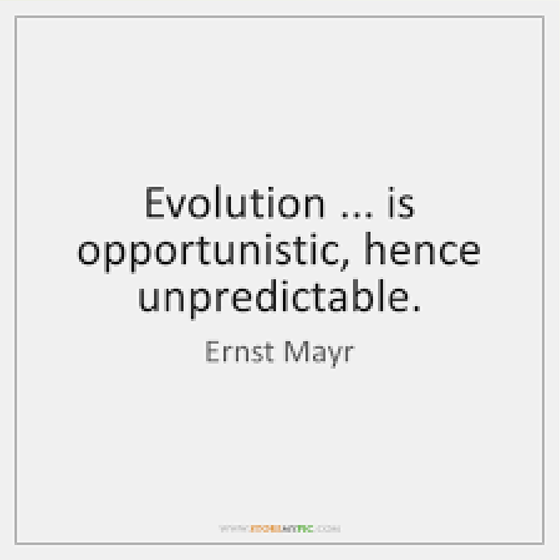
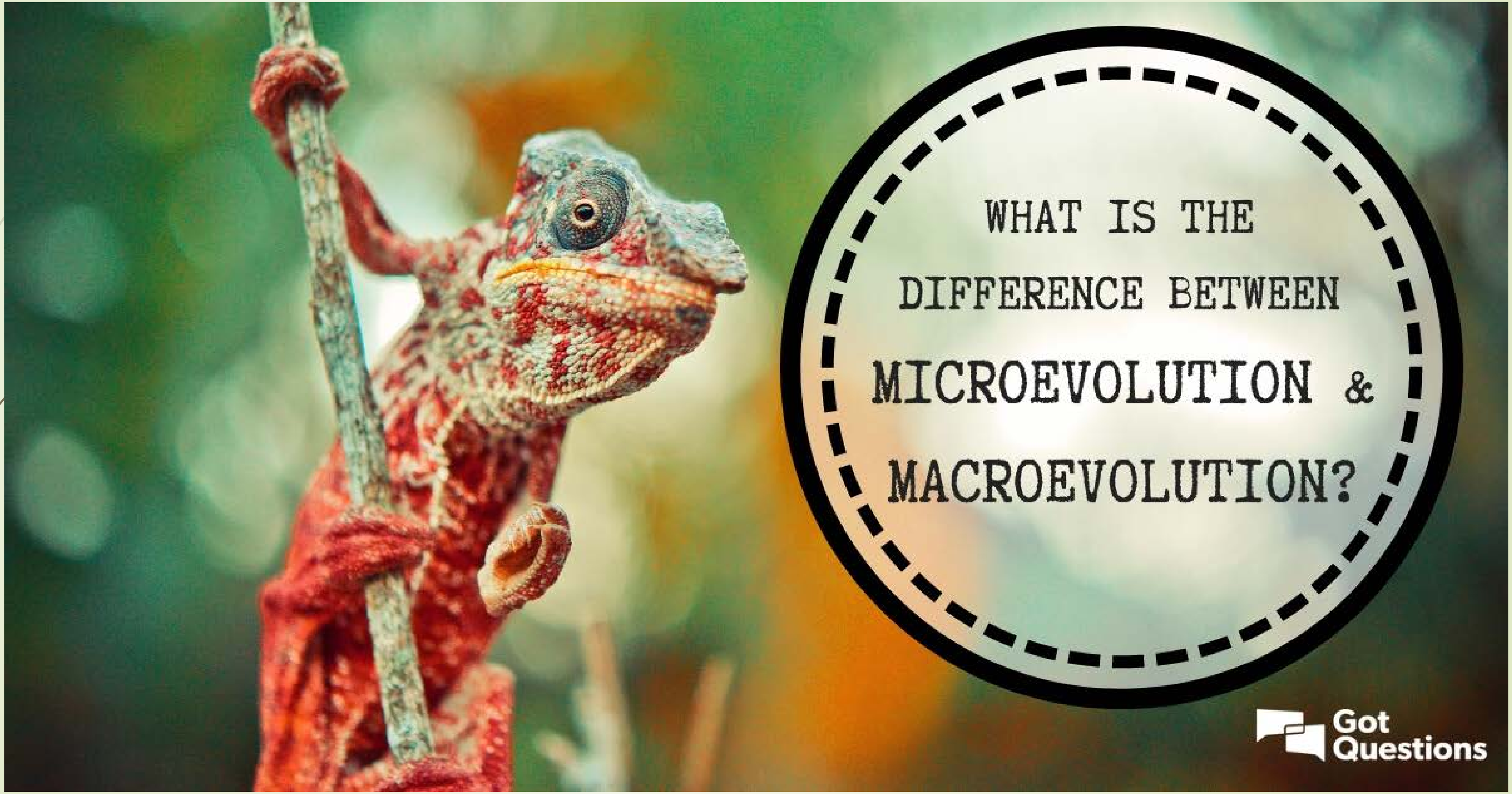
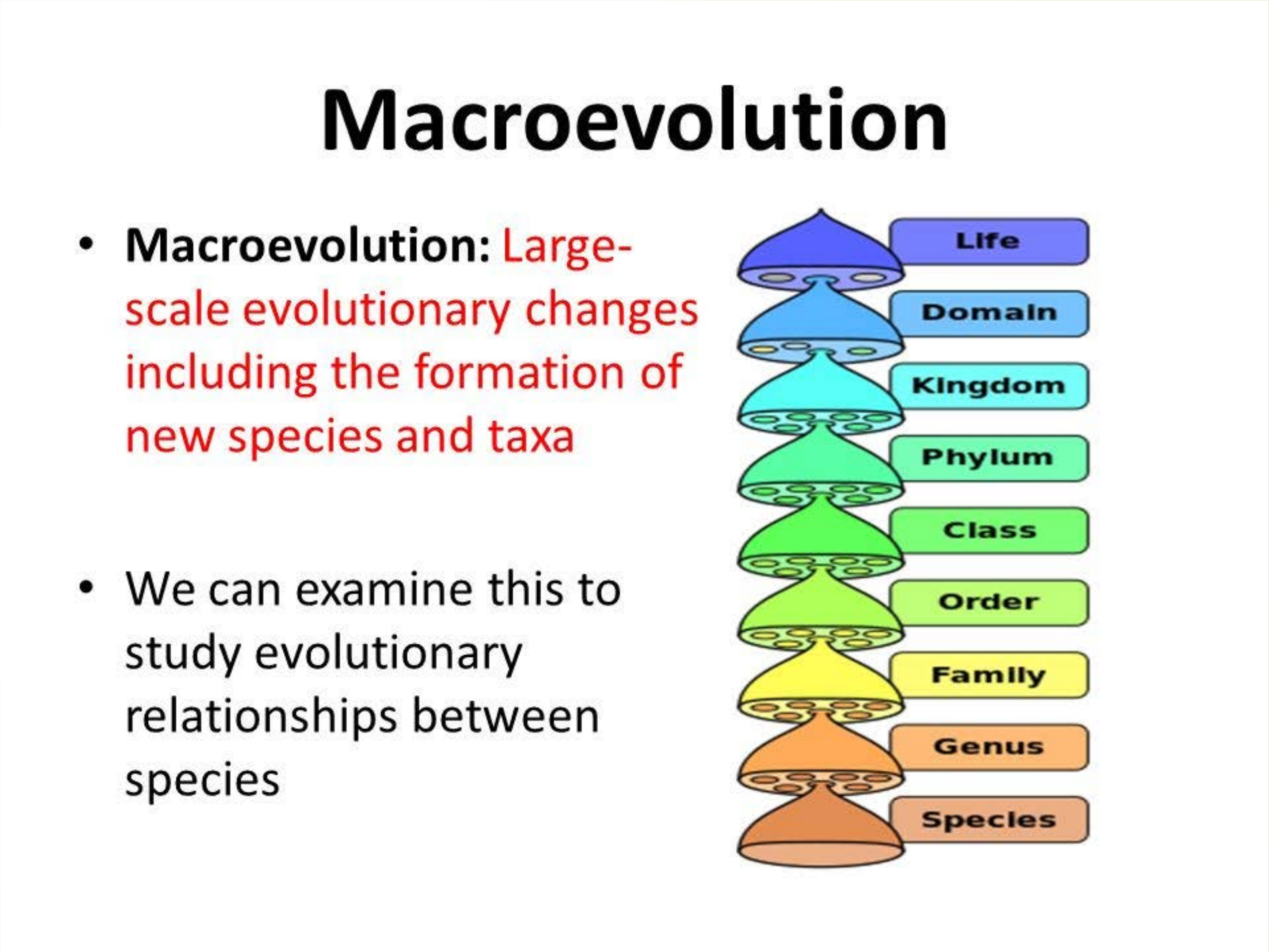

Evolution ... is
opportunistic, hence
unpredictable.
Ernst Mayr

Speciation


WHAT IS THE
DIFFERENCE BETWEEN
MICROEVOLUTION &
MACROEVOLUTION?
Got
Questions

Macroevolution

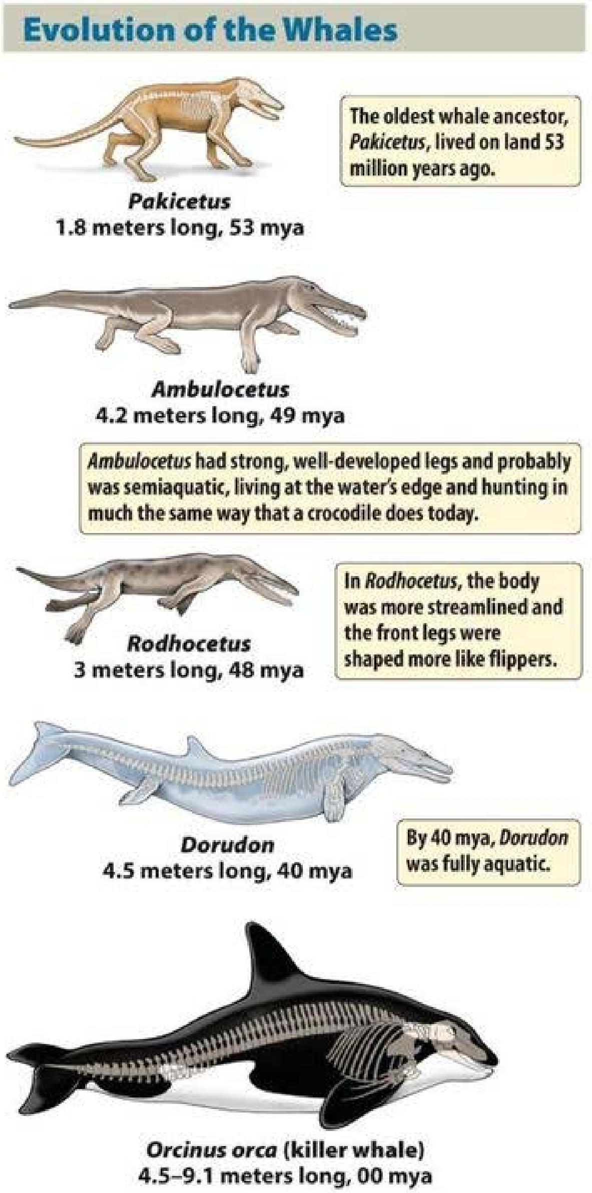
- Major Changes
- Whole Taxonomic Groups
- Factors
  - Reproductive Isolation
  - Rate
    - Gradual
    - Punctuated
      - Mass Extinction
      - Low competition
      - Stable Environment
- Supporting Evidence
  - Fossils
  - Living Organism
    - Homologous
    - Analogous
    - Vestigial



Macroevolution Describes Large-Scale Alterations in Form

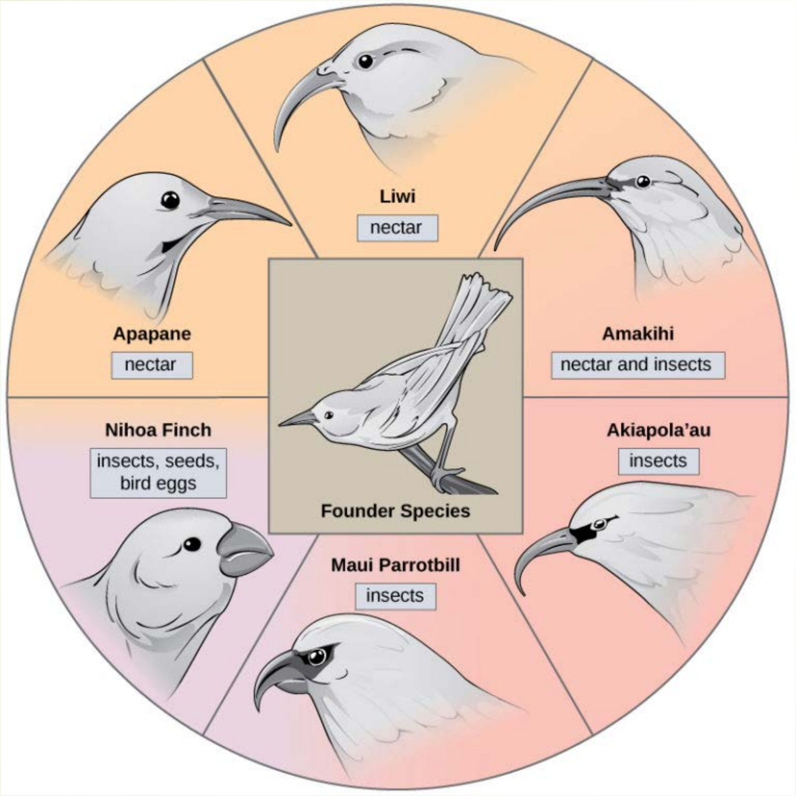
- Organisms differ radically in form, in embryological development, in body plans, in behavior, and in ecology.
- **Macroevolution** refers to large-scale changes in organisms, generally occurring over millions of years.

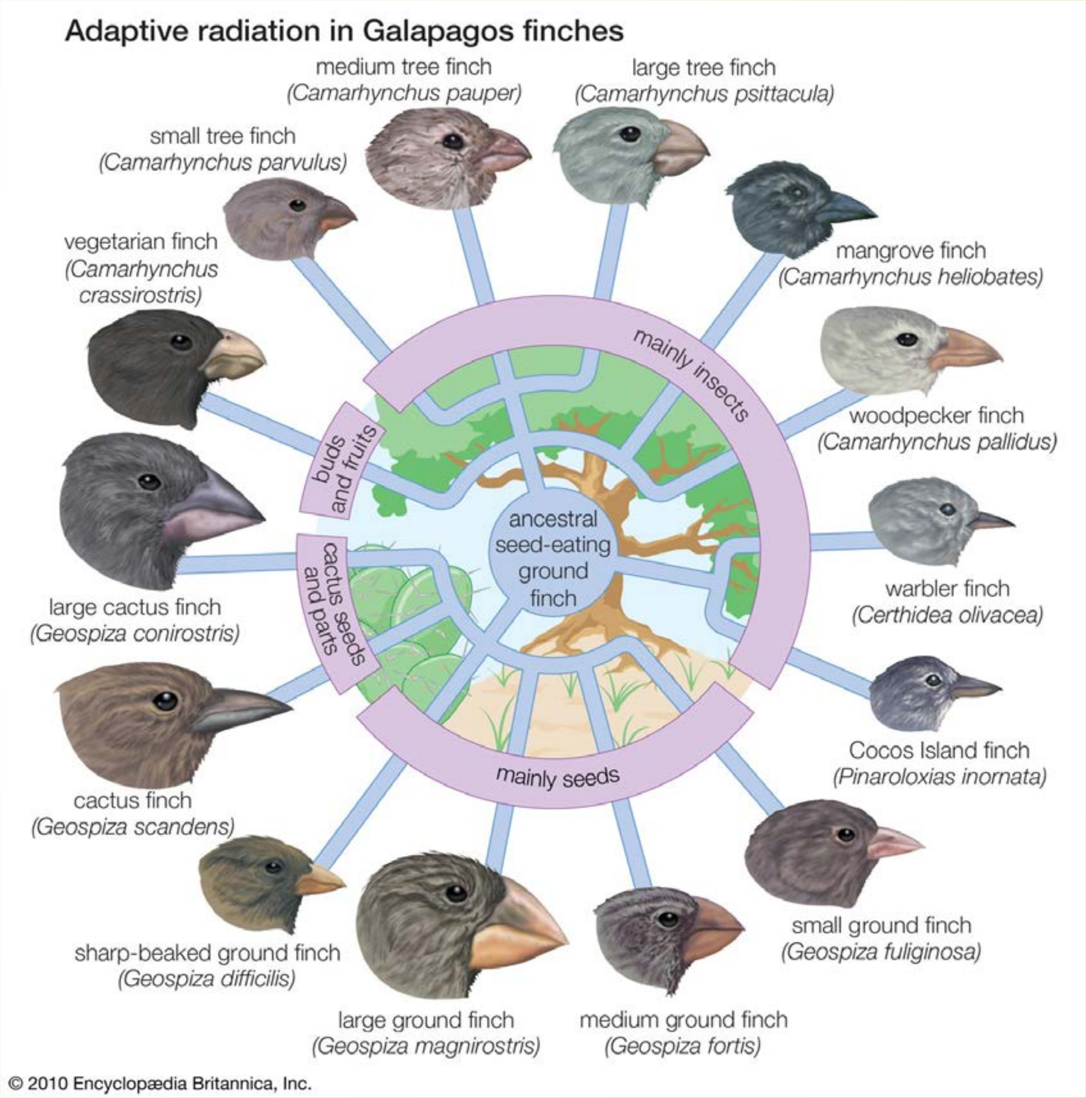
The body plan of whales has been radically altered by adaptations to aquatic life compared with the body plan of their terrestrial ungulate (hoofed) ancestors.



Discover Biology, 6/e Figure 16.1

Macroeveolution: Adaptive Radiation





Time

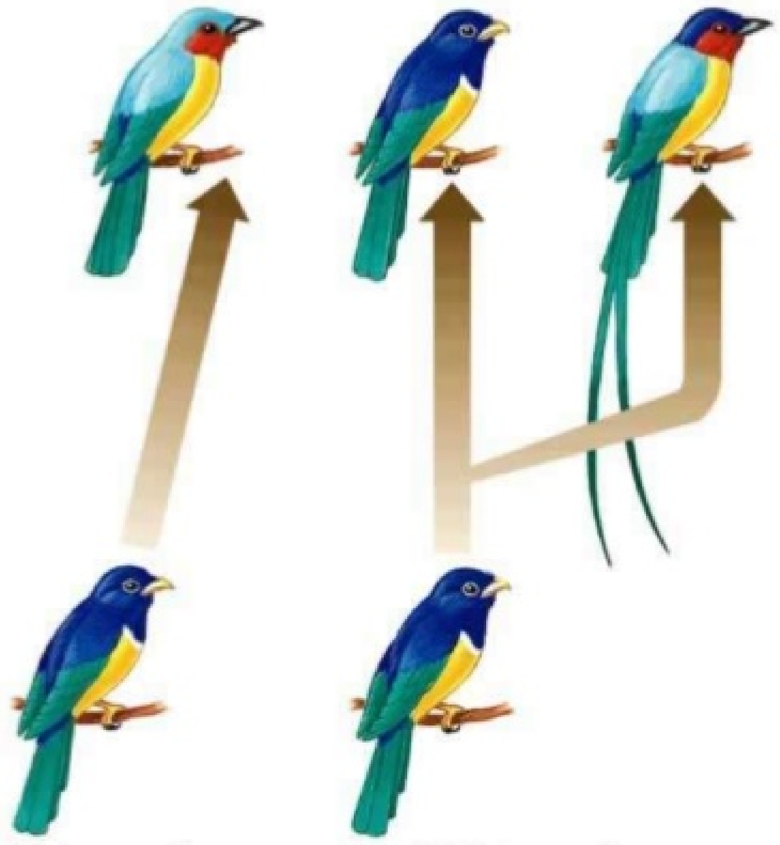
Two Patterns of Speciation

1. Gradualism (Anagenesis)

A slow, gradual accumulation of heritable changes (adaptations) in a population, due to many small episodes of natural selection. So, one species changes slowly, step-by-step, until it looks so different that we call it a new species.

2. Branching (Cladogenesis)

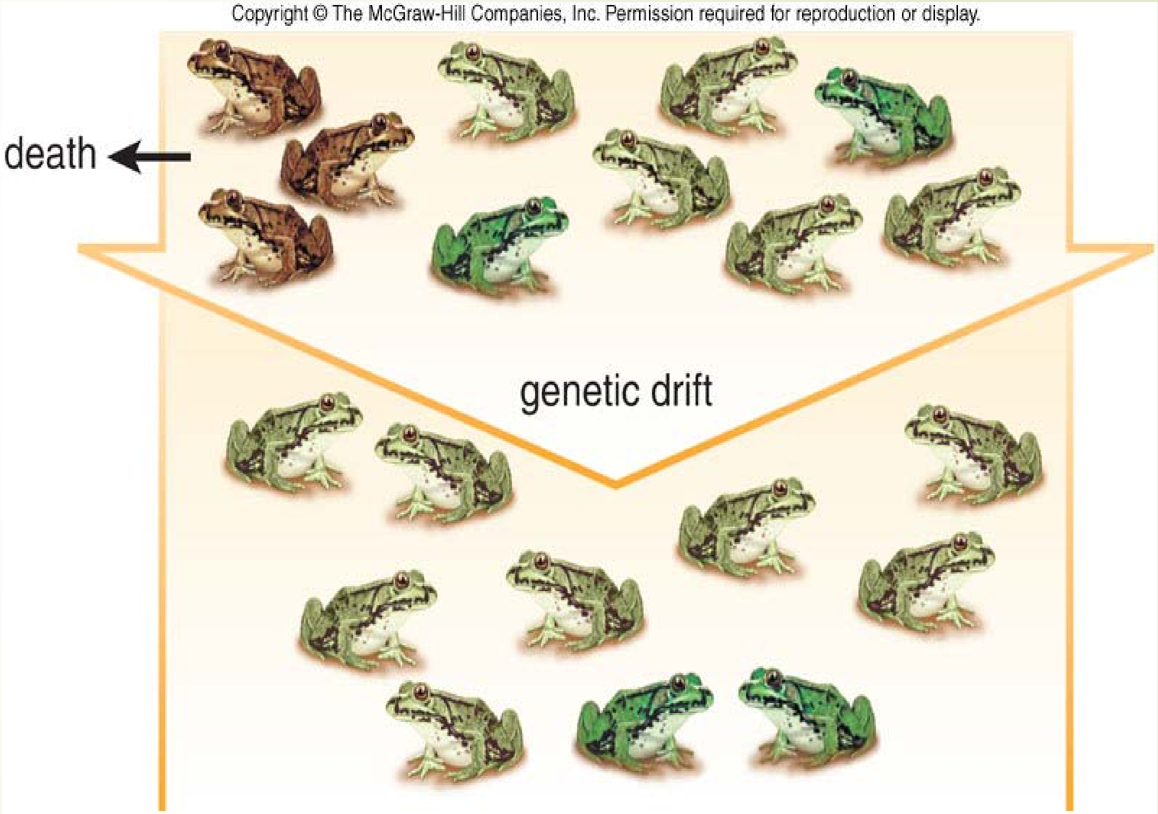
A more rapid splitting of one or more new species from an original species that may or may not continue to exist. So one species branches into two or more new ones. This process is the basis for all biological diversity.



(a) Anagenesis (b) Cladogenesis

Microevolution

- Survival through inheritance
  - Gene Pool Population
  - Change in allele frequencies
  - Time: one generation to the next
- Causes
  - Gene Flow
  - Genetic Drift
  - Mutations
  - Inbreeding
- Selection
  - Artificial
  - Natural → Adaptation

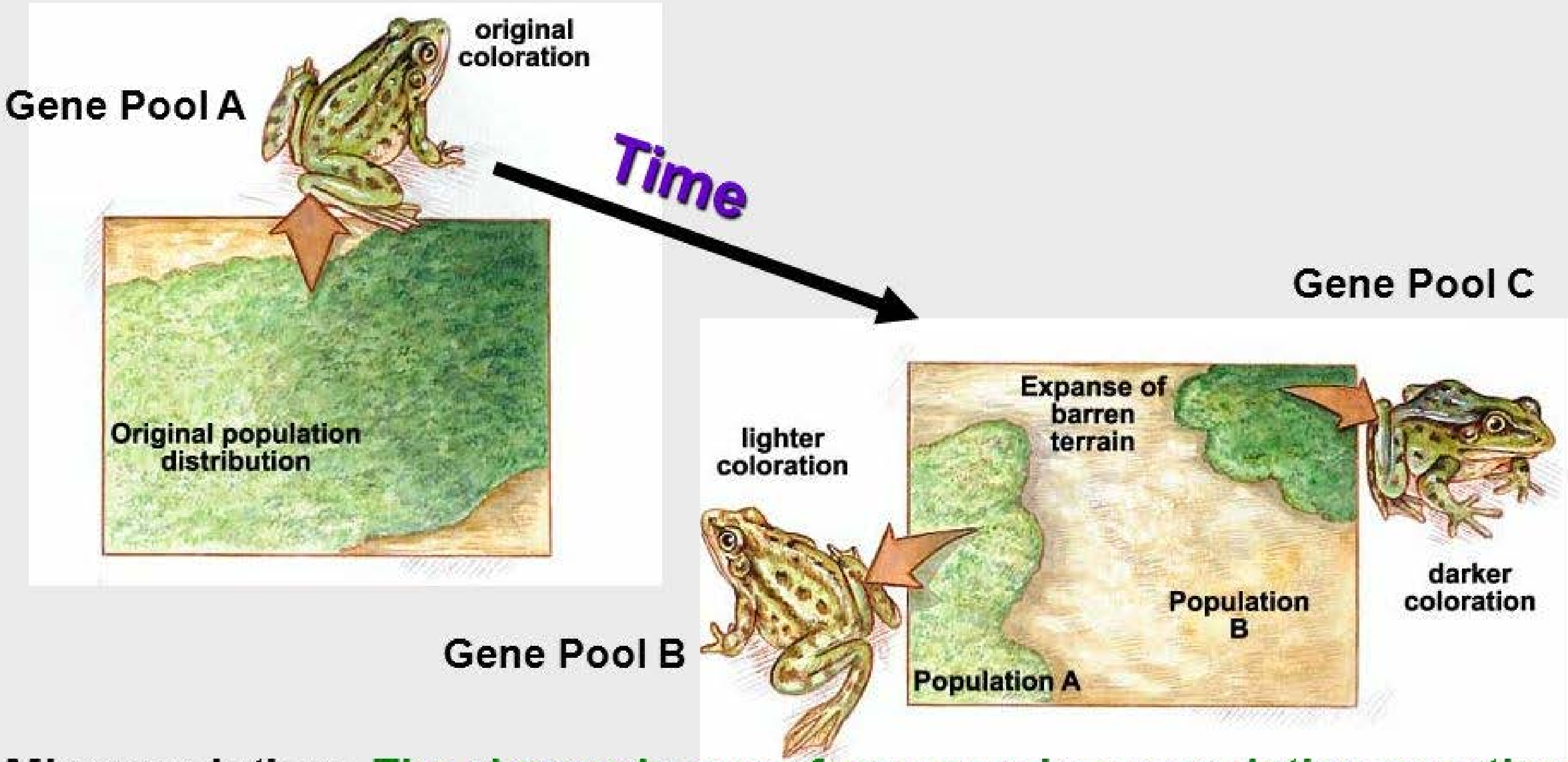


The Evolution of Population: The Mechanisms of Microevolution

I. Evolution (What actually changes?)

A. Gene frequency: the amount of a particular allele as found in the gene pool

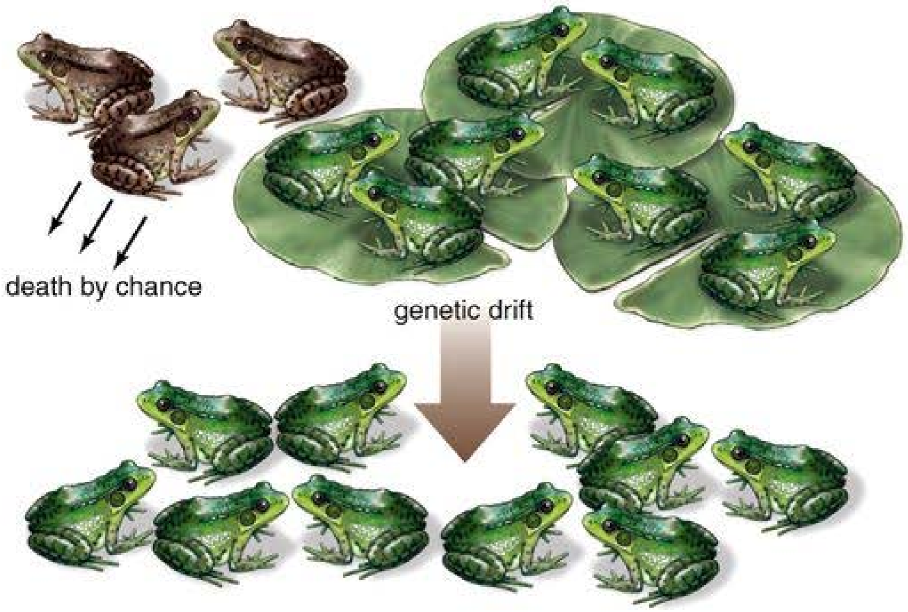
B. Gene Pool: sum total of all the alleles in a population



Microevolution: The change in gene frequency in a population over time

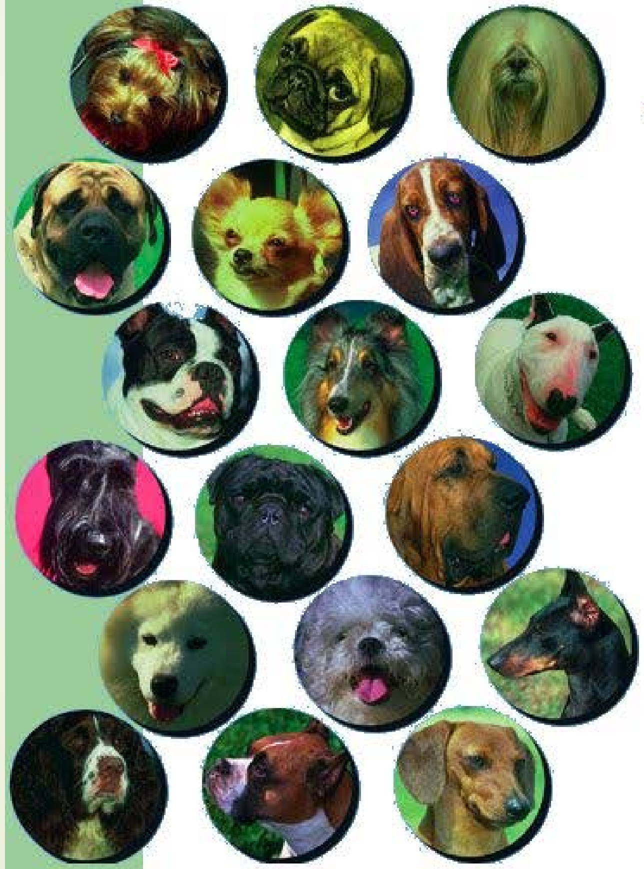
What are some causes of microevolution·

- Genetic mutations
  - Increases diversity
- Gene flow Into or out of
  - More gene flow = less diversity
- Nonrandom mating
  - Inbreeding decreases diversity
  - Assortative mating
  - Sexual selection
- Genetic drift
  - Random change in allele frequencies



- **Selection: Artificial and Natural**

Macroevolution/Microevolution



- **Dog Variability** When bred for certain traits, dogs become different and distinctive. This is a common example of microevolution—changes in size, shape, and color—or minor genetic alterations. It is not macroevolution: an upward, beneficial increase in complexity.

MICROEVOLUTION

- Mutations & Gene shuffling
- Natural selection of traits
  - Single gene traits
  - Polygenic traits
- Genetic drift
- Gene flow

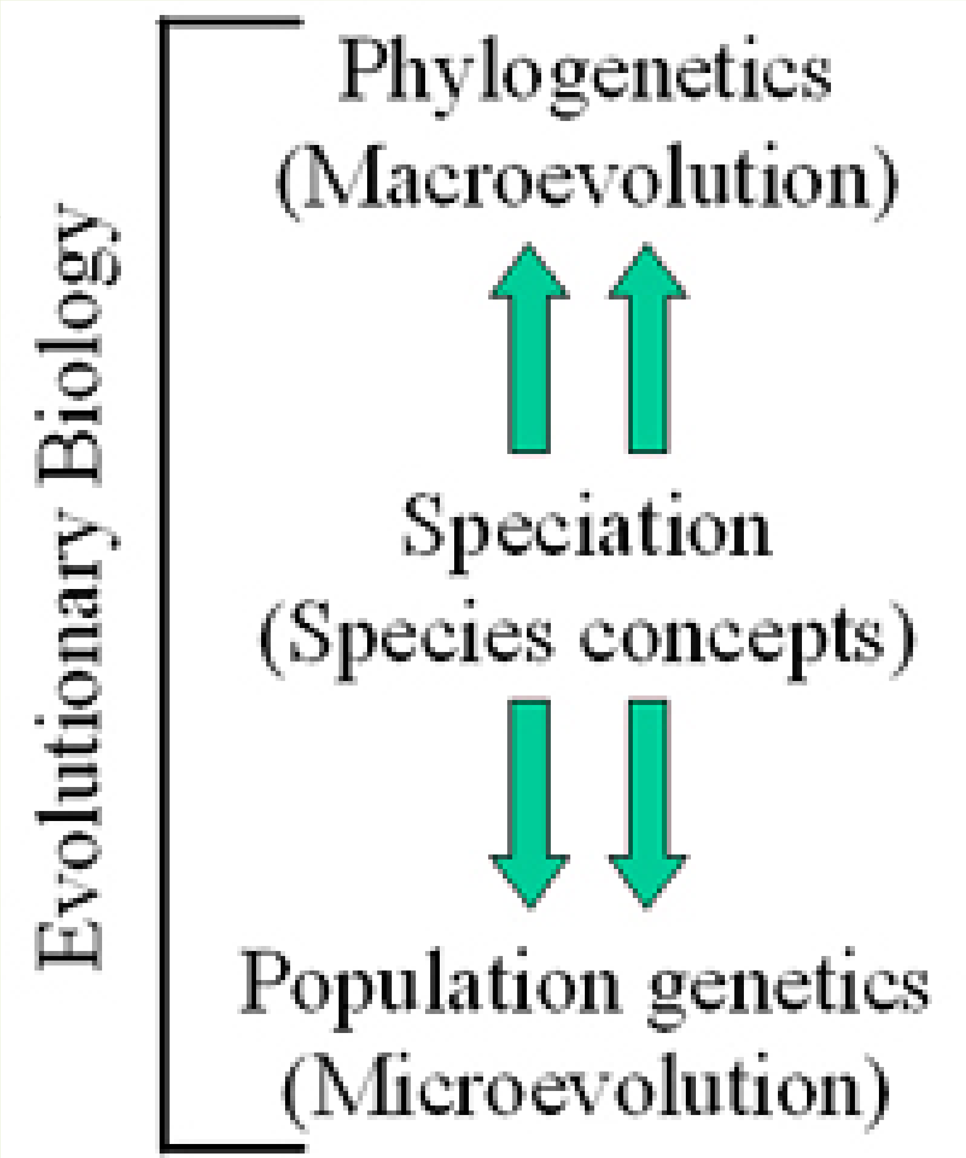
Smaller Picture

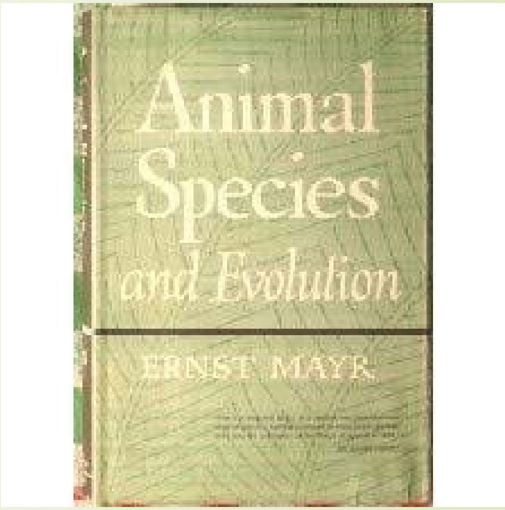
MACROEVOLUTION

Mutations
Natural selection + 3.8 billion years = Macroevolution
Genetic Drift
Gene flow

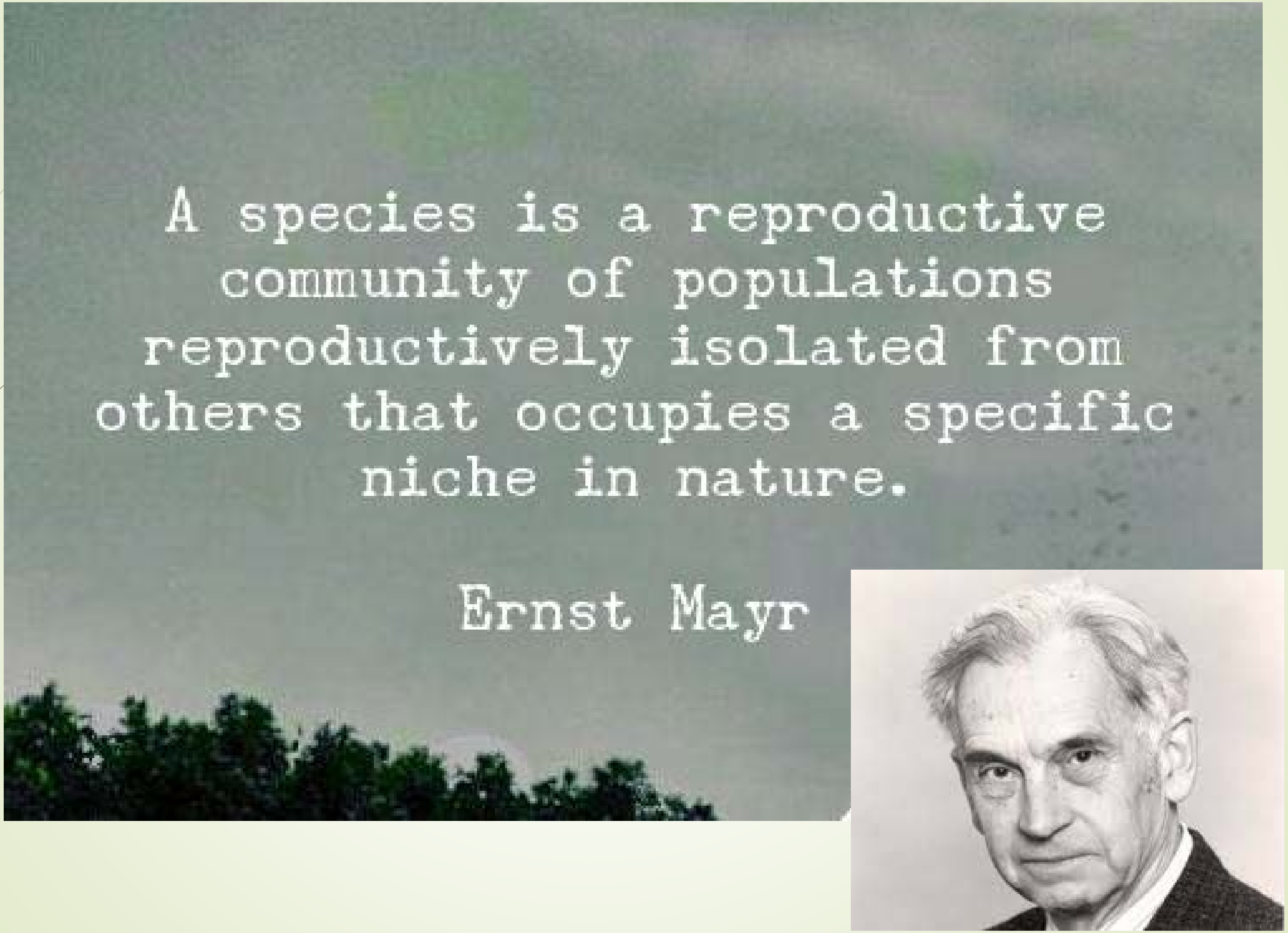
- Adaptive radiation
- Convergent & divergent evolution
- Coevolution
- Gradualism
- Punctuated equilibrium
- Mass extinction

Bigger Picture


Evolutionary Biology
Phylogenetics
(Macroevolution)
Speciation
(Species concepts)
Population genetics
(Microevolution)

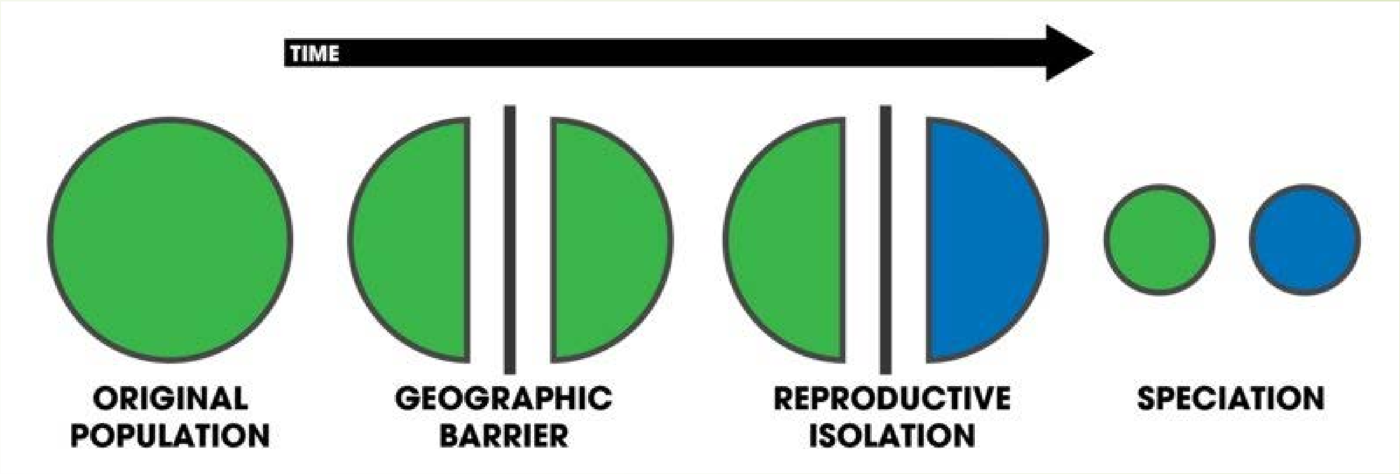

Animal
Species
and Evolution
ERNST MAYR

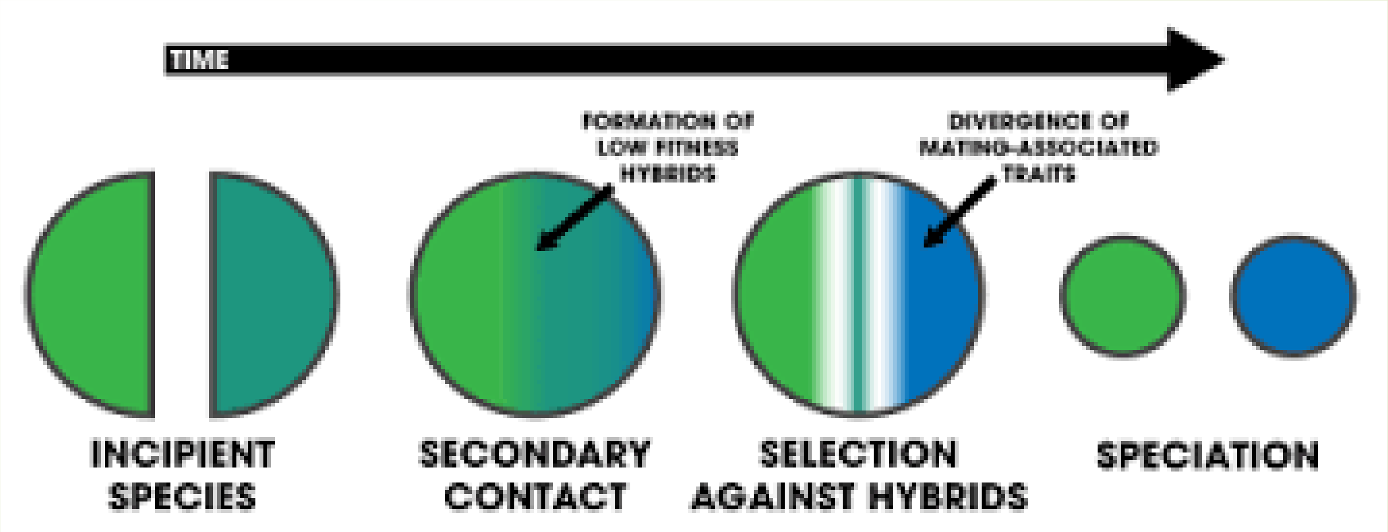
1963


A species is a reproductive community of populations reproductively isolated from others that occupies a specific niche in nature.
Ernst Mayr

Speciation

- Define terms
  - Species
  - Speciation
- Characteristics
- Barriers
- Isolation
- Processes
- Time





Natural selection and genetic drift can change the relative frequencies of alleles in a population and lead to speciation.

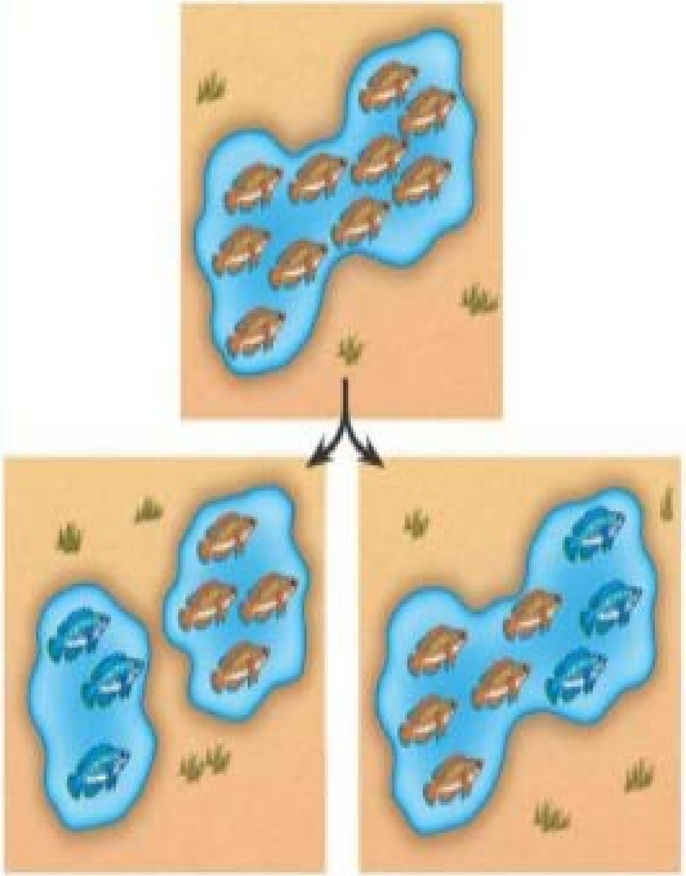
Speciation is the formation of new species.

A species is a group of organisms whose members can interbreed with one another and produce fertile offspring.

This means that the members of a species share a common gene pool. A genetic change in one individual can spread through the population **if it increases fitness.**

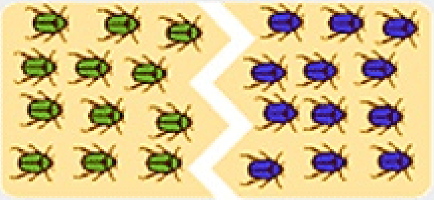
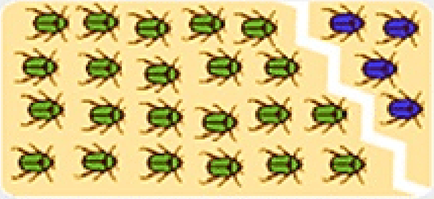
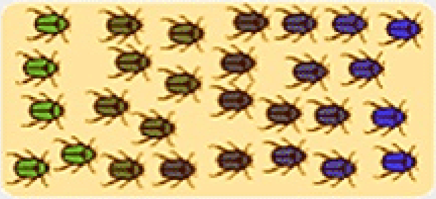
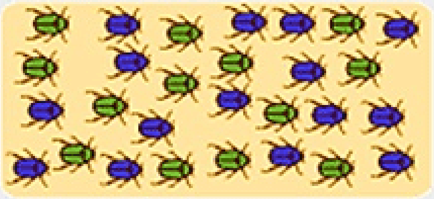
Causes of Speciation

- Populations must become isolated
  - geographically isolated
    - allopatric
      - » geographic separation; *"other island"*
    - sympatric
      - » still live in same area; *"same island"*
  - reproductively isolated
    - -before fertilization (**prezygotic barries**)
    - -after fertilization (**postzygotic barriers)**
- – isolated populations evolve independently

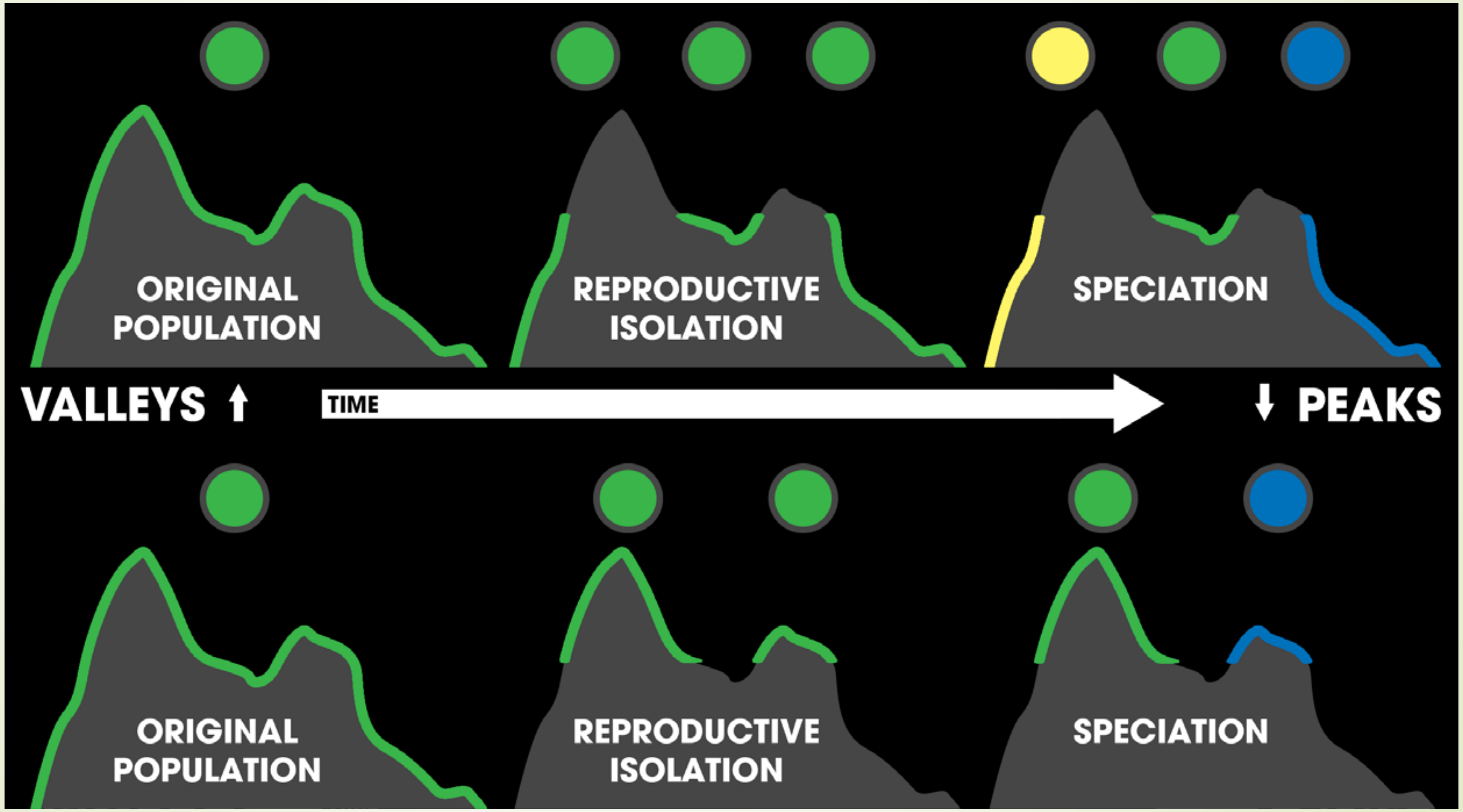


(a) Allopatric speciation. A pop- (b) Sympatric speciation. A

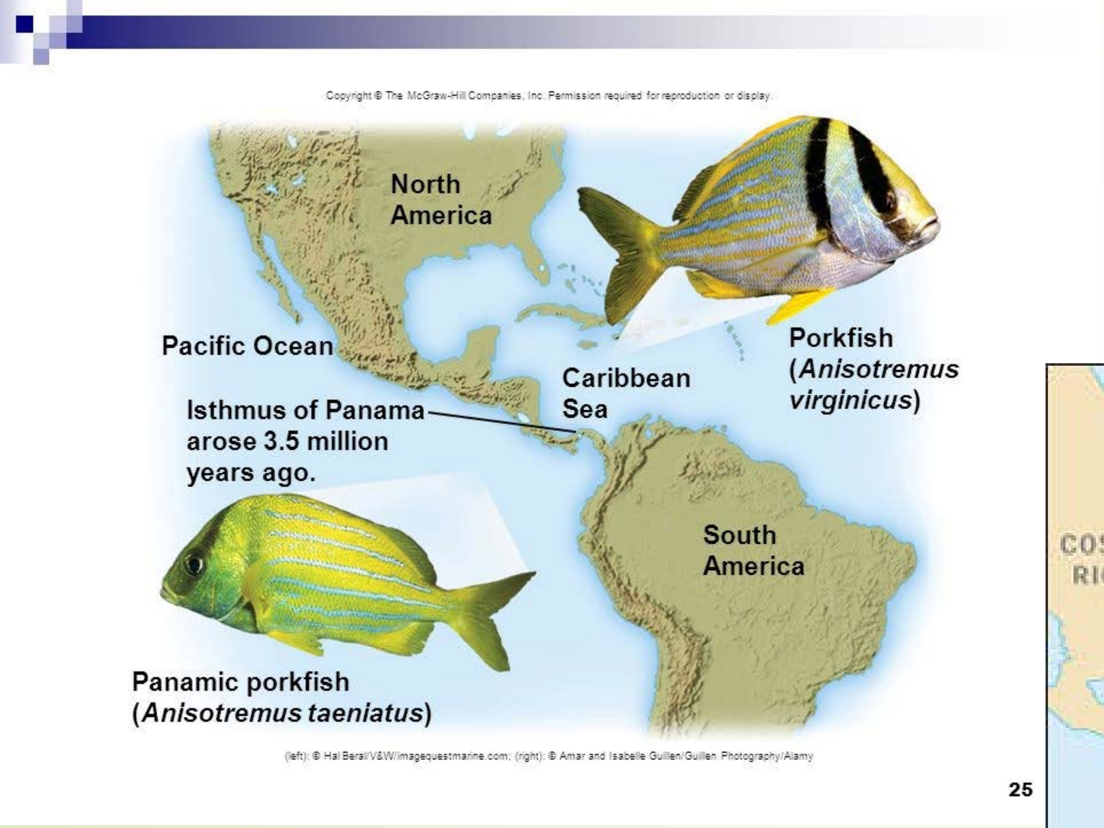
Geographic Modes of Speciation

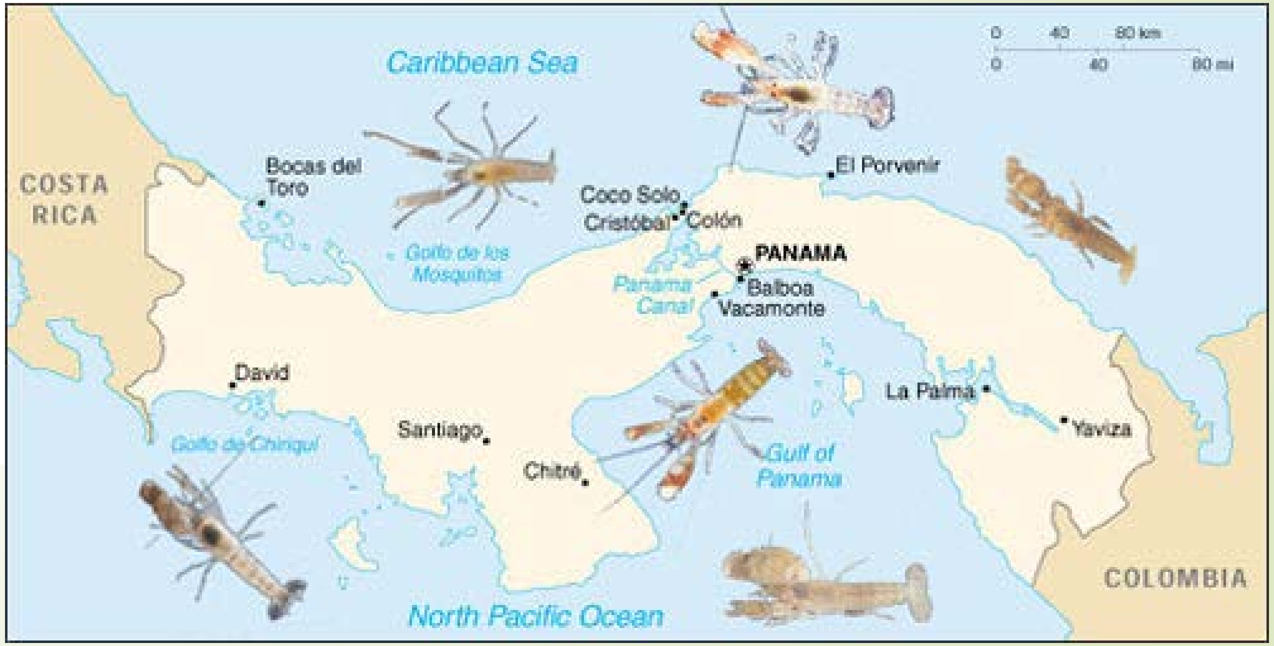
Mode of speciation	New species formed from...	
Allopatric (allo = other, patric = place)	geographically isolated populations	
Peripatric (peri = near, patric = place)	a small population isolated at the edge of a larger population	
Parapatric (para = beside, patric = place)	a continuously distributed population	
Sympatric (sym = same, patric = place)	within the range of the ancestral population	

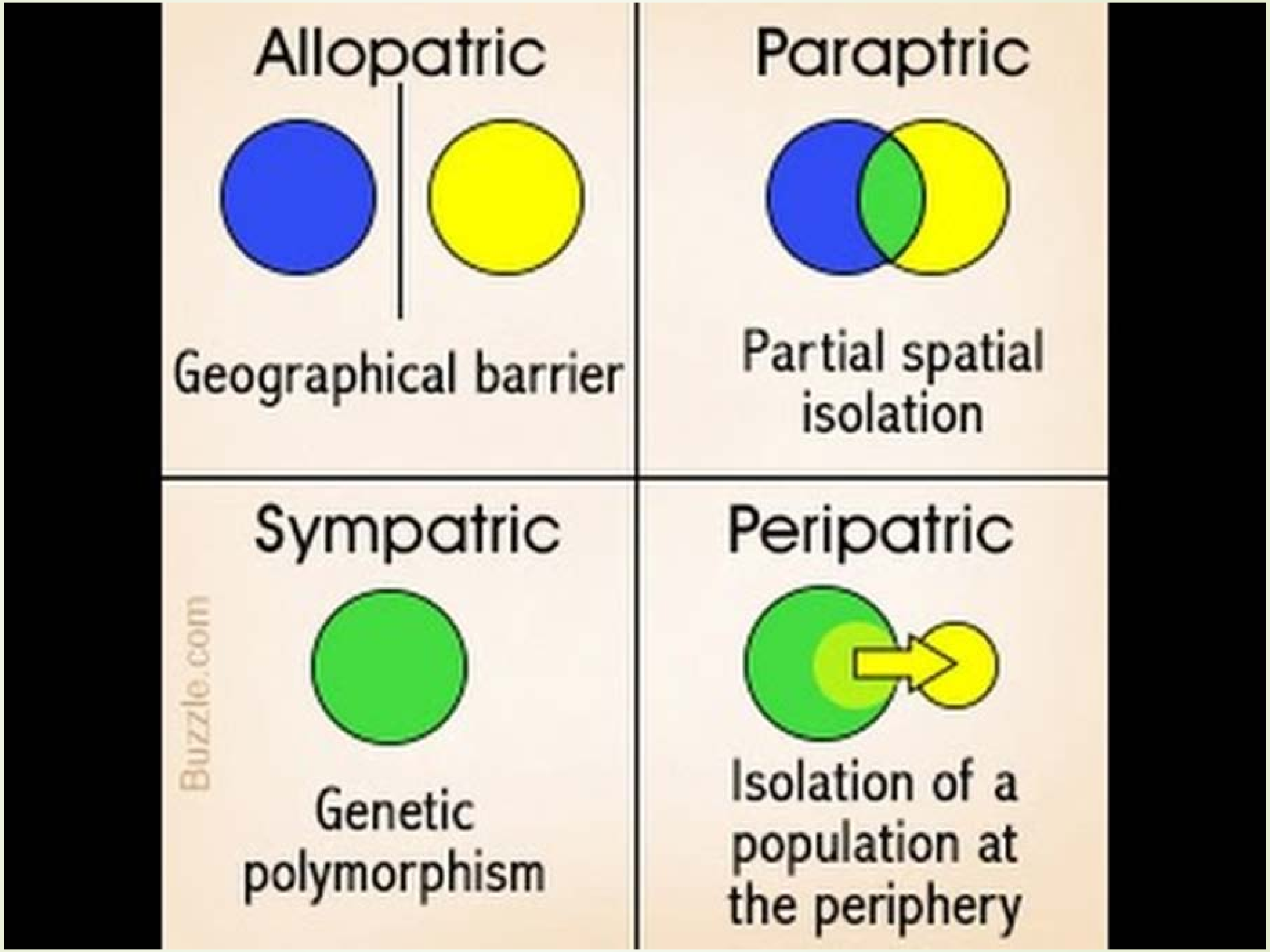
Geographic Barriers



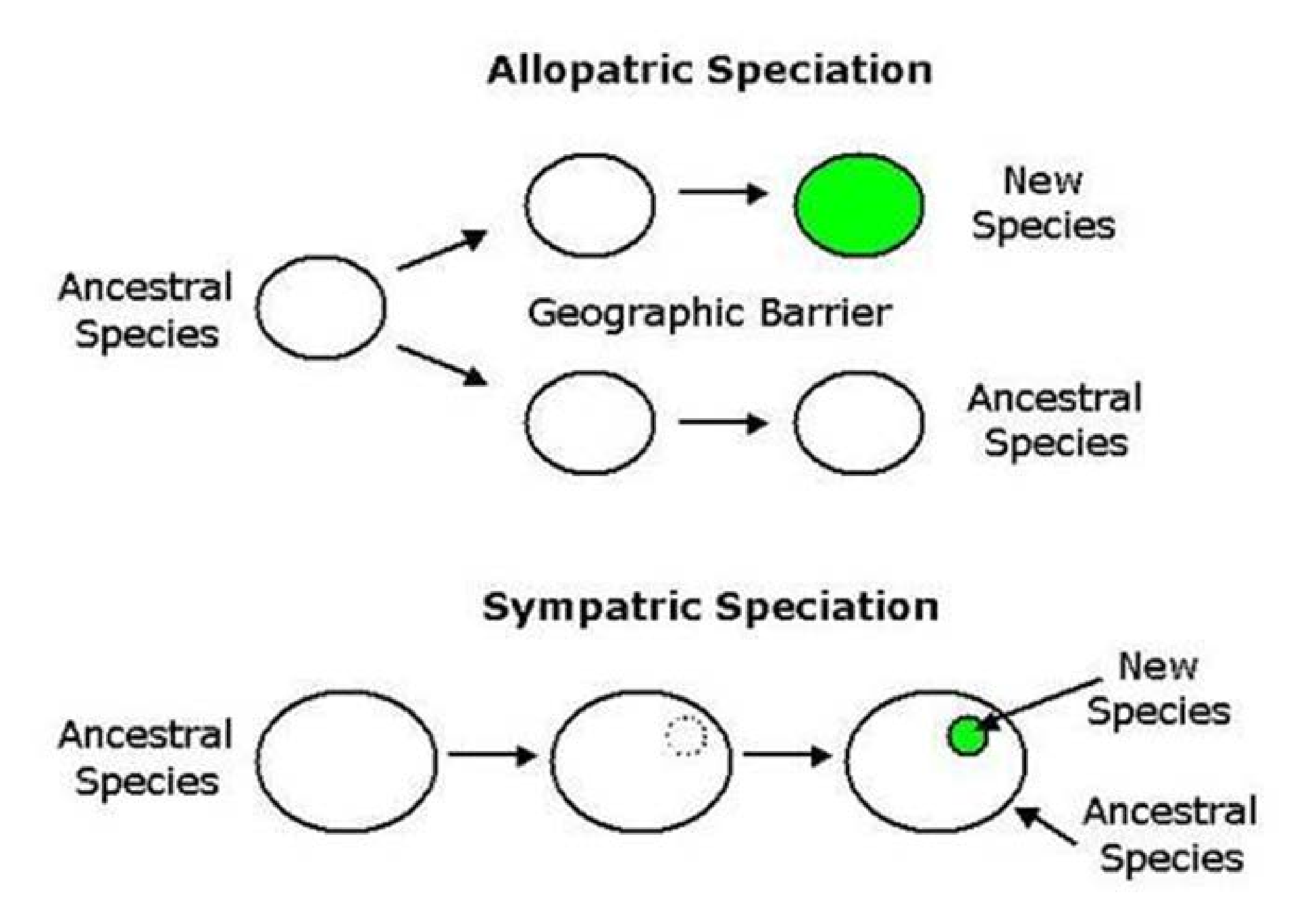
Allopatric Speciation



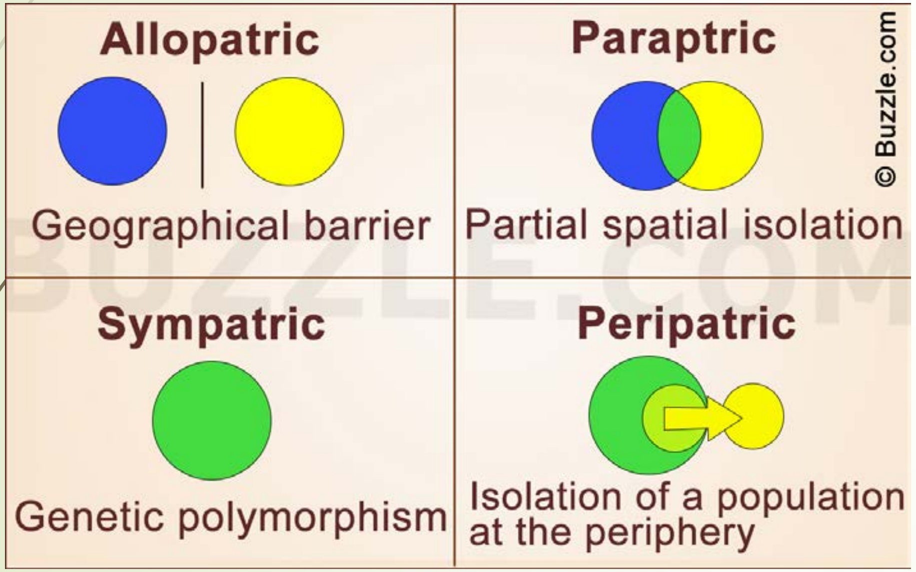


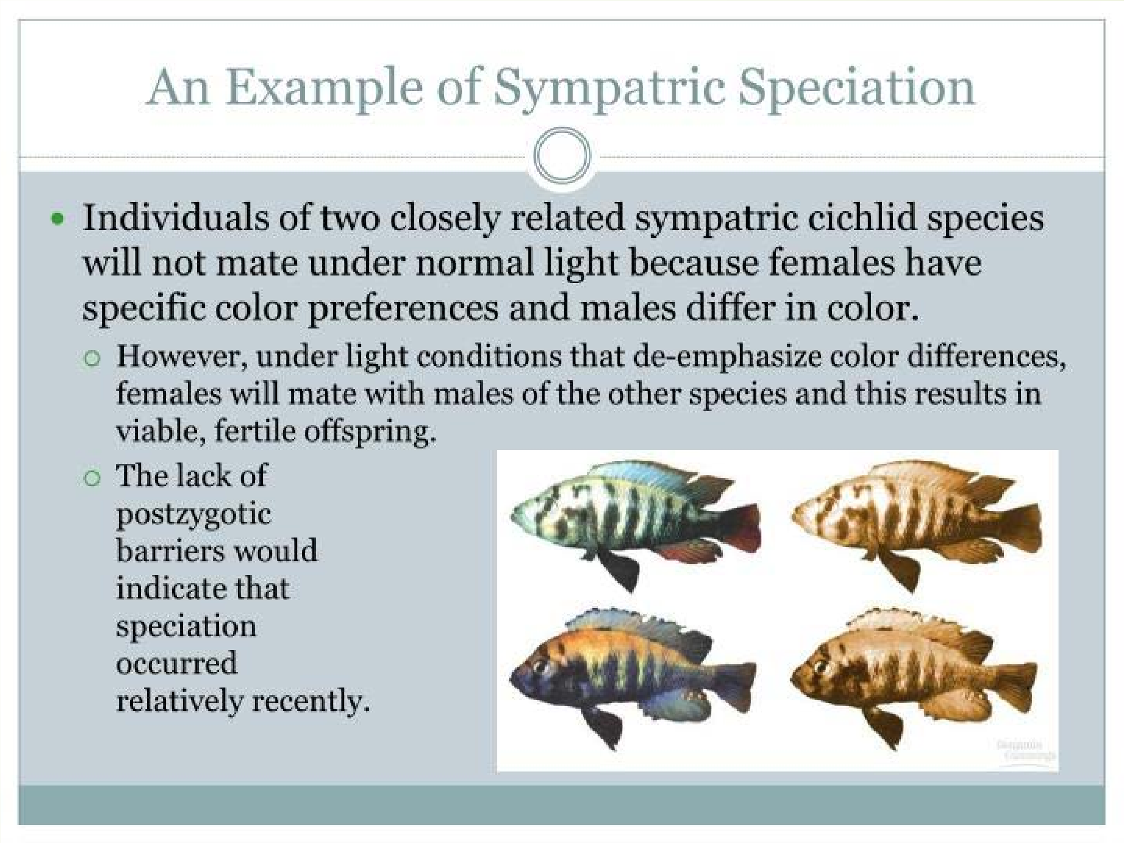

Allopatric
Geographical barrier
Paraptric
Partial spatial isolation
Sympatric
Genetic polymorphism
Peripatric
Isolation of a population at the periphery
Buzzle.com

Sympatric Speciation

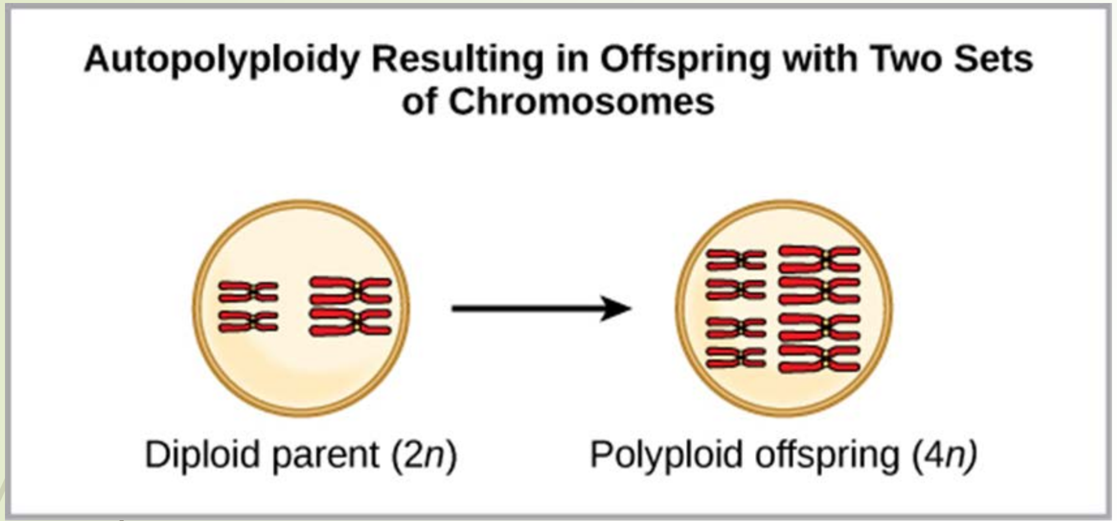


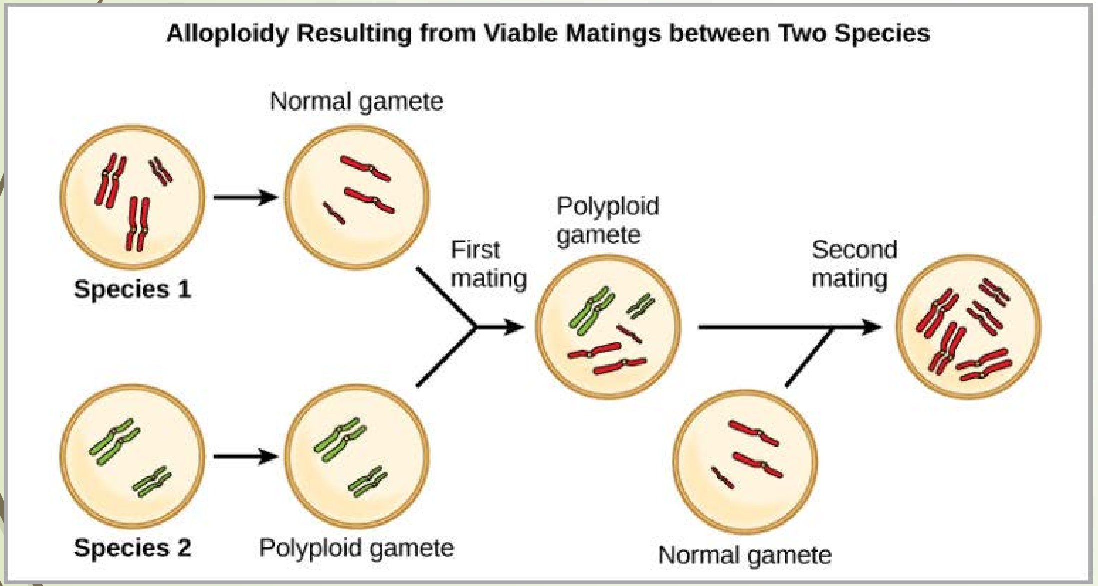
Sympatric Speciation





Causes for Sympatric Speciation





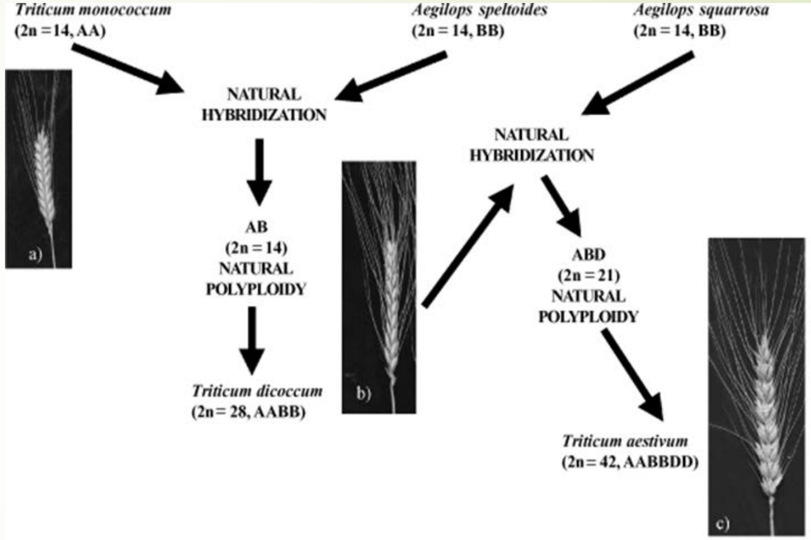
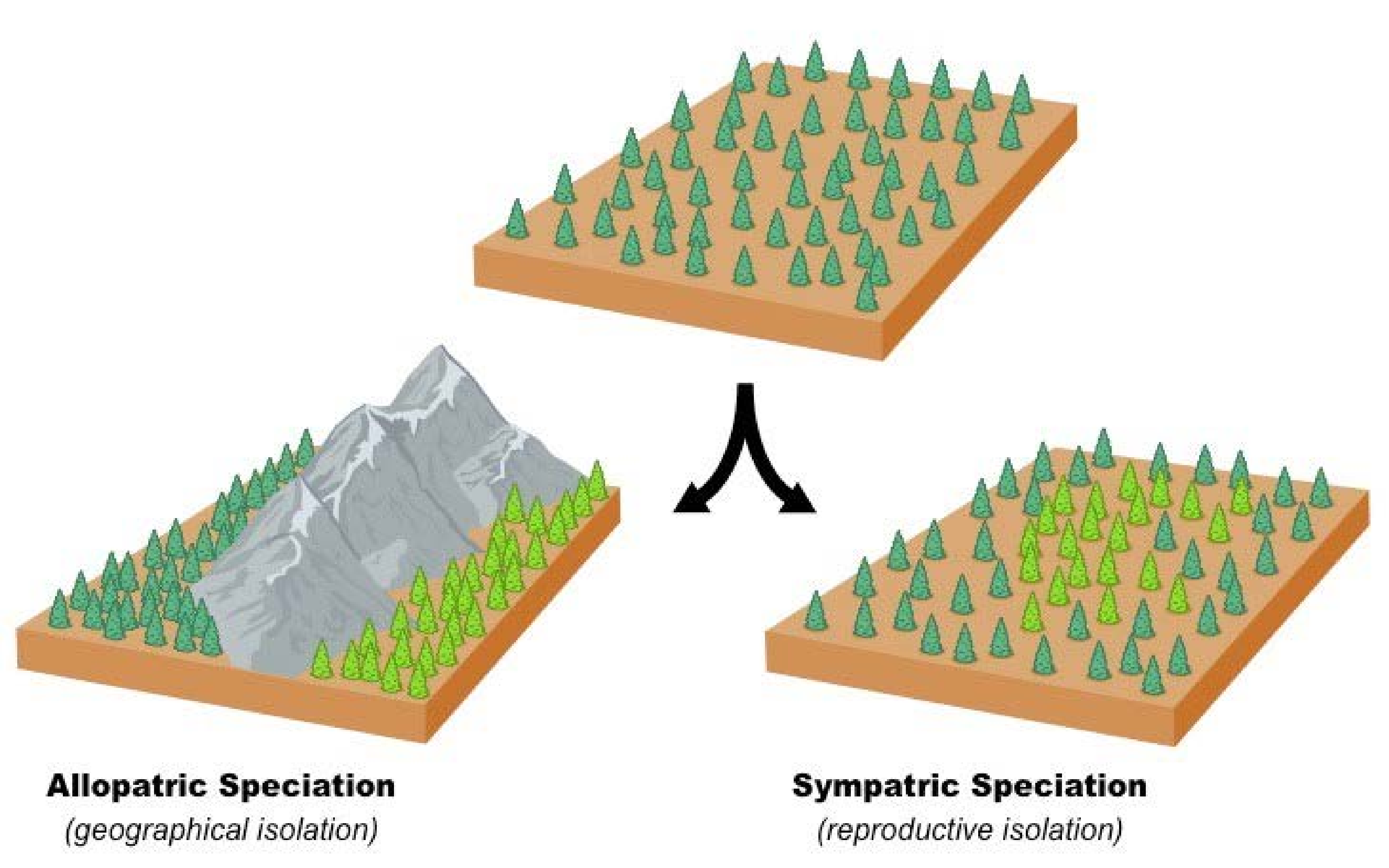


Figure 1 - Synoptic chart of cultivated wheats evolution: the diploid (2n = 14, AA) forms of *Triticum monococcum* (**a**) were naturally pollinated by weed species, possible *Aegilops speltoides* (2n = 14, BB?), in about 10,000 B.C. primitive farms. The subsequent genome duplication of hybrids by natural polyploidy gave rise to several wild and cultivated tetraploid species (2n = 28, AABB) like *Triticum dicoccum* (**b**) and *Triticum durum* (Figure 2a); again, the natural pollination of the tetraploid *T. dicoccum* (**b**) by another weed species, *Aegilops squarrosa* (2n = 14, DD) gave rise to the hexaploid (2n = 42, AABBDD) species (**c**).

Wheat
Cotton
Tobacco

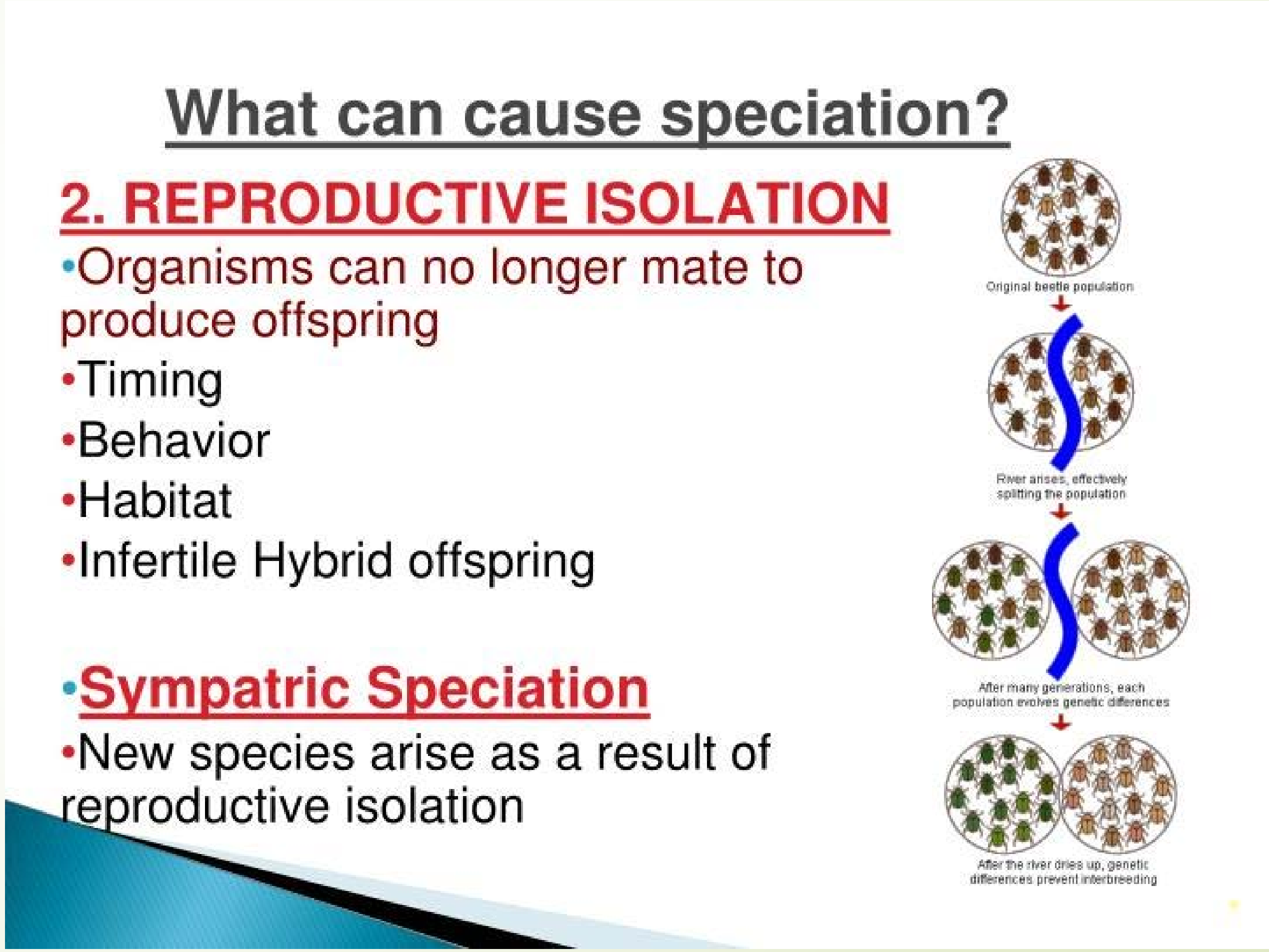
Polyploidy



Allopatric Speciation
(geographical isolation)
Sympatric Speciation
(reproductive isolation)

Reproductive Barriers → Speciation

- Seasonal
- Ecological
- Behavioral
- Mechanical
- Mutations

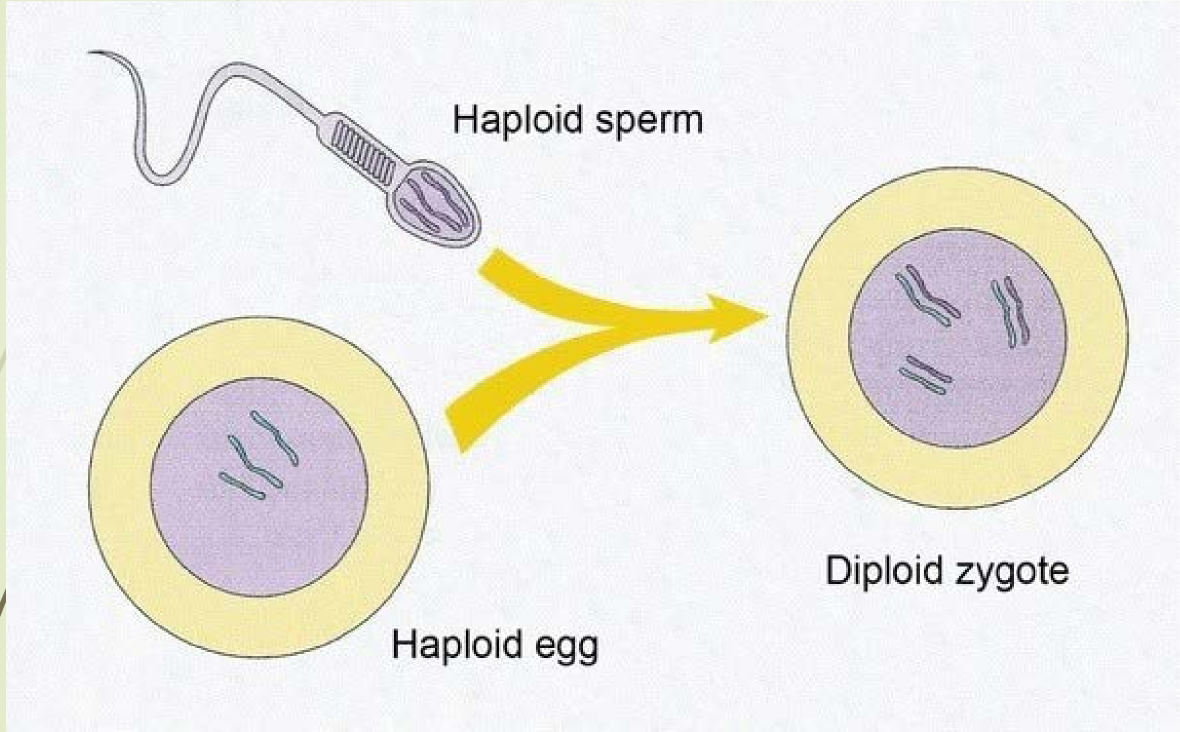


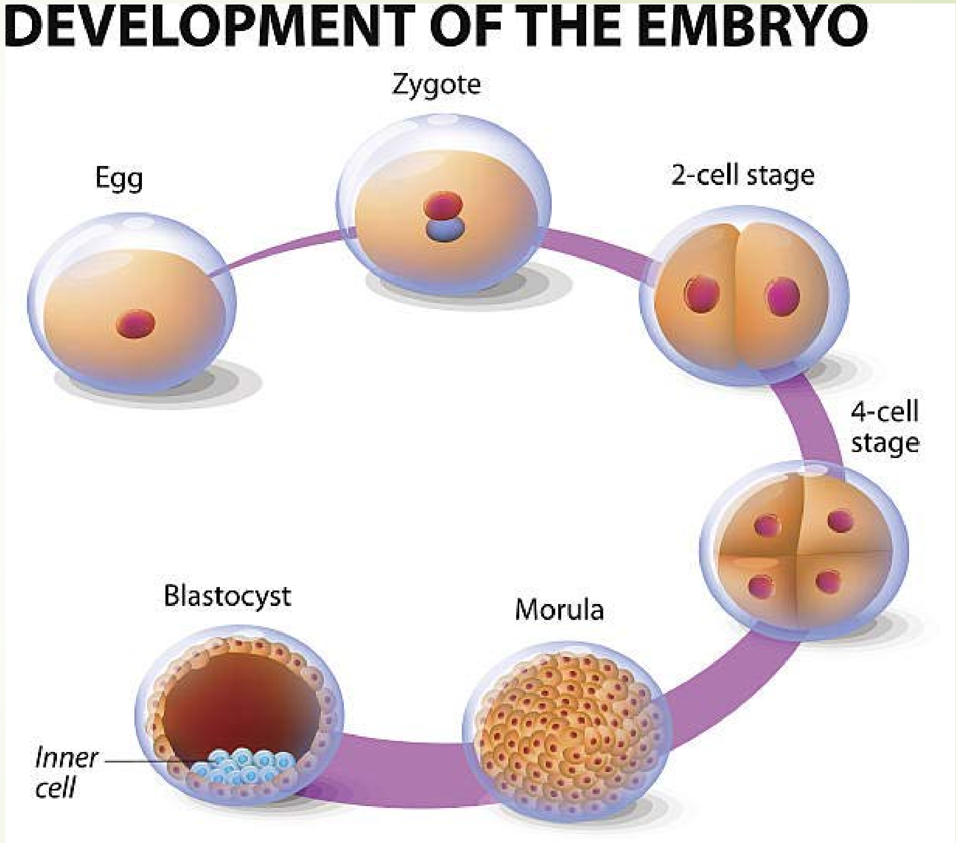
Species Characteristics

African Fish Eagle

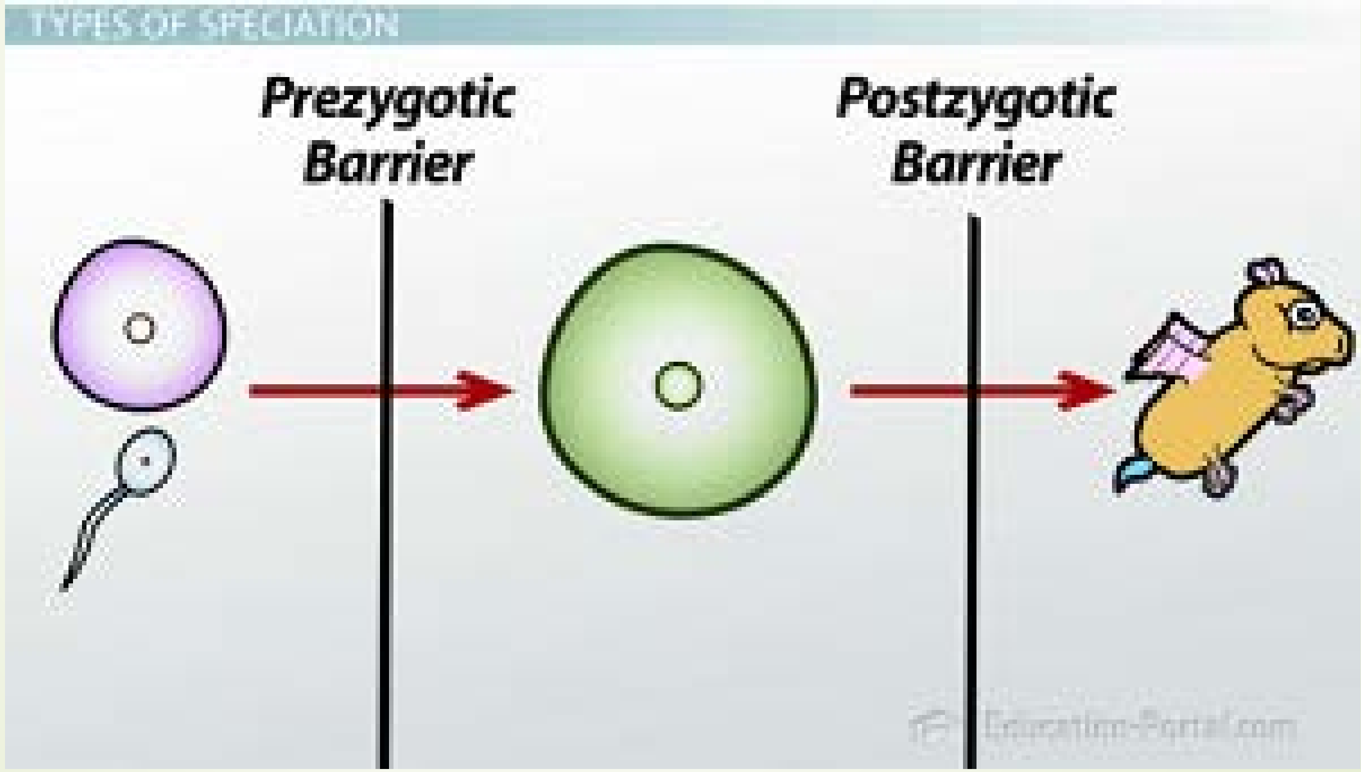
American Bald Eagle

Zygote Review





Prezygotic and Postzygotic Reproductive Barriers



Prezygotic Barriers: Environmental

Temporal

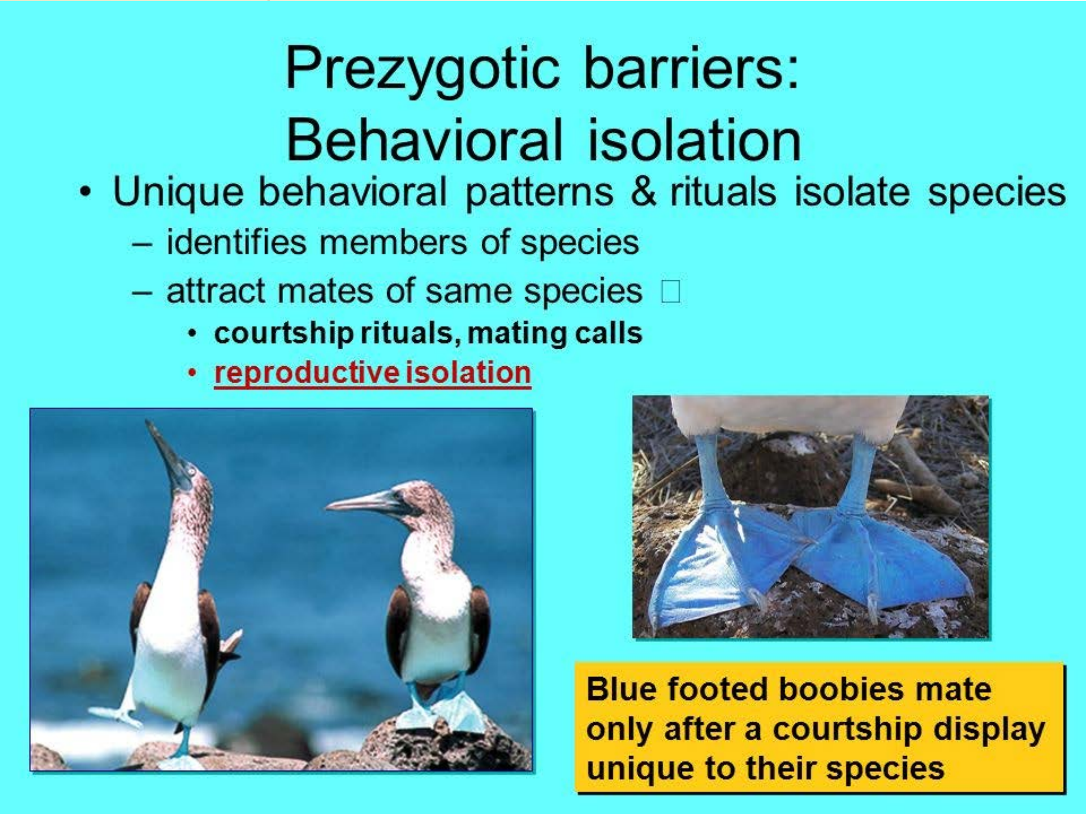
(a) (b)

Habitat (Ecological)

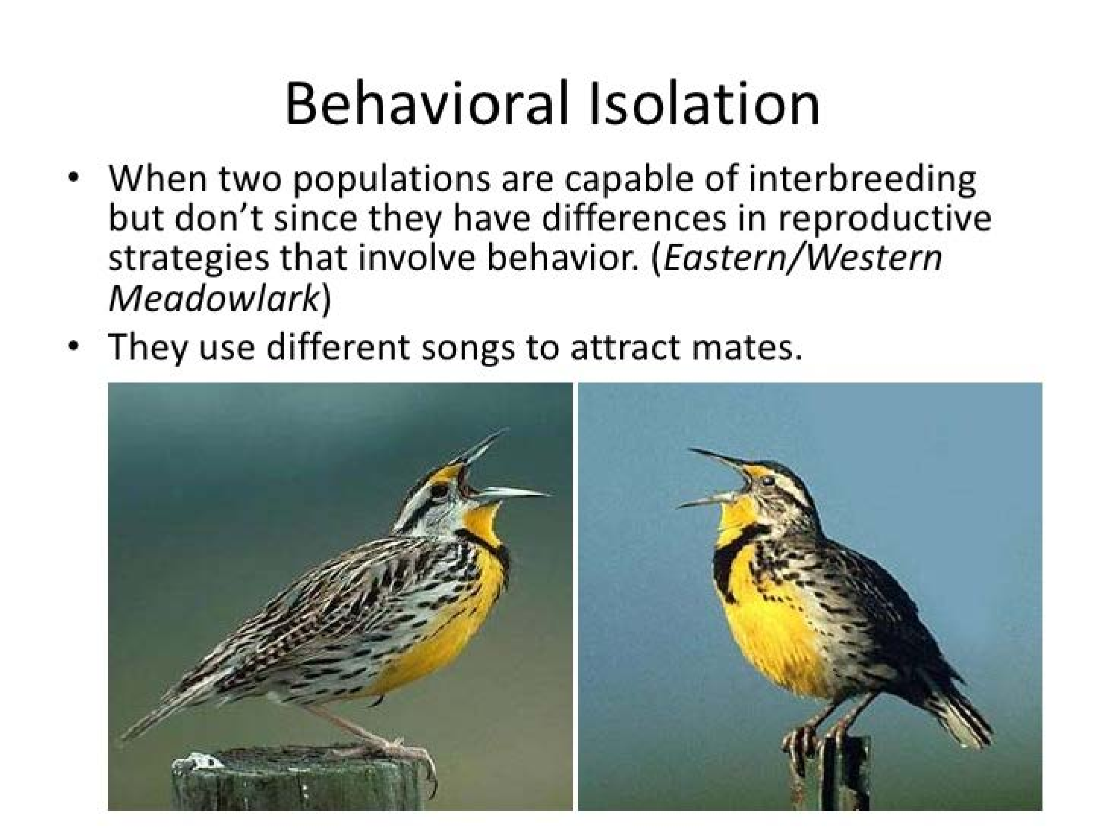
(a) *Gryllus pennsylvanicus* prefers sandy soil.

(b) *Gryllus firmus* prefers loamy soil.

Prezygotic Barriers: Behavioral

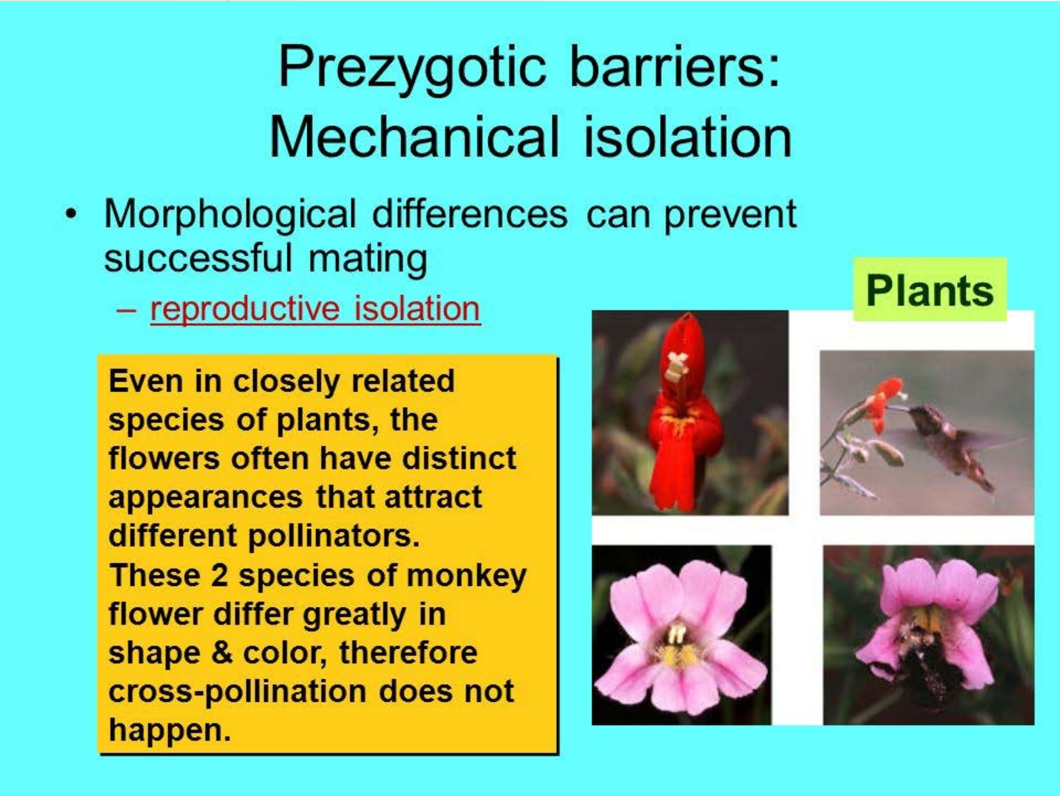


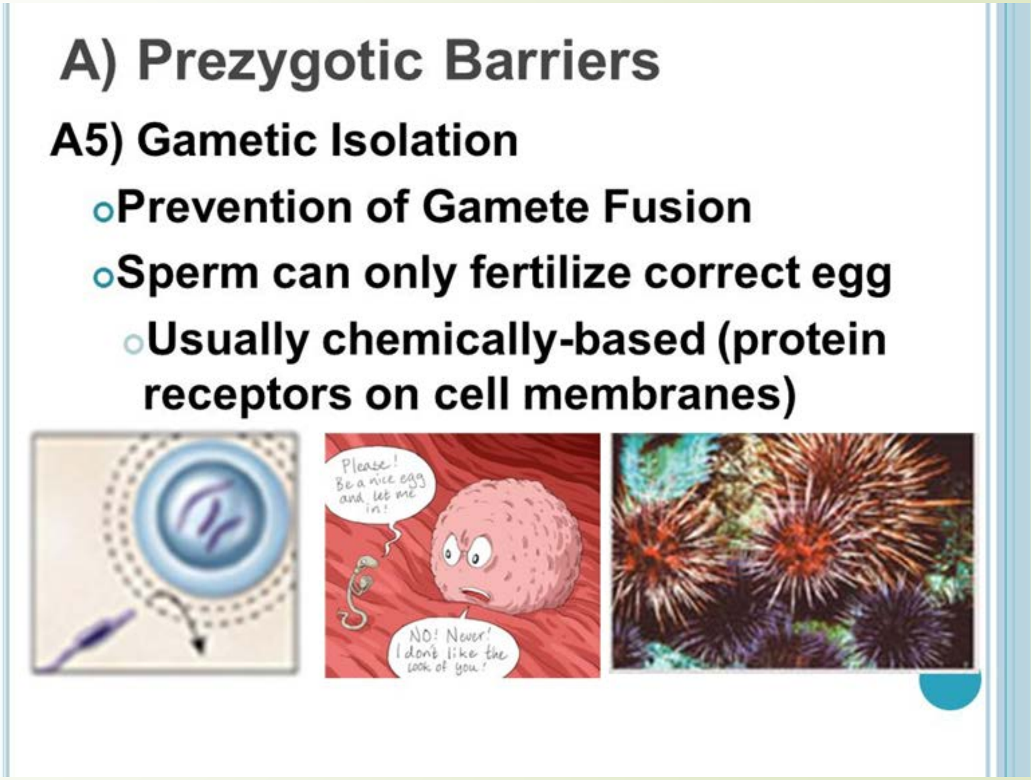
Courtship rituals



Mating Songs

Prezygotic Barriers: Mating and Gametes





Peripatric Speciation

- Reproductive isolation evolves in a small population, isolated from its parent population.
- Also known as founder effect speciation.
- Genetic divergence arises largely through genetic drift and natural selection.
- Proposed explanation for the rapid speciation of Hawaiian *Drosophila*.

Hawaiian fruit fly
Drosophila setosimentum

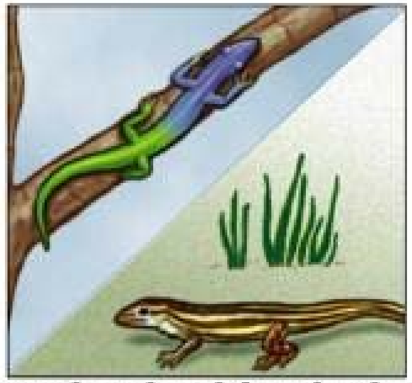
BioEd Online

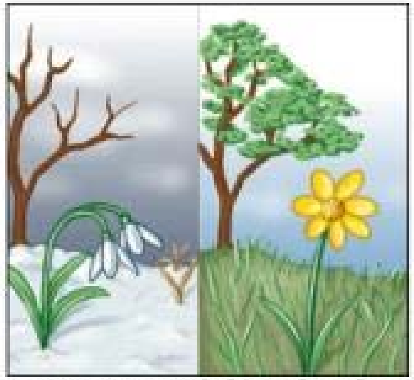
Summary

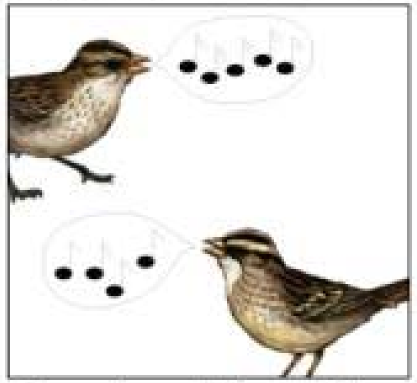
Prezygotic barriers

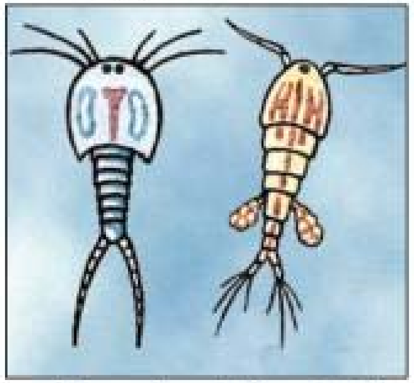
- Obstacle to mating or to fertilization if mating occurs

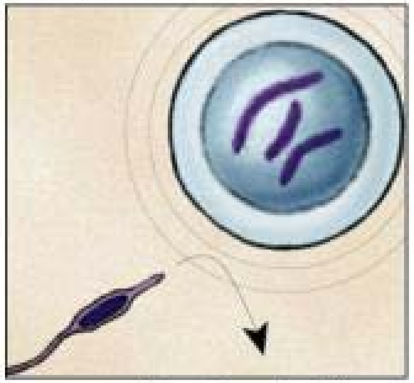

geographic isolation


ecological isolation


temporal isolation


behavioral isolation


mechanical isolation


gametic isolation

Postzygotic barriers

- Prevent reproduction in offspring
- Examples
  - Hybrid Inviability (Zygotic Mortality)
  - Hybrid Breakdown (F2)
  - Hybrid infertility (sterility)

Hybrid survives
Can not reproduce

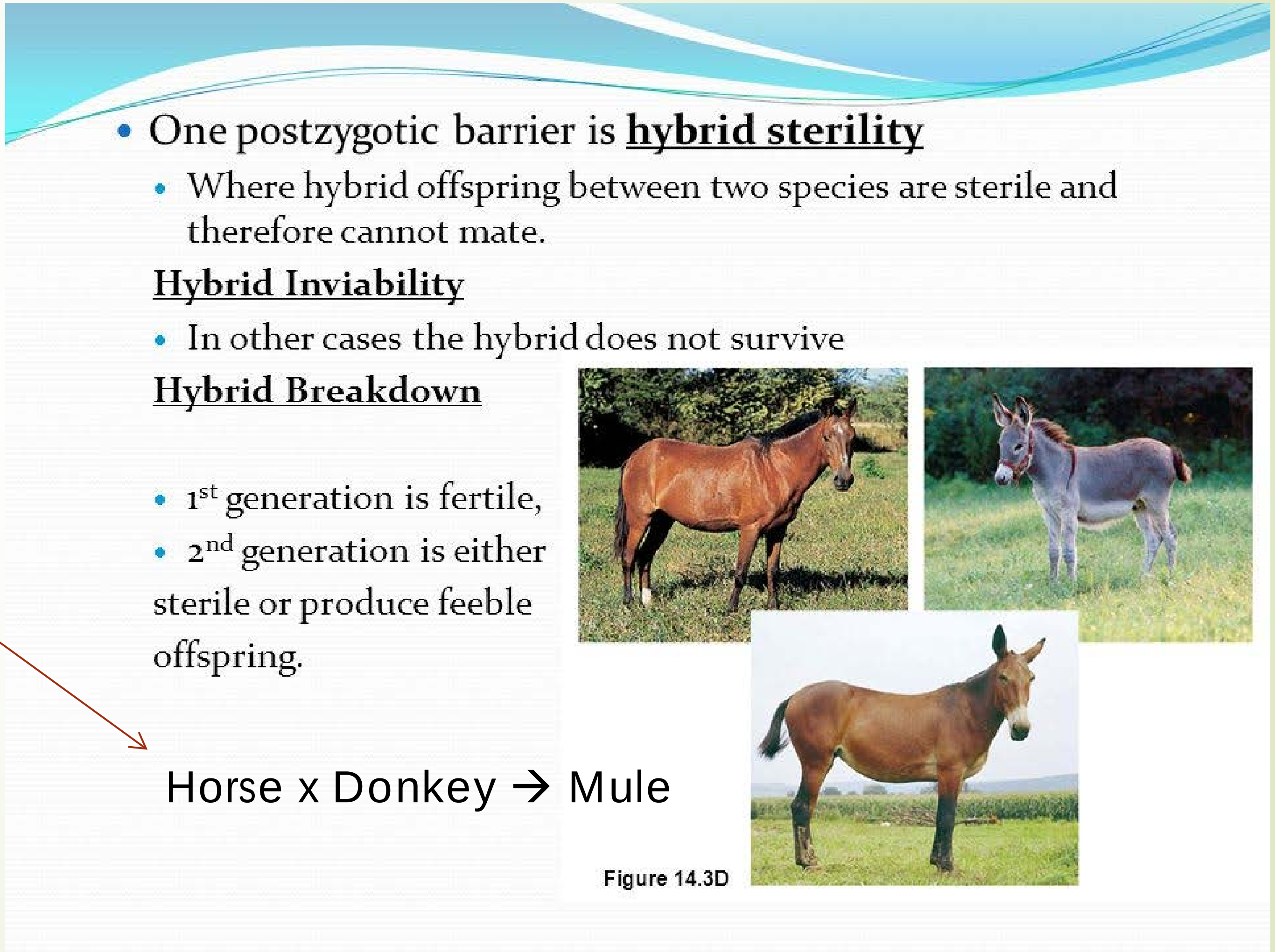
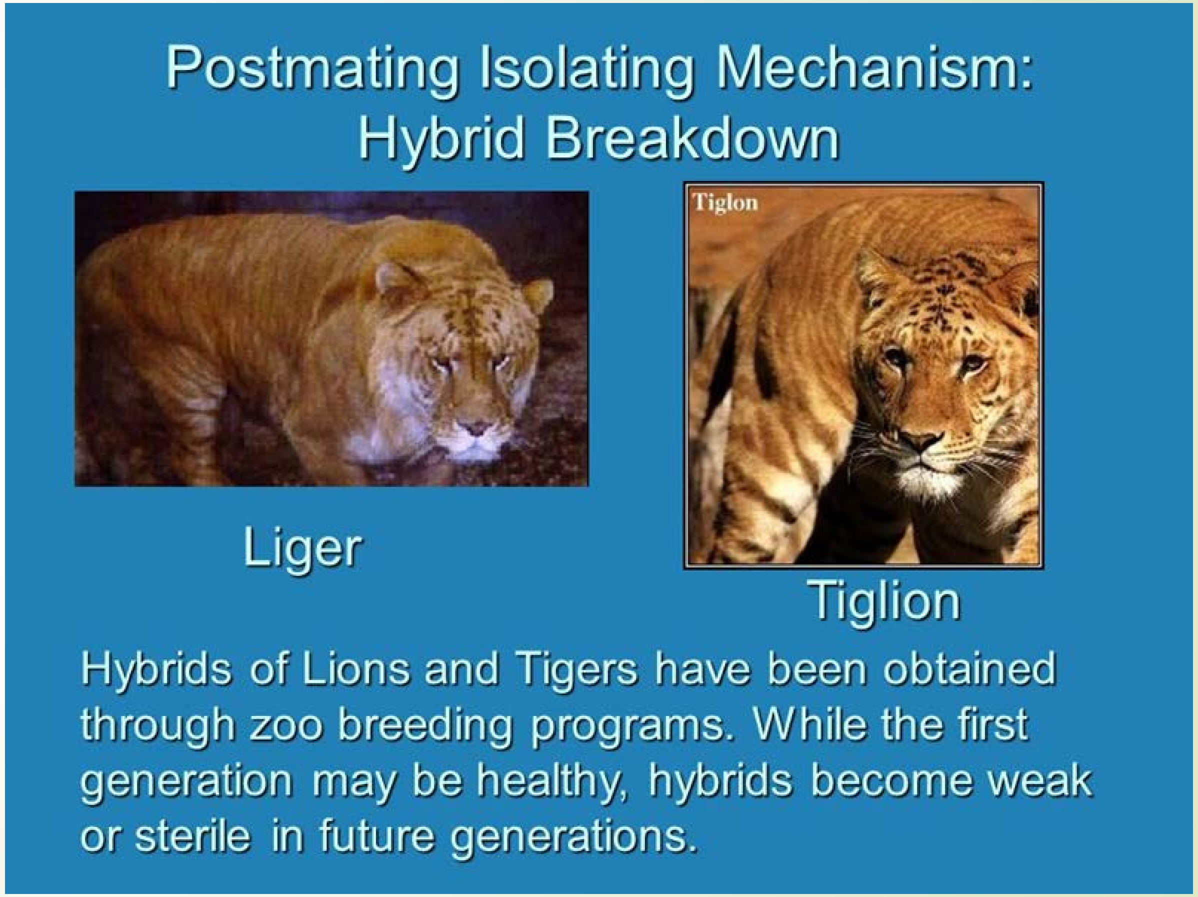


Figure 14.3D

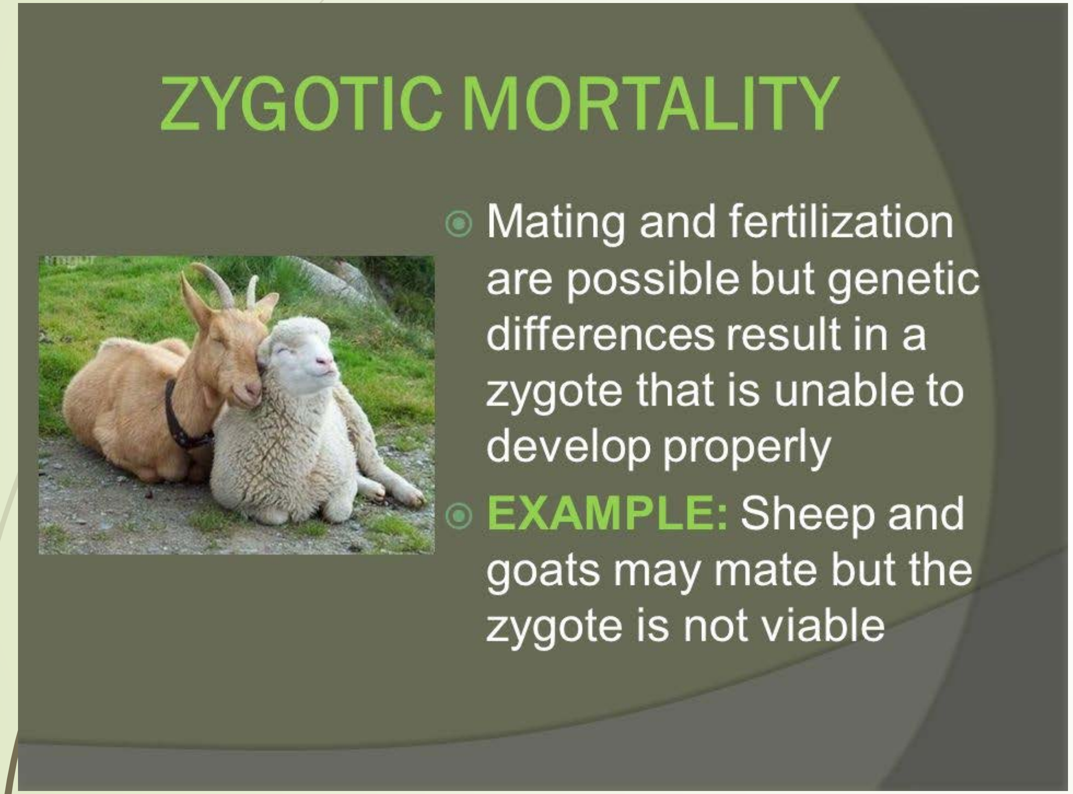
Hybrid Sterility: F2 reduced fitness

- Hinny
  - Donkey x Stallion
- Cama (F Llama x M Camel)
- Zebra
  - Zedonk
  - Zebroid
  - Zorse
  - Zonkey
  - Zony
- Leopon
  - Lioness x Leopard
- Lipard
  - Leopardess x Lion

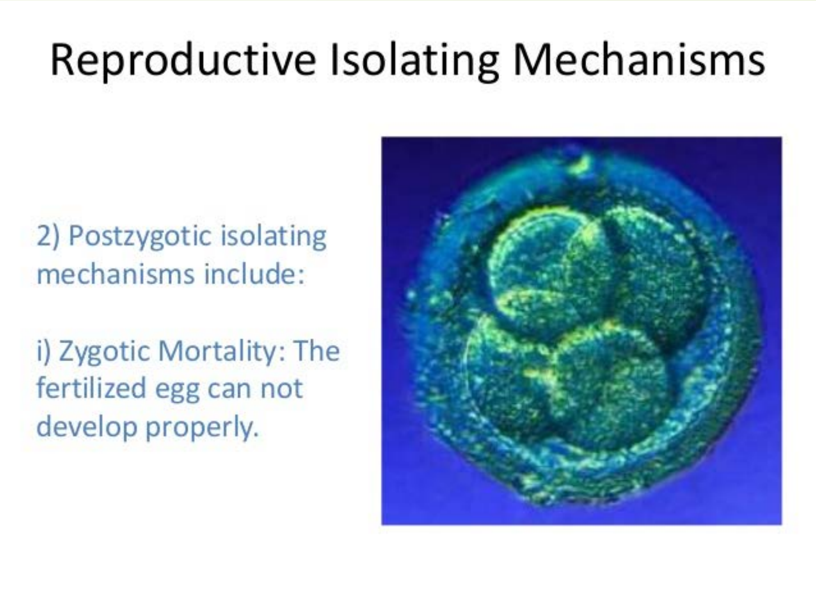


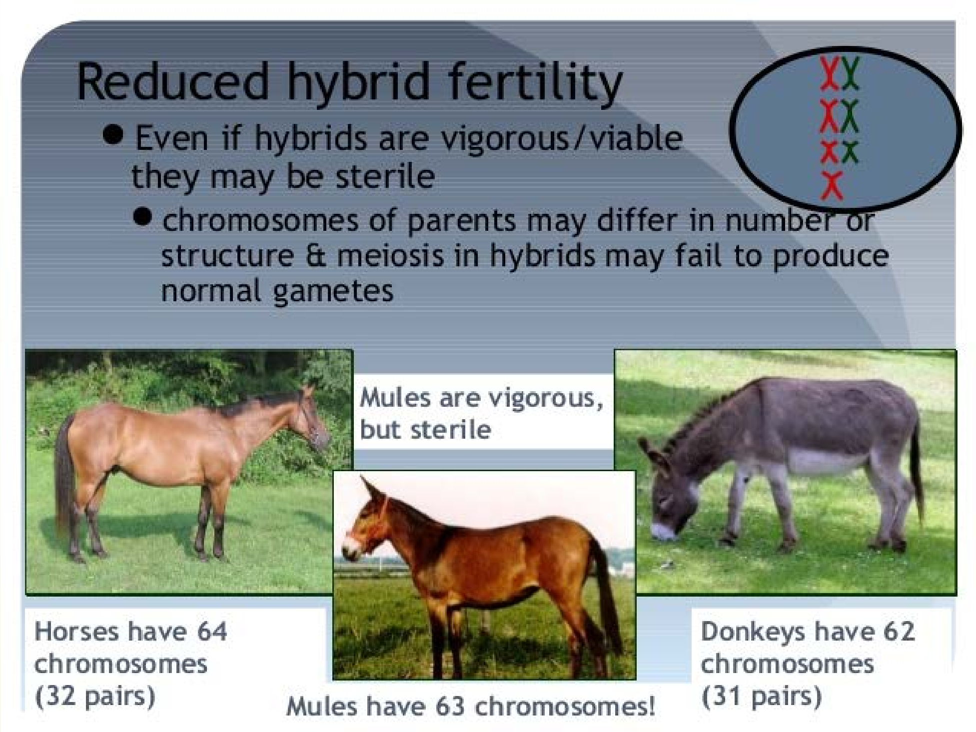
Hybrid Breakdown

Postzygotic Barrier: Hybrid Inviability



Fail to complete gastrulation





Hybrids that are Fertile

- Plants
- Birds (sparrows)
- Insects
- Some Mammals
  - Cats
  - Dogs

Summary

Types of Reproductive Barriers

Prezygotic Barriers:

- Impede mating/fertilization

Types:

- Habitat isolation
- Temporal isolation
- Behavioral isolation
- Mechanical isolation
- Gametic isolation

Postzygotic Barriers:

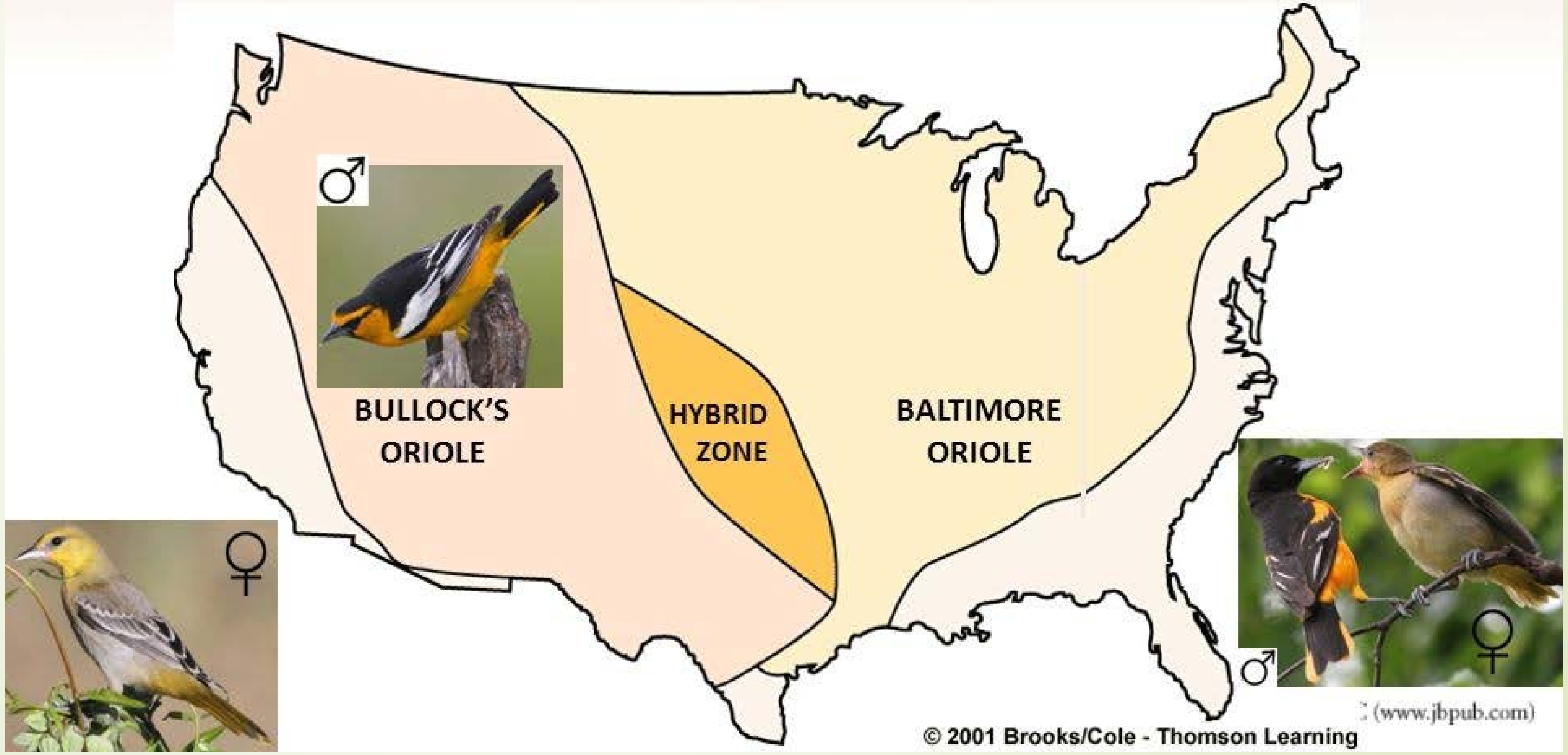
- Prevent hybrid zygote from developing into viable adult

Types:

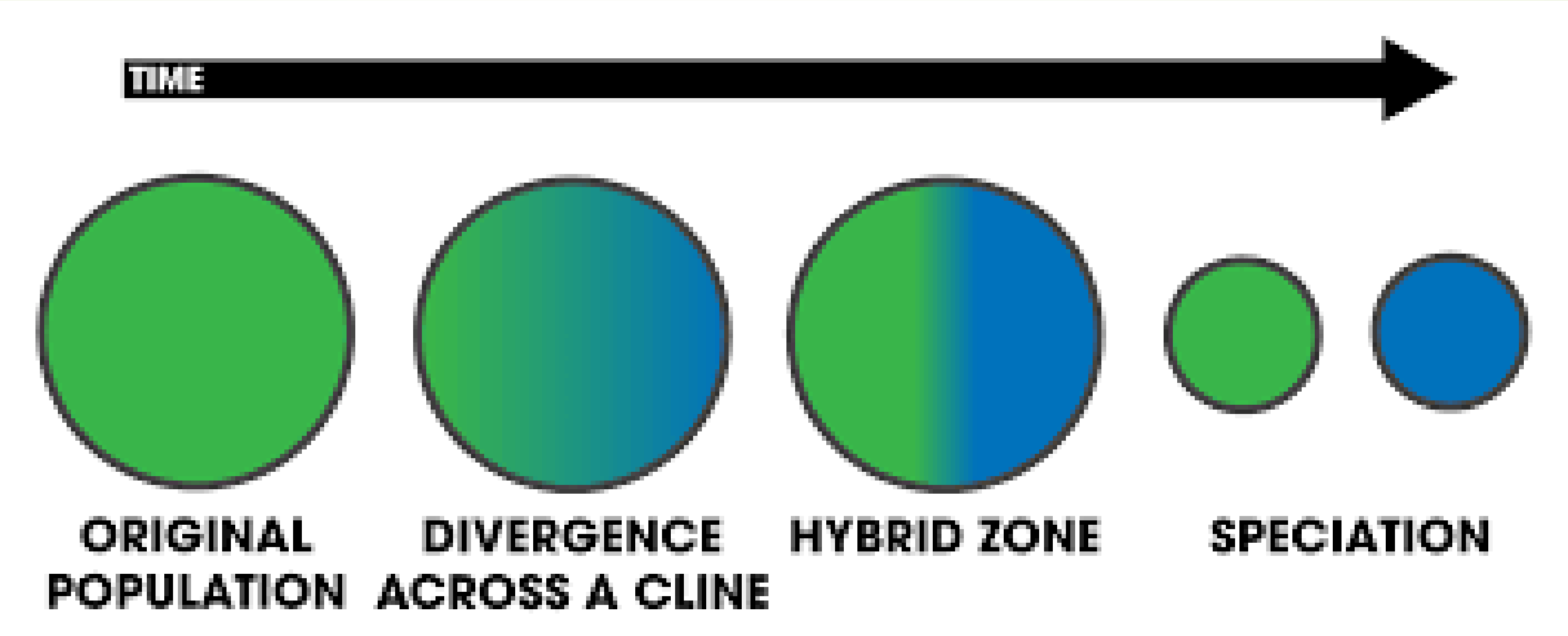
- Reduced hybrid viability
- Reduced hybrid fertility
- Hybrid breakdown

Parapatric Speciation

Adjacent populations evolve into distinct species while maintaining contact along a common border



Hybrid Zone



Two adjacent species meet

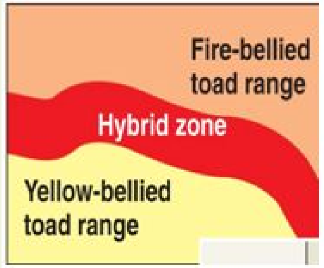
Reduced Fitness

Complex interactions

Hybrid Zones cause reproductive isolation

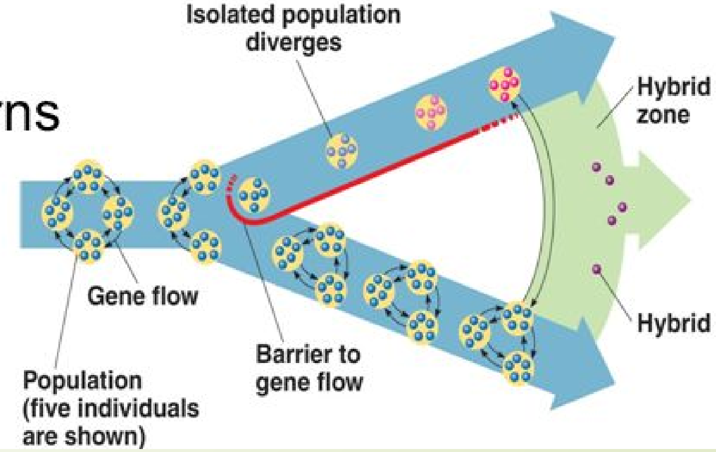
1. A **<u>Hybrid Zone</u>** is a region in which members of different species meet and mate, producing at least some offspring of mixed ancestry.

a. Narrow band pattern



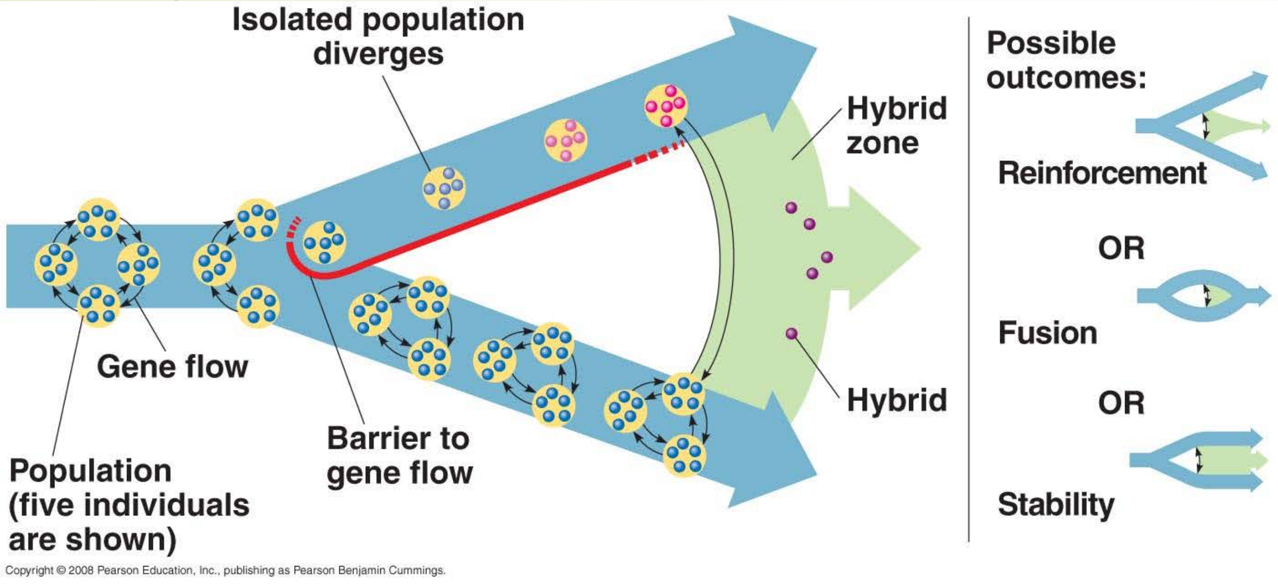
- there is an obstacle to gene flow
- obstacle is probably that hybrids have increased rates of embryonic mortality and a variety or morphological abnormalities (therefore, poor survival and reproductive rates)

b. Complicated spatial patterns



C. ENVIRONMENTAL CHANGES

Hybrid Zones: A Reconnection

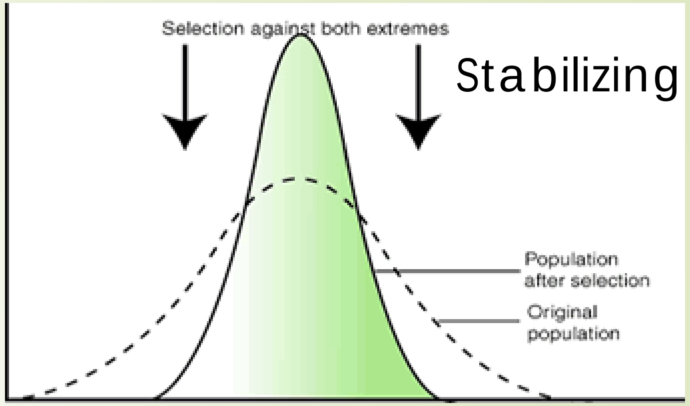


- Species
  - Closely Related
  - Interaction
- Zone changes
  - Reinforcement
  - Fusion
  - Stability
- Reproduction
  - New Species (hybrid)
  - Reconnection

Hybrid Zones over Time

- When closely related species meet in a hybrid zone, there are *three possible outcomes*:
  - ***Reinforcement*** -- Strengthening of reproductive barriers reducing gene flow.
  - ***Fusion*** -- Weakening of reproductive barriers with eventual fusion into one species.
  - ***Stabilizing*** -- Continued formation of hybrid individuals.

Reproductive Results for Hybrids



Reinforcement: Strengthening Reproductive Barriers

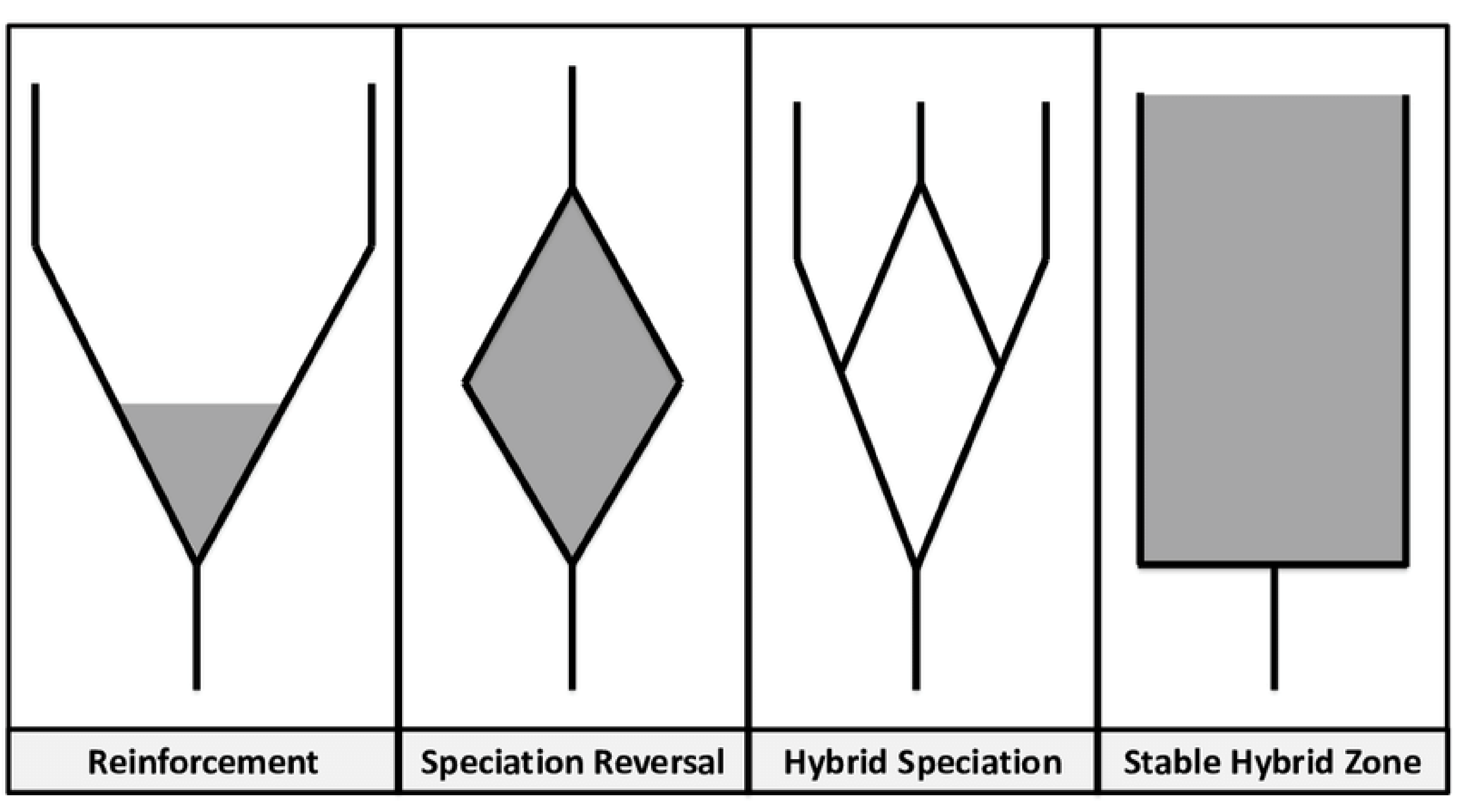
- **The reinforcement of barriers occurs when hybrids <u>are less fit</u> than the parent species that is reproduce less successfully.**
- **Where reinforcement occurs, reproductive barriers should be stronger for sympatric than allopatric species**

Reduced Gene Flow

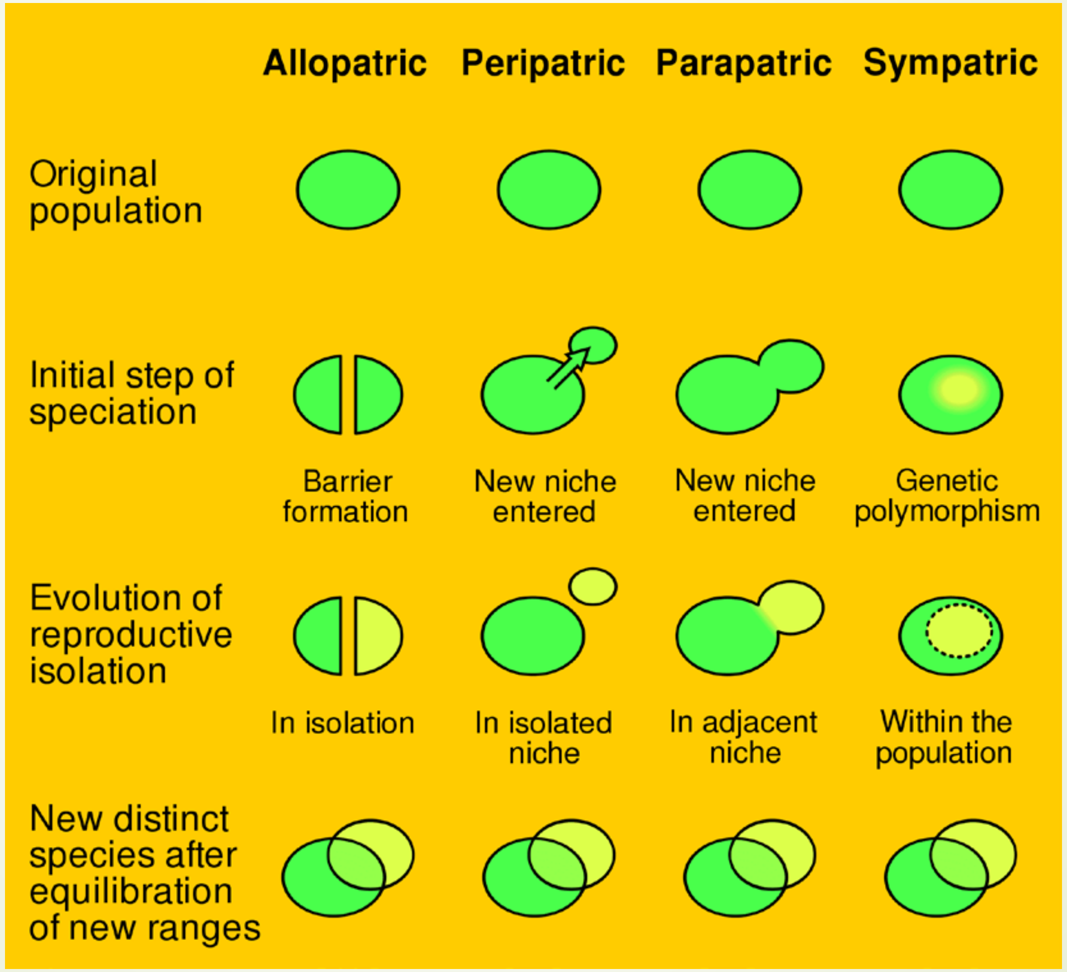
Fusion: Weakening Reproductive Barriers

- **If hybrids are as fit as parents, there can be substantial gene flow between species**
- **If gene flow is great enough, the parent species <u>can fuse into a single species</u>**

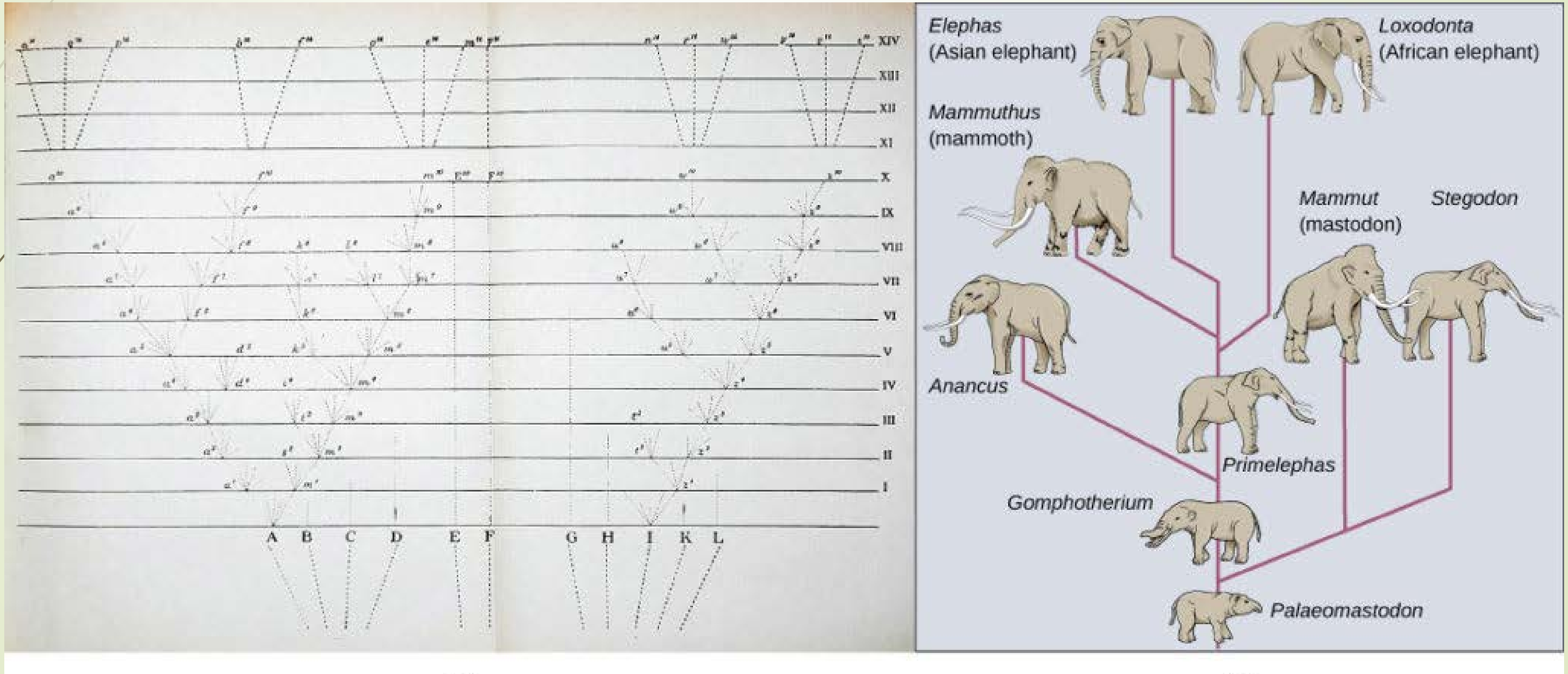
Hybrid Outcomes



Speciation Types: Summary



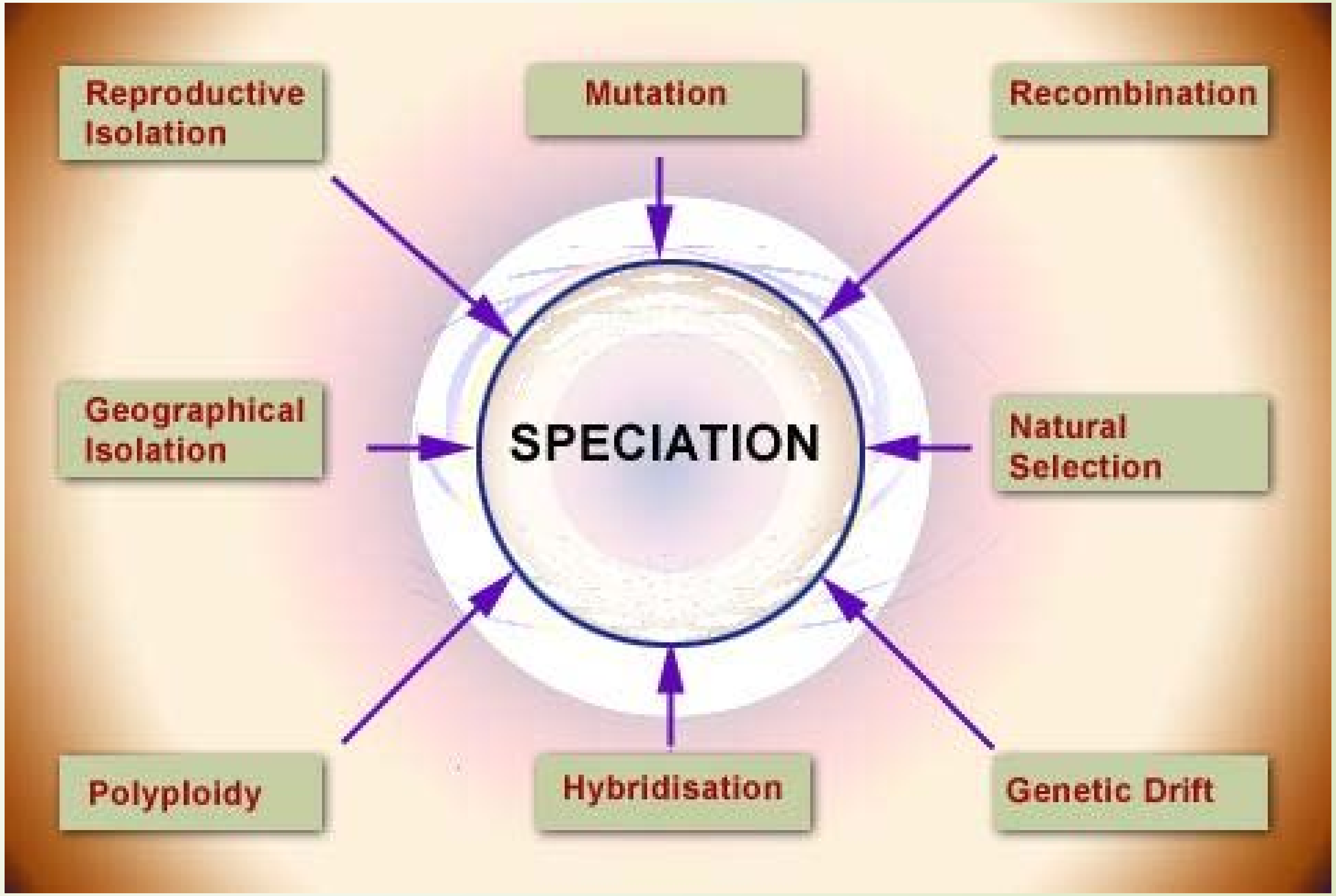
Speciation → Biological Diversity



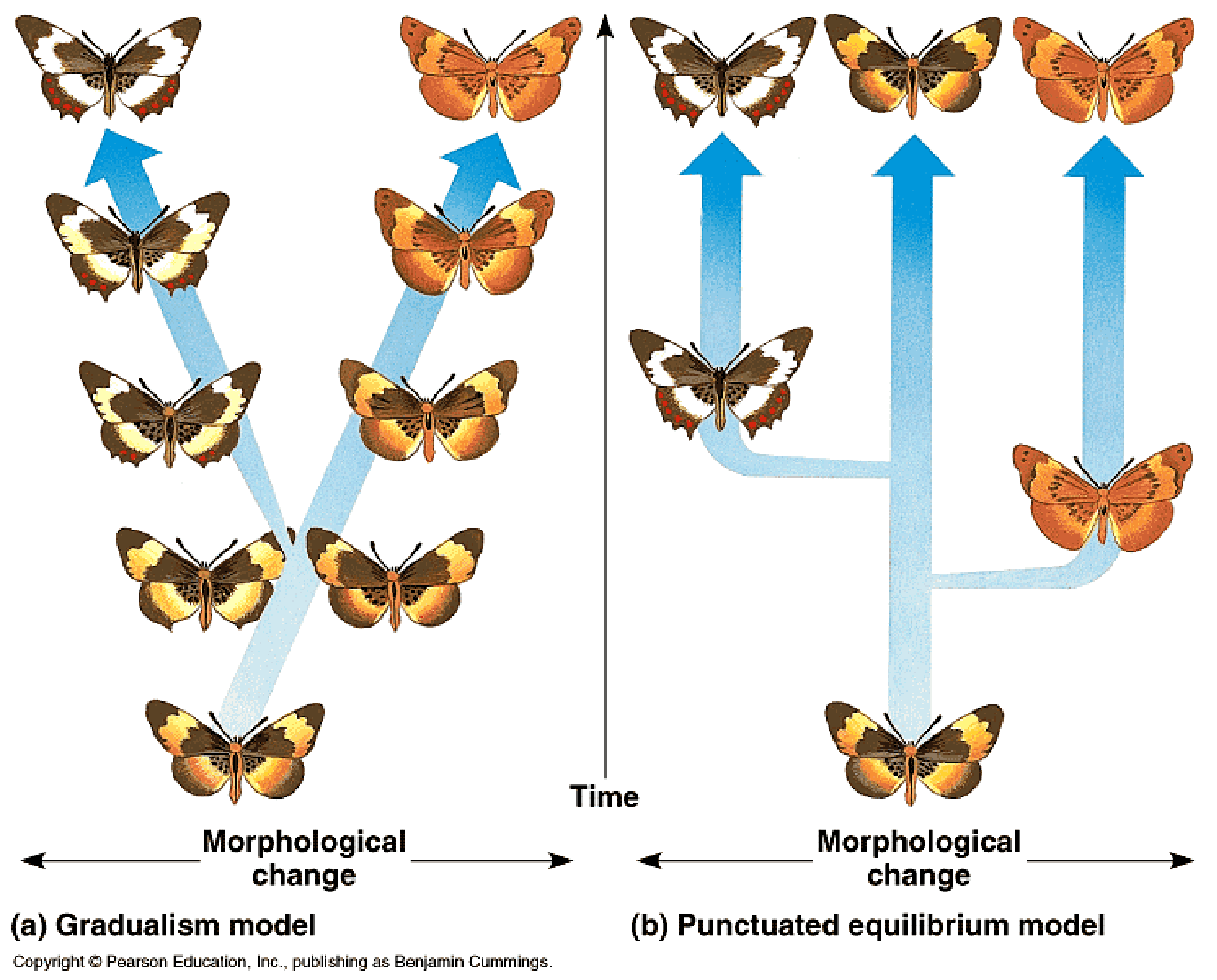
(a) (b)

Species Concepts and Interactions

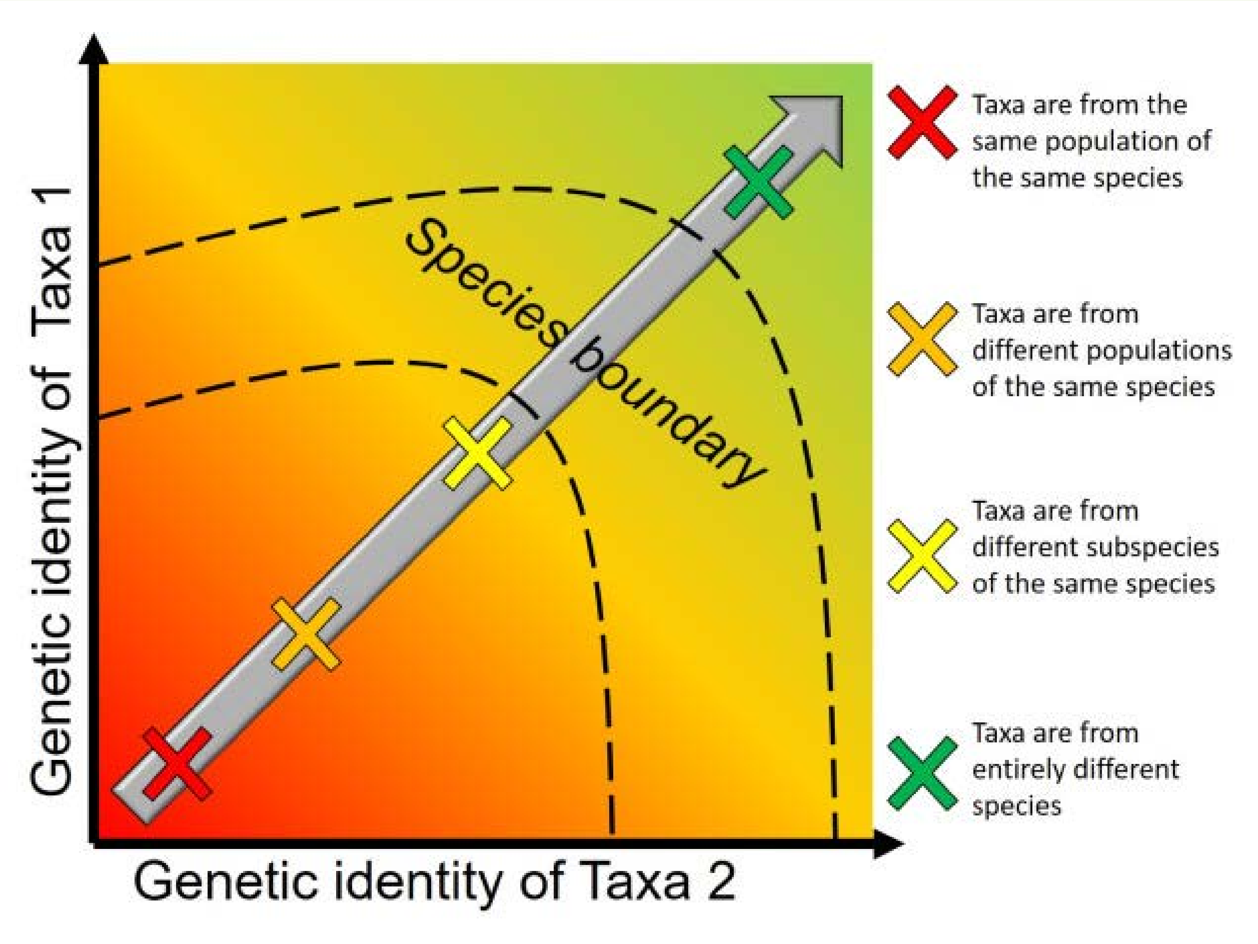
- Morphological
- Ecological
- Phylogenic



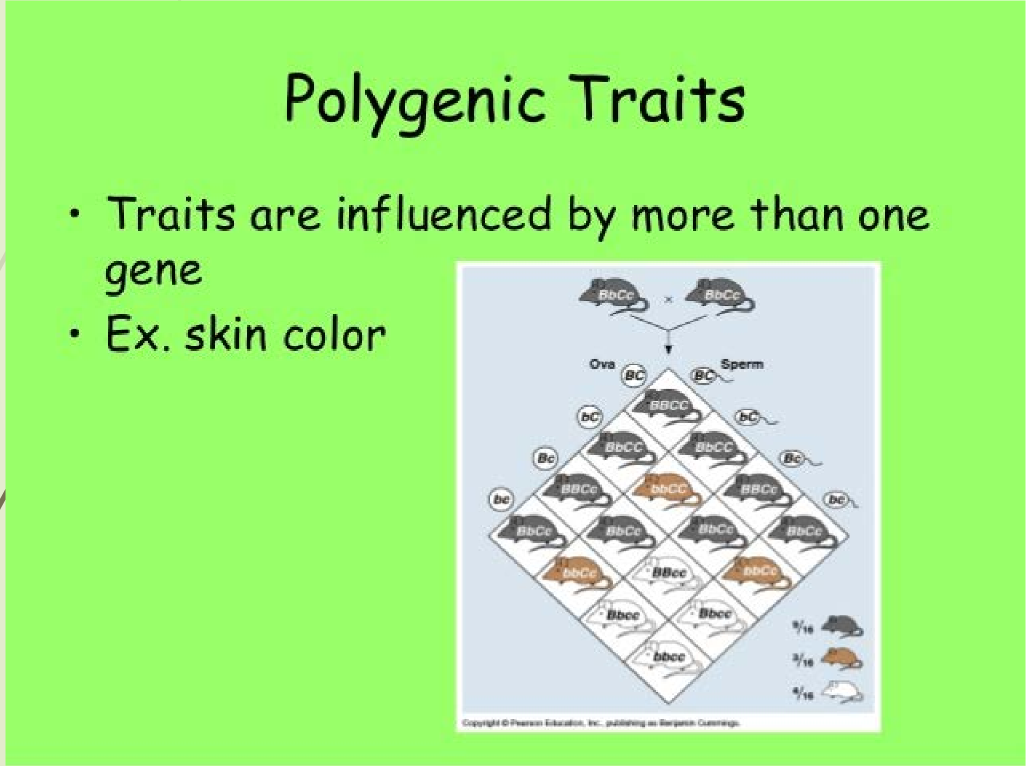
Speciation rates

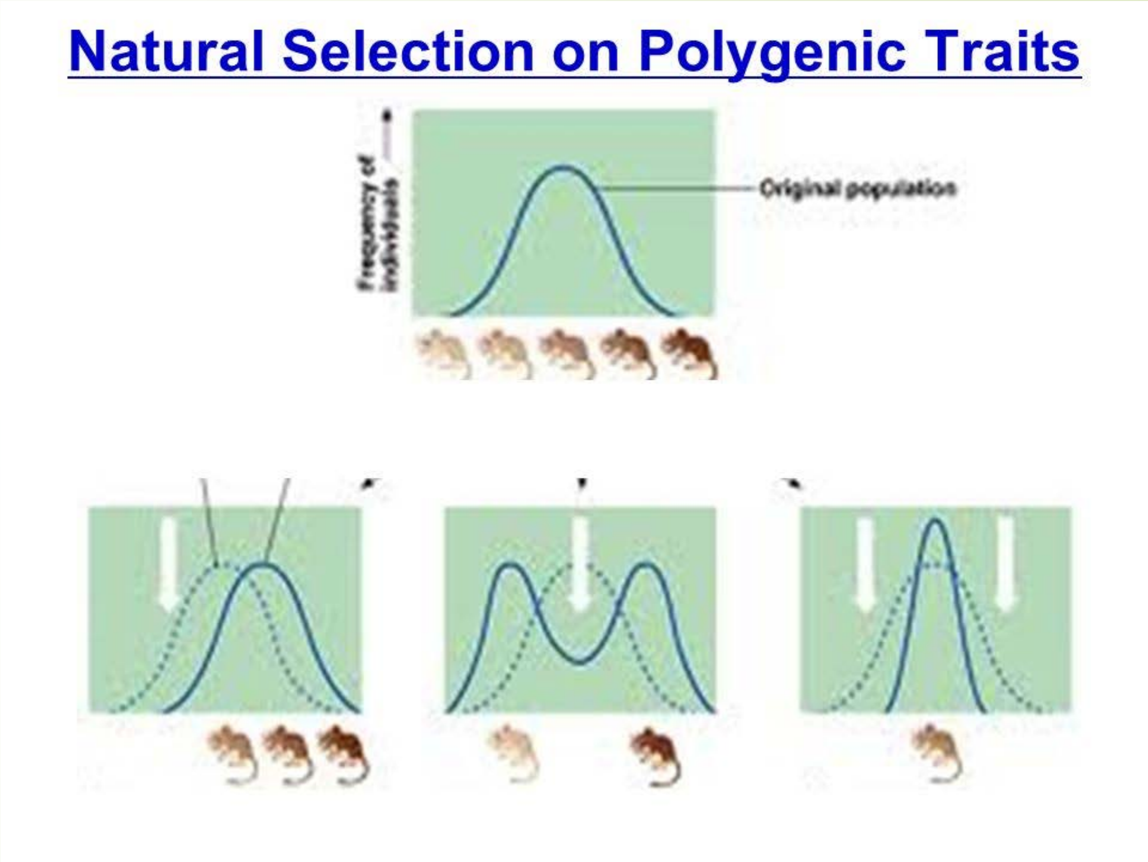


Genetics of Speciation

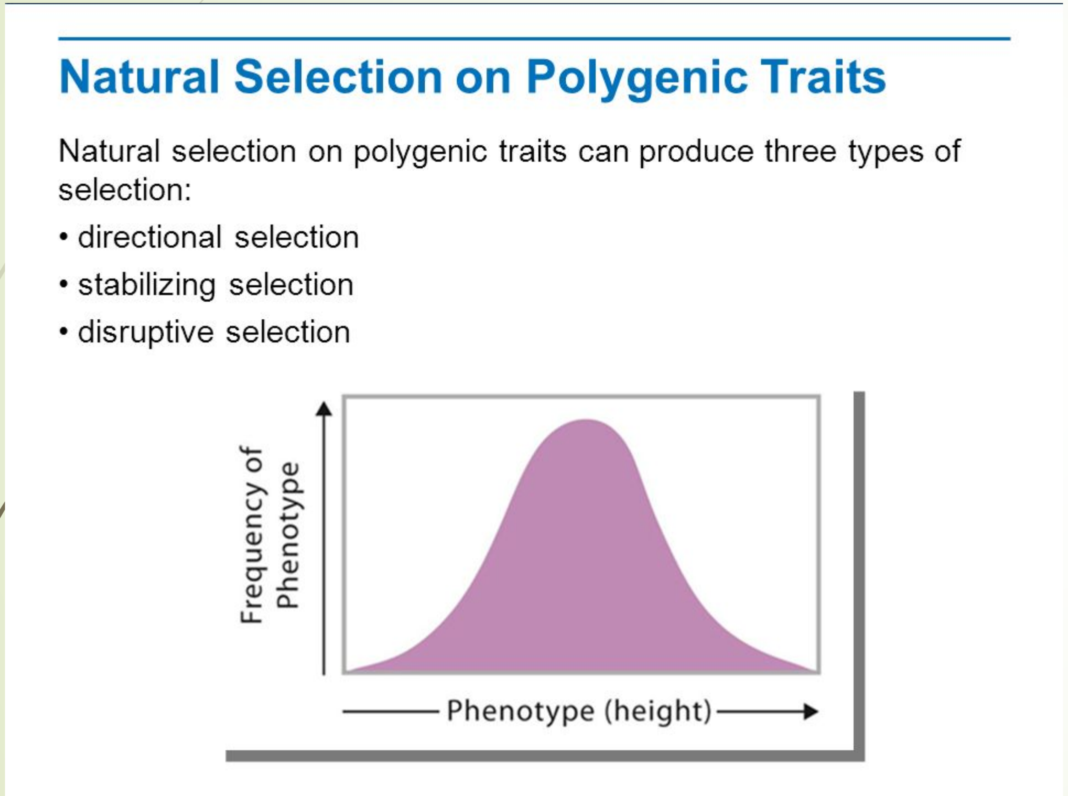


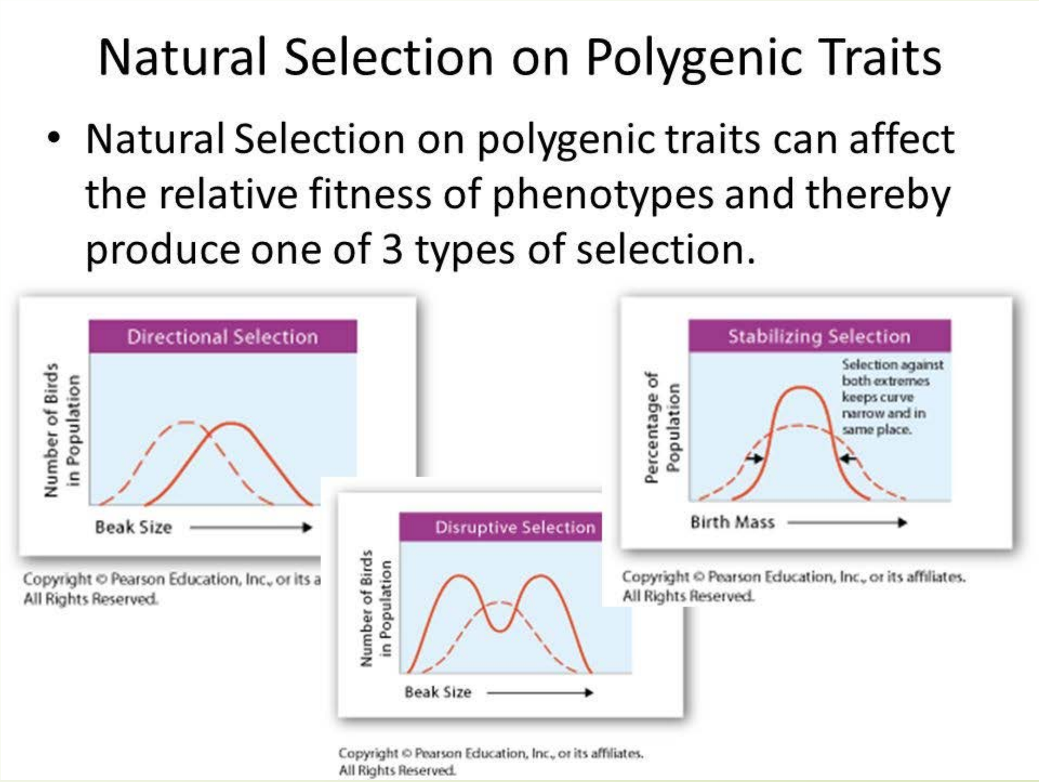
Genetic Selection: Polygenic Traits



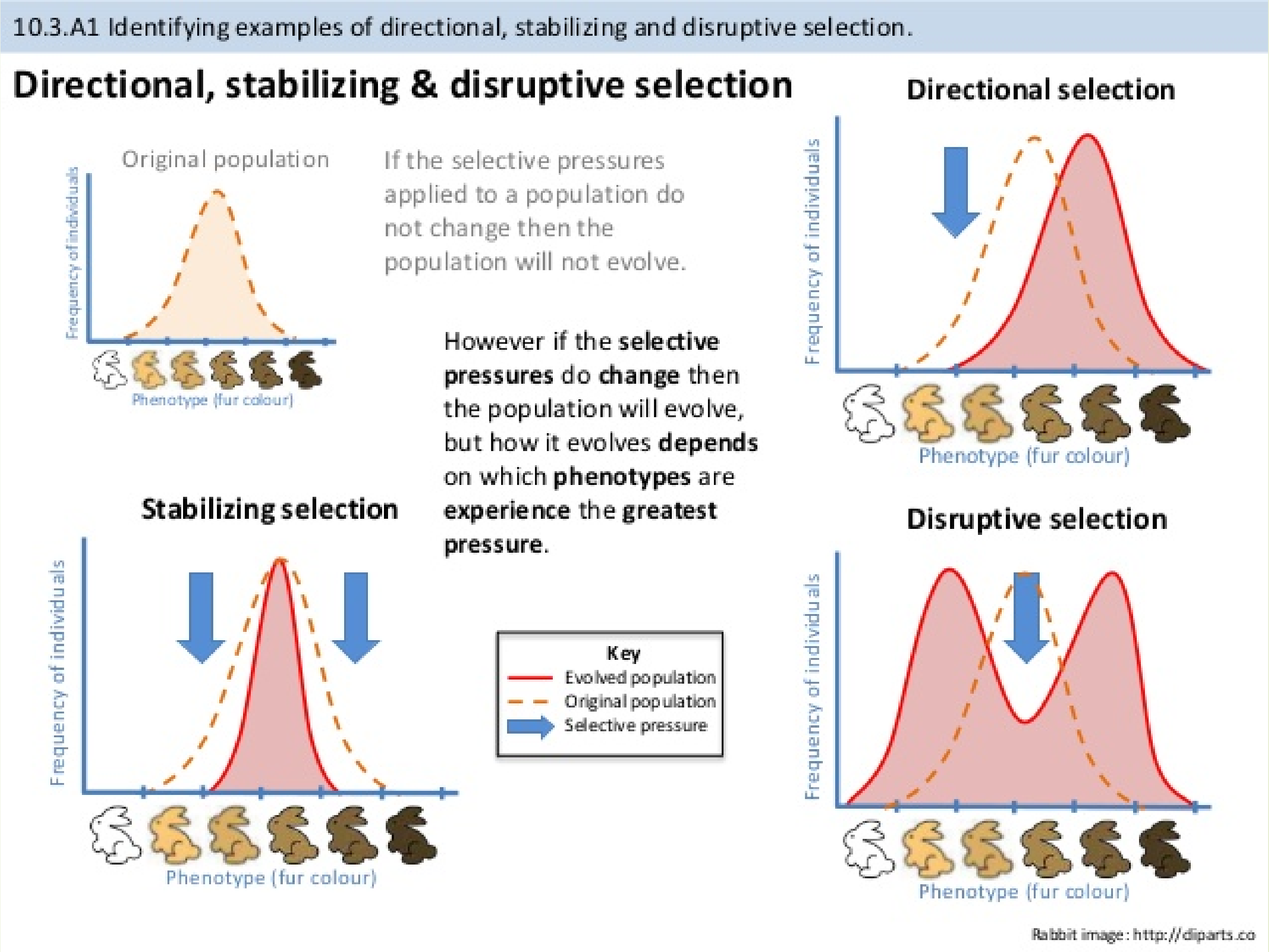


Fitness of Phenotypes





Selective Pressures

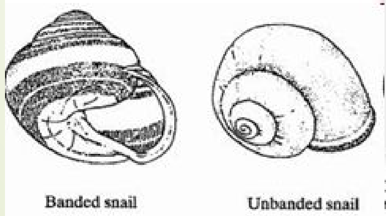


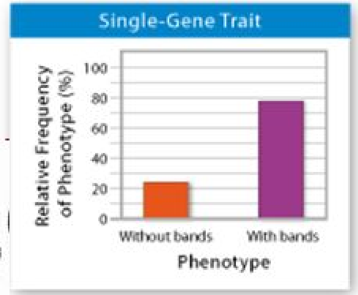
Genes and Variation

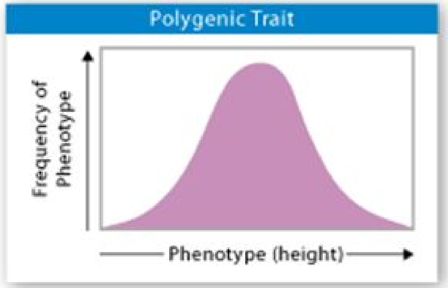
Single-Gene and Polygenic Traits

- Single-Gene Trait
  - Controlled by one gene that has two alleles
  - Two distinct phenotypes
  - Ex: bands or no bands on snails

- Polygenic Trait
  - Controlled by more than one gene
  - Many possible genotypes and phenotypes
  - Ex: Human Height





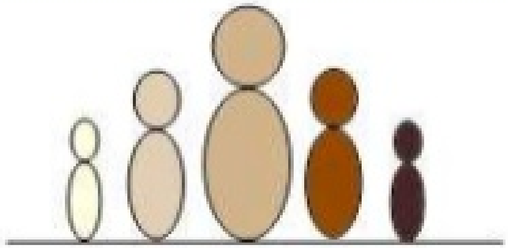


Quantitative

Qualitative

10.2.U3 Variation can be discrete or continuous. AND 10.2.U4 The phenotypes of polygenic characteristics tend to show continuous variation.

Polygenic Inheritance of Skin Colour



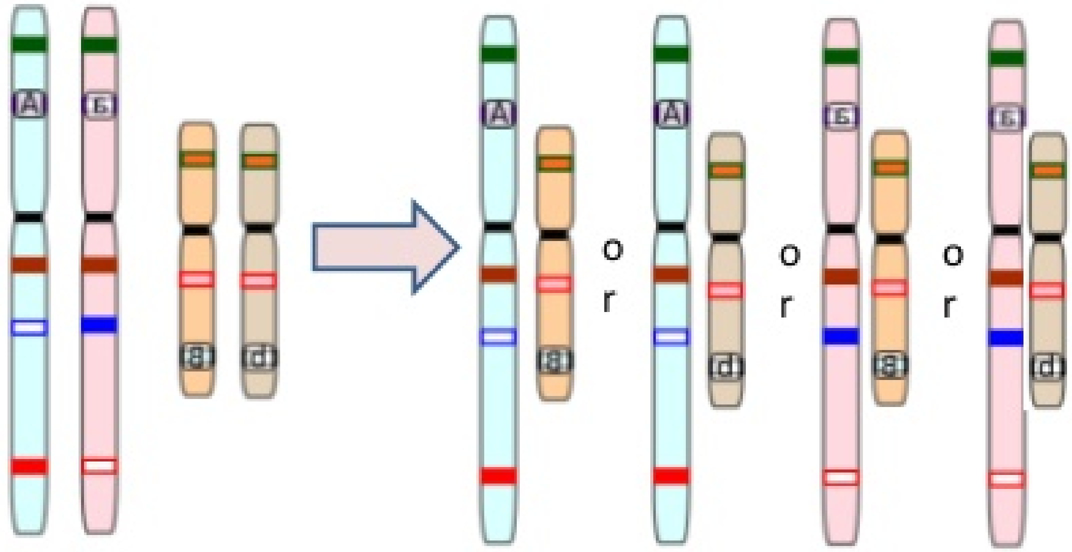
Example: 2 genes (A and B), 2 alleles each
Assume: genes are <u>not linked</u> (separate chromosomes)

In polygenics, alleles can be:

- Contributing (they add to the phenotype)
- Non-contributing (they do not add to the phenotype)

Key to alleles:
A = add melanin
a = don't add melanin
B = add melanin
b = don't add melanin

How many genotypes are possible?



gametes

Remember that alleles segregate during meiosis.

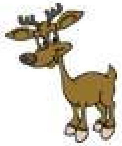
Alleles of unlinked chromosomes orient randomly.

There is also random fertilisation of gametes.

So many combinations!

i-Biology

Disease Questions ← Genetic Answers



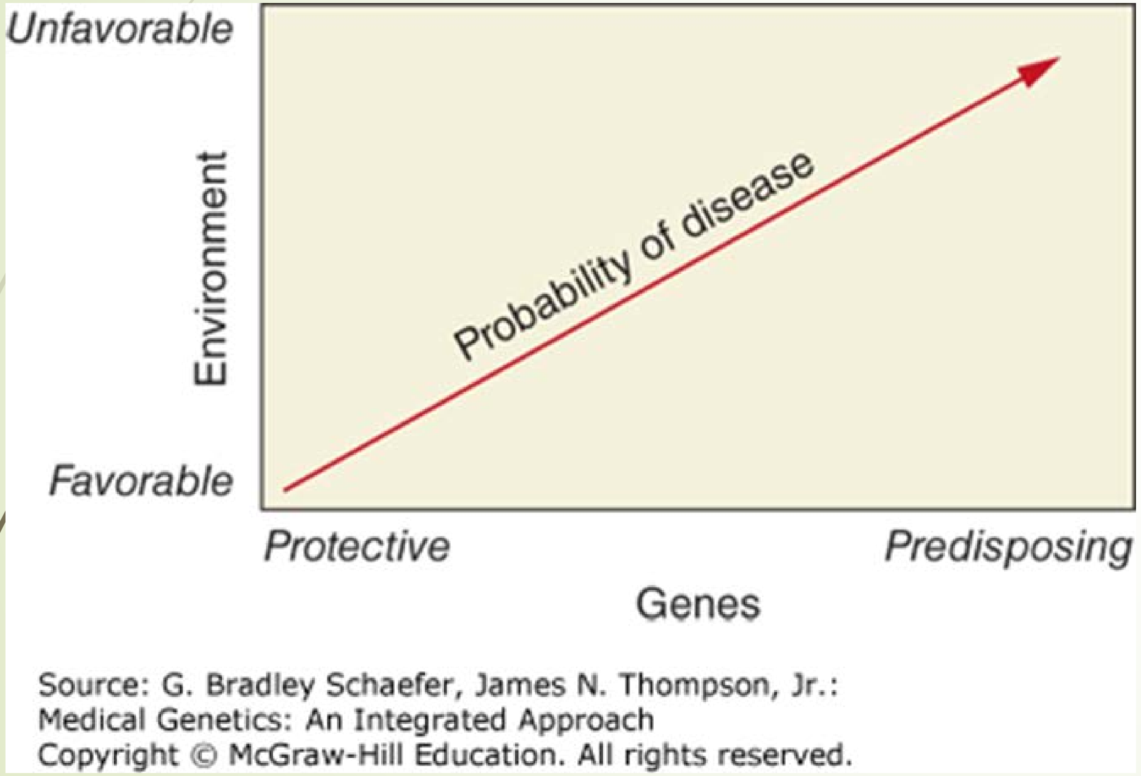
Susceptibility ← Individual heterogeneity in infection risk

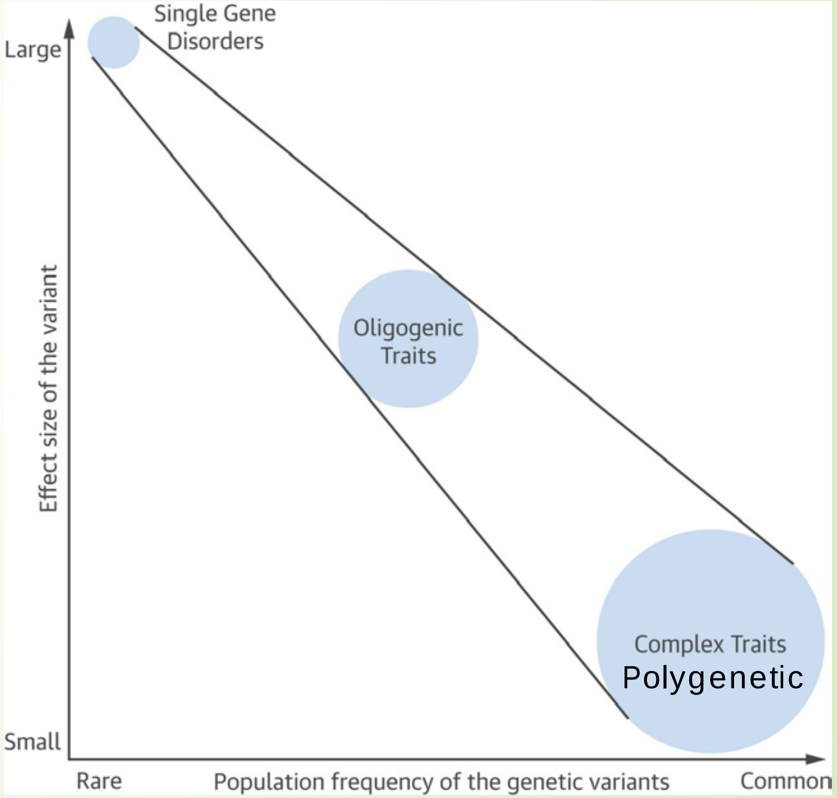
Fitness impacts ← Potential for population impacts

Transmission ← Complex & non-homogeneous dynamics

Spatial spread ← Monitoring on the landscape

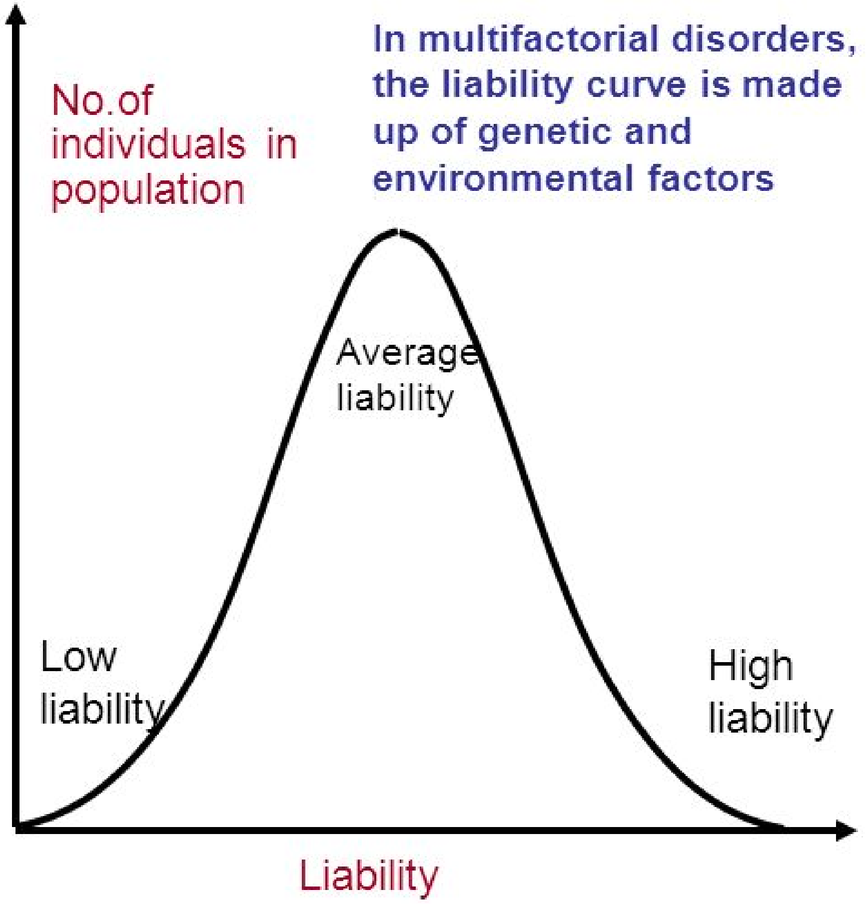
Monofactoral vs Multifactoral



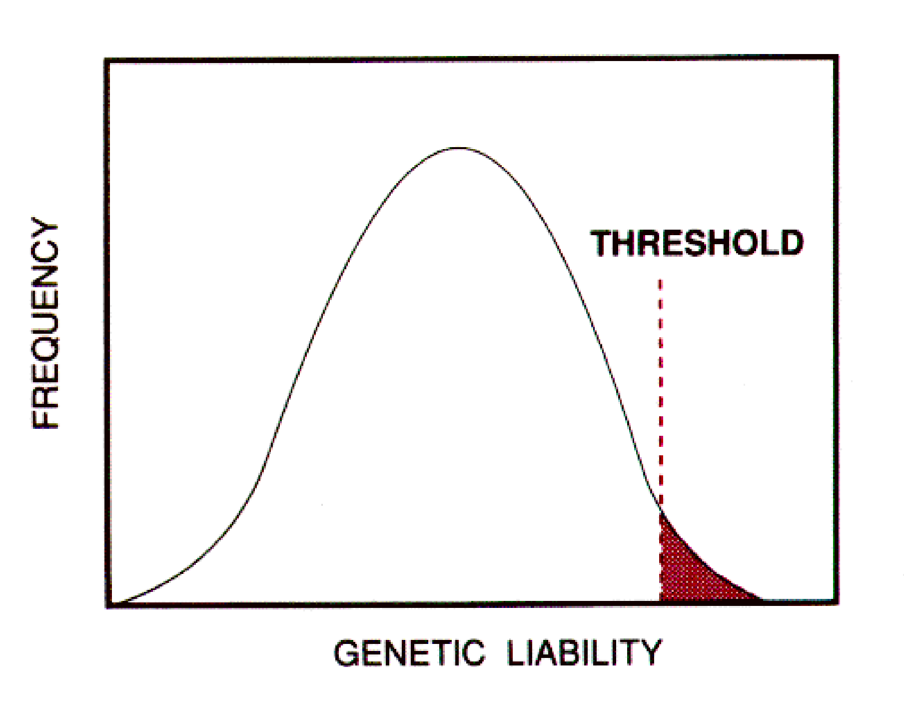


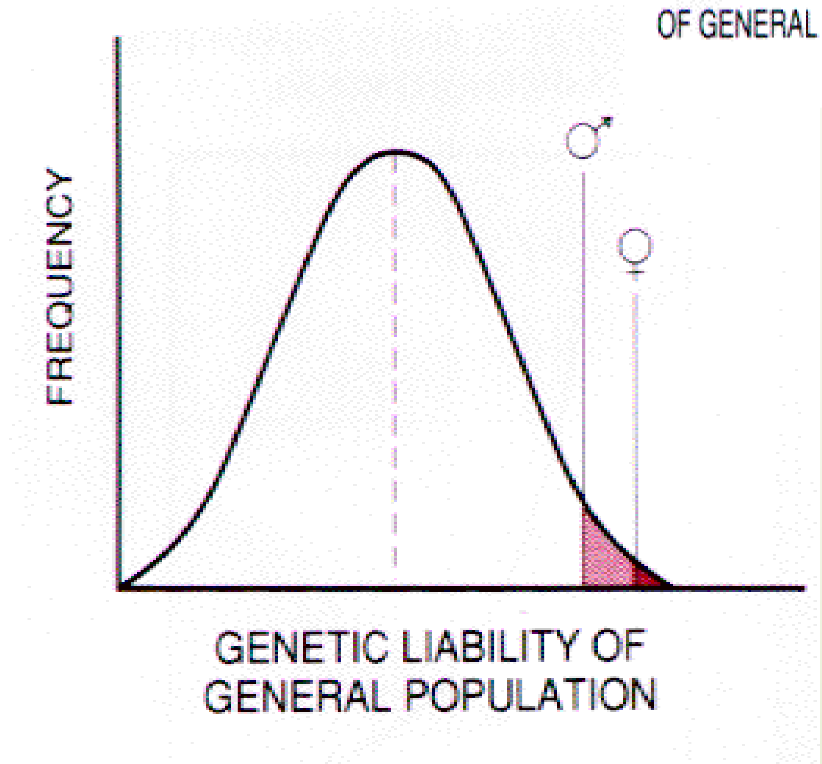
Principles of Multifactorial Inheritance

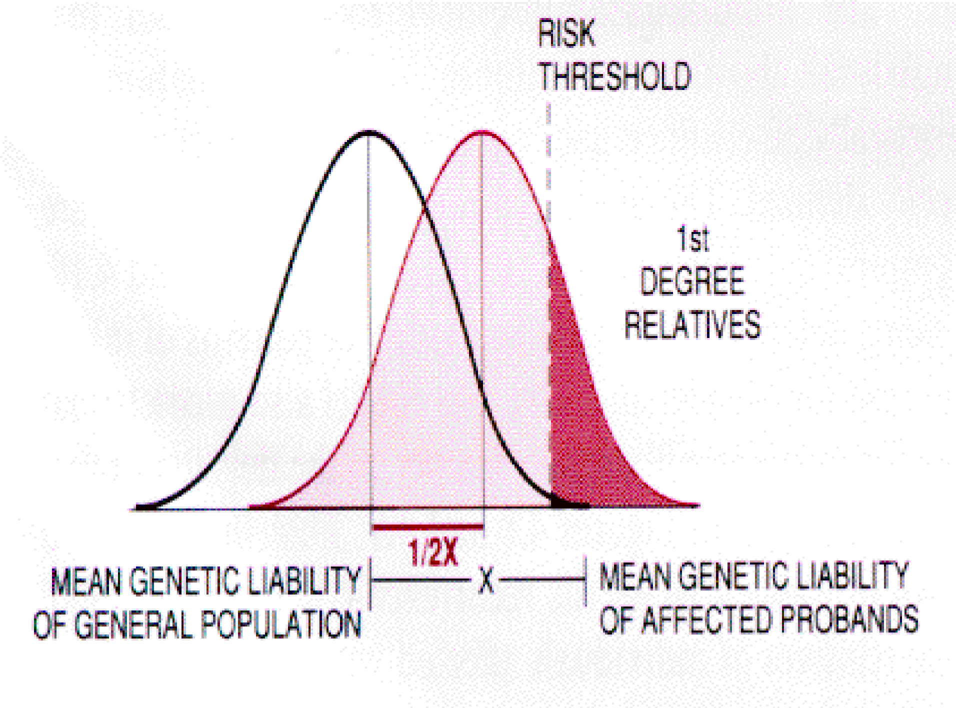
- The Basic Model
  - Polygenic traits
  - Multifactorial traits (quantitative traits: blood pressure, height, etc)
  - individual genes in multifactorial inheritance : Mendelian principles of segregation and independent assortment, but acting together



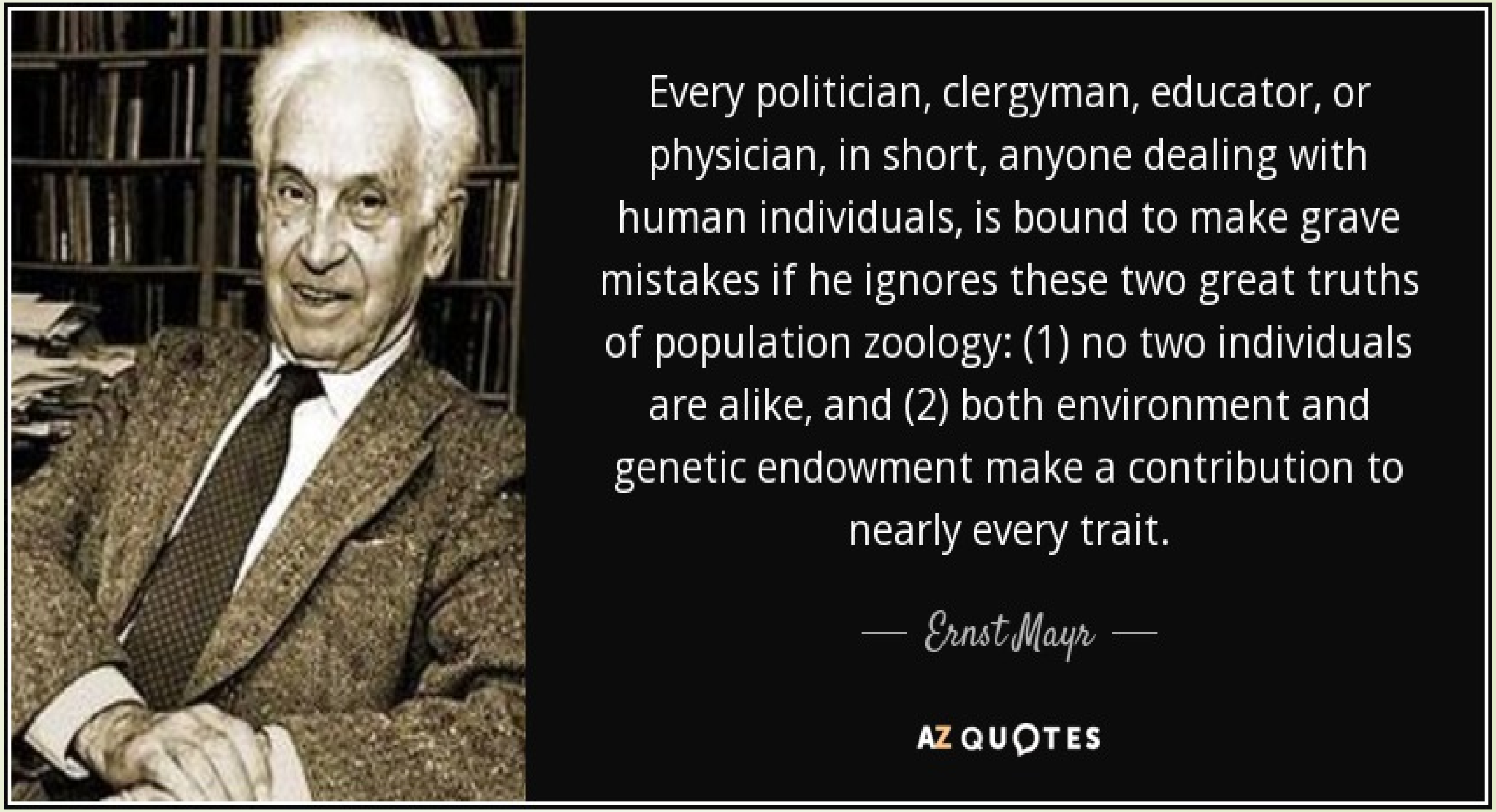
Threshold for Disorders

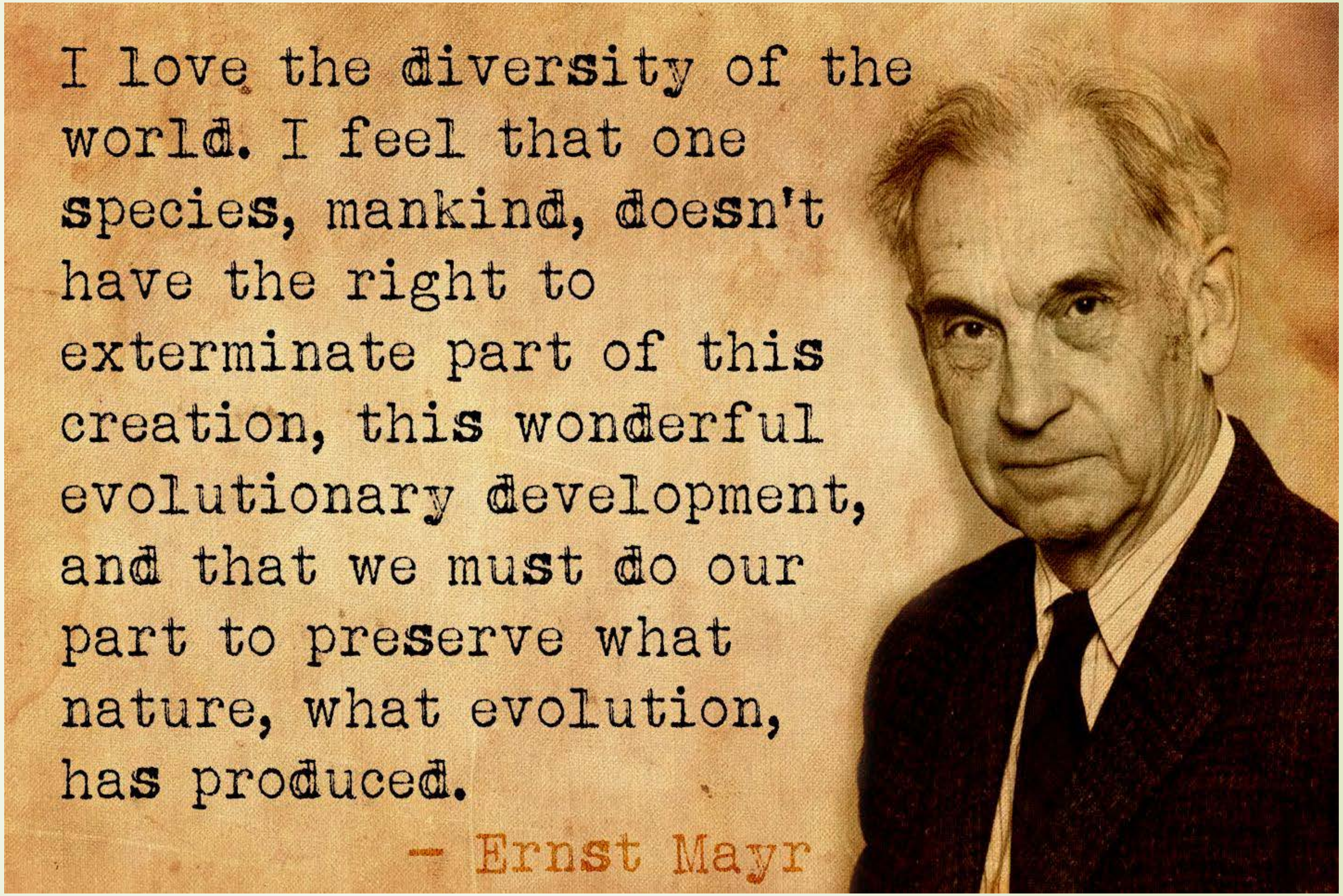






Ernst Mayr quote:




I love the diversity of the world. I feel that one species, mankind, doesn't have the right to exterminate part of this creation, this wonderful evolutionary development, and that we must do our part to preserve what nature, what evolution, has produced.
- Ernst Mayr

Questions?