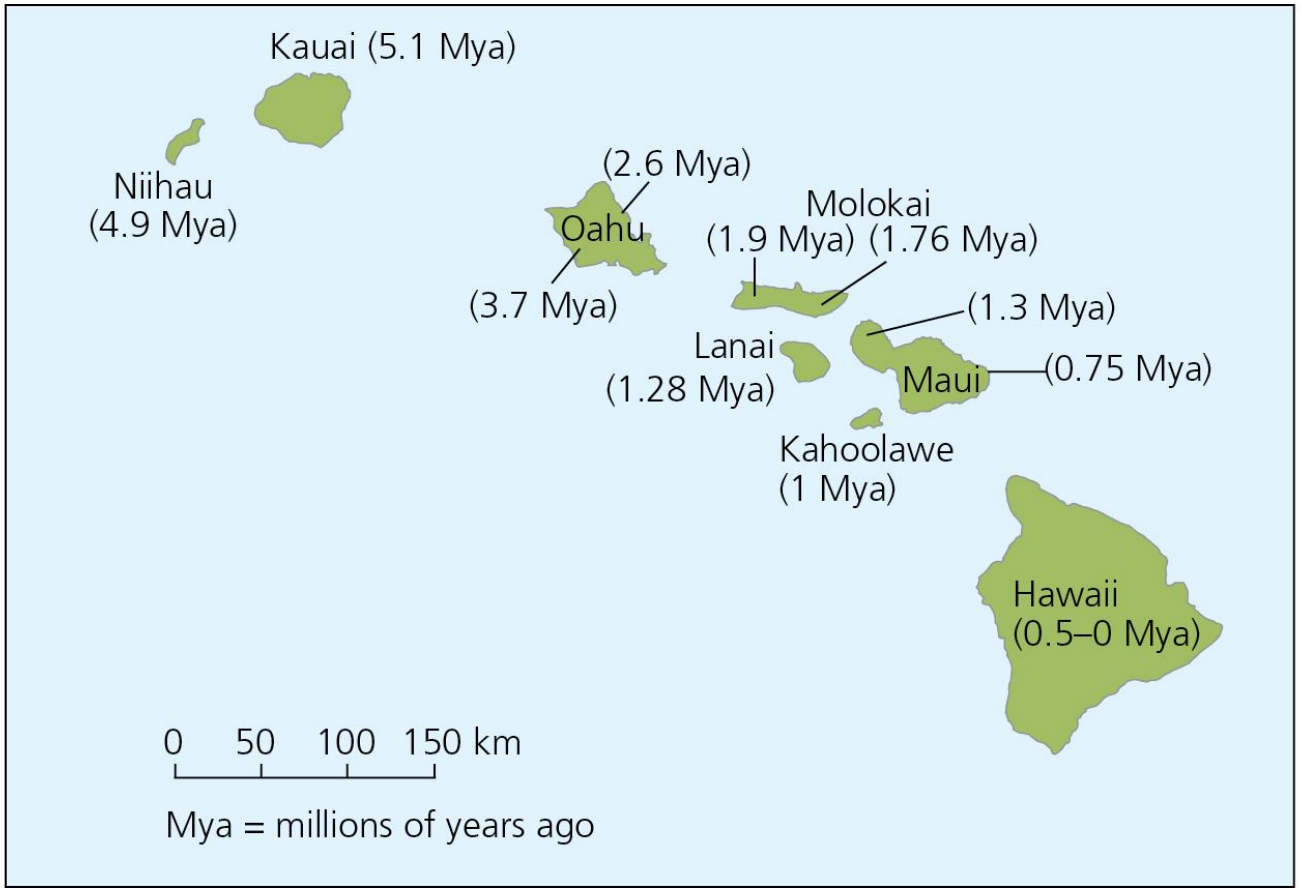
Individuals arrive at new island, isolated valley, ponds



Ex. Galapagos finches!

Islands provide opportunity for allopatric speciation

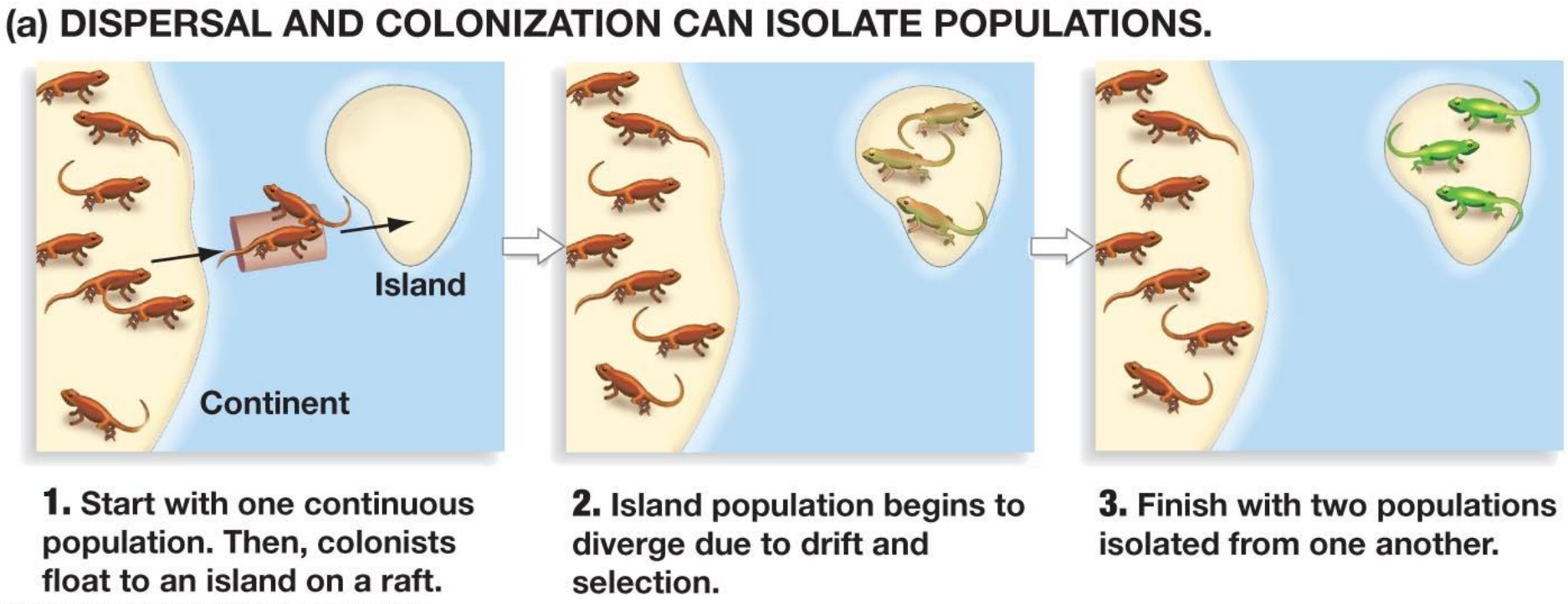
(Text example of crickets fits in here too…but I am not going to focus on.)



Ex. Snails in Hawaii
Experienced a series of founder events as they cross into valleys and then became isolated there.

What affects the likelihood of speciation occurring? (in either a vicariance or founder event situation)

Pops are on different islands-what factors will influence whether they speciate or evolve to be quite different after being separated….?

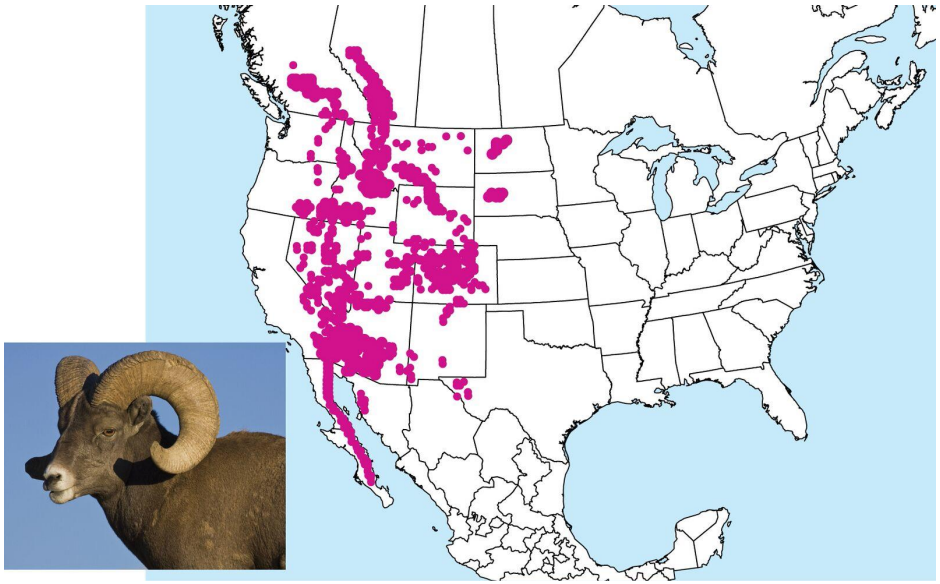


Likelihood of speciation may

Depend on **selective pressures** in each location…..

More likely if..

Less likely if…



Depend on **size** of population…

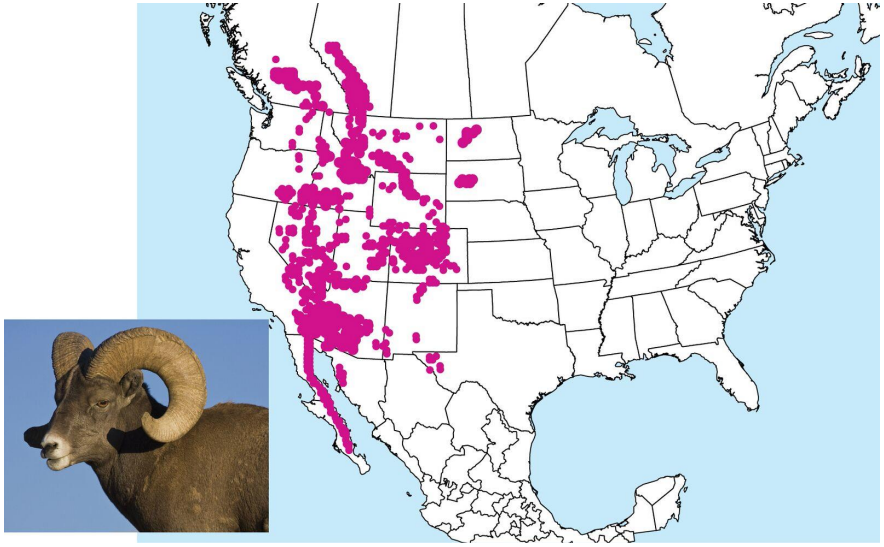
More likely if..

Less likely if…

Depend on **passage of time**…

More likely if..

Less likely if…



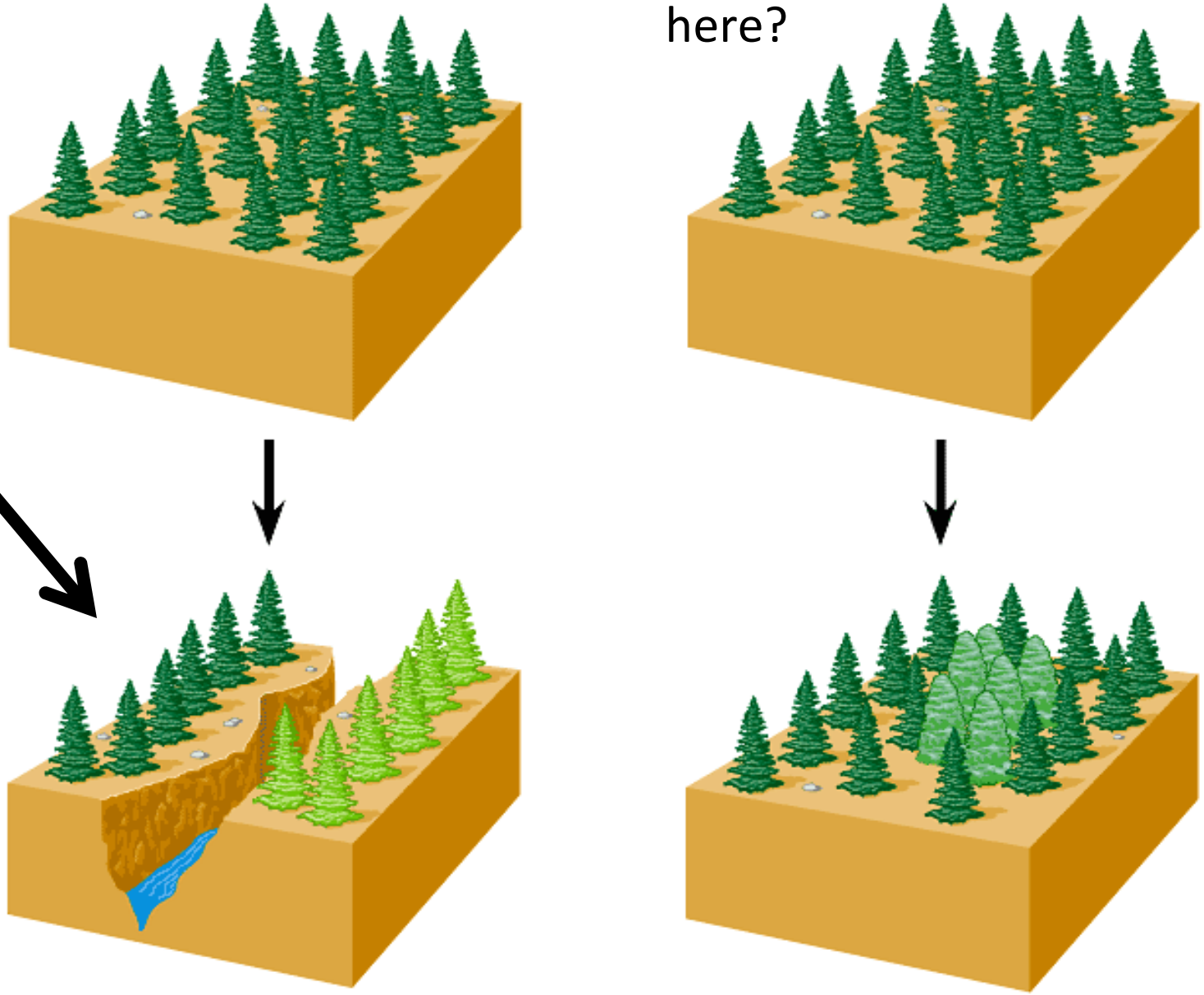
Remember

What stops gene flow in one species will be different from what stops gene flow in another species.

A feature in the landscape (a barrier) that might stop gene flow for a snail, a terrestrial beetle or a small rodent would not work for a bird or large mammal!

So is this a good visual to represent allopatric speciation?

Now what is happening here?



(a) Allopatric speciation

(b) Sympatric speciation

- Allopatric
    1. Vicariance
    2. Founder

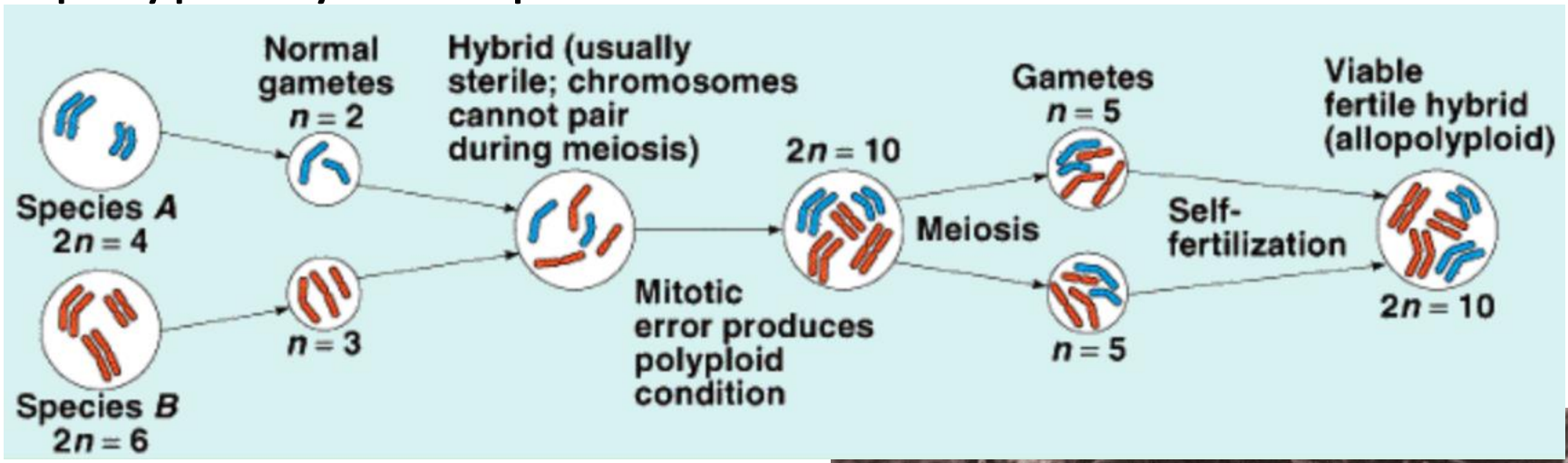
- Sympatric Speciation
    1. Polyploidy
    2. “meet and mate” (my language) **Skip**

Sympatric Speciation occurs within the geographic range of parent species-gene flow is theoretically possible..

Polyploidy (allopolyploidy and autopolyploidy)

De Vries-primrose

Allopolyploidy-two species



Autopolyploidy-one species

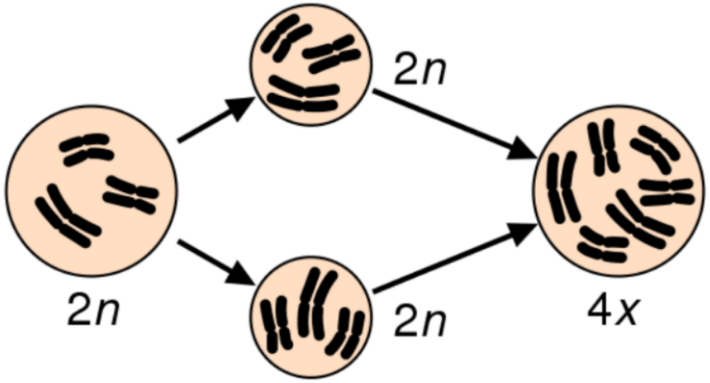
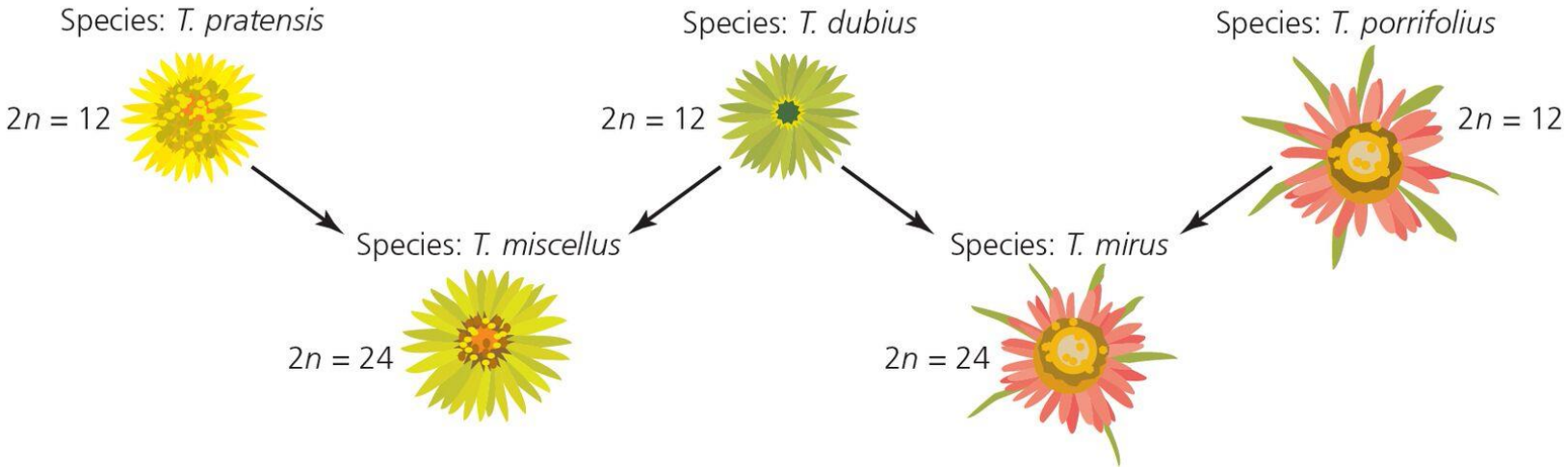


Figure 1: Autopolyploidy

Goat's beard-a local roadside species!

Genus: *Tragopogon*



Polyploidy is an instant, easy, way to make a new species in **plants**..extremely common

(we went over this example earlier in semester)

Oats, cotton, potatoes, tobacco, wheat…..

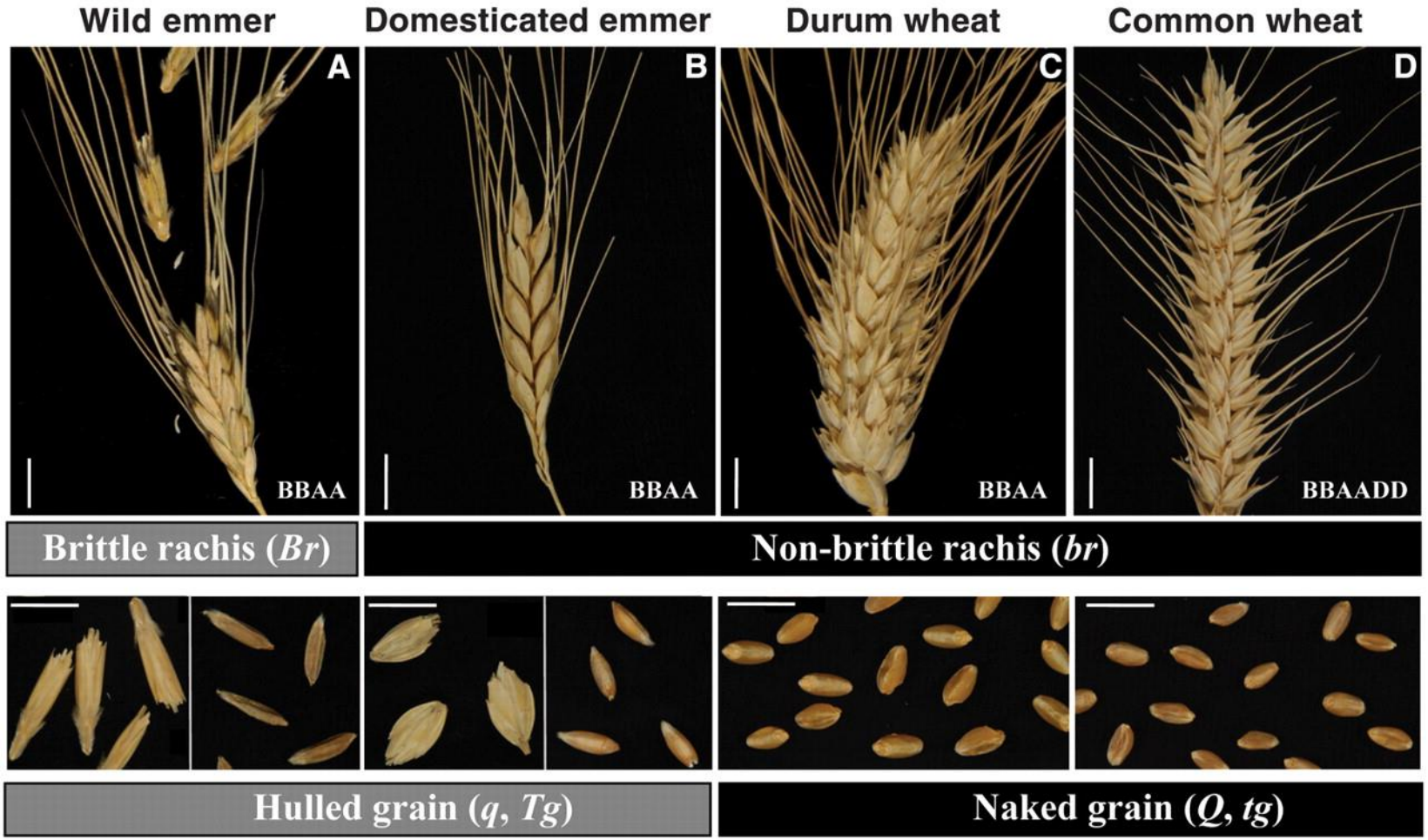
Wild wheat is normal and diploid (2x) like us…but has 2 each of 7 different chromosomes=14 chromosomes total

Durum wheat is 4x=tetraploid

Bread wheat is 6x=hexaploid

Spelt wheat is 6x=hexaploid

Fig. 1. Wheat spikes showing (A) brittle rachis, (B to D) nonbrittle rachis, (A and B) hulled grain, and (C and D) naked grain.



Jorge Dubcovsky, and Jan Dvorak Science 2007;316:1862-1866

- Allopatric
    1. Vicariance
    2. Founder

- Sympatric Speciation
    1. Polyploidy - common
    2. “meet and mate” (my language) Cool but **Skip**

Sympatric Speciation occurs within the geographic range of parent species-gene flow is theoretically possible..

Topics for this Chapter

- How do we define species?
- How do new species form?
- **Fate of hybrid zones**
- Reproductive barriers
- Problems with bacteria
- Bears, bears, bears

NOW what can happen when **two species ranges** begin to overlap?

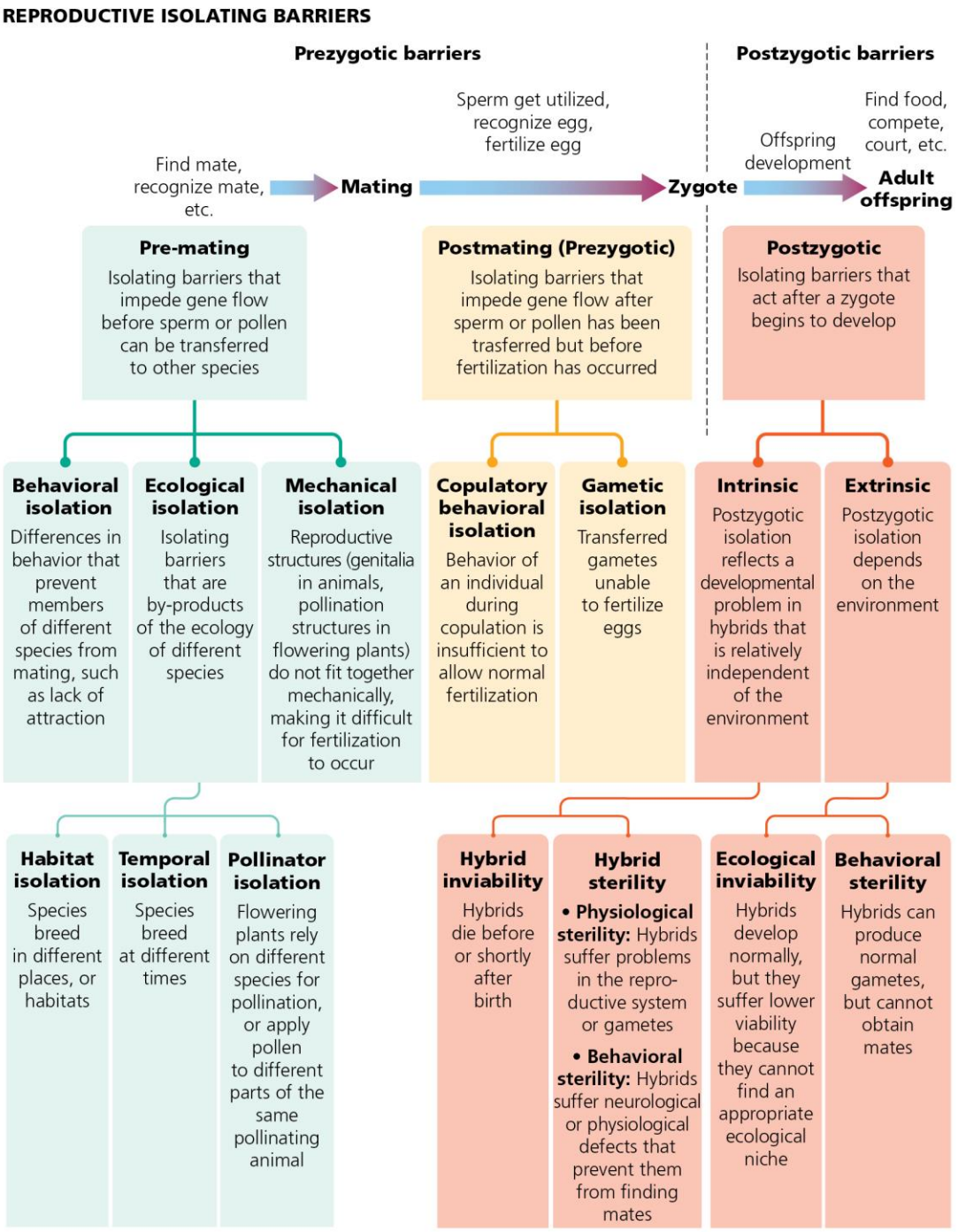
Imagine one species diverged into two species because they were geographically separated by glaciers.

As the glaciers recede what are the possible outcomes?

A. Sometimes they are fully reproductively isolated or reproductive barriers may prevent them from interbreeding.

What does this mean?
Why might they not interbreed?
Tons of examples!

Overview of different ways of reproductively isolating two species



My Overview of actual examples in text….

(All of these can keep species from breeding with one another and thus keep them separate species…)

1. What fruits you meet on to mate and lay your eggs (flies)
2. Timing of when you release your eggs and sperm in to the ocean (corals)
3. Who pollinates your flowers and when are they pollinated (monkey flowers)
4. What flashing pattern you flash when advertising to mate (lightening bug)
5. Whether the lock gets stuck in the keyhole of the female (carabus beetles)
6. Whether your sperm's binding patterns recognize eggs of your species in the ocean (sea urchins)
7. Whether your offspring are fertile or not (mules =donkey x horse cross)

NOW what can happen when **two species ranges** begin to overlap?

Imagine one species diverged into two species because they were geographically separated by glaciers.

As the glaciers recede what are the possible outcomes?

A. Sometimes they are fully reproductively isolated (reproductive barriers may prevent them from interbreeding)

What does this mean?
Why might they not interbreed?
Tons of examples!

B. Sometimes they interbreed and hybrid individuals might survive creating a **hybrid zone**.

Several interesting things happen in hybrid zones!

B. Sometimes they interbreed and hybrid individuals might survive creating a **hybrid zone**. (**SKIP**)

Bullock's (left) and Baltimore (right) Orioles often hybridize in the Great Plains, creating intermediates like the hybrid at center. *Photos, left to right: Brian Small, Bryan Calk/Macaulay Library, David Speiser.*

Over time this hybrid zone might…. https://www.allaboutbirds.org/analysis-hybrid-birds-are-supercolliders-of-speciation/

1. **Fuse** - hybrids interbreed successfully with parental populations across generations-**cline**
2. **Be a stable hybrid zone** - continue to produce hybrids (some of whom have some reproductive issues so don't do great but do ok…)

B. Sometimes they interbreed

1. **Fuse**
2. **Hybrid zone**
3. **Reinforcement might evolve**! (**SKIP**)

What is this?

When hybrids are less fit we often see selection in favor of individuals that prefer to mate with their own species!

"pickiness for own species evolves"

Maybe they develop the ability to perceive differences in mating song (if a bird) (short finch video we watched?)

Any individuals that have that ability will be selected for.

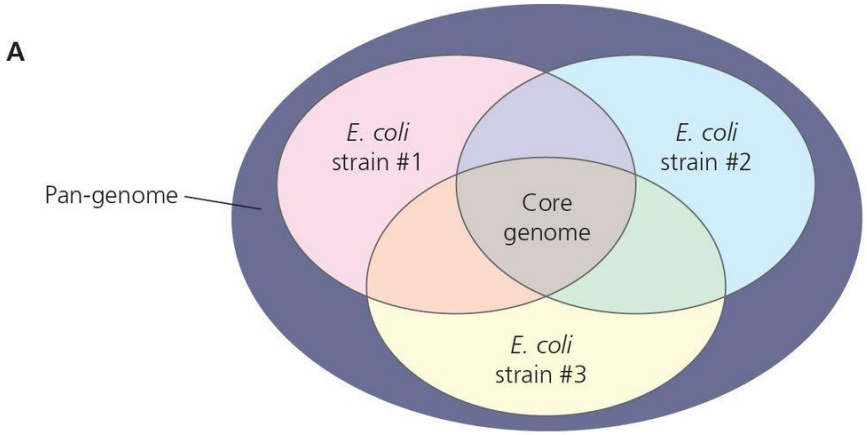
- How do we define species?
- Reproductive barriers exist!
- How do new species form?
- Fate of hybrid zones
- **Problems with bacteria**
- Bears, bears, bears

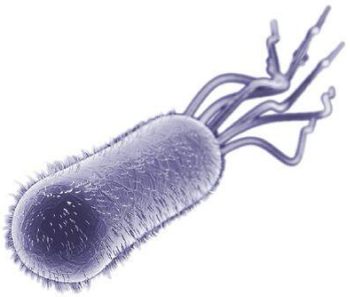
What are some of these problems with defining species in bacteria?
(Go back to our species concepts or species "definitions.")

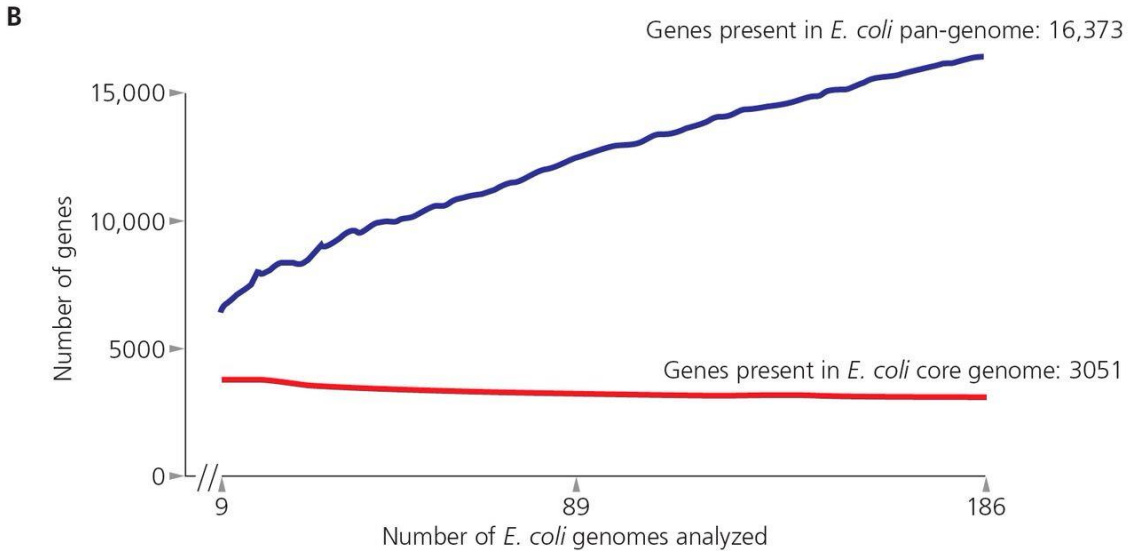
1. Interbreeding?
2. Morphology?
3. Phylogenetic (this can work-kind of)

Three strains of single species had only a small part of their genome in common!

The **genetic structuring** of bacterial populations is totally different than in Eukaryotes!

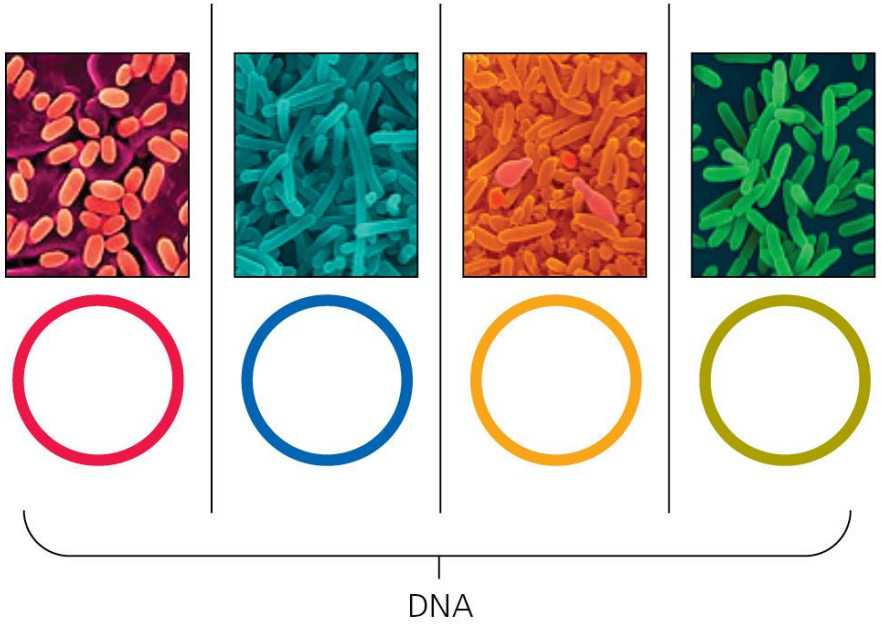




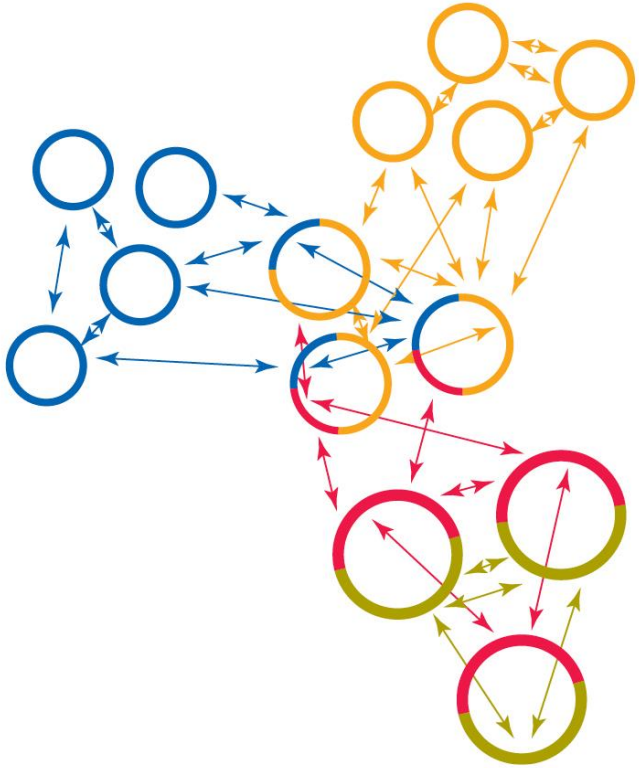


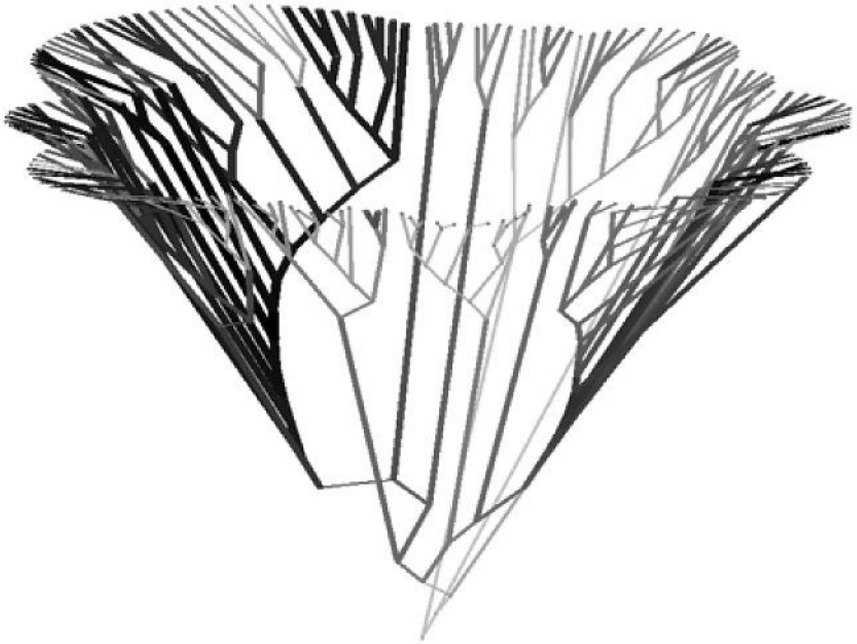
Horizontal gene transfer really messes things up when we are trying to define species!

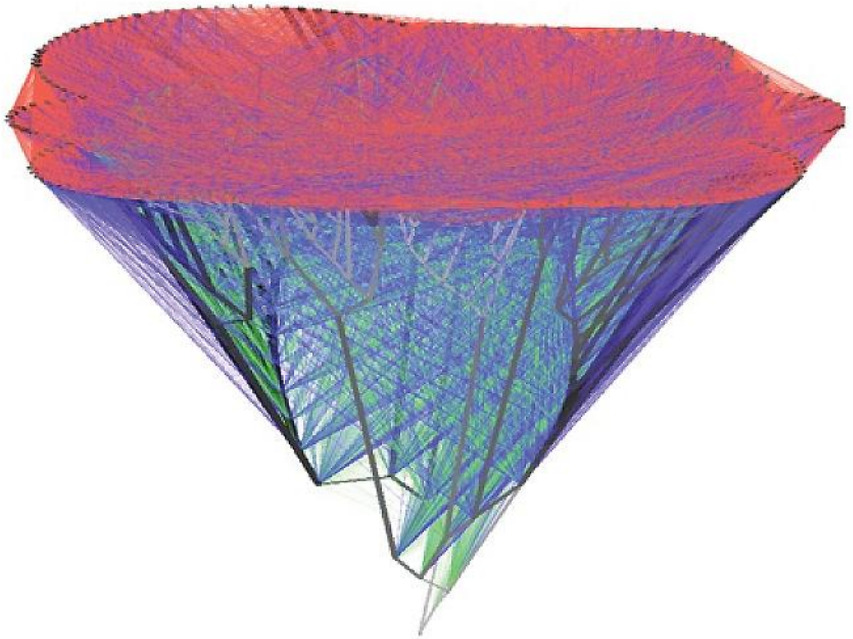
Instead of being neatly divided by species barriers ...



...the genomes of microbes have been mixed together by horizontal gene transfer.







Horizontal gene transfer is common..basically gene flow in bacteria is HGT!

This is what happens when we try to visualize it.

Bears, bears, bears

Polar bears diverged from brown or grizzly bears pretty recently.

(FYI there are also black bears - that is what we have in MN)

Hypothesis for divergence date #1 based on fossils 150,000-800,000

Hypothesis for divergence date #2 based on molecular clock 343,00-479,000

Population that evolved into polar bears were probably an isolated population of brown bears that began to experience strong selection for certain traits.

How do we figure out whether differences in genes between the two are a result of selection?

"strong selection can sweep alleles to fixation, carrying with them flanking stretches of DNA" p435

(So just like lactase persistence!)

Many of the regions that show signs of strong selection are important to their new ecological niche (their way of life)

- One region involved in pigmentation
  Why important?
- One region helps them handle large amouts of cholesterol
  Why important?
- One region is related to heart function
  Why important?

Gene flow between these two species has occurred since divergence (interbreeding, introgression or admixture)

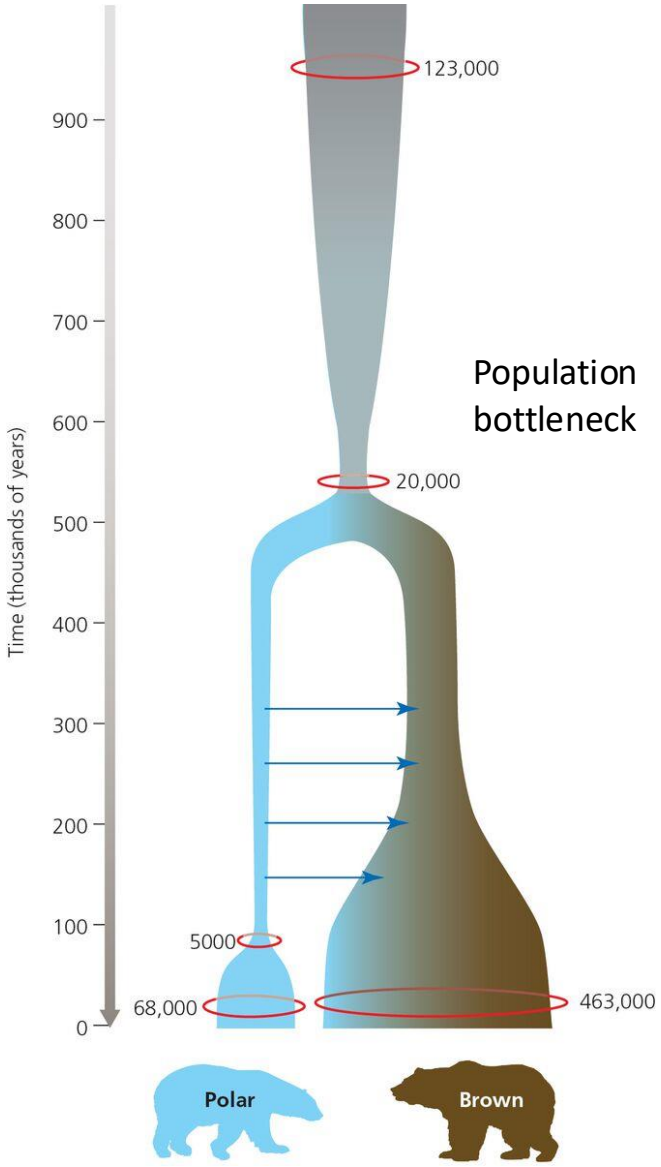
But only occurring in one direction!

Given the gene flow graphic whose genes are being selected against in which habitat?

What might cause polar bear genes to show up in brown bear populations when brown bear genes are NOT showing up in polar bear populations?

Brown bear genes in polar bear habitat!

Has happened in past but may be becoming more common due to climate change!



If you found a hybrid bear, how could you tell what species the mother was and what species the father was?

Be sure to Read
Love in the time of climate change.

Grizzlies and polar bears are now mating

You might consider checking in on your understanding of the following review questions….

- Speciation is always about stopping_____.
- What are the three main species concepts we talked about?
- What is allopatric speciation?
- What are the two different kinds of allopatric speciation?
- Sympatric speciation is….?

RESEARCH ARTICLE | EVOLUTION

Iguanas rafted more than 8,000 km from North America to Fiji

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Abstract

Founder-event speciation can occur when one or more organisms colonize a distant, unoccupied area via long-distance dispersal, leading to the evolution of a new species lineage. Species radiations established by long-distance, and especially transoceanic, dispersal can cause substantial shifts in regional biodiversity. Here, we investigate the occurrence and timing of the greatest known long-distance oceanic dispersal event in the history of terrestrial vertebrates—the rafting of iguanas from North America to Fiji. Iguanas are large-bodied herbivores that are well-known overwater dispersers, including species that colonized the Caribbean and the Galápagos islands. However, the origin of Fijian iguanas had not been comprehensively tested. We estimated the phylogenetic relationships and evolutionary timescale of the iguanid lizard radiation using genome-wide exons and ultraconserved elements (UCEs). Those data indicate that the closest living relative of extant Fijian iguanas is the North American desert iguana and that the two taxa likely diverged during the late Paleogene near or after the onset of volcanism that produced the Fijian archipelago. Biogeographic models estimate North America as the most probable ancestral range of Fijian iguanas. Our analyses support the hypothesis that iguanas reached Fiji via an extraordinary oceanic dispersal event from western North America, and which spanned a fifth of the earth's circumference (>8,000 km). Overwater rafting of iguanas from North America to Fiji strengthens the importance of founder-event speciation in the diversification of iguanids and elucidates the scope of long-distance dispersal across terrestrial vertebrates.