

# **LS1101**

# **Introduction to Biology**

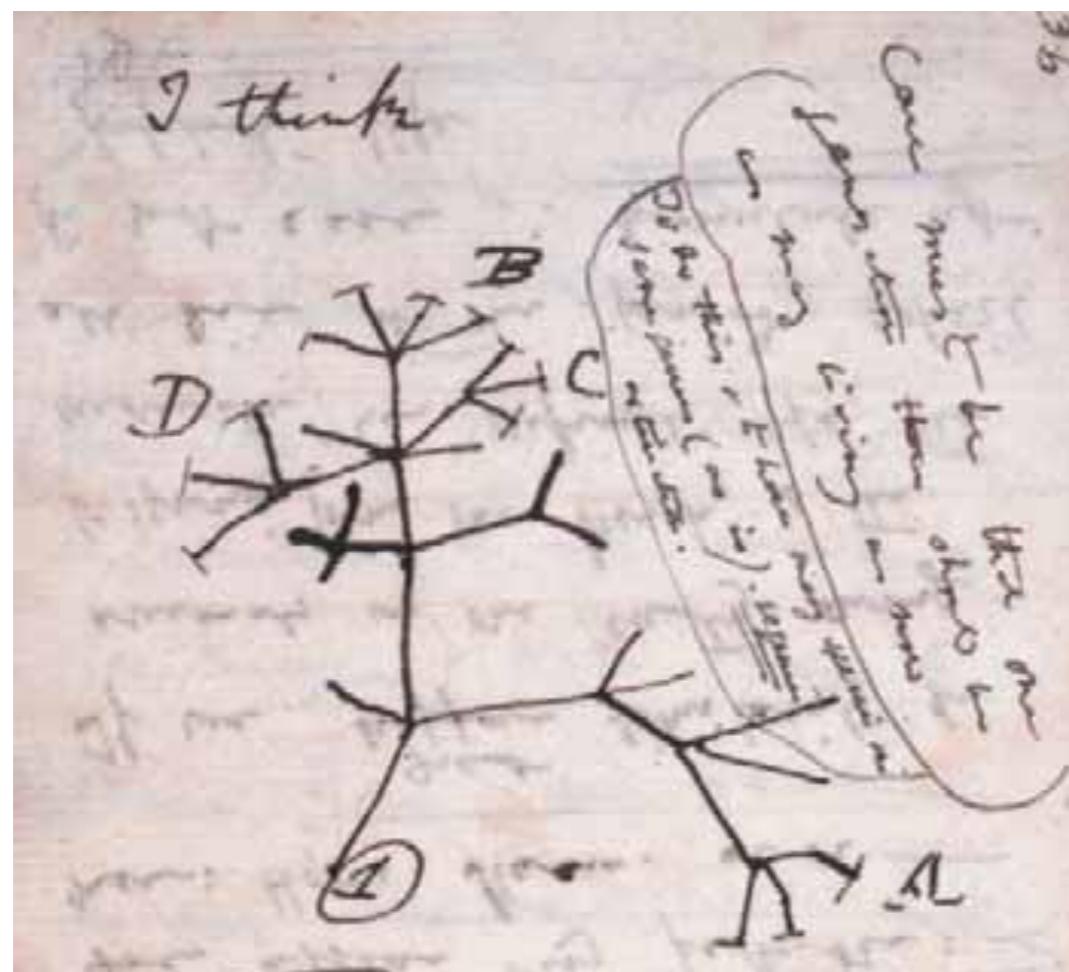
**Test on 24th January!!**

**Radhika Venkatesan**

# 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.



**Every time speciation happens, the diversity increases!!**

**Phylum**

**Order**

**Family**

**Genus**

**Species**

**Brassica**

***B. napus***

***B. nigra***

***B. rapa***

***B. juncea***

***B. oleracea***

***B. narinosa***

***B. elongata***



***P. tigris***

**Panthera**



***P. leo***



***P. onca***



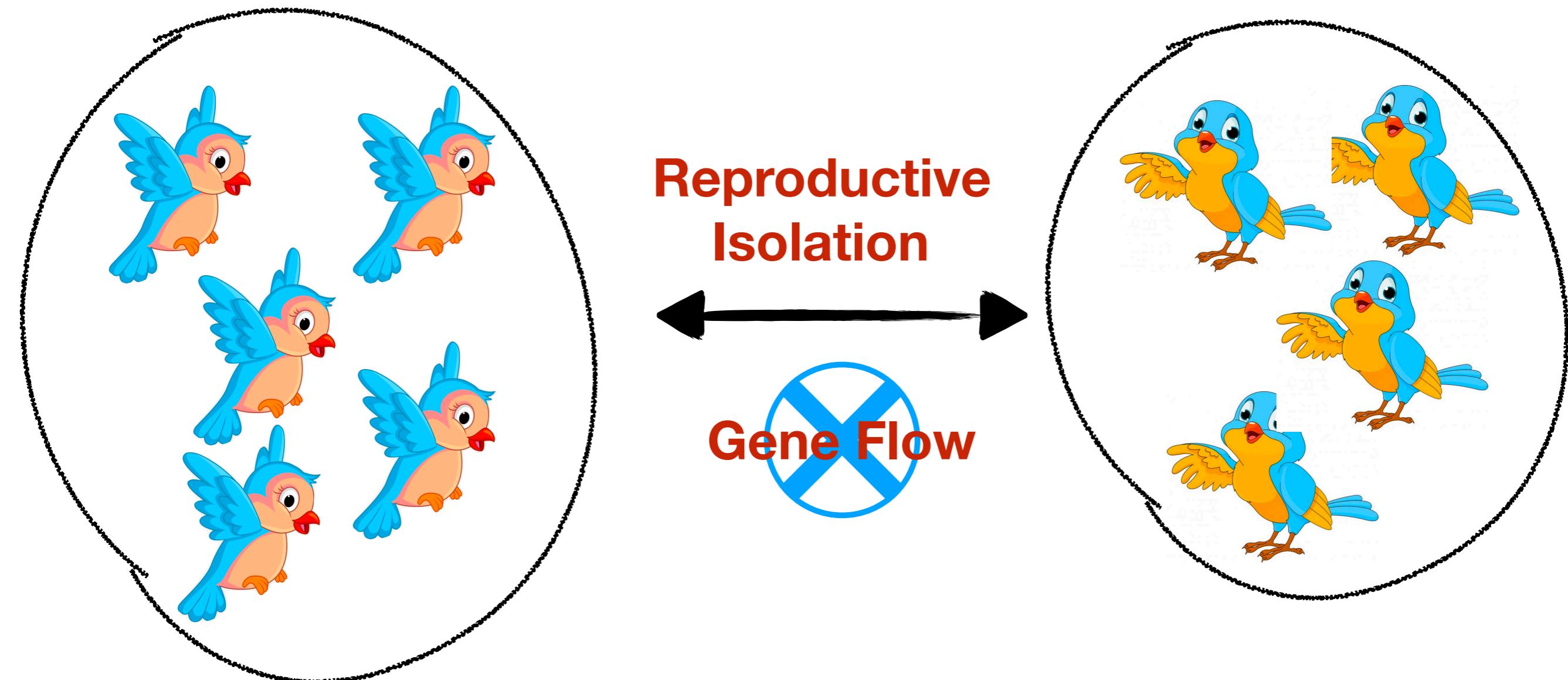
***P. pardus***



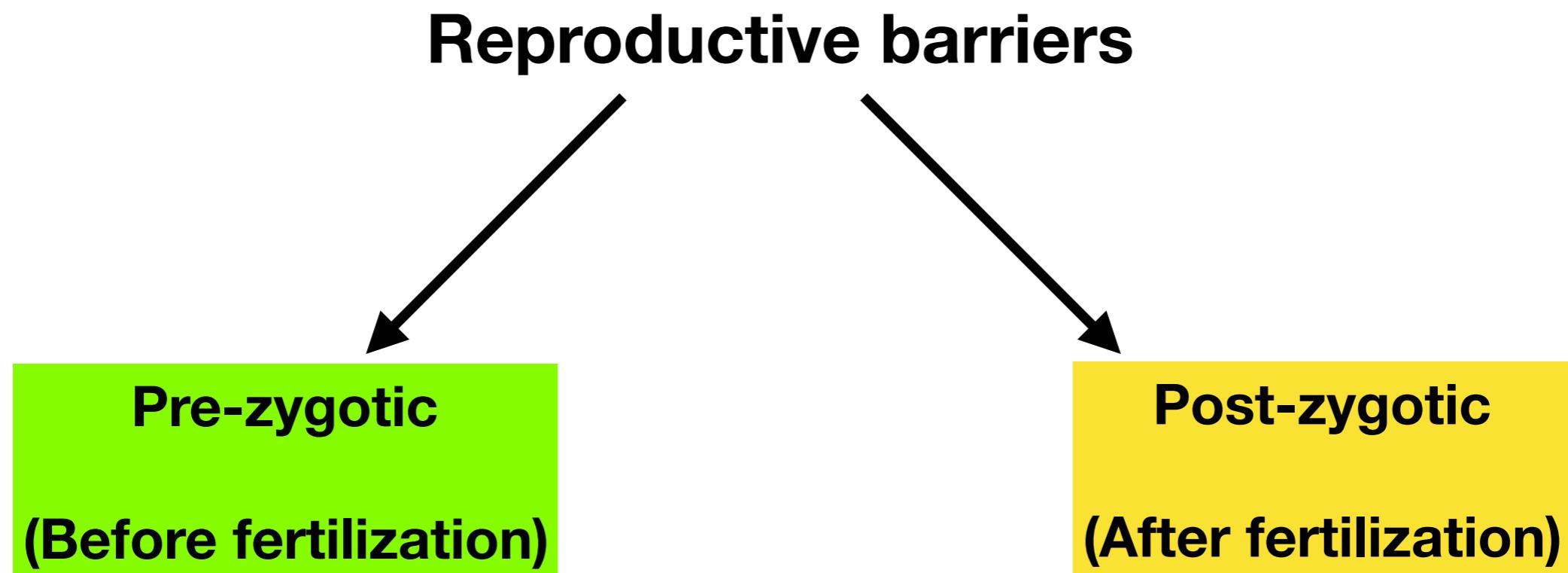
***P. uncia***



# 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



## **Post-zygotic (After fertilization)**

### **Zygote Mortality: Gametic isolation**

Purple sea urchin  
(*Strongylocentrotus purpuratus*)

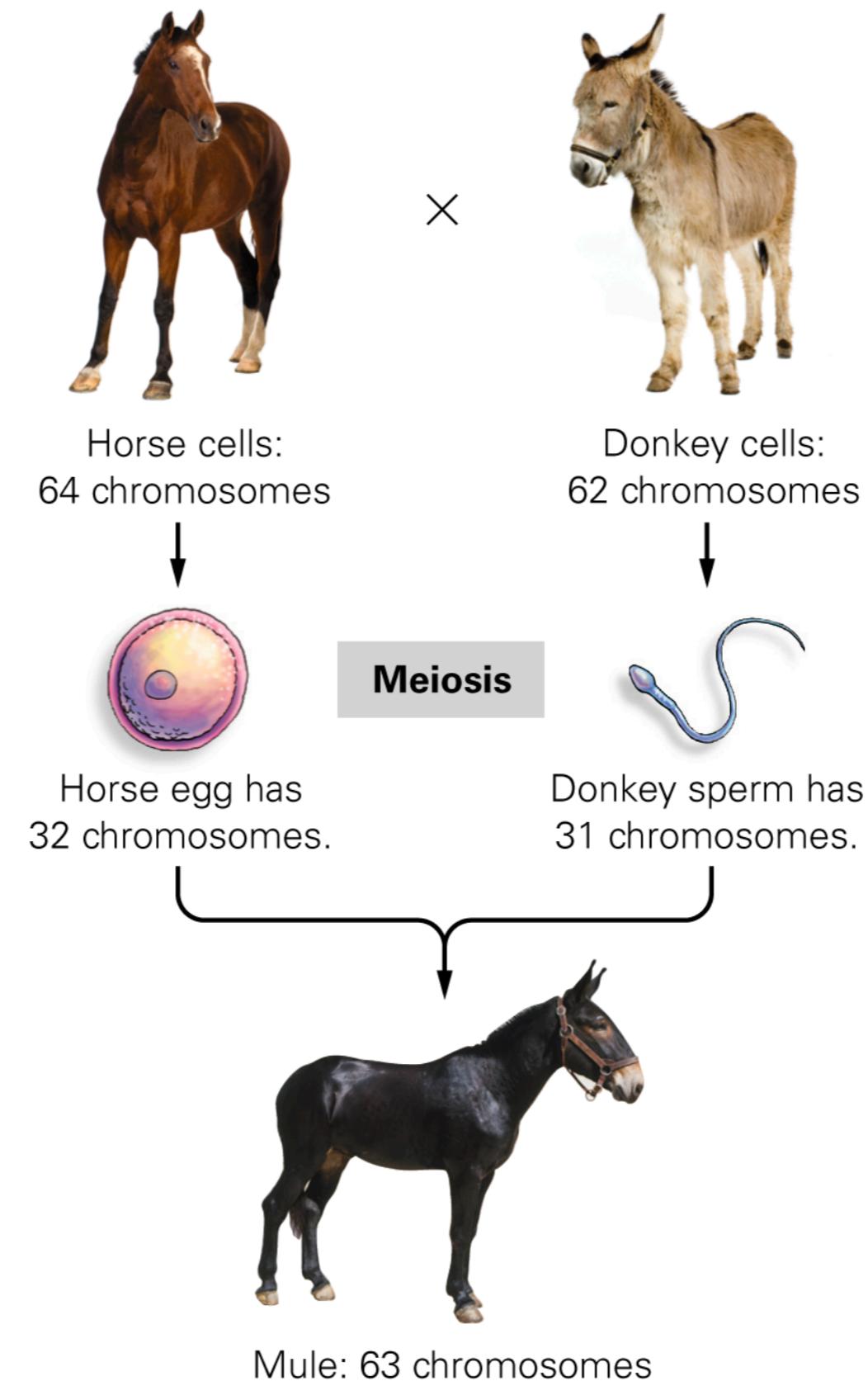


Red sea urchin  
(*Strongylocentrotus franciscanus*)

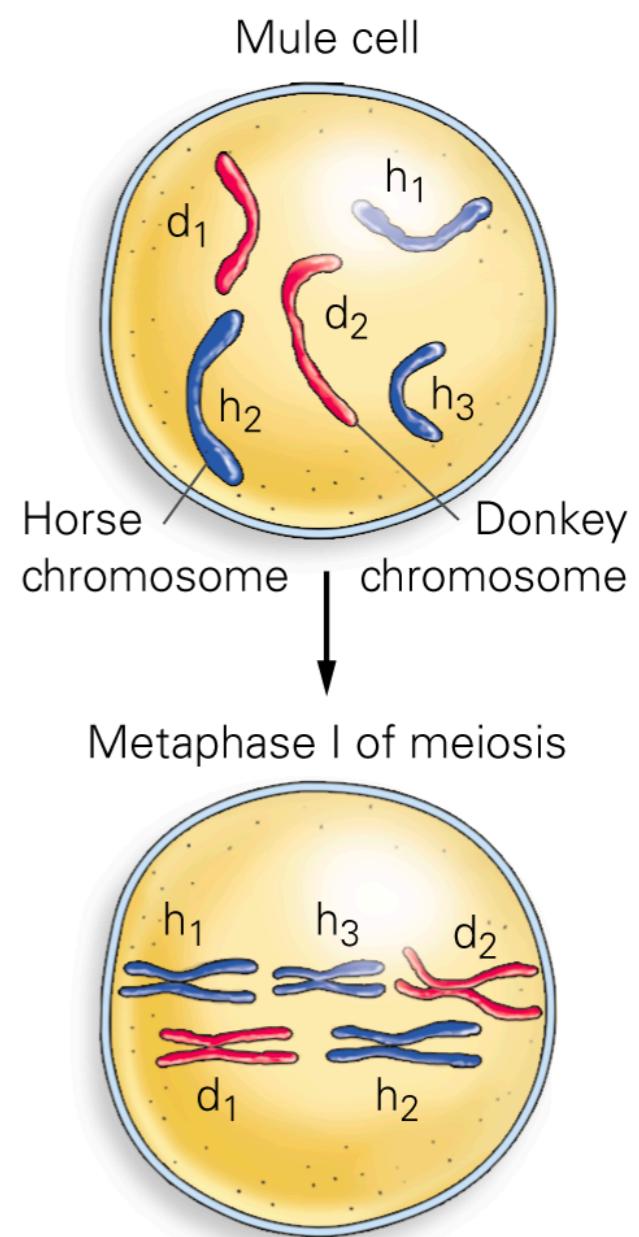
**Due to molecular incompatibility, zygote mortality occurs.**

# Hybrid Sterility

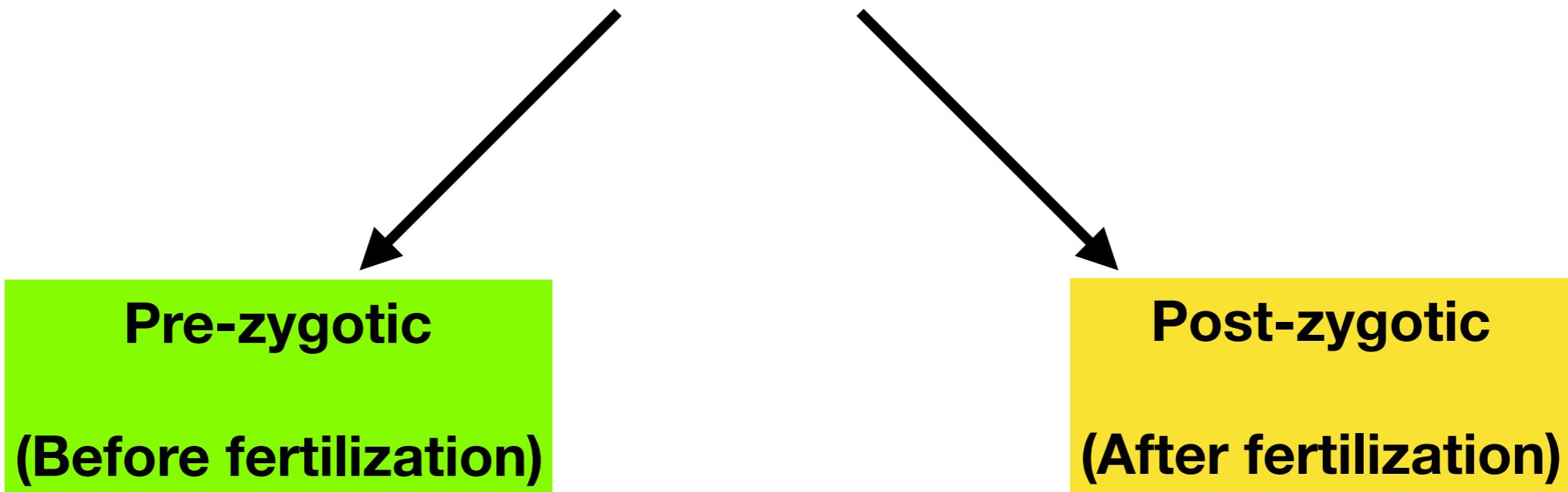
**(a) A mule results from the mating of a horse and a donkey.**



**(b) Why mules are sterile**



# 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)**

**LS1101**

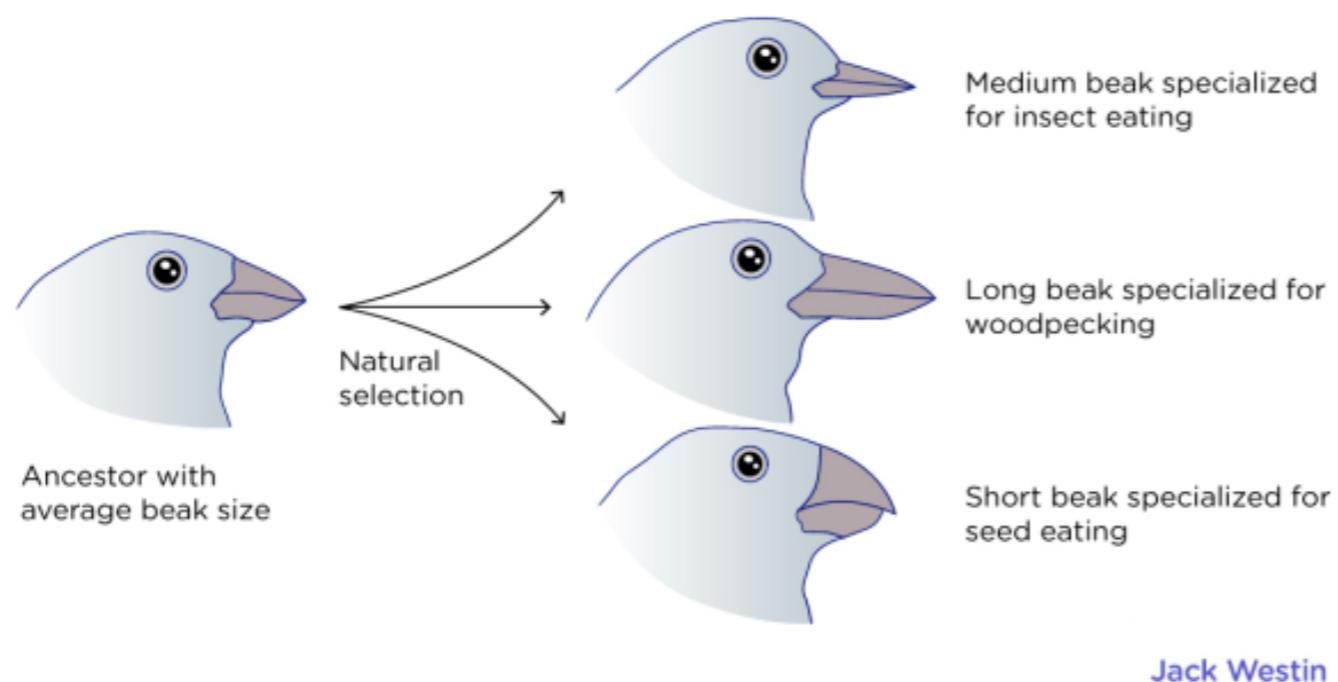
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**Radhika Venkatesan**

# Speciation

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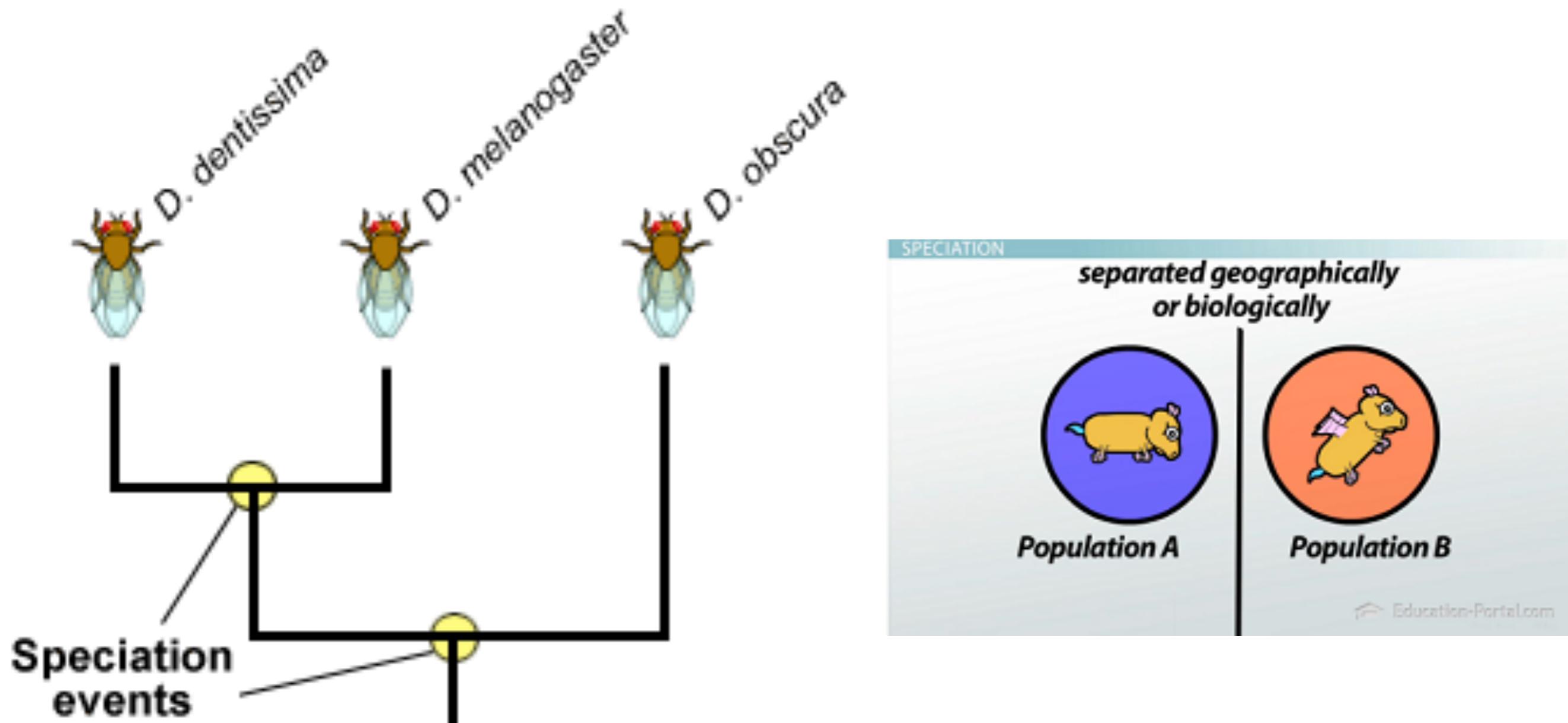
**speciation:** the process by which one species splits into two or more species.



**Every time speciation happens, the diversity increases!!**

# How new species arise?

A key event in the origin of a new species is the separation of a population from other populations of the same species.

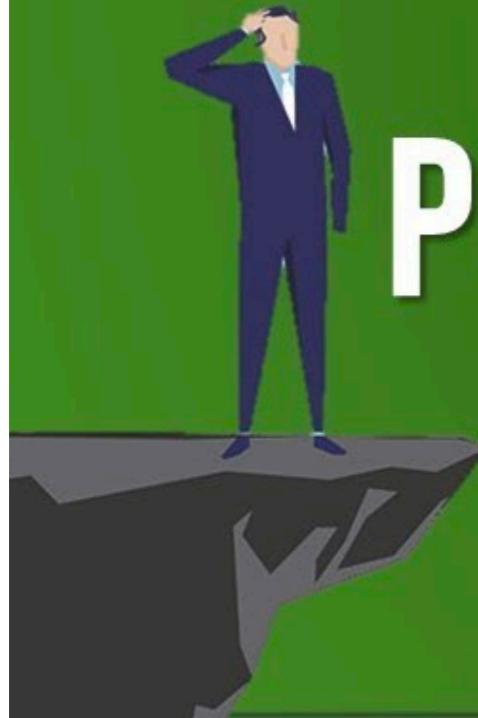


## Type of Speciation

**Allopatric**



**Peripatric**



**Sympatric**



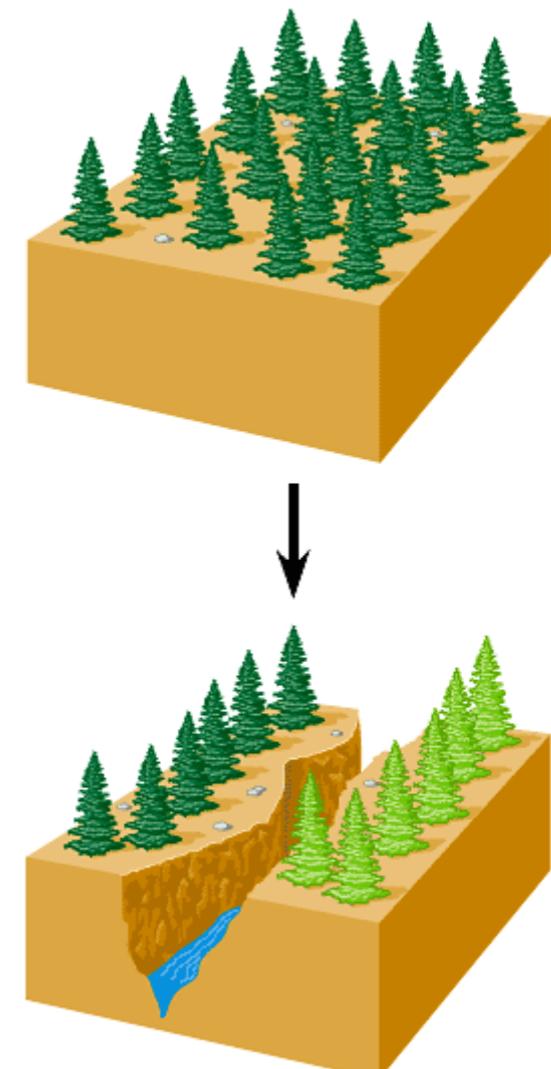
**Parapatric**

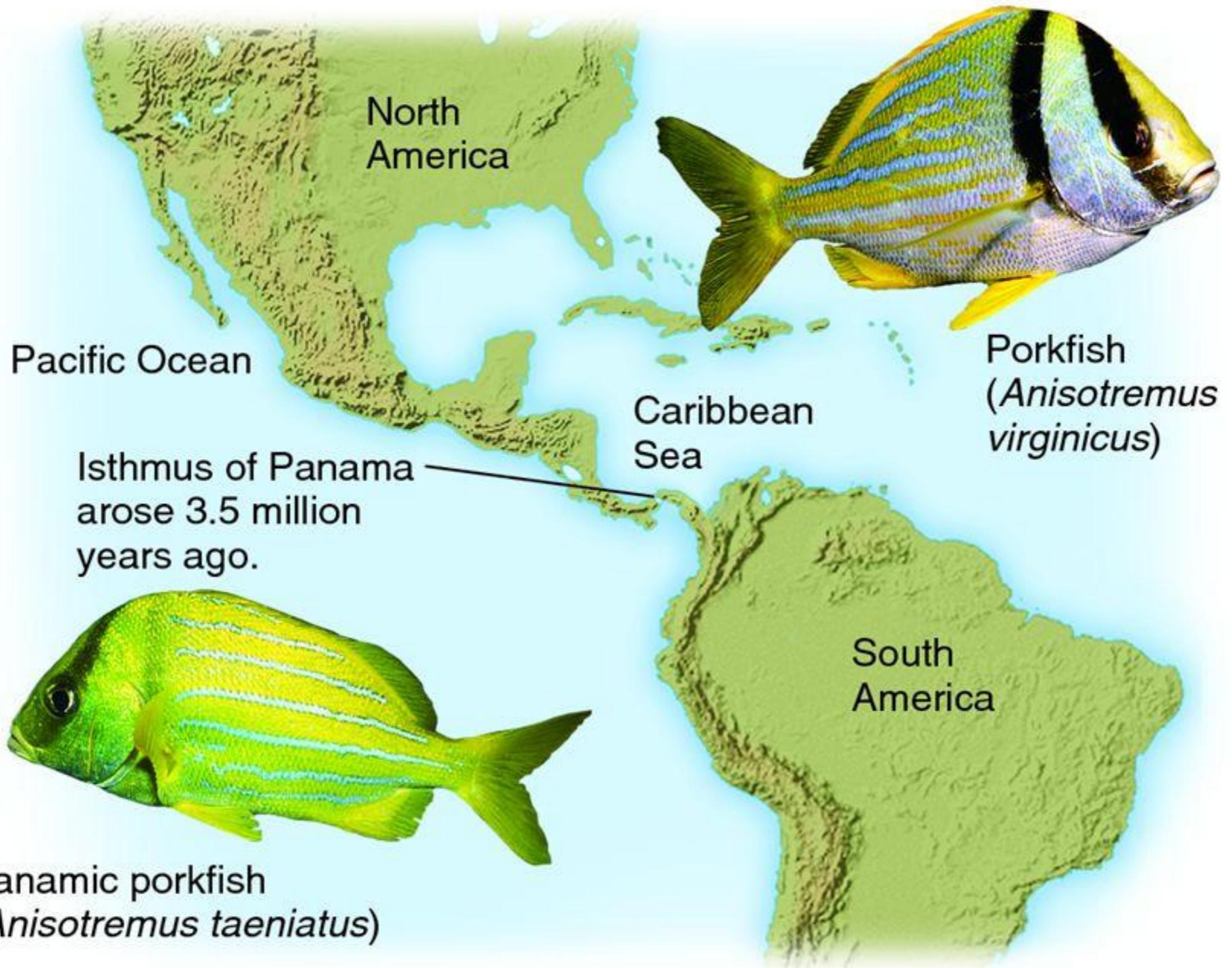


# ALLOPATRIC SPECIATION

## Geographic Barriers

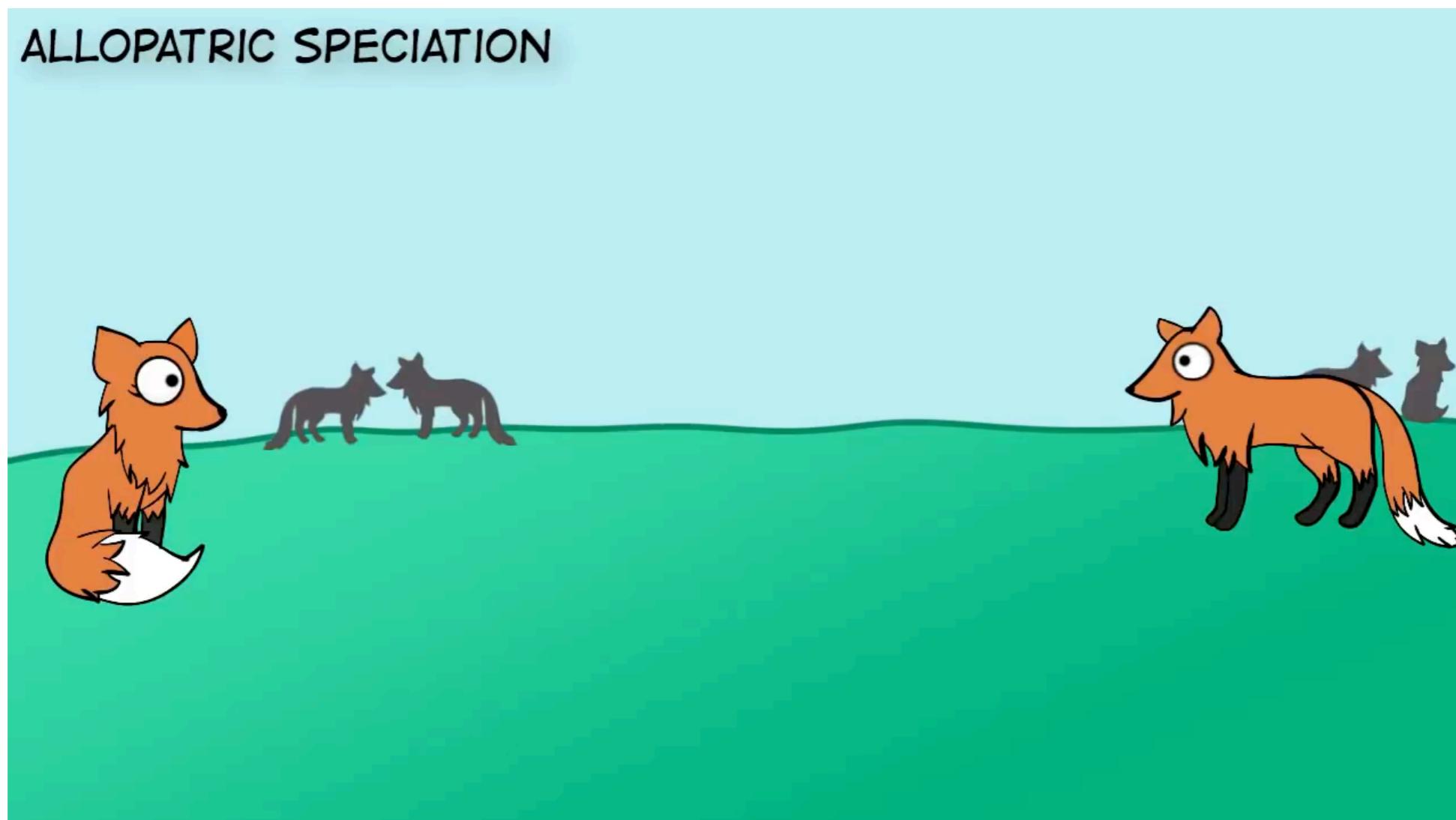
- A mountain emerging and splitting a population
- A large lake drying up into smaller lakes isolating populations
- Continental drifts
- Individuals colonising new geographic area and getting isolated





# Why geographic barriers creates new species?

- New environment might be different (food, predators etc.)
- Population traits change as per the environment creating reproductive isolation



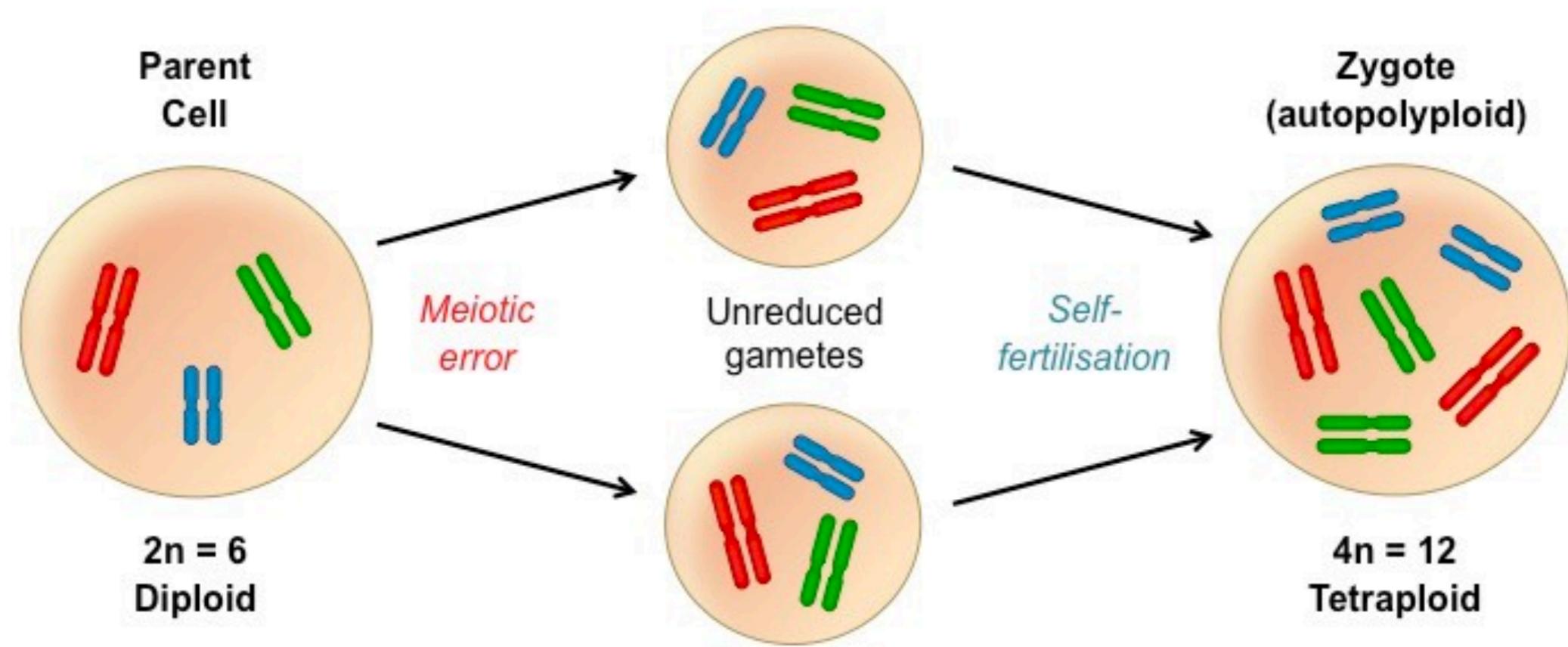
# SYMPATRIC SPECIATION

## Speciation without geographic barriers

This can occur when mating and the resulting gene flow between populations are reduced by factors such as polyploidy, habitat differentiation, and sexual selection.

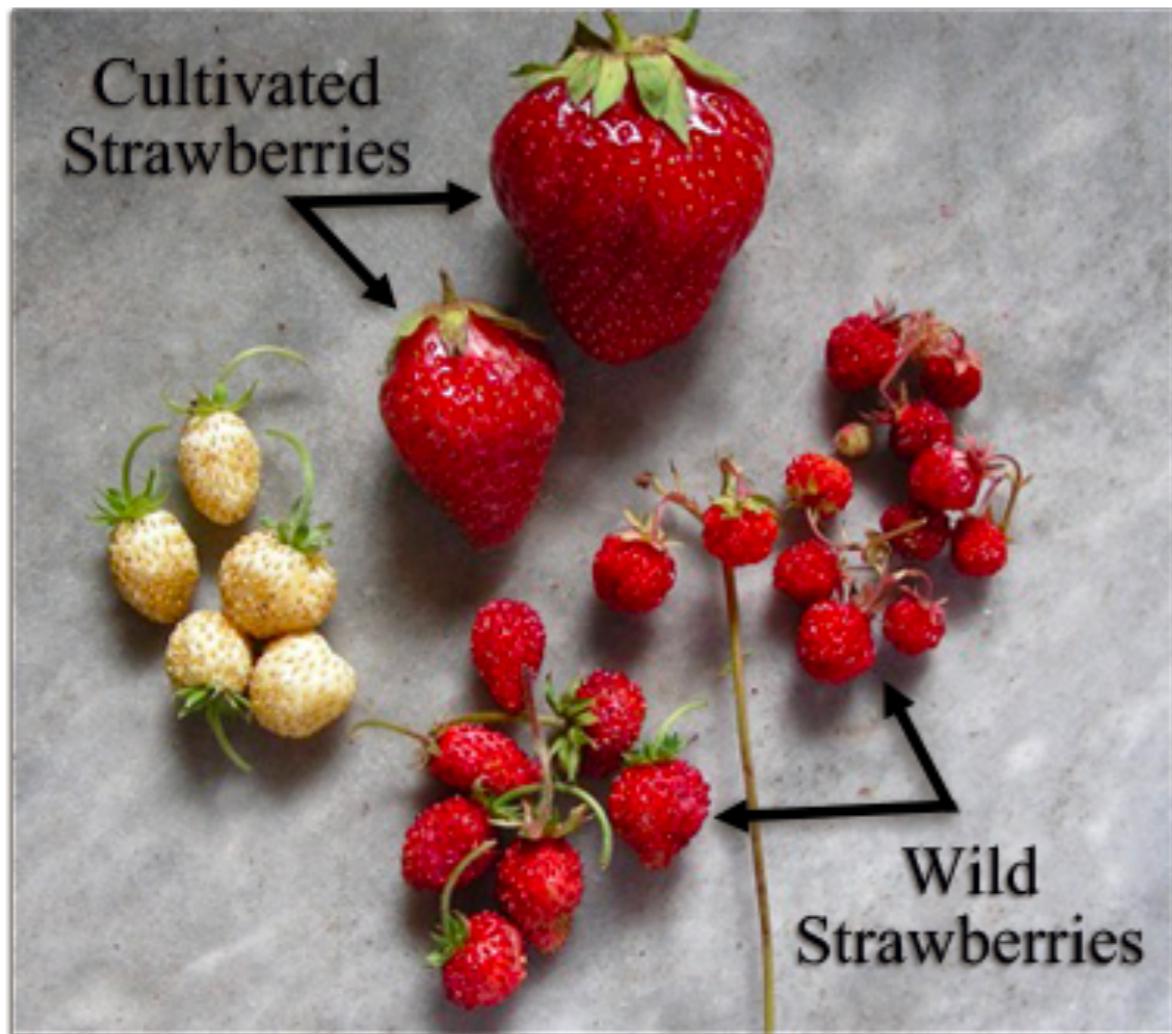
**PLOIDY - Number of sets of chromosomes**

**POLYPLOIDY - more than complete set (2) of chromosomes**

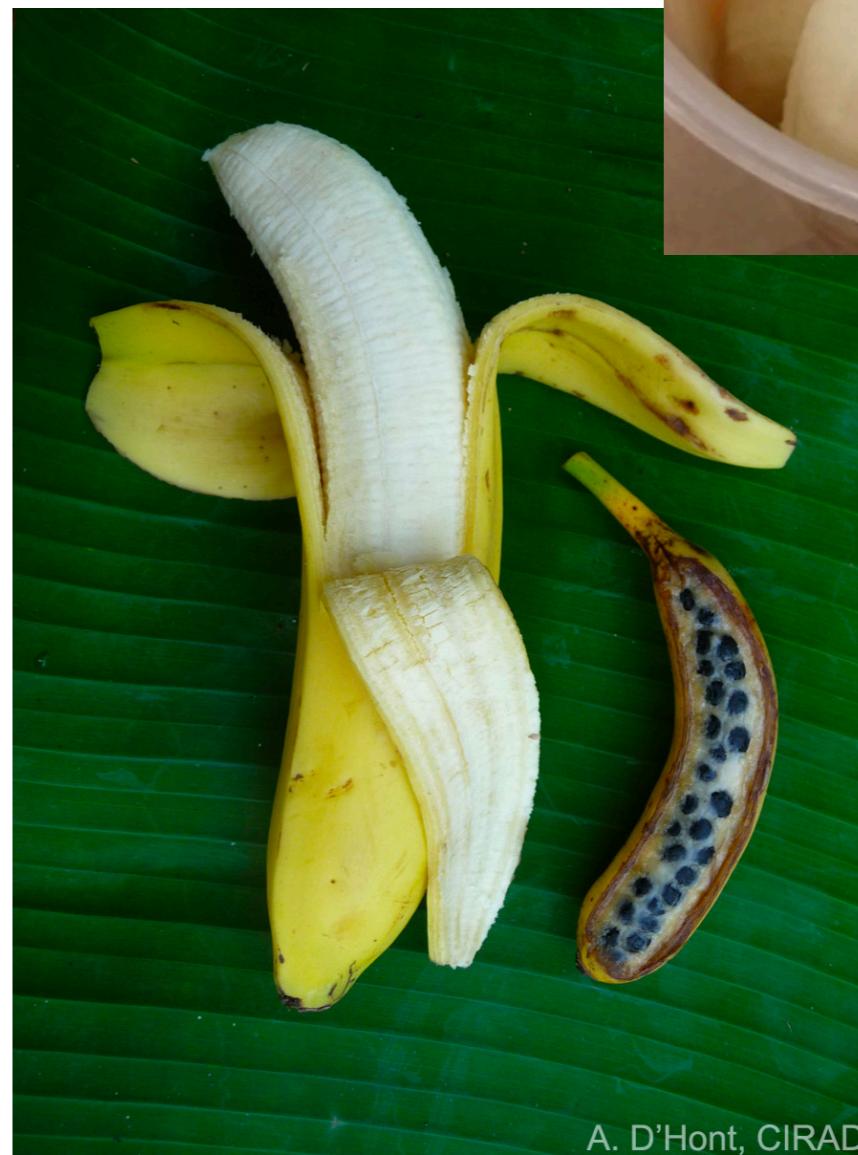


The formation of a tetraploid ( $4n$ ) plant is an instantaneous speciation event: A new species, reproductively isolated from its parent species, is produced in just one generation. Very common in plants!!!

## Larger fruits



## Seedless fruits



A. D'Hont, CIRAD



# Common polyplloid plants

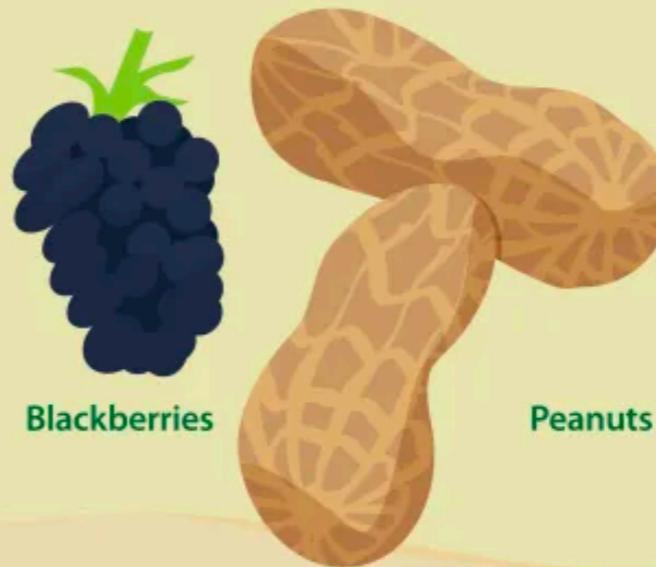
XXX Triploid



Seedless watermelon

Banana

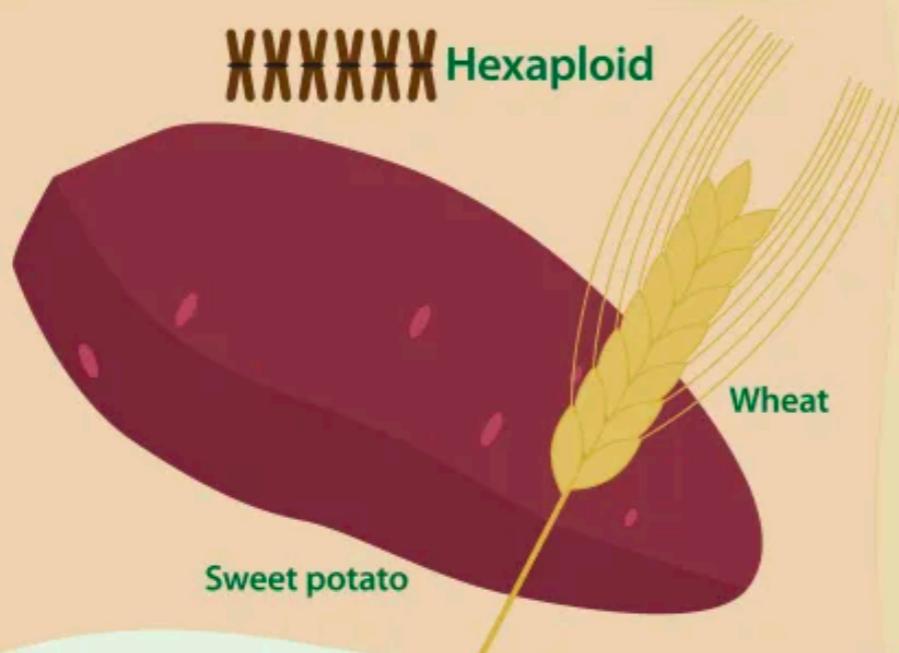
XXXX Tetraploid



Blackberries

Peanuts

XXXXXX Hexaploid



Sweet potato

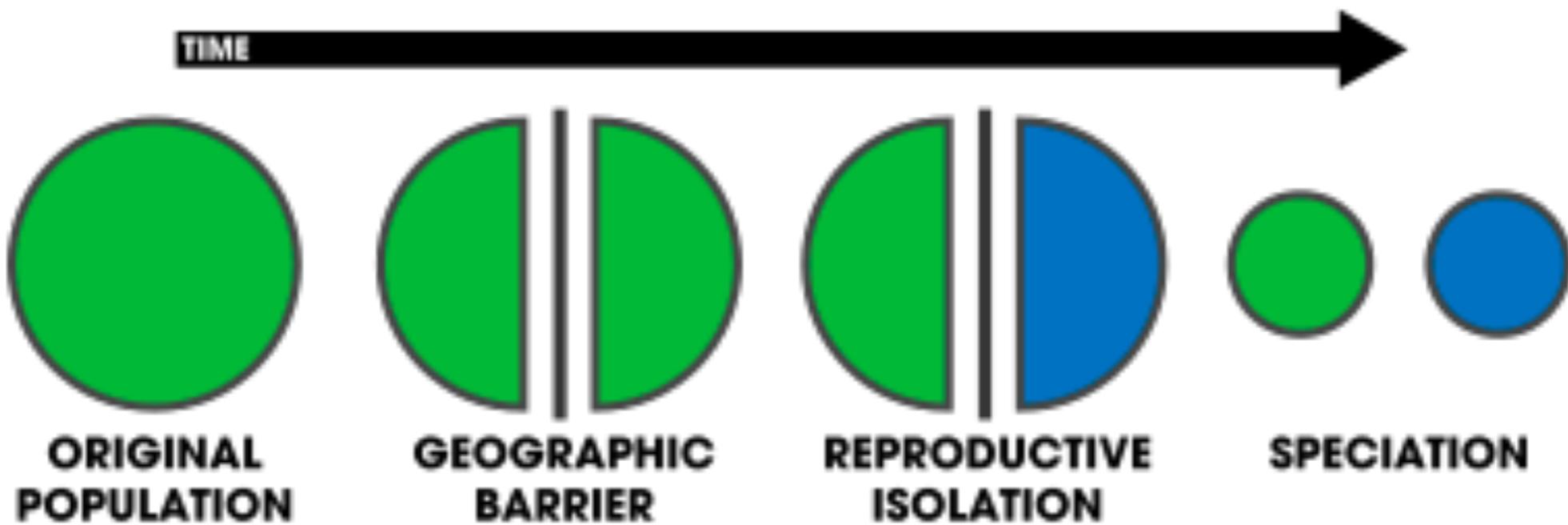
Wheat

XXXXXXXX Octoploid

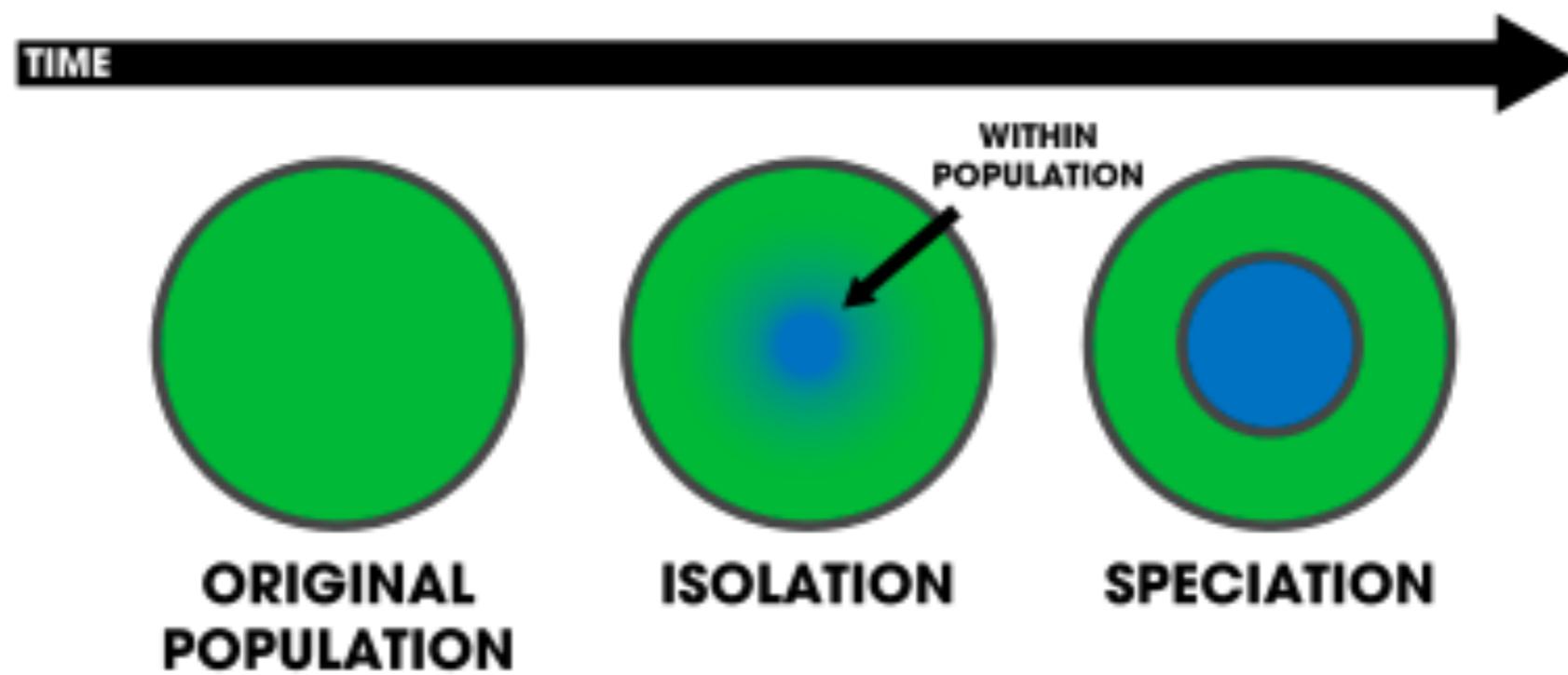


Strawberry

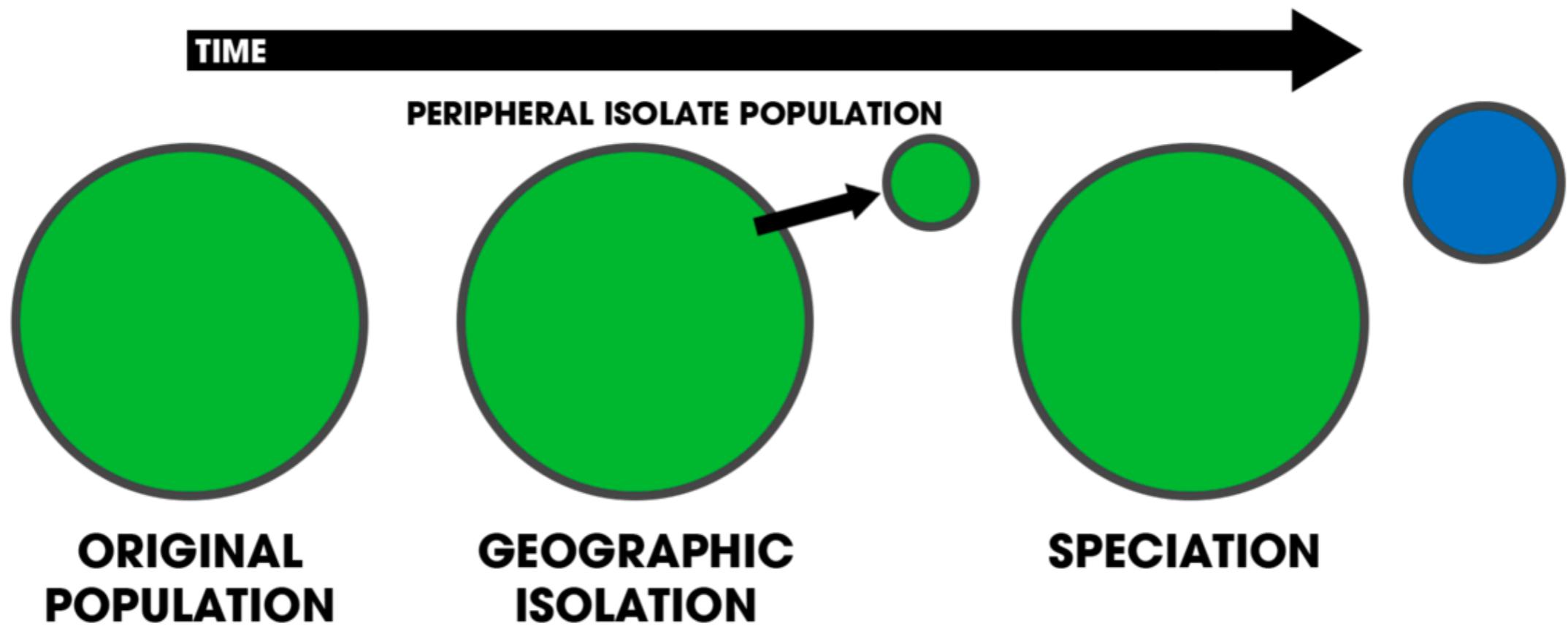
## ALLOPATRIC SPECIATION



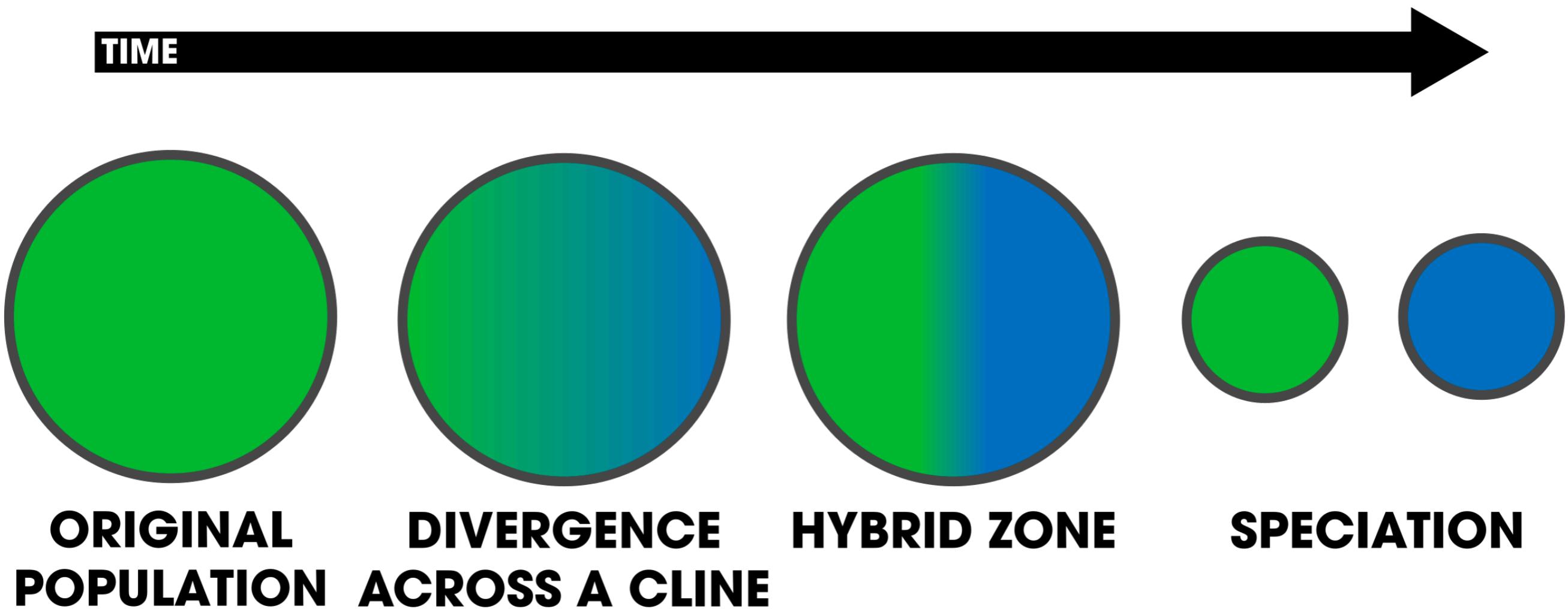
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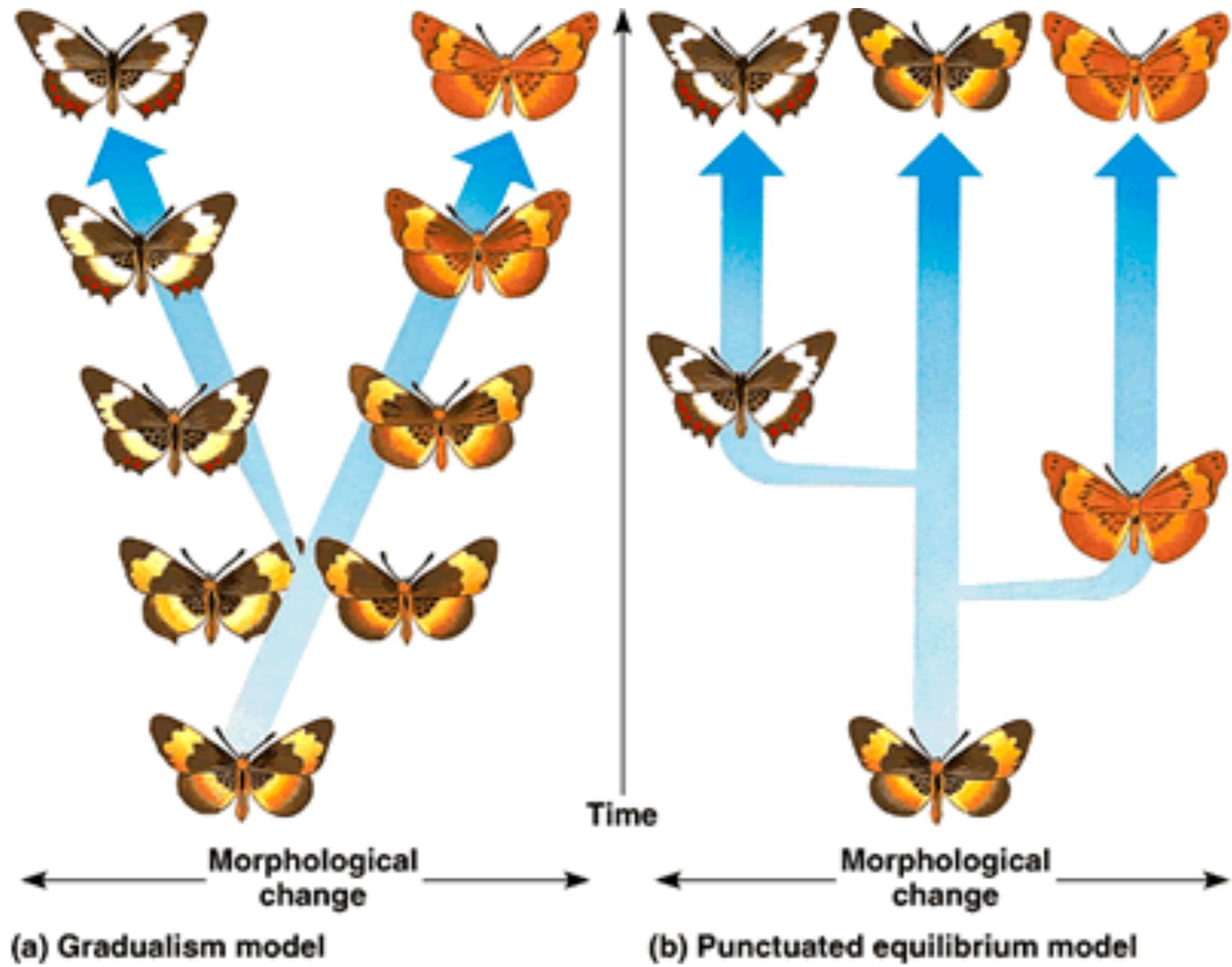


# PERIPATRIC SPECIATION



# PARAPATRIC SPECIATION

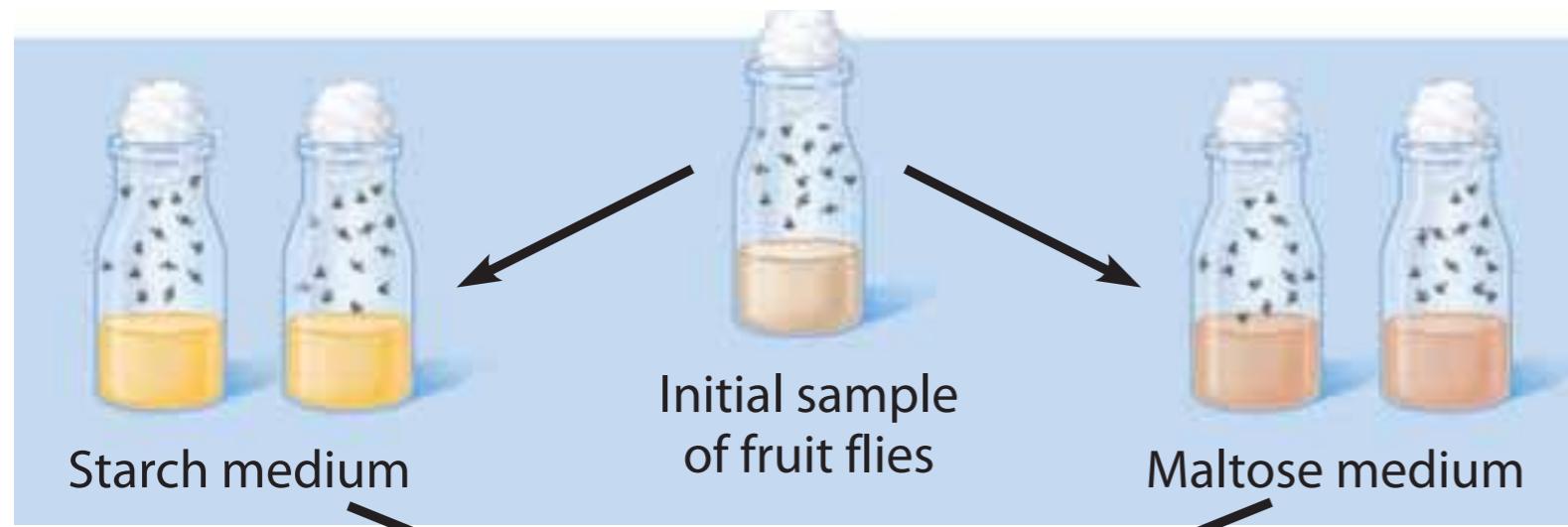
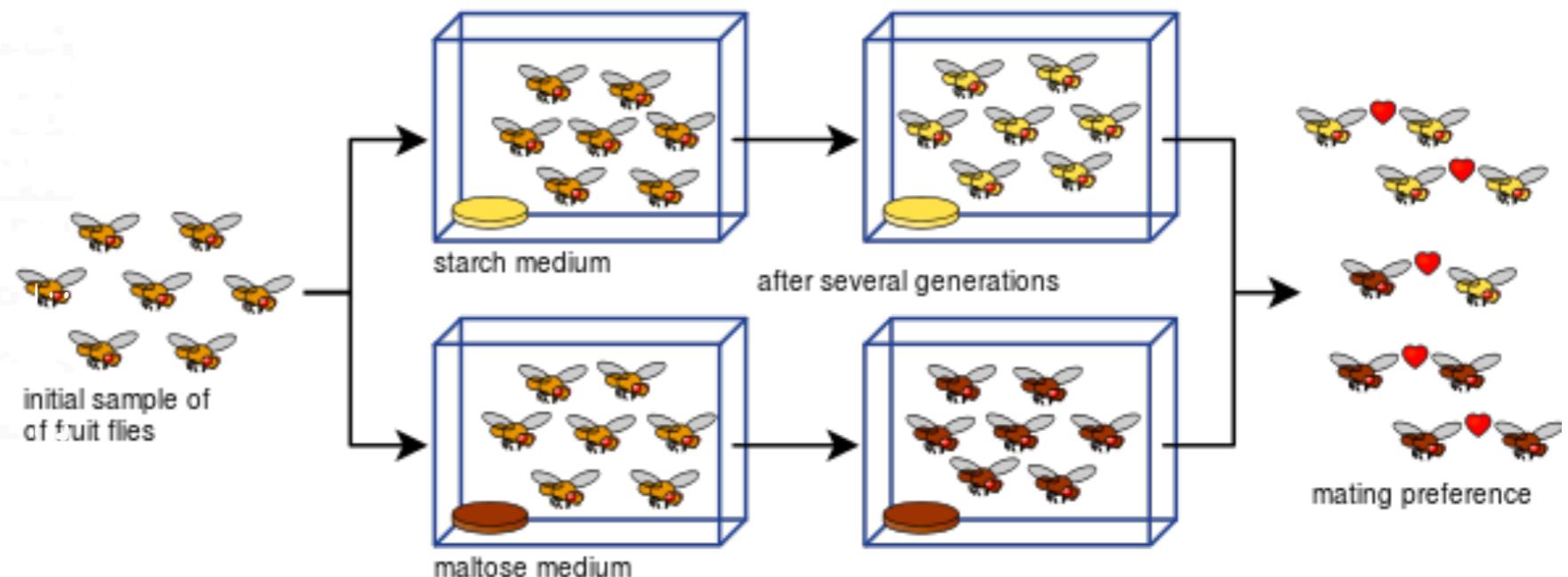




**Gradual Evolution**

**Punctuated Evolution**

**Speciation might take few hundreds to thousands of years.**



Mating experiments

Results

		Female Starch	Female Maltose		
Male Starch	Male Starch	22	9	Population #1	Population #2
	Male Maltose	8	20		
Male Maltose	Male Starch	18	15	Pop#2	Pop#1
	Male Maltose	12	15	Pop#1	Pop#2

**Number of matings in experimental groups**

**Number of matings in starch control groups**

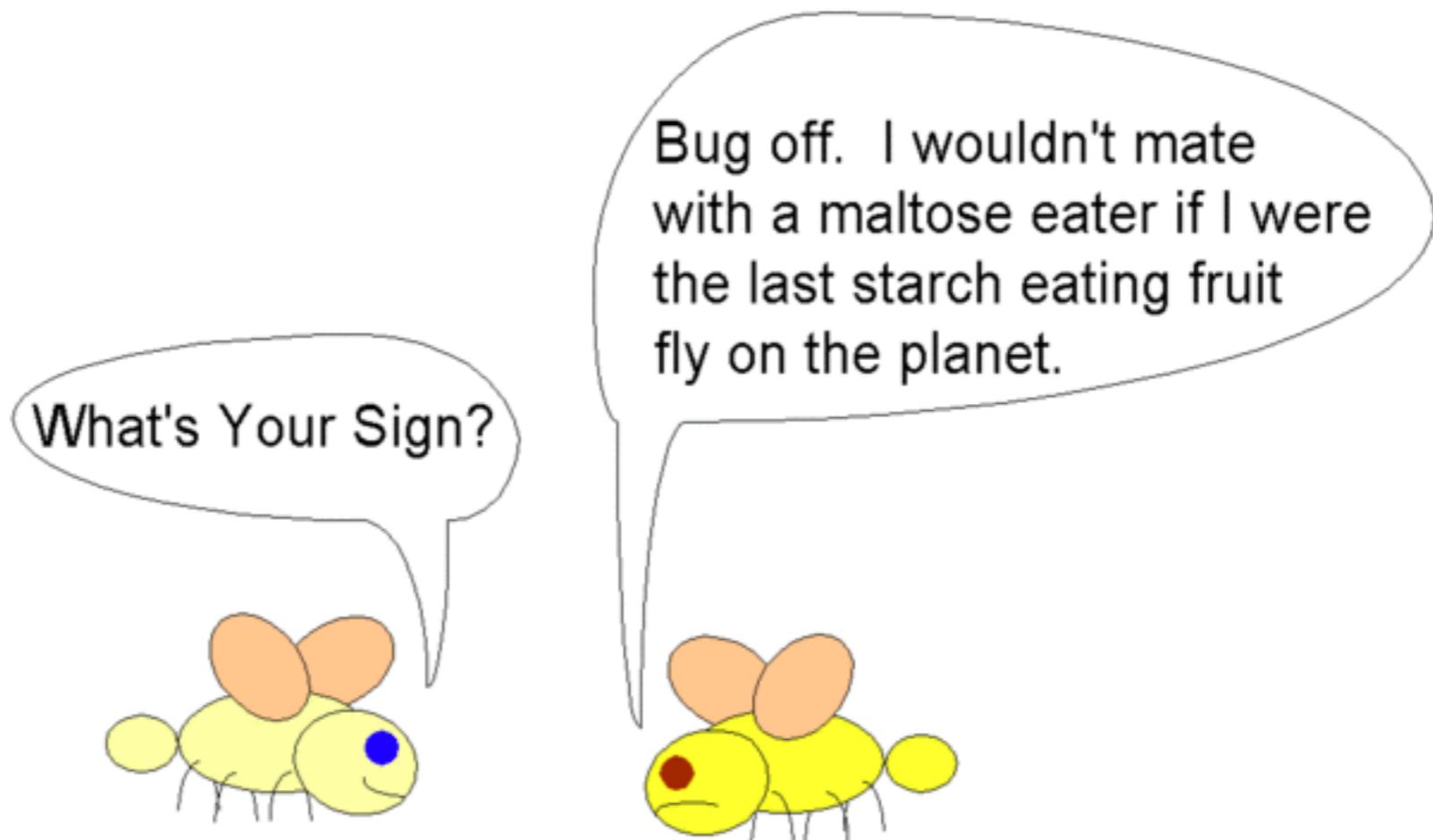
## Diane Dodd Experiment, Yale Univ.

**Number of matings between starch fed and maltose fed flies were less.**

Reproductive isolation was under way as these allopatric populations became adapted to different environments.

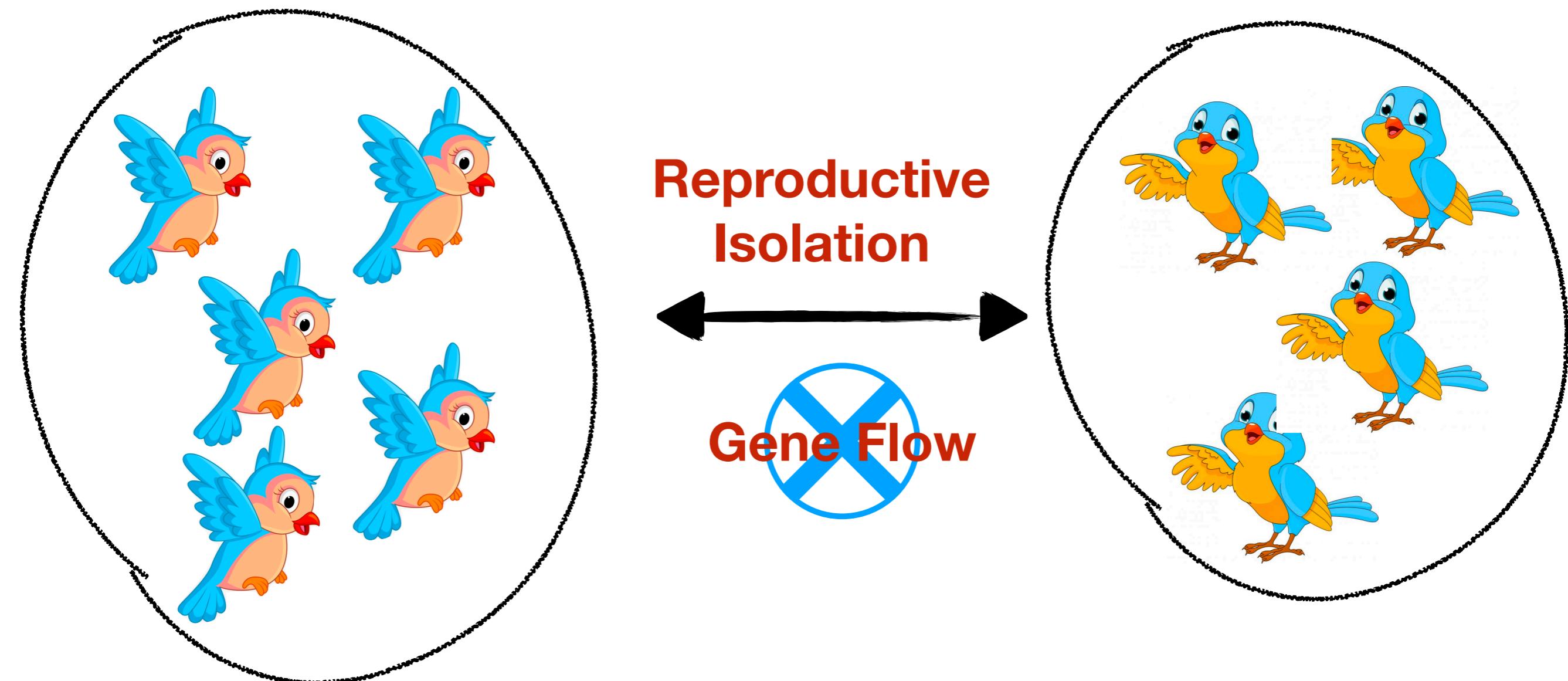
Diane Dodd's fruit fly experiment suggests that isolating populations in different environments (e.g., with different food sources) can lead to the beginning of reproductive isolation. These results are consistent with the idea that geographic isolation is an important step of some speciation events.

Dodd, Diane M. B. (1989), "Reproductive Isolation as a Consequence of Adaptive Divergence in *Drosophila pseudoobscura*", *Evolution*, 43 (6): 1308–1311



## Speciation in the Lab

# What keeps species separated?



# Reproductive barriers

## Pre-zygotic (Before fertilization)

- Habitat
- Temporal
- Mechanical
- Behavioural

## Post-zygotic (After fertilization)

- Gametic
- Hybrid



## 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.



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*Sinistral Euhadra quaesita*

*Dextral Euhadra aomoriensis*

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



Western  
Meadow Lark



Eastern  
Meadow Lark



## Post-zygotic (After fertilization)

### Zygote Mortality: Gametic isolation

Purple sea urchin  
(*Strongylocentrotus purpuratus*)

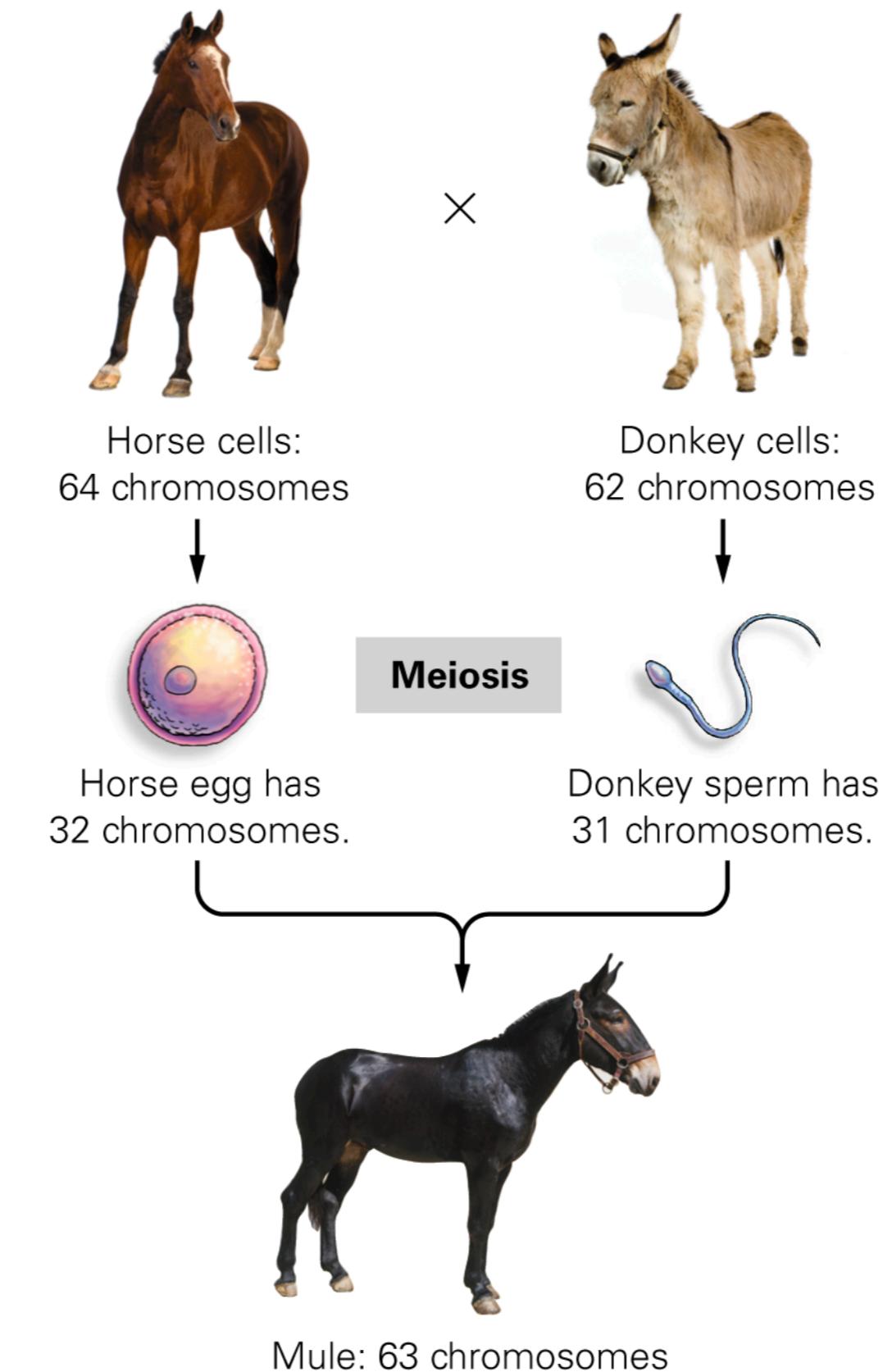


Red sea urchin  
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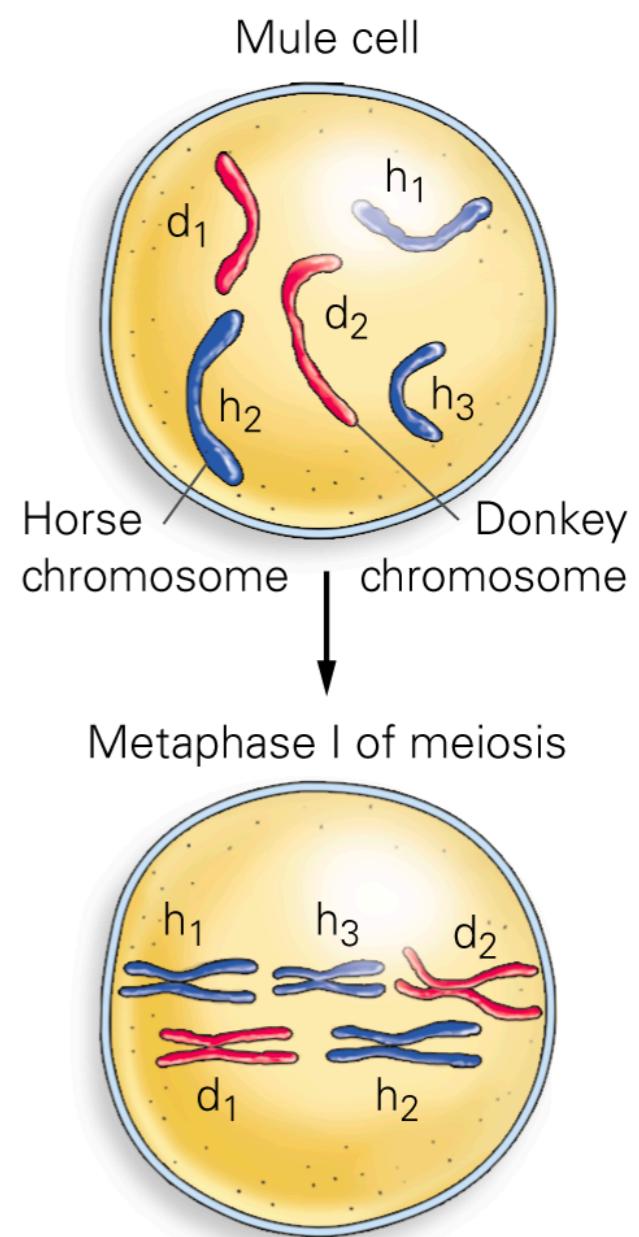
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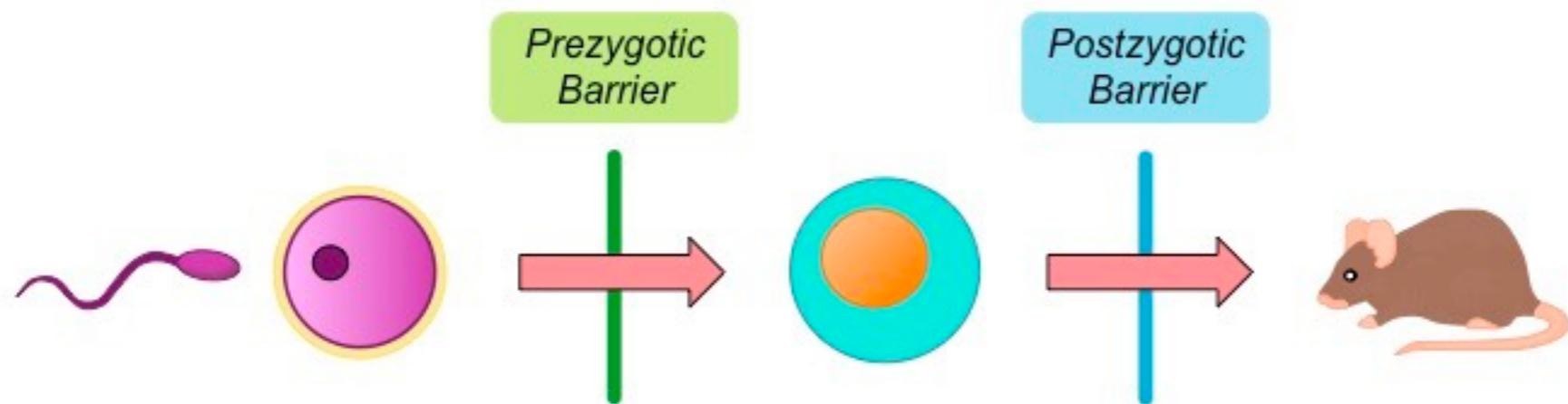
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**(b) Why mules are sterile**

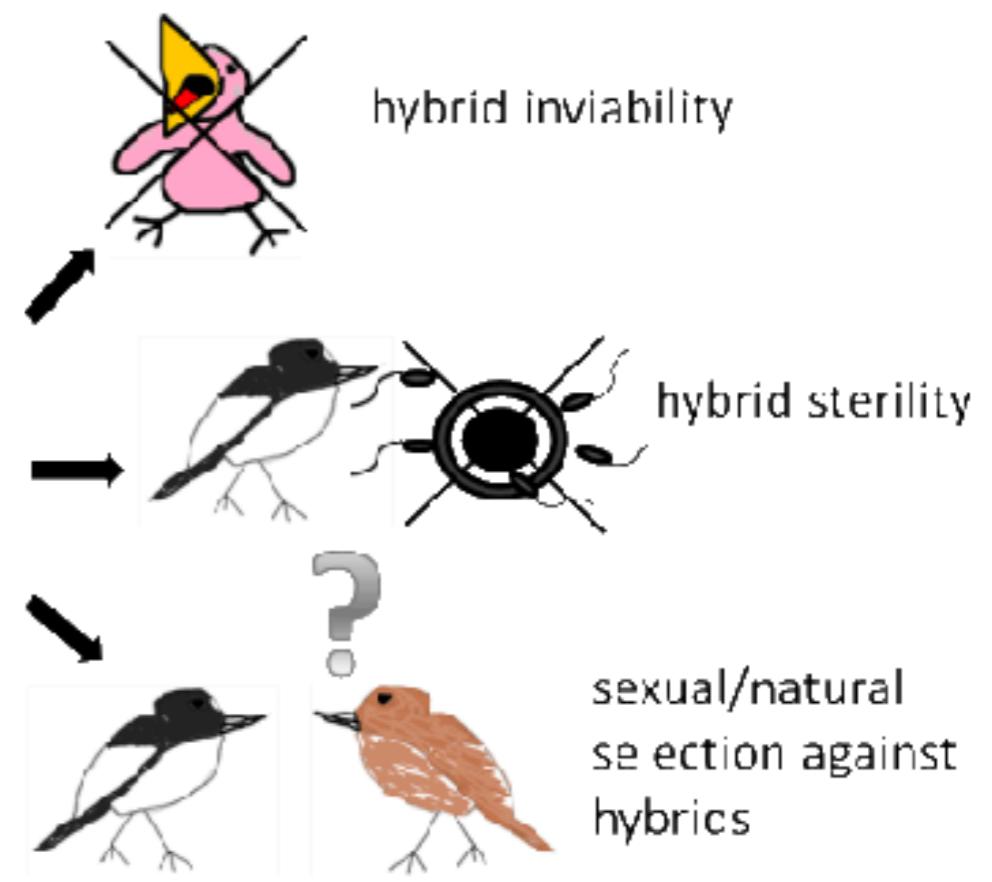


The chromosomes are from different species with different numbers of chromosomes, so they are unable to pair during the first part of meiosis.



## postzygotic

Prezygotic Isolation Mechanisms					
Habitat Isolation			Temporal Isolation		
			Gametic Isolation		
Behavioural Isolation					
Mechanical Isolation					



**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)**

# Habitat differentiation/specialisation

Apple maggot fly



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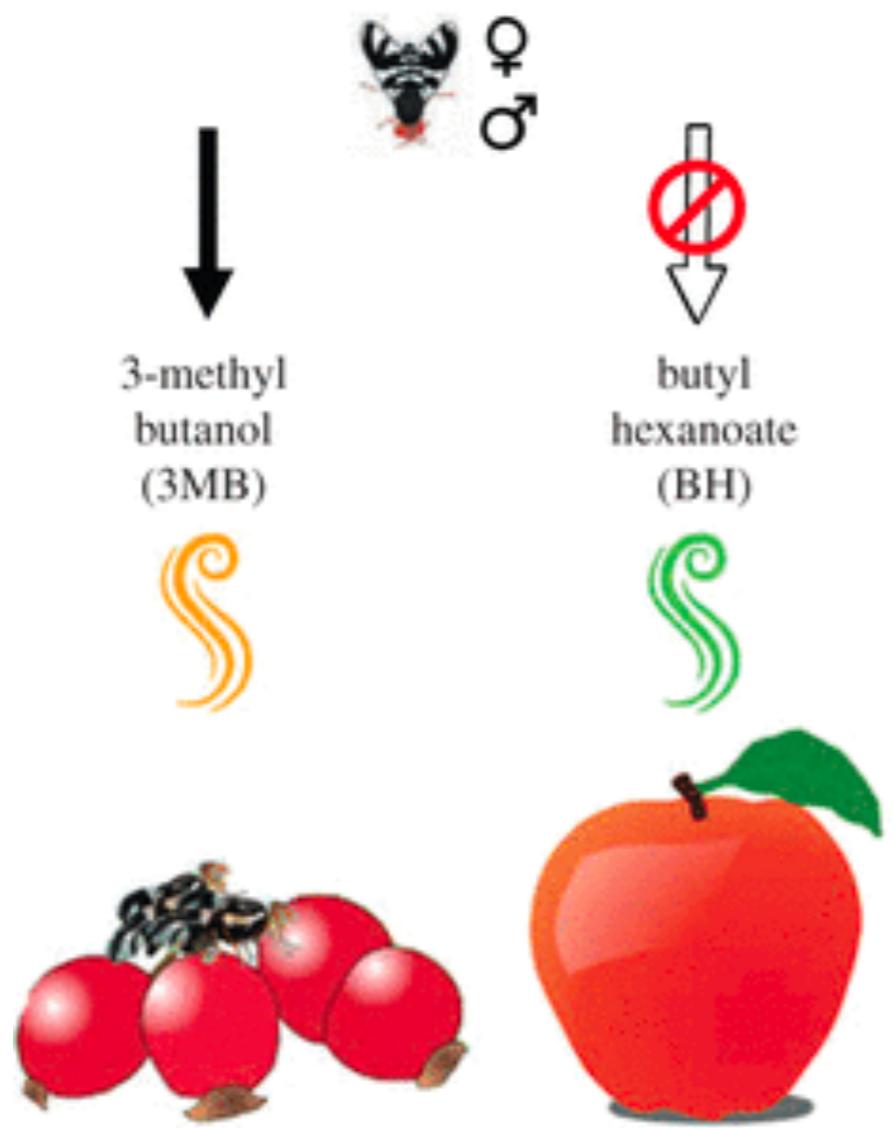
Hawthorn fly



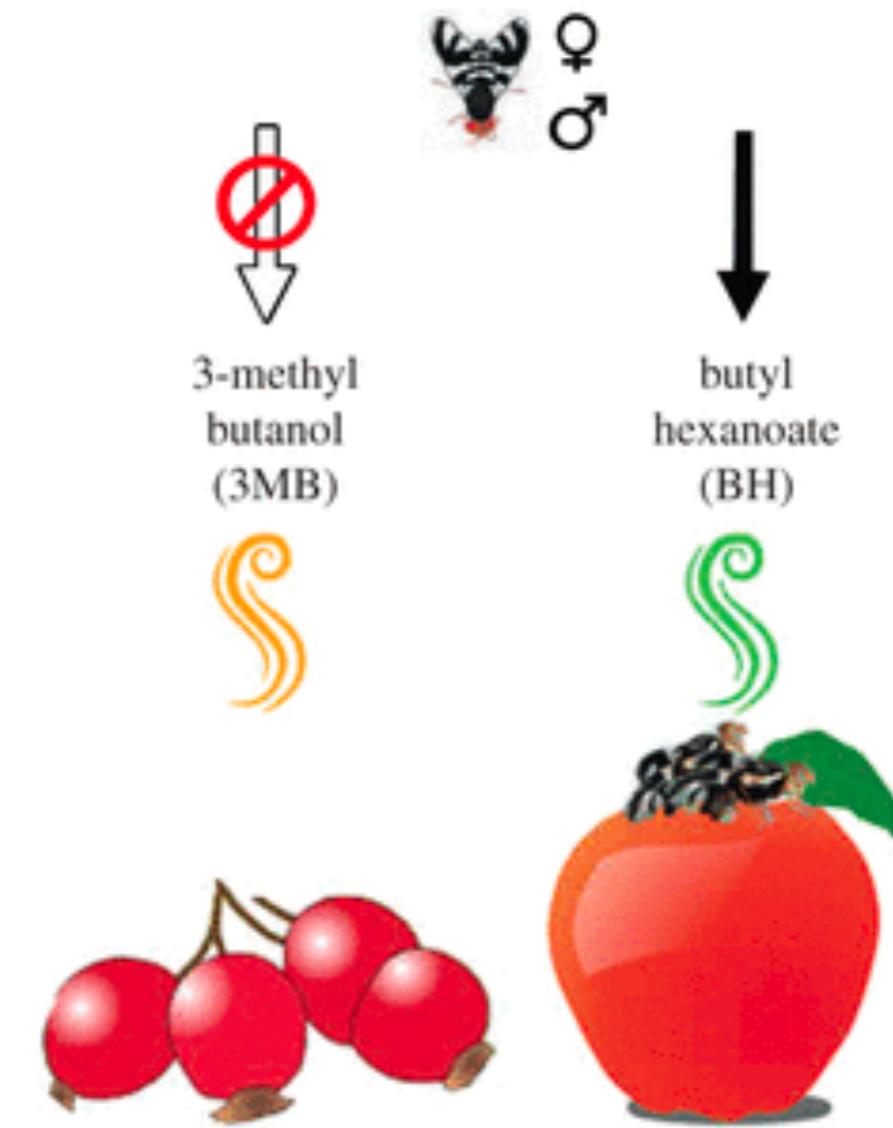
**New ecological niches present in the habitat can lead to differentiation and drive speciation.**

Roughly 180 years ago, some hawthorn fruit flies in the Eastern coast of North America smelt the fruits on apple trees - a fairly recent import into that region from Europe - and found them attractive. Today, nearly 2 centuries later, the flies have evolved into two distinct 'species'. One is called hawthorn flies, prefer to use native North American hawthorn fruit to lay their eggs on, while the other, called apple flies attack crops of domesticated apples. Apple flies are currently one of the greatest pest threats to apple production in Northeast America and Canada.

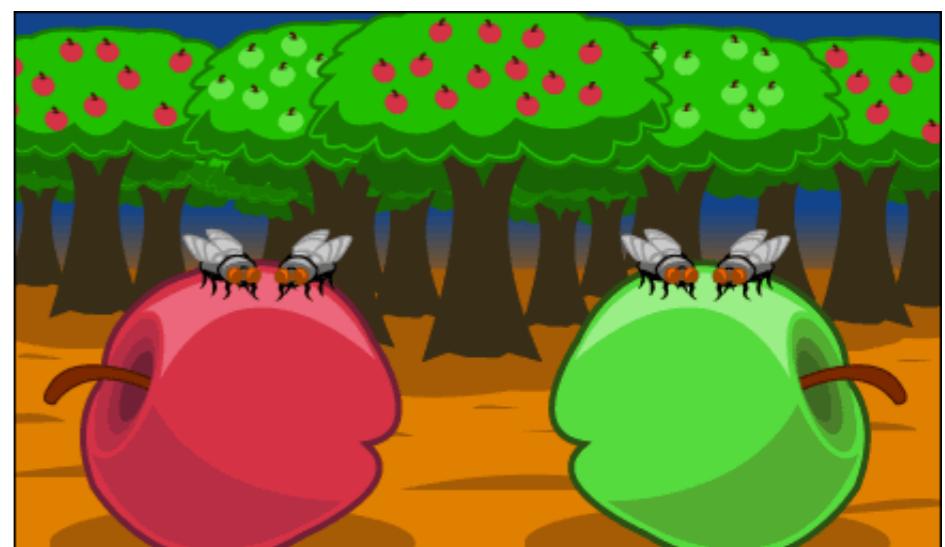
(a) ancestral hawthorn race



(b) derived apple race



In general, sympatric speciation occurs within populations that are not completely separate, but have separate behaviors or choices that ISOLATE them.



# Isolated islands are often showcases of speciation



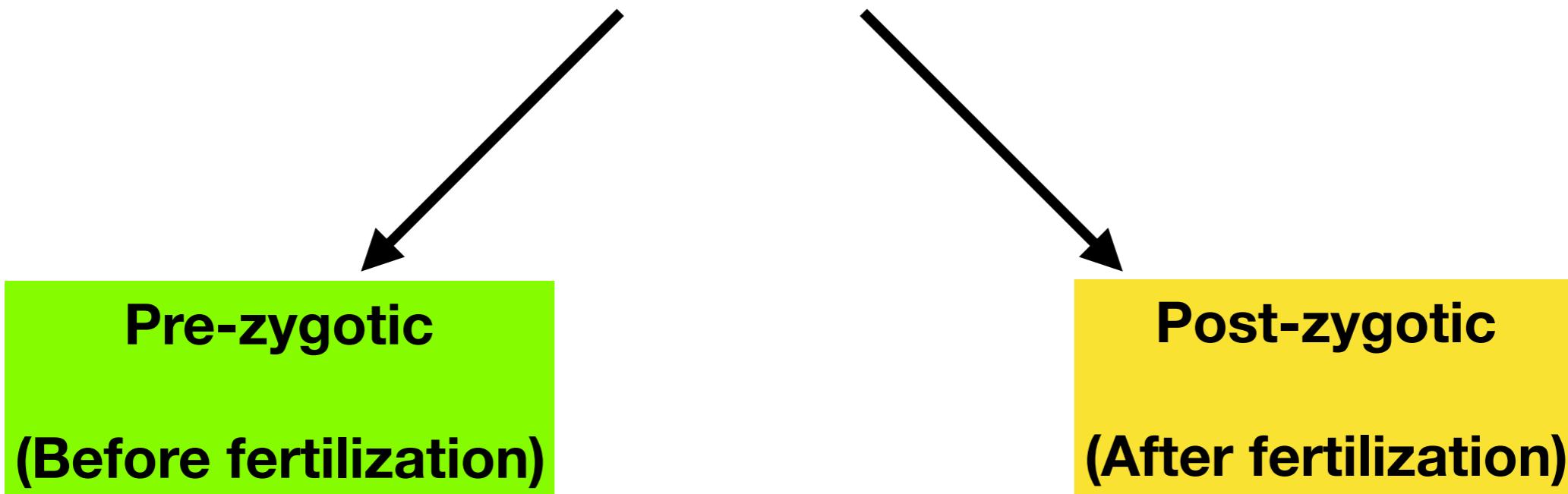
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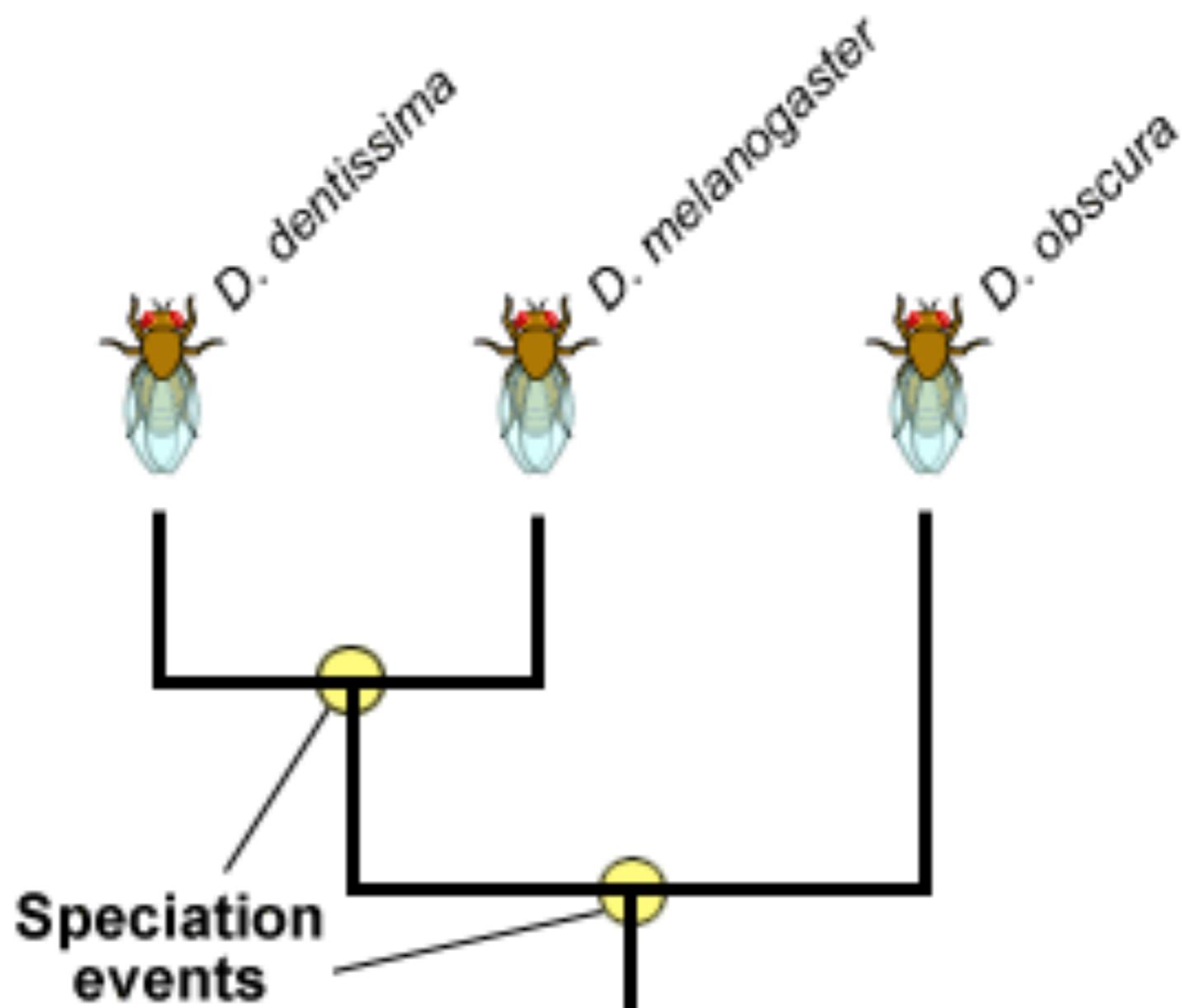
# Reproductive barriers



- **Habitat**
  - **Temporal**
  - **Mechanical**
  - **Behavioural**
- **Gametic**
  - **Hybrid**

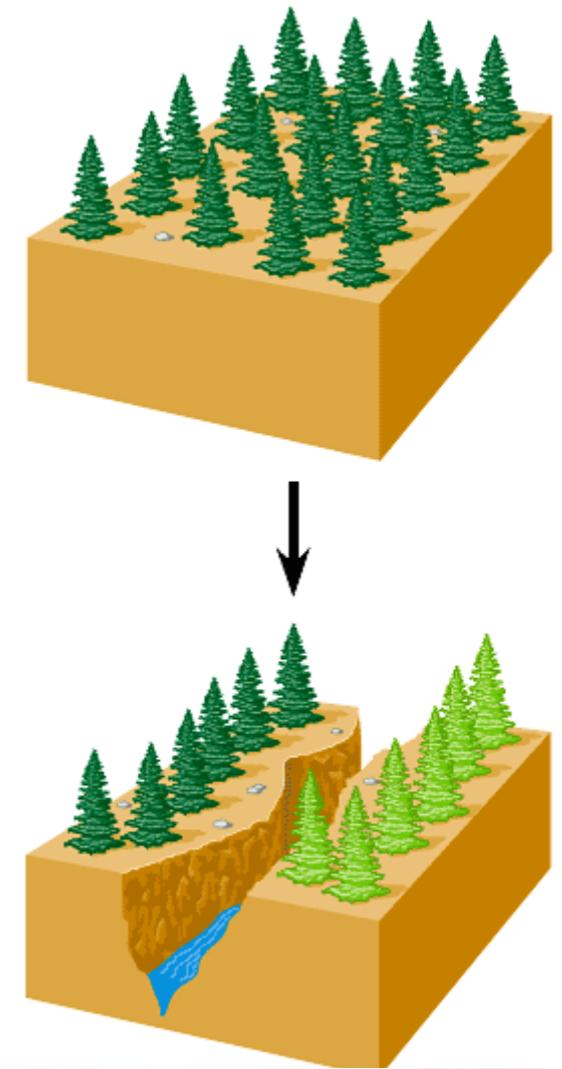
# How new species arise?

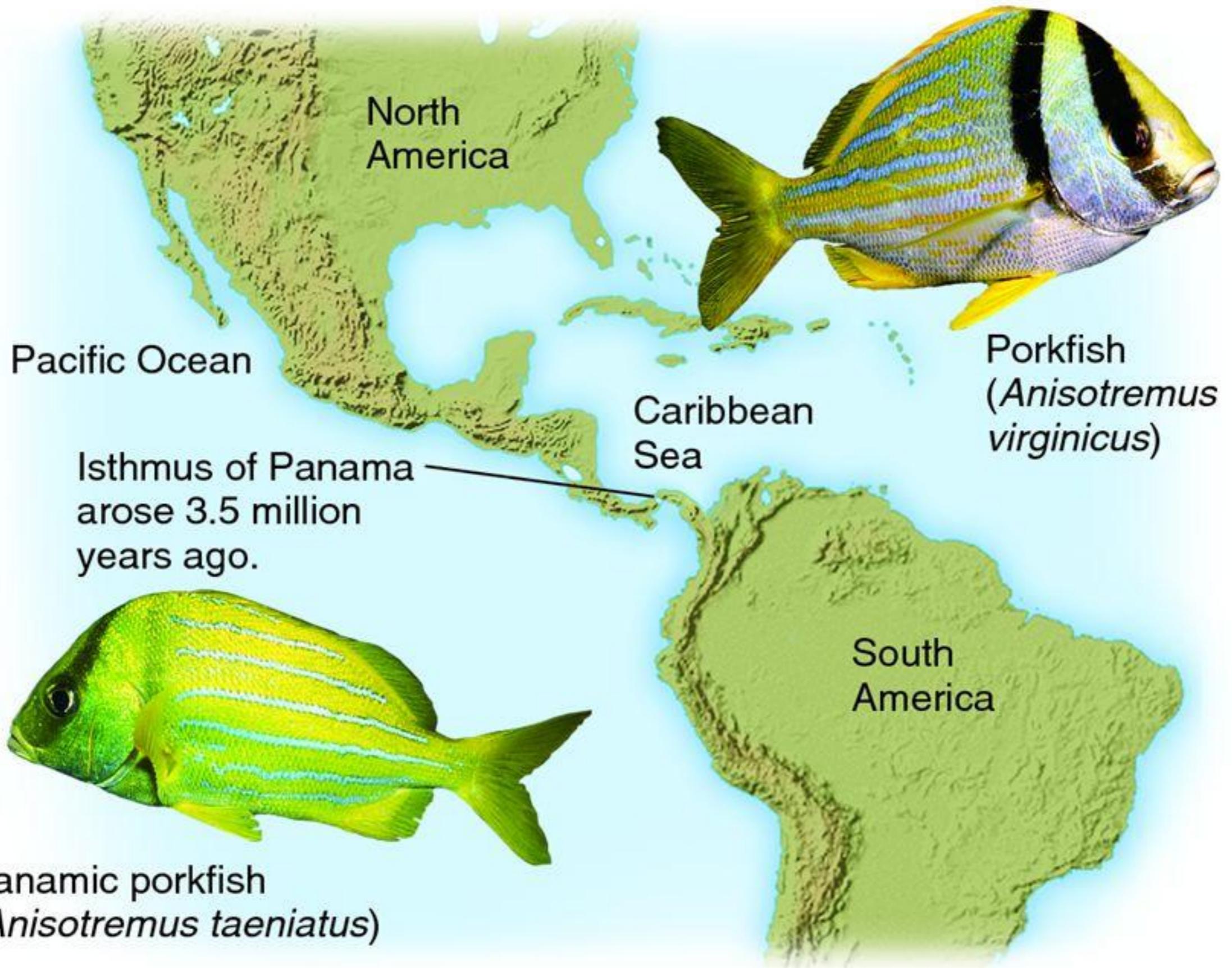
A key event in the origin of a new species is the separation of a population from other populations of the same species.



# Geographic Barriers **ALLOPATRIC SPECIATION**

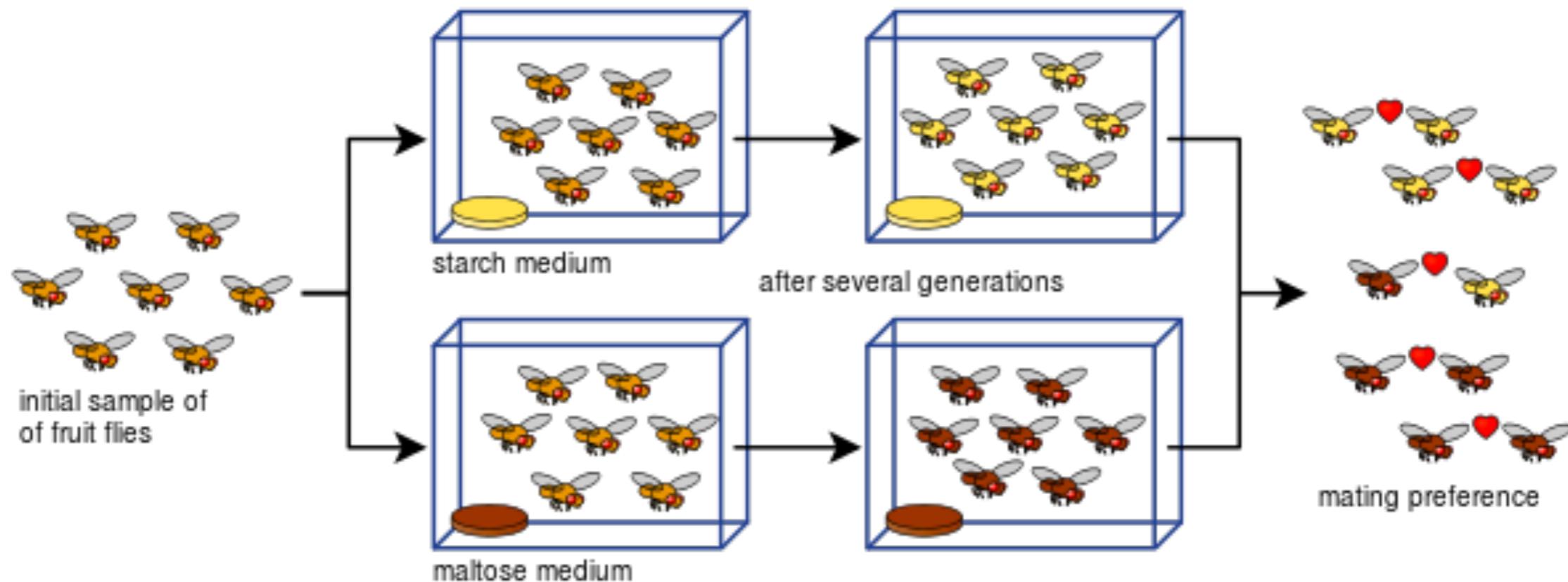
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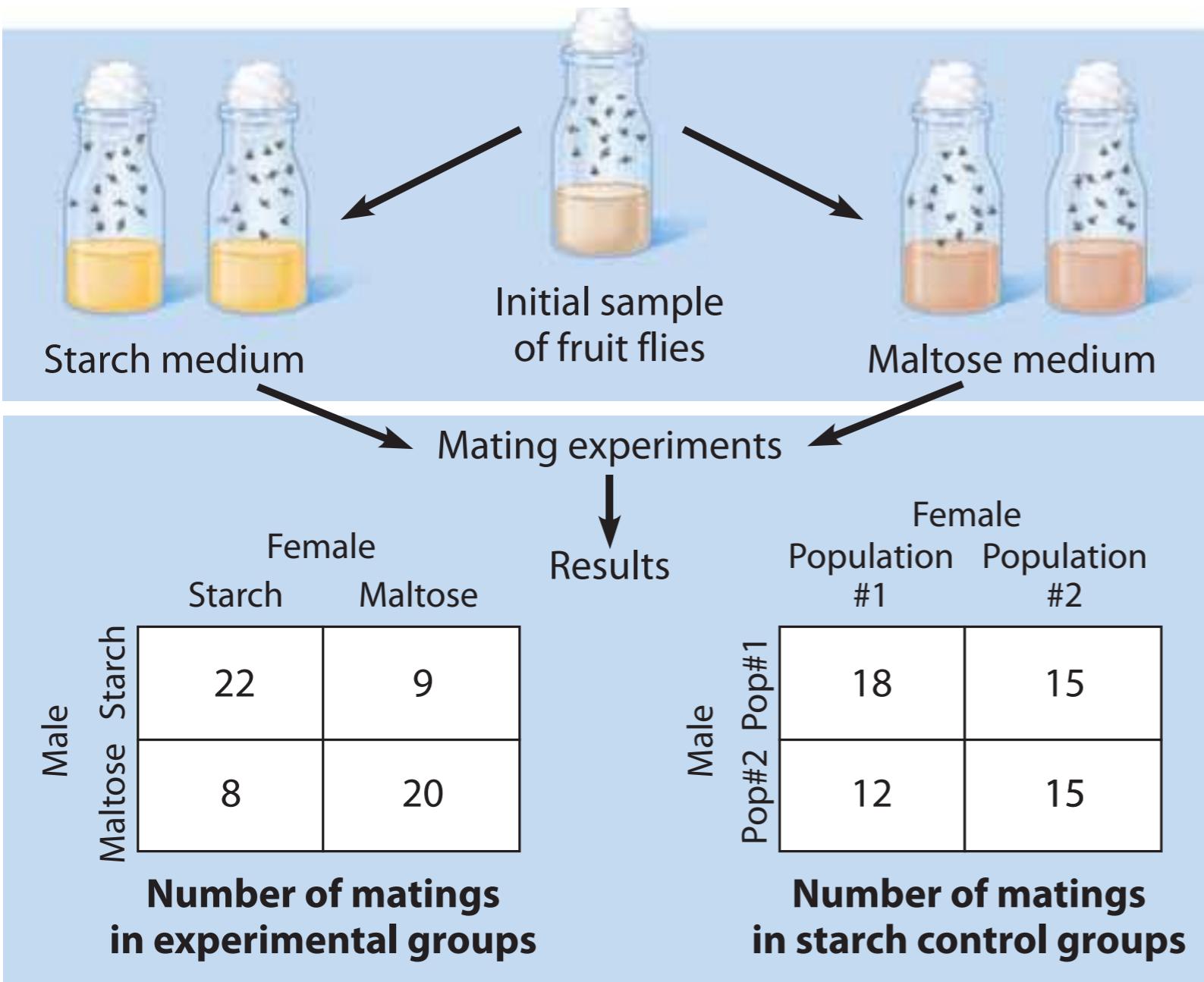


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- Population traits change as per the environment creating reproductive isolation



Diane Dodd Experiment, Yale Univ.



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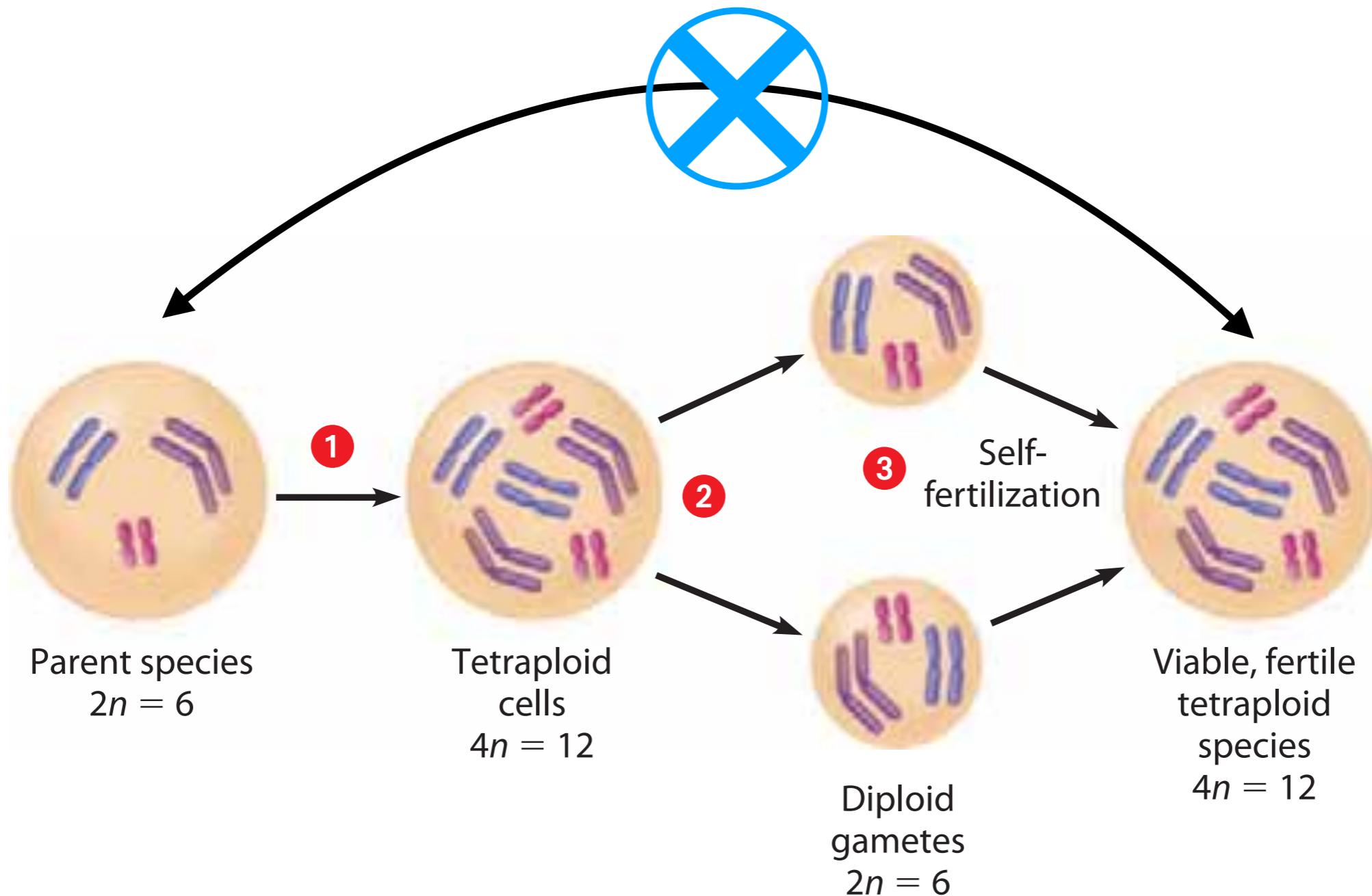
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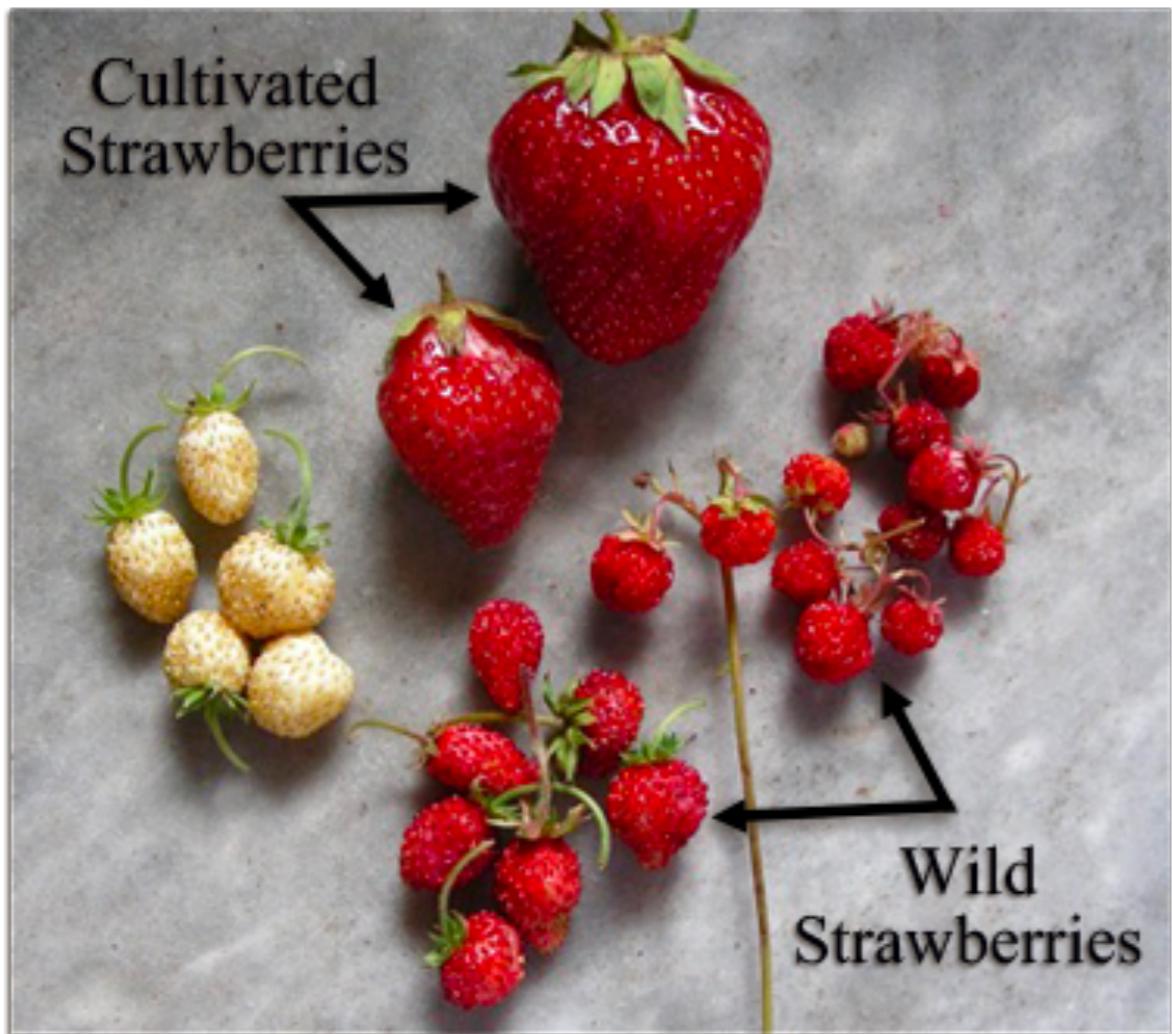
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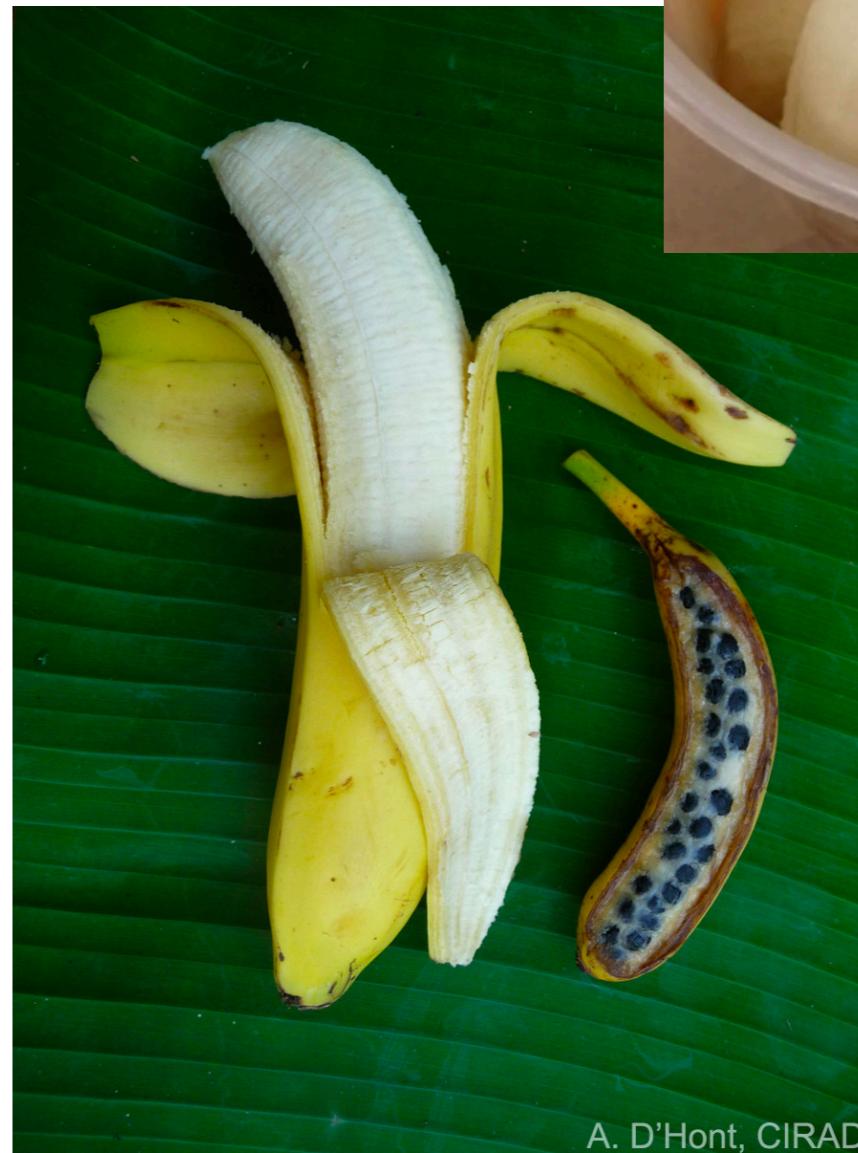


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## Larger fruits



## Seedless fruits



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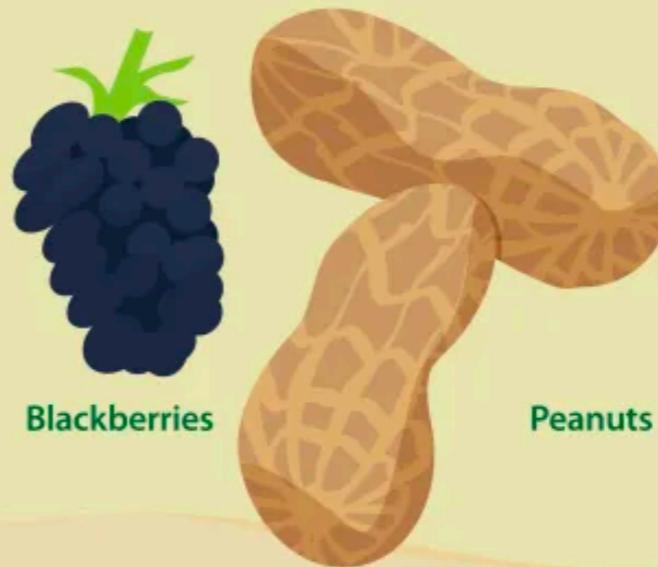
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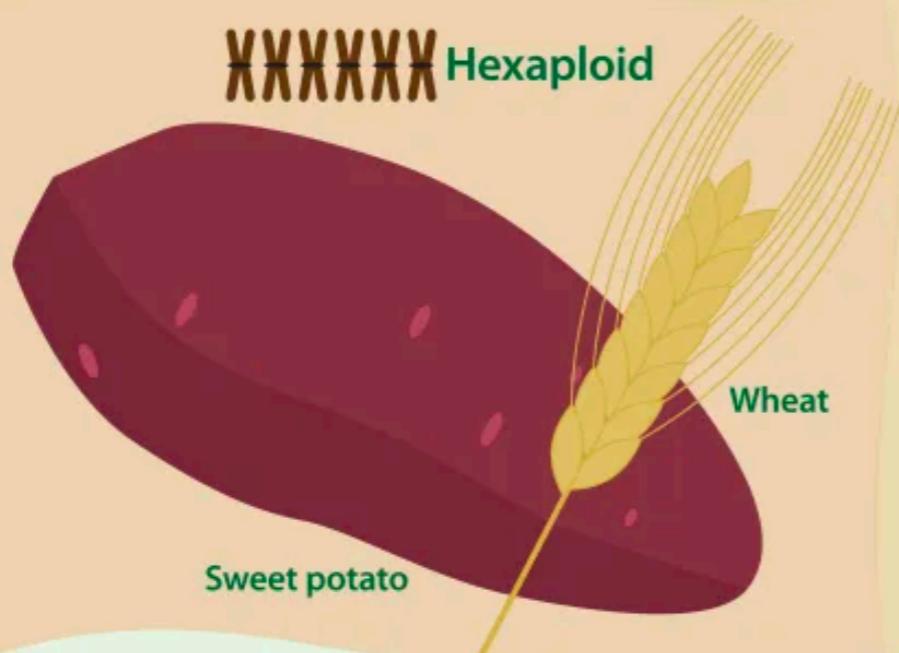
XXXX Tetraploid



Blackberries

Peanuts

XXXXXX Hexaploid



Sweet potato

Wheat

XXXXXXXX Octoploid



Strawberry

**Other ways for sympatric speciation can occur -**

**Habitat differentiation  
Sexual selection**

# Habitat differentiation/specialisation

Apple maggot fly



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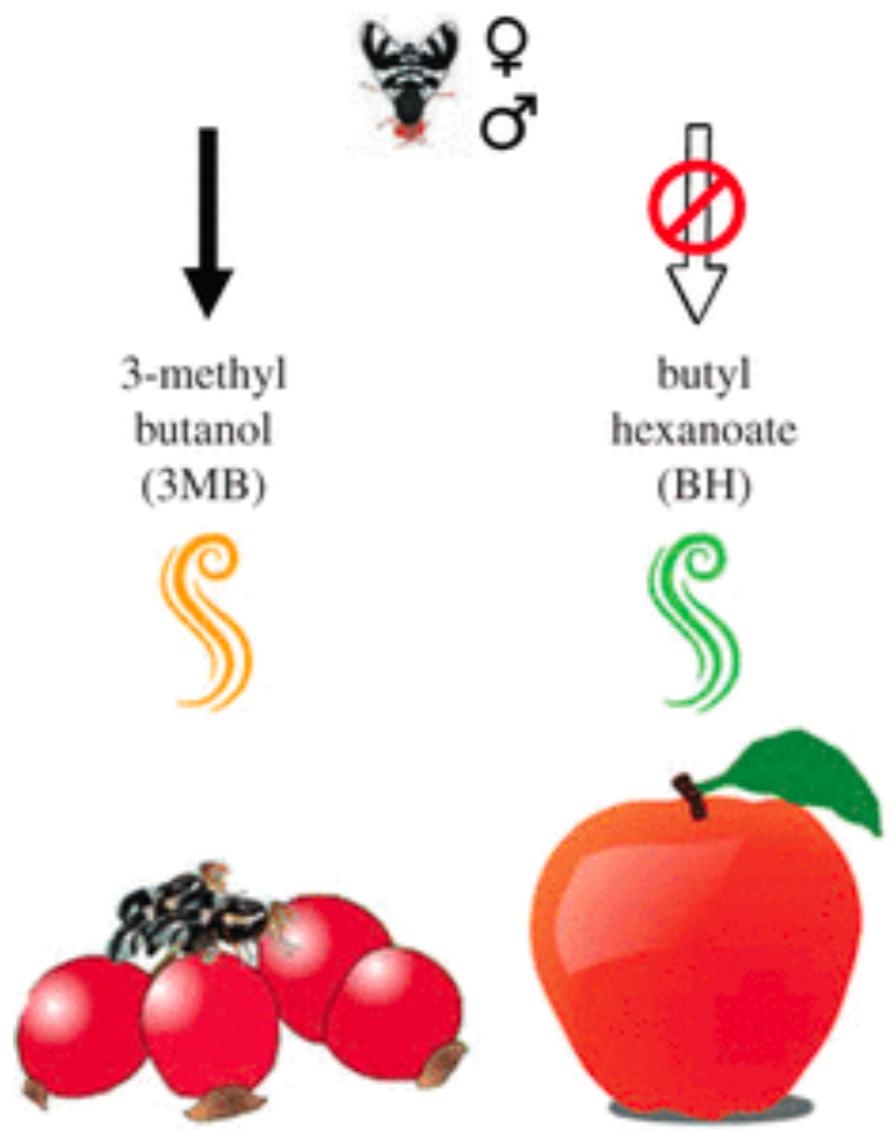
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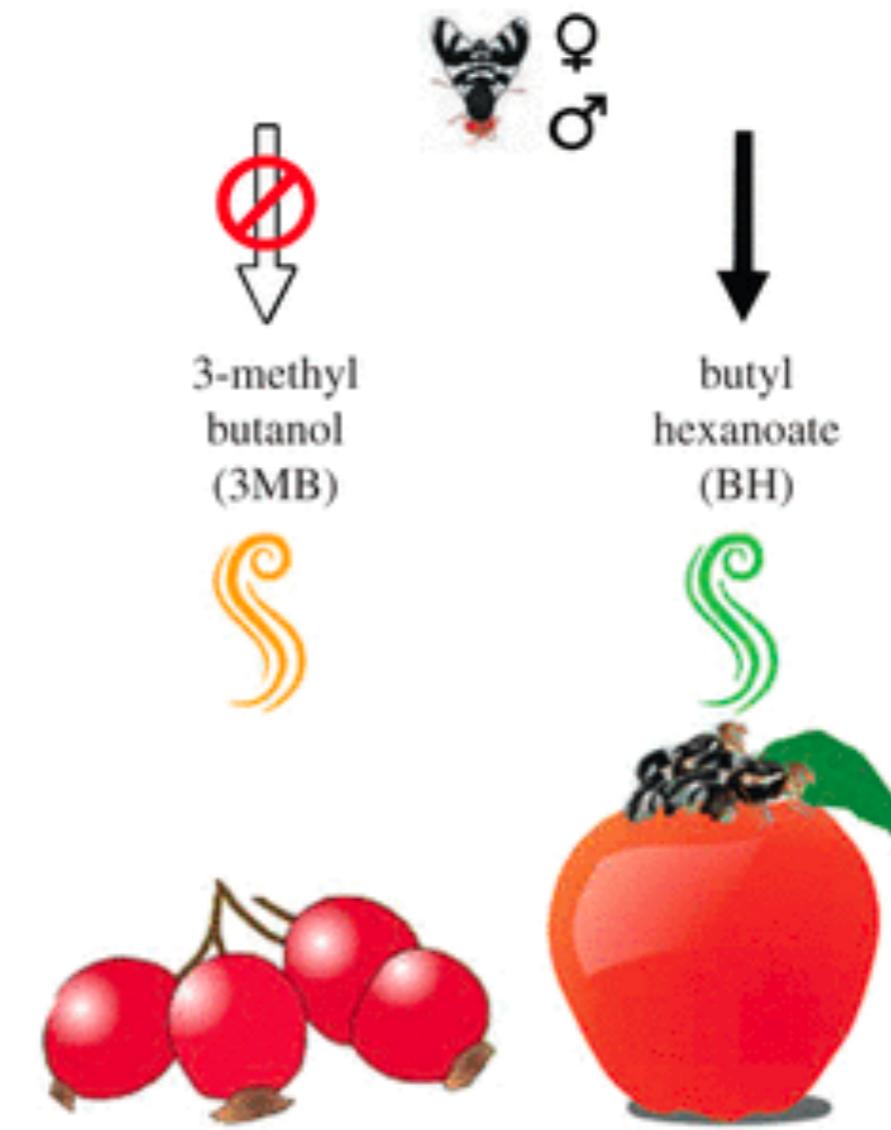
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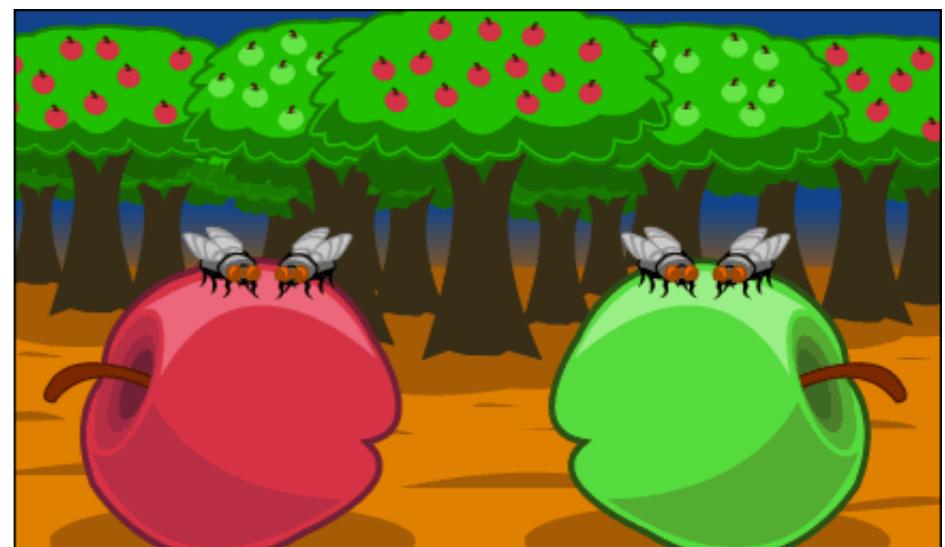
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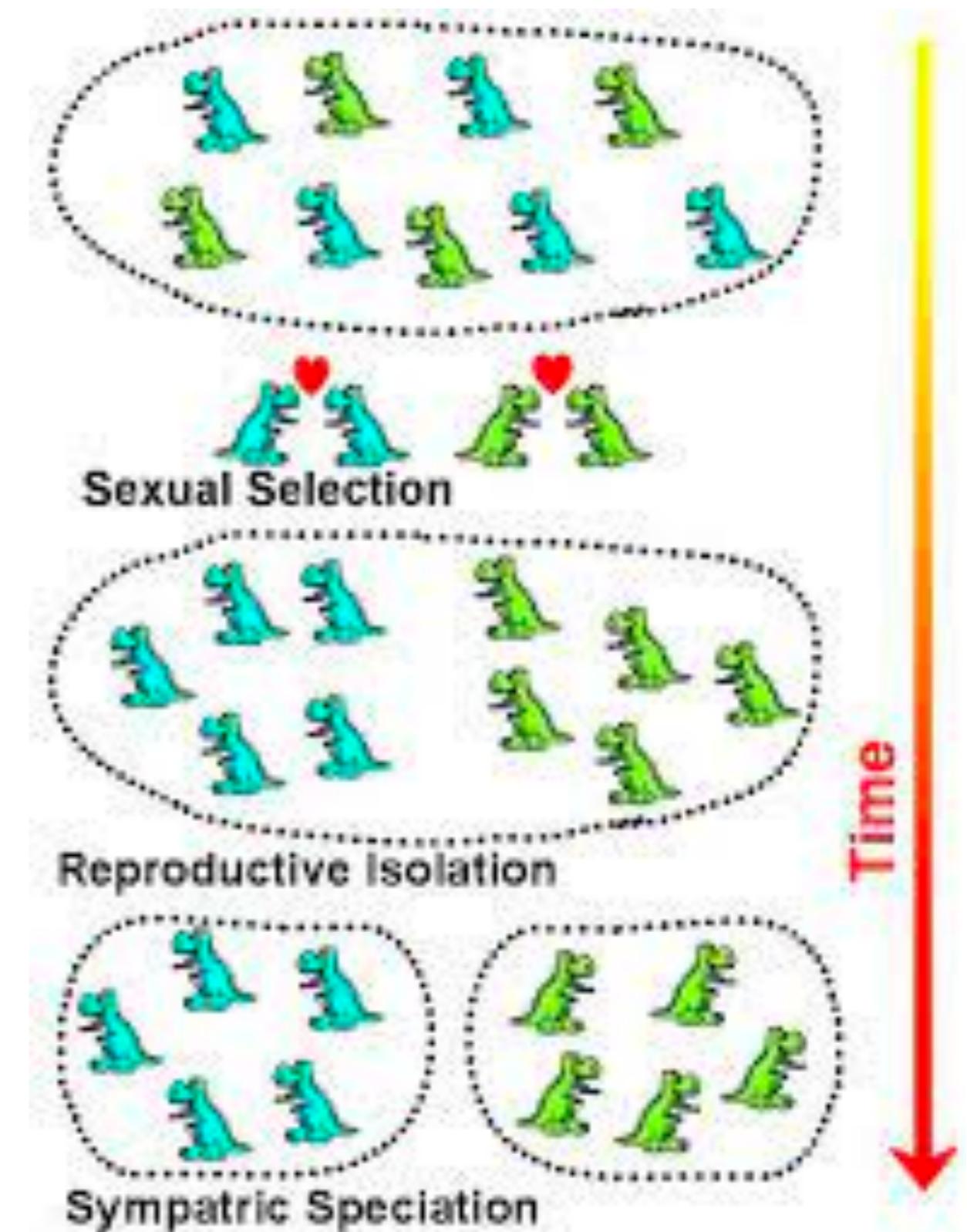
# Sexual Selection can drive sympatric speciation

## Cichlid fishes in Lake Victoria

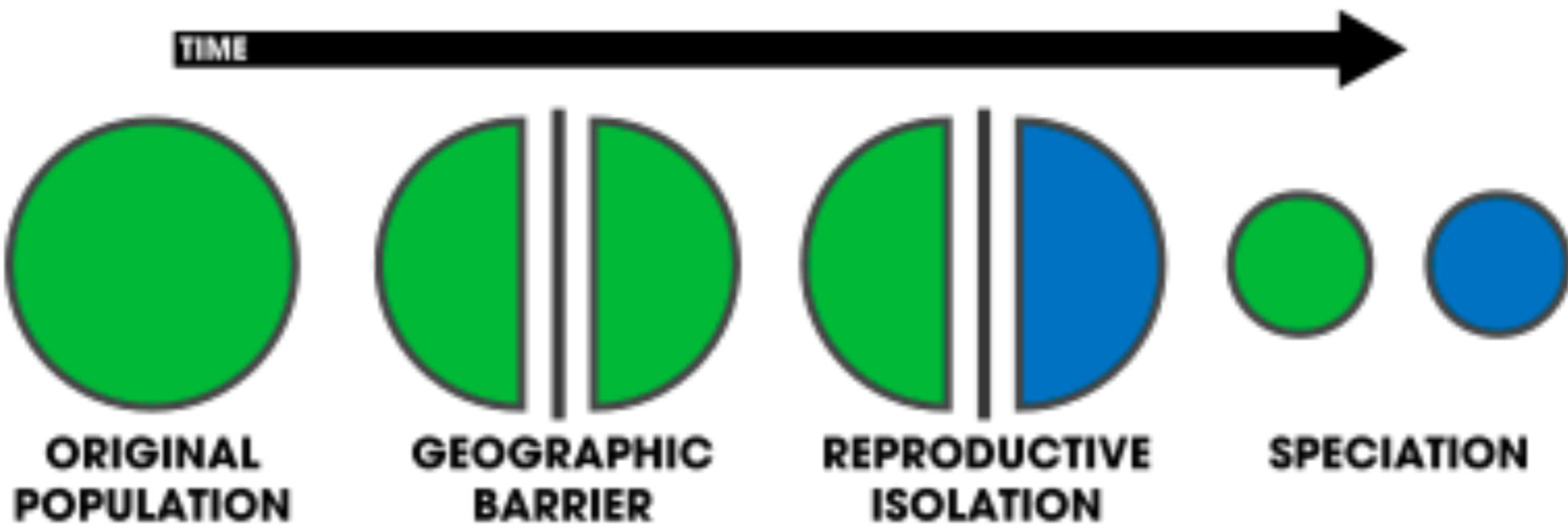
*P.  
pundamilia*



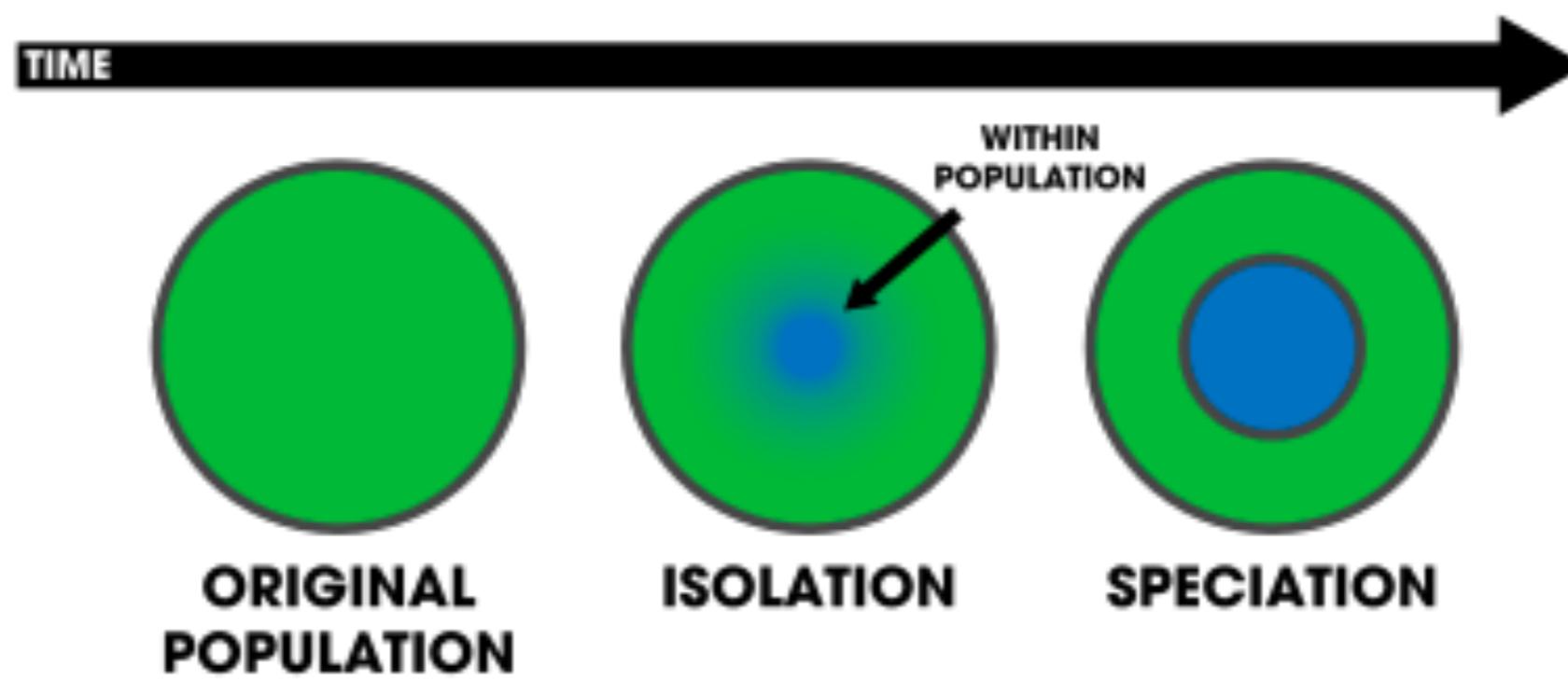
*P. nyererei*



## ALLOPATRIC SPECIATION



## SYMPATRIC SPECIATION



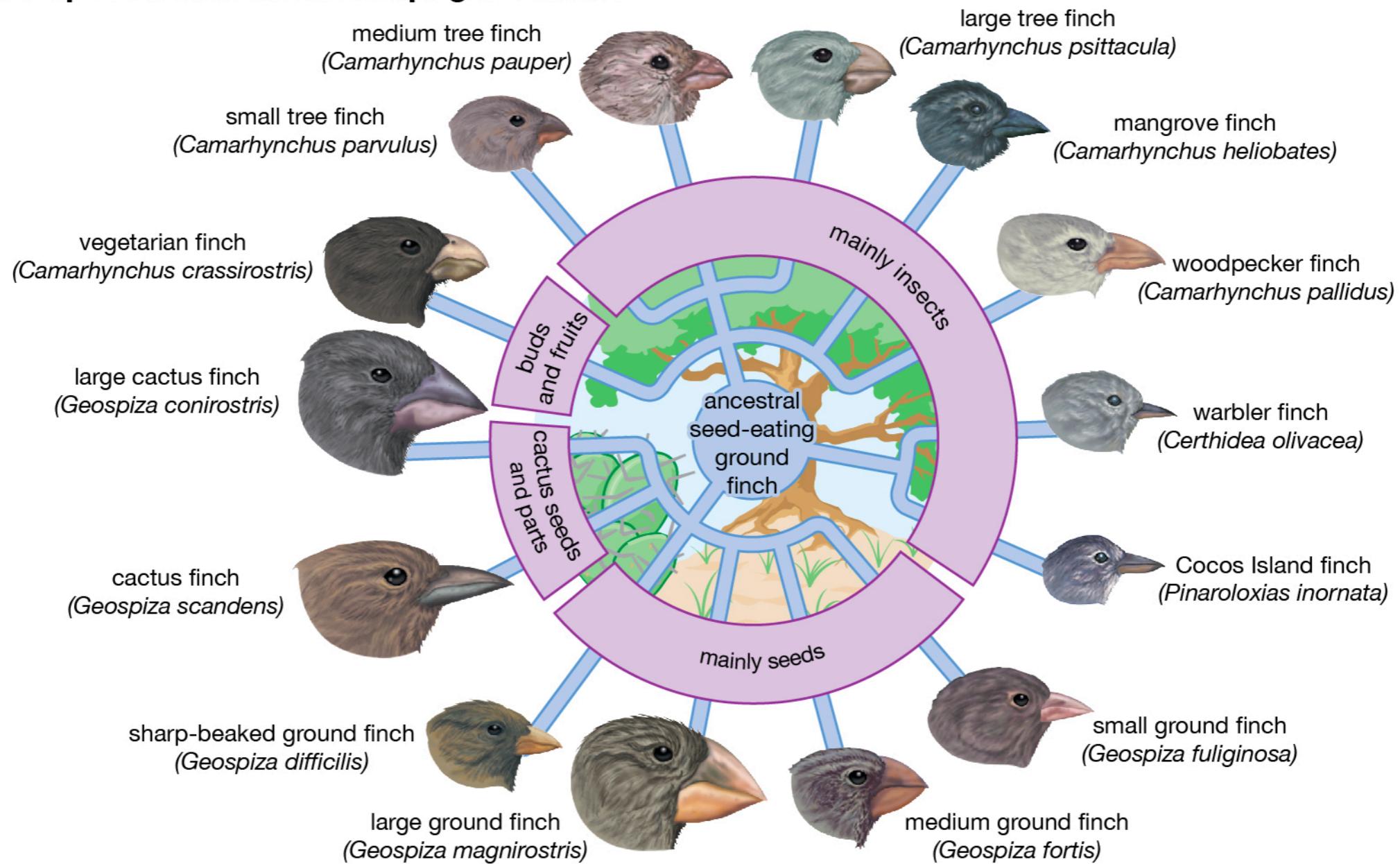
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# Adaptive Radiation

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



Previously, the finches occupied the South American mainland, but somehow managed to occupy the Galapagos islands, over 600 miles away. As population began to grow in the islands, competition increased. The finches managed to find new ecological niches to reduce competition.

Some ate insects, some ate seeds of a different size and some ate fruits and so on.

Original finches might have died out if not for this adaptation by diversification.

- New resources are available**
- New challenges such as colonisation of new habitat**
- Environmental niches**
- Evolvability**

# ADAPTIVE RADIATION VERSUS DIVERGENT EVOLUTION

Adaptive radiation is the diversification of a group of individuals into forms filling different ecological niches

A type of microevolution

Brings morphological and ecological changes to a particular population

A rapid process

Divergent evolution is a process of developing two or more species from a common ancestor over time

A type of macroevolution

Generates a new species that is unable to interbreed with the original species

A slow process

**One species diversifies into many new forms each of which has an adaptive advantage in a particular environmental niche.**

**Development of new species from an existing species.**