UNIT 3

BIODIVERSITY and EVOLUTION

MR. GILLAM HOLY HEART

EVOLUTION

EVOLUTION

- **Evolution** the relative change in genetic traits of populations that occurs over successive generations

- **microevolution** gradual change in allele frequencies in a population over time

- **macroevolution** large-scale evolutionary changes including the formation of new species or other taxa

EVOLUTION

- **adaptation** a structure, behaviour, or physiological process that helps an organism survive and reproduce in a particular environment
- Structural Adaptations
- Behavioural Adaptations
- Physiological Adaptations

- Develop as a result of gradual change in the genetic traits of members of a population over time, and improve the chances of survival and reproduction

EVOLUTION

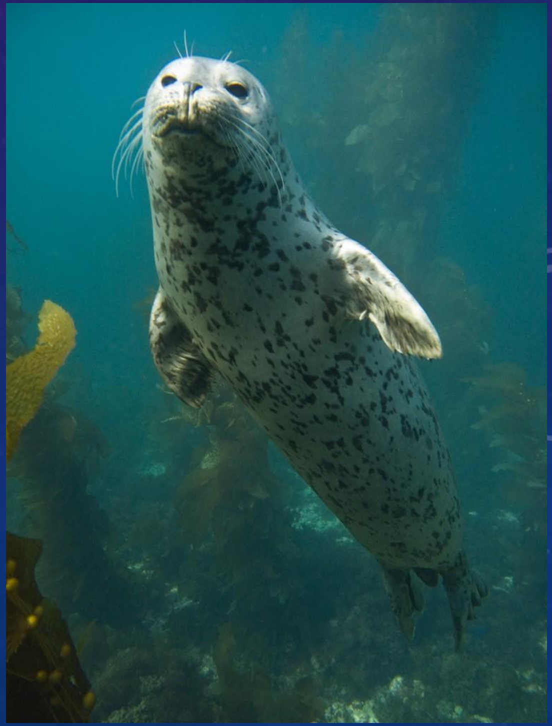
- **Structural Adaptations** are physical features on an animal that have evolved over time to help them survive and breed.
  - Camouflage
  - Eagle Claws
  - Eagle Vision
  - Burnt Cape cinquefoil - Hairy Leaves to retain water

EVOLUTION

- **Behavioural Adaptations** are changes in behavior that certain organisms or species use to survive in a new environment.
  - **Migration**
  - **Hibernation**
  - **Dormancy**

EVOLUTION

- **Physiological Adaptations** refers to the metabolic or physiologic adjustment within the cell, or tissues, of an organism in response to an environmental stimulus resulting in the improved ability of that organism to cope with its changing environment.
  - Harbour Seal - heart rate slows conserving oxygen during dives
  - Temperature regulation in animals
  - Antifreeze in fish



VARIATION WITHIN A SPECIES

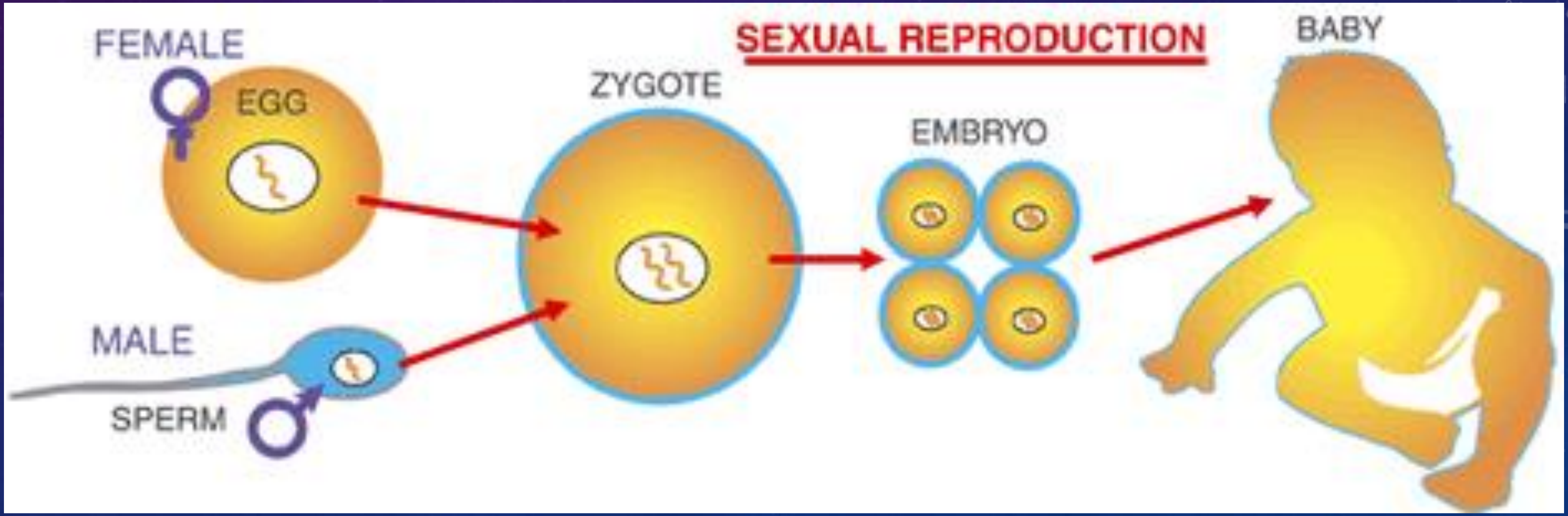
- **variation** a visible or invisible difference among some members of a population

- How does variation occur?

EVOLUTION

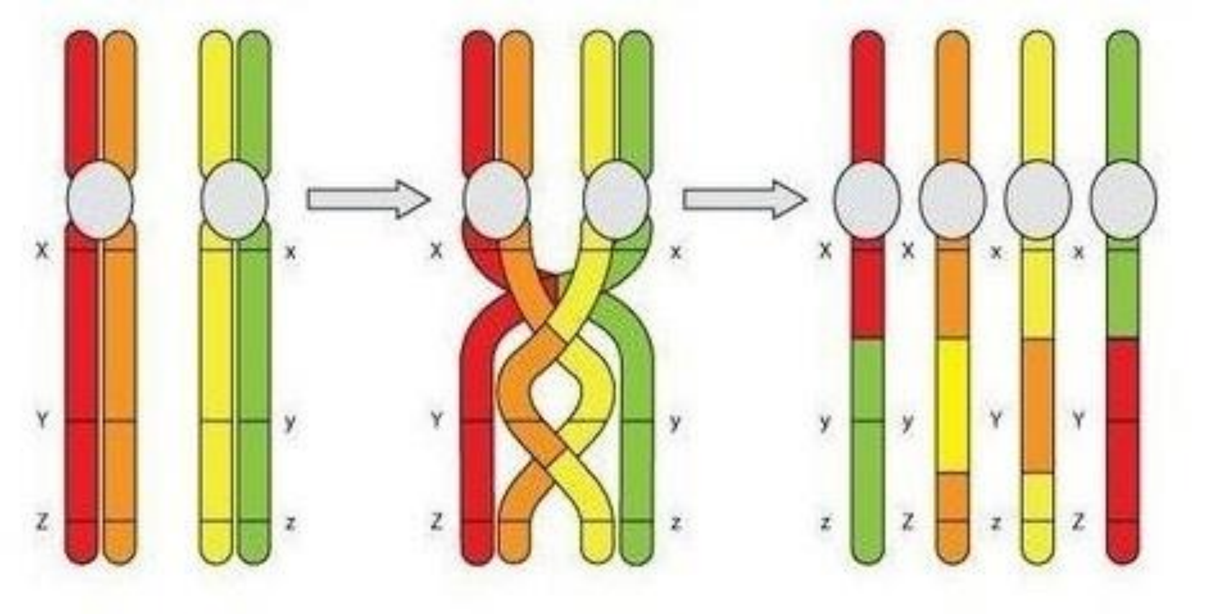
EVOLUTION

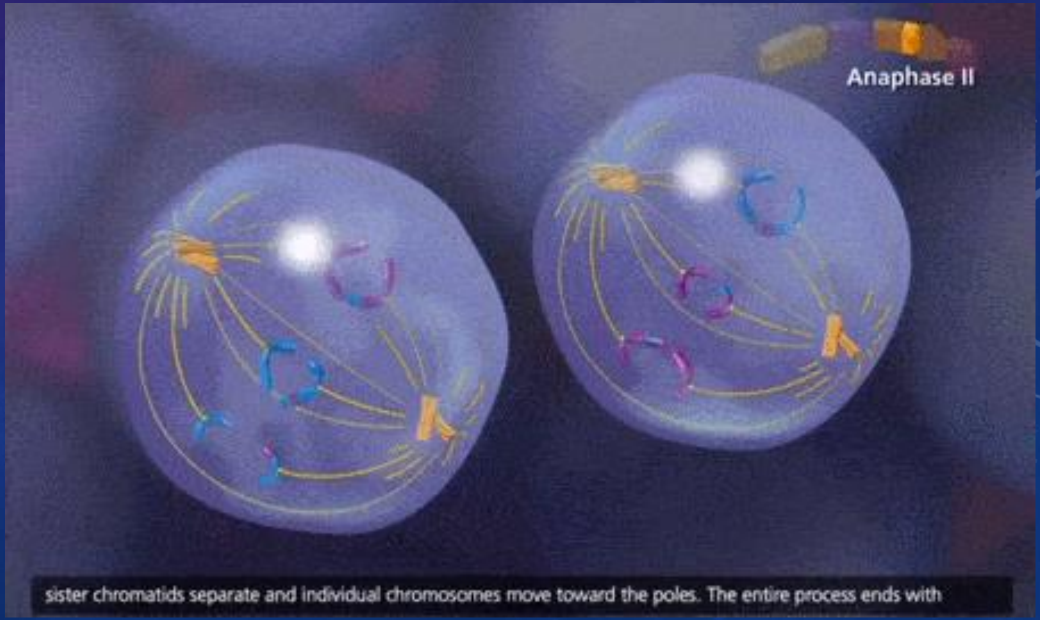
- **Sexual Reproduction** is a source of variation. Through sexual reproduction, parents pass down hereditary information (genes) to their offspring.
- The number of possible combinations of genes that offspring can inherit from their parents results in great genetic variation among individuals within a population.



EVOLUTION

- **Crossing Over Meiosis**
  Genetic variation is increased by meiosis
- Recombination or crossing over occurs during prophase I. Homologous chromosomes – 1 inherited from each parent – pair along their lengths, gene by gene. Breaks occur along the chromosomes, and they rejoin, trading some of their genes.





EVOLUTION

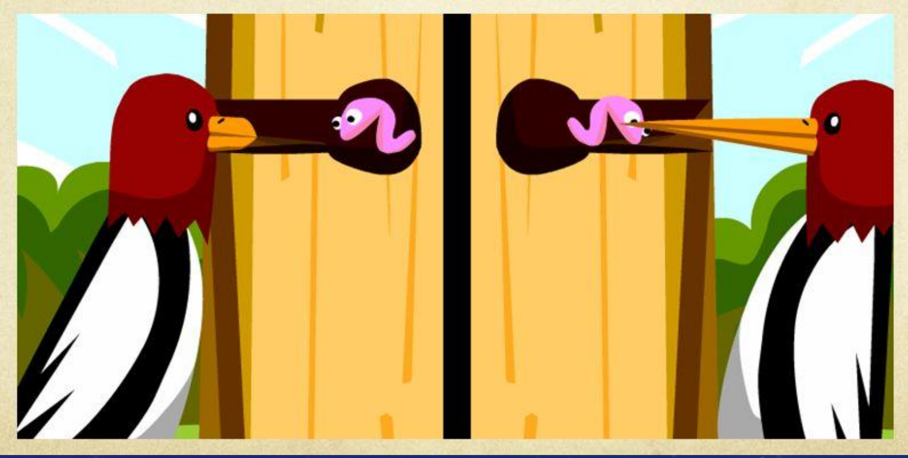
- **Mutations** mutations are a source of variation in populations. Mutations happen continuously in the DNA of any living organism. They can occur spontaneously, when DNA is copied before a cell divides.

- A **germ line** *mutation* occurs in a sperm or egg cell and the mutation may be passed down to succeeding generations.
- Thus, mutations are a significant source of genetic variation in populations.

EVOLUTION

MUTATIONS CAN PROVIDE A SELECTIVE ADVANTAGE

- Mutations that significantly alter proteins in DNA **often adversely affect the well-being of an organism** and can be **harmful.**
- In some instances a mutation enables an organism to **survive** in its environment **better**, which, in turn, means that the organism is more likely to **survive and reproduce**.
- This situation is more common when an organism's environment is changing. Mutations that once were no advantage, or perhaps were even a disadvantage, may become **favourable in a new environment.**



EVOLUTION

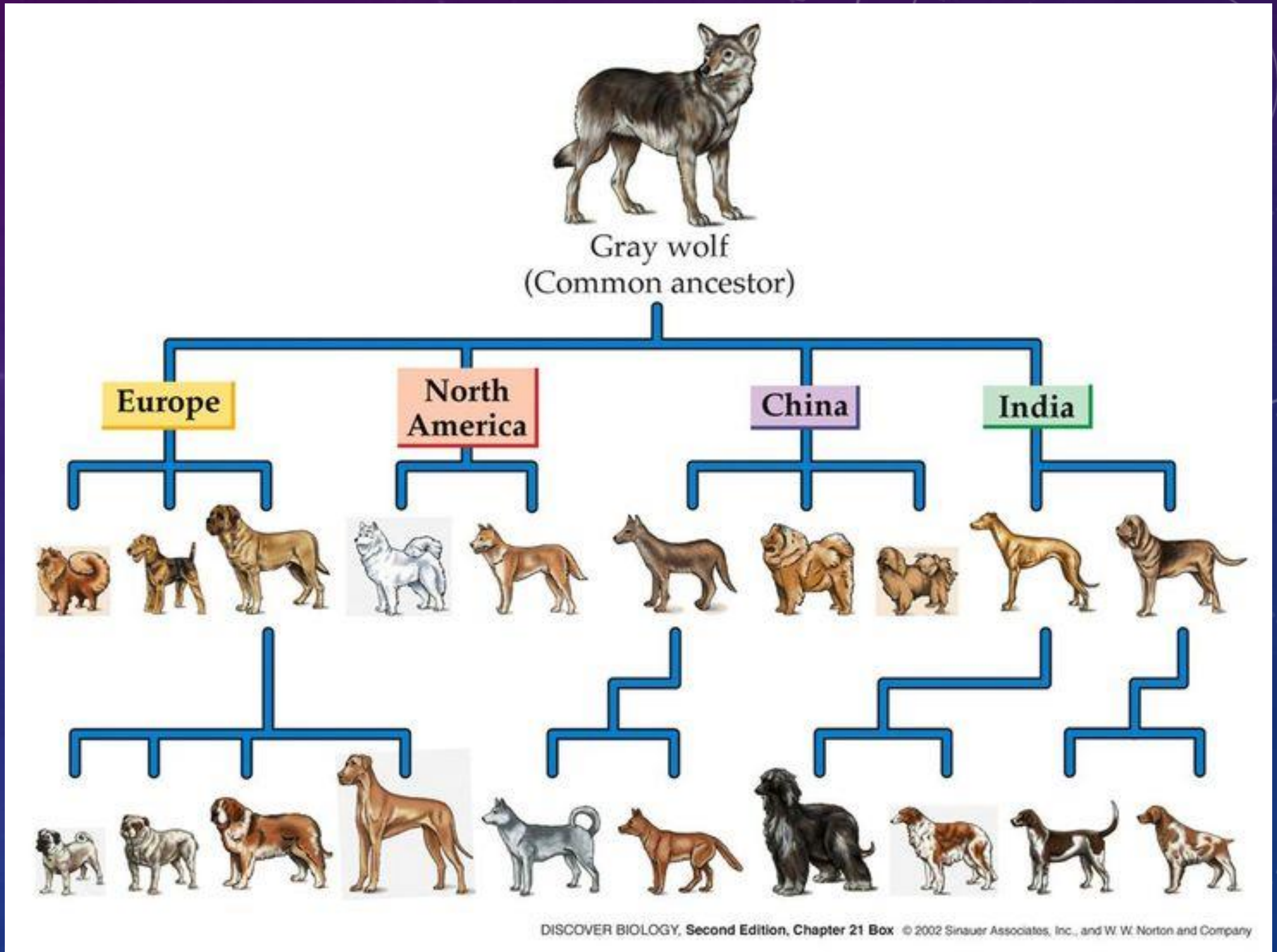
- Students are expected to personally design and carry out investigations to measure variation in inherited traits within two populations. The focus should be developing detailed procedures and using appropriate tools to collect accurate, reliable measurements. **Investigation 16.A (*NL Biology*, p. 638) provides a suggested procedure.**
- These investigations provide an opportunity to assess a significant number of skill outcomes. In addition to SCOs 1.0, 3.0, 4.0, 5.0, 6.0, 16.0, and 22.0, teachers may also assess skill outcomes 2.0, 13.0, 15.0, 19.0, 23.0, 26.0, and 27.0. Refer to the *Integrated Skills* unit for elaboration of these outcomes.

EVOLUTION

ARTIFICIAL SELECTION

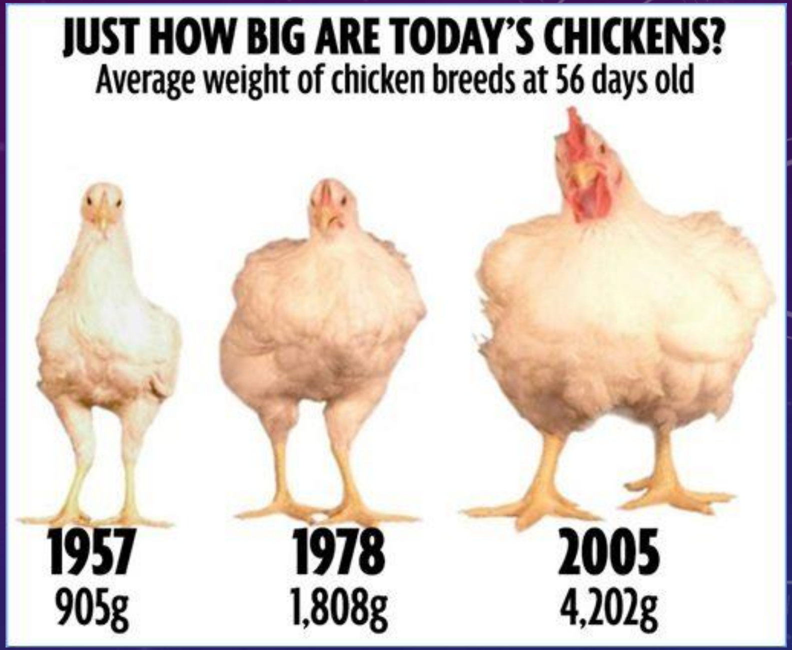
- **artificial selection** selective breeding to obtain varieties of plants or animals with desired traits

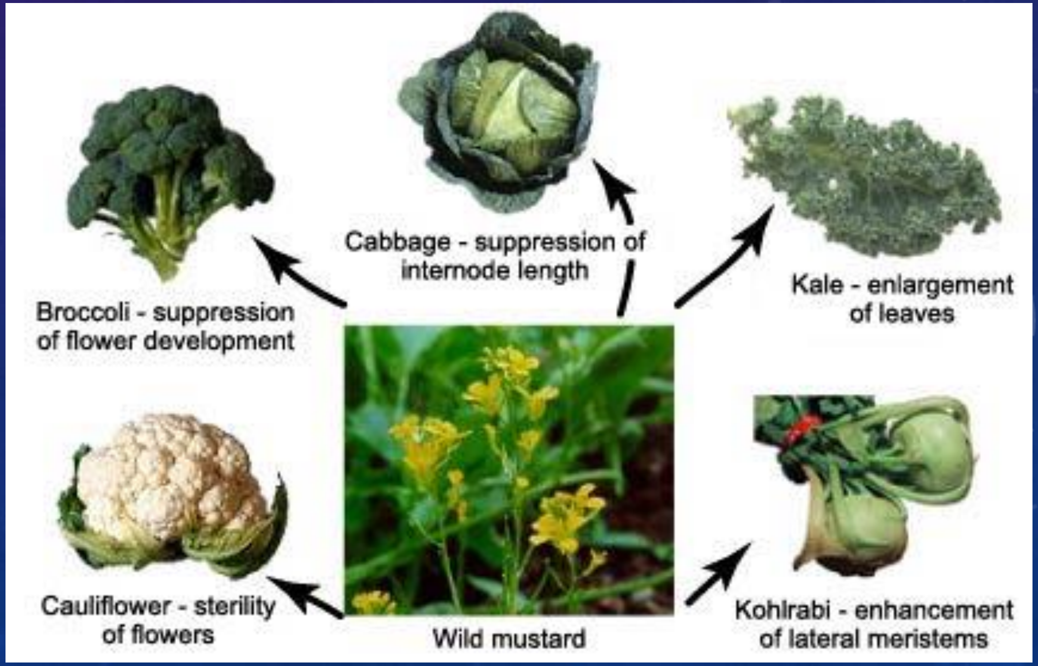
- Artificial selection during domestication and crop improvement involved selection of specific alleles of genes controlling traits resulting in **reduced genetic diversity** relative to unselected genes.



EVOLUTION

- The m**eats** sold today are the result of the selective breeding of **chickens, cattle, sheep, and pigs.** Many **fruits** and **vegetables** have been improved or even created through artificial selection.
- For example, **broccoli, cauliflower**, and **cabbage** were all derived from the wild **mustard plant** through selective breeding.
- Early indigenous peoples developed the ancestral versions of the **corn** that we know today from one or more ancient grasses, including teosinte.

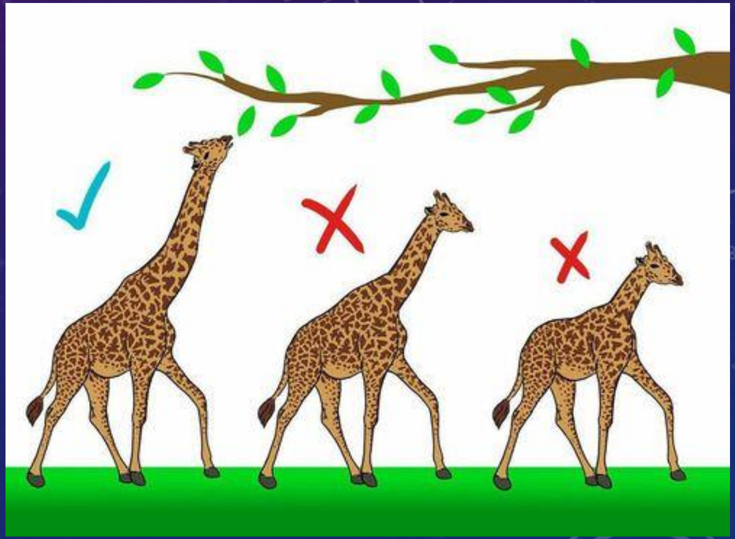




EVOLUTION

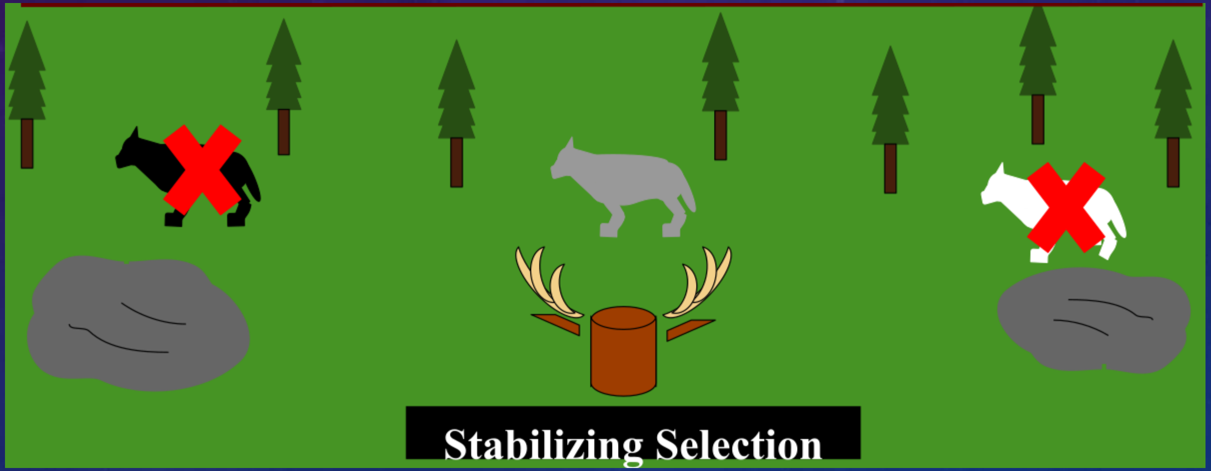
NATURAL SELECTION

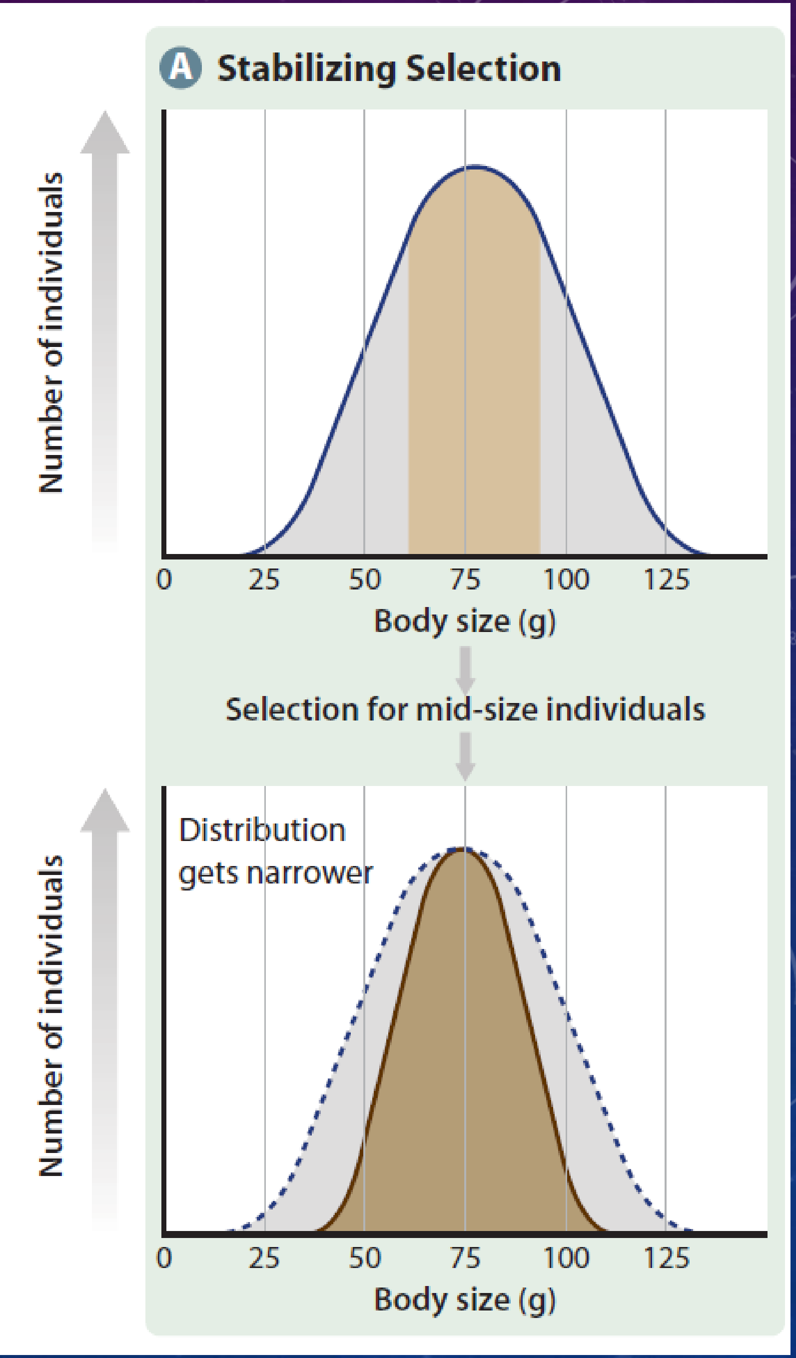
- **Natural Selection** is the process through which populations of living organisms adapt and change. Individuals in a population are naturally variable, meaning that they are all different in some ways.
- This variation means that some individuals have traits better suited to the environment than others.
- Individuals with adaptive traits—traits that give them some advantage—are more likely to survive and reproduce.
- These individuals then pass the adaptive traits on to their offspring.
- Over time, these advantageous traits become more common in the population.



TYPES OF NATURAL SELECTION

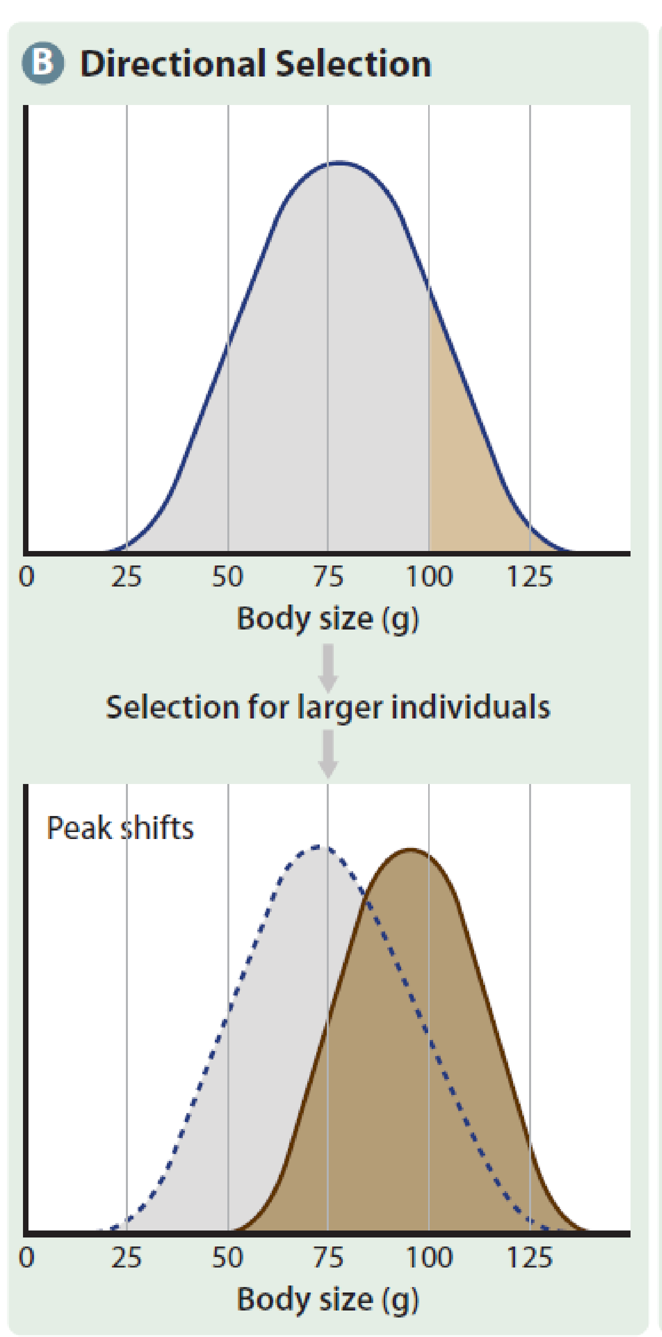
- **stabilizing selection** a form of natural selection that favours an intermediate phenotype and acts against extreme versions of the phenotype.





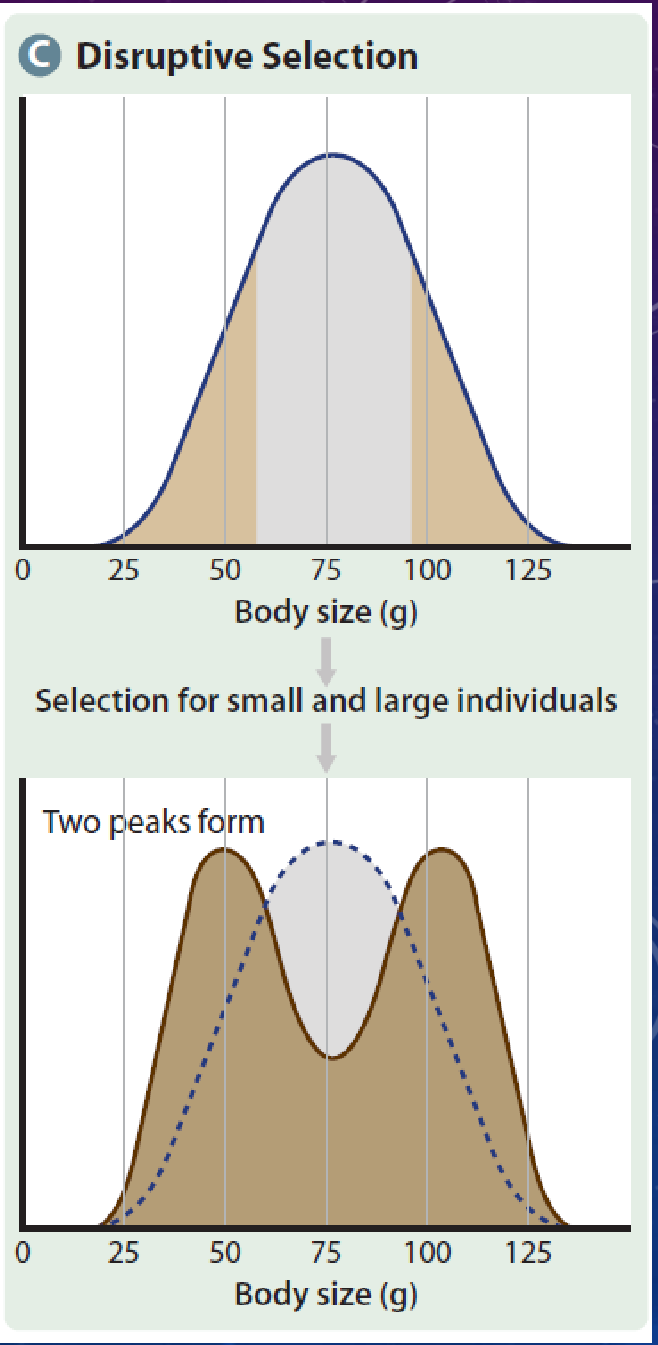
EVOLUTION

- **directional selection** a form of natural selection that favours the phenotype at one extreme over the other



EVOLUTION

- **disruptive selection** a form of natural selection that favours the extremes of a range of phenotypes over intermediate phenotypes, and may eliminate intermediate phenotypes from the population



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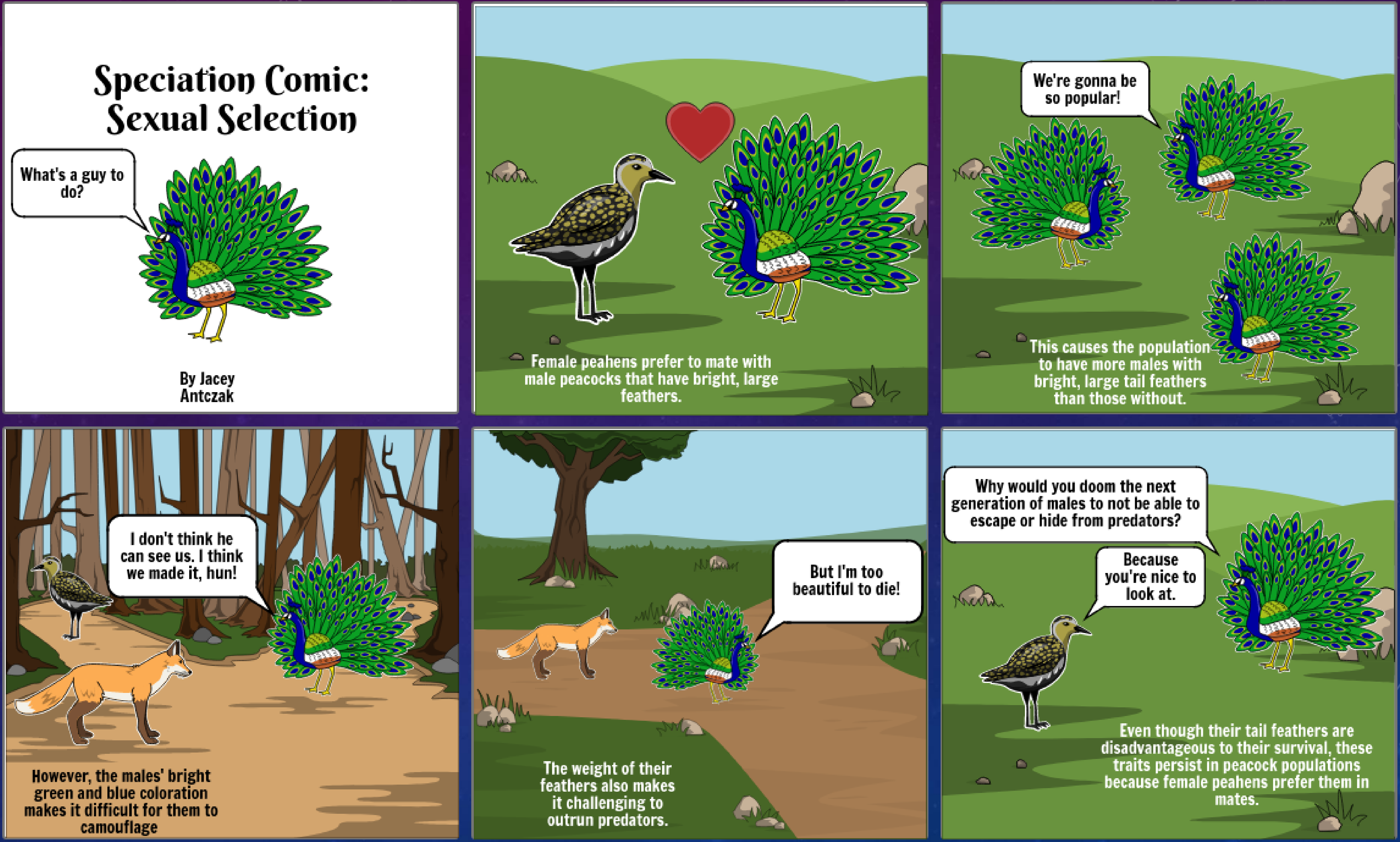
- **sexual selection** a special case of natural selection in which a particular phenotype improves an individual's chances of obtaining a mate

EVOLUTION


Speciation Comic: Sexual Selection
What's a guy to do?
By Jacey Antczak
Female peahens prefer to mate with male peacocks that have bright, large feathers.
We're gonna be so popular!
This causes the population to have more males with bright, large tail feathers than those without.
I don't think he can see us. I think we made it, hun!
However, the males' bright green and blue coloration makes it difficult for them to camouflage
But I'm too beautiful to die!
The weight of their feathers also makes it challenging to outrun predators.
Why would you doom the next generation of males to not be able to escape or hide from predators?
Because you're nice to look at.
Even though their tail feathers are disadvantageous to their survival, these traits persist in peacock populations because female peahens prefer them in mates.

INDUSTRIAL MELANISM

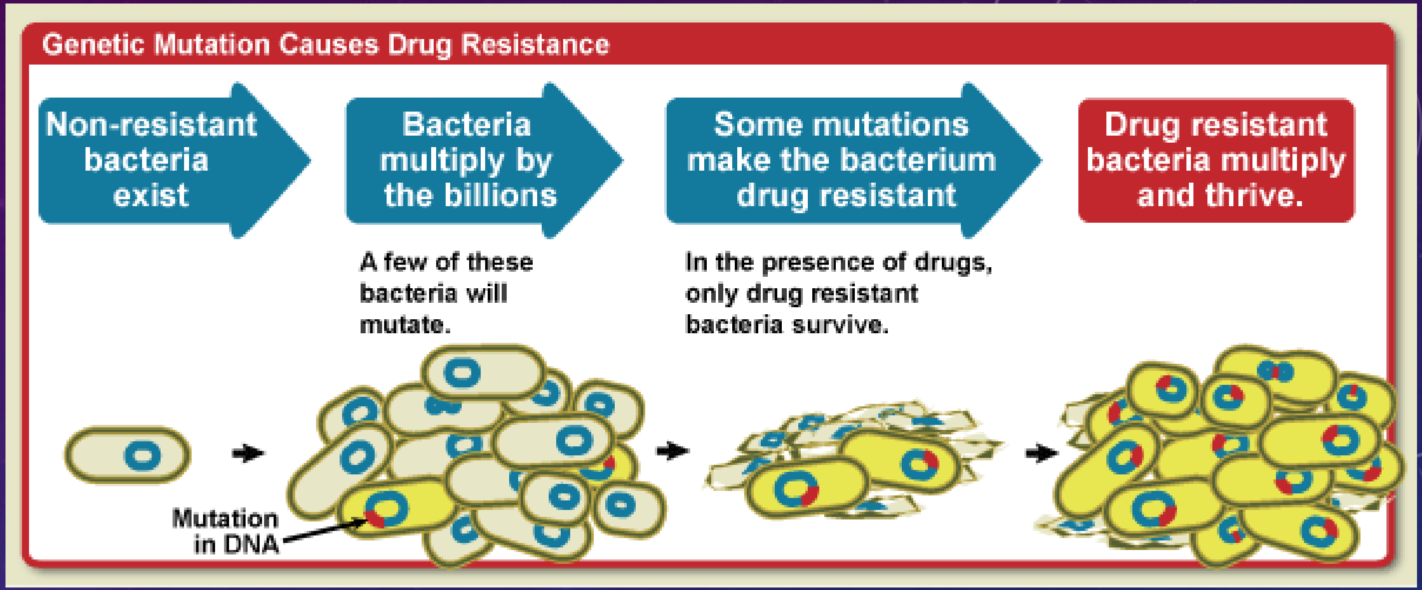
EVOLUTION

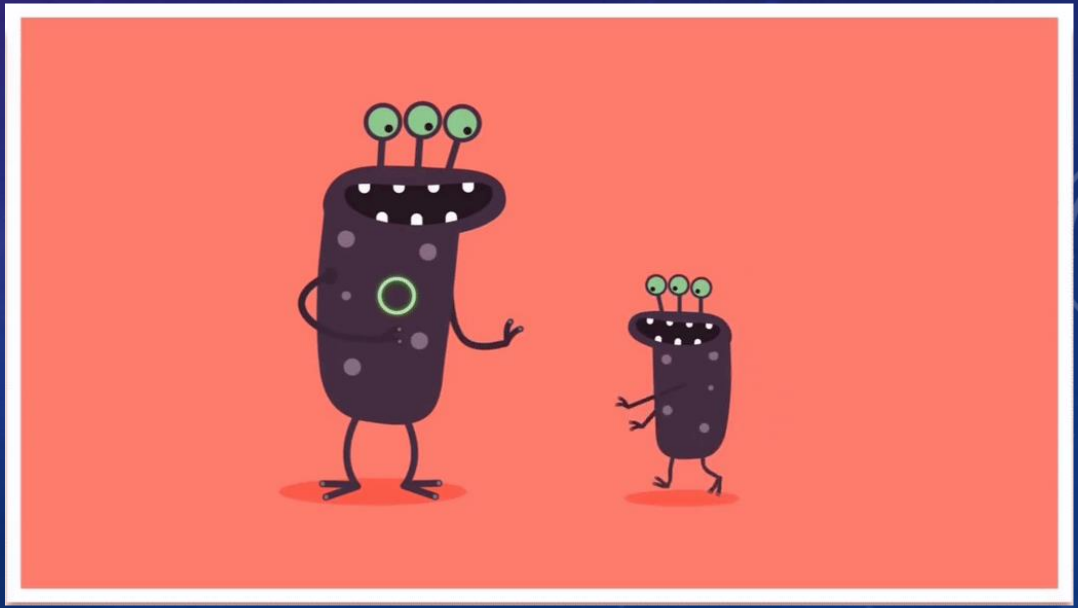
- **Industrial melanism** is an evolutionary effect prominent in several arthropods, where dark pigmentation (melanism) has evolved in an environment affected by industrial pollution, including sulphur dioxide gas and dark soot deposits.
- The **peppered moth** has two colour variations: greyish-white flecked with black dots and black
- Individuals of flecked and dark moth populations fluctuated over relatively short periods that **corresponded** to the amount of **air pollution** in the moth's habitat.

EVOLUTION

ANTIBIOTIC RESISTANT BACTERIA

- Some types of bacteria not only pass down their genes when they reproduce, but also can transfer their genes to bacterial cells in their own generation. This form of gene transfer, called horizontal genetic transfer, is one reason that genes for antibiotic resistance spread quickly in bacterial populations.





EVOLUTION

- **Extirpation** is the condition of a species that ceases to exist in a chosen geographic area of study, though it still exists elsewhere.

- **Extinction** is the termination of a kind of organism or of a group of kinds, usually a species. The moment of extinction is generally considered to be the death of the last individual of the species, although the capacity to breed and recover may have been lost before this point.

EXTIRPATION EXAMPLE

- **Madagascar** is also the only place in the world where **lemurs** are found. However, the fossil record shows that lemurs were once widespread throughout Africa.
- So why are lemurs no longer present in Africa?
- When Madagascar permanently separated from Africa 50 million years ago, monkeys had not yet evolved.
- Monkeys do not appear in the fossil record until about 35 million years ago, so they had no way of reaching the island of Madagascar (because the channel between Africa and Madagascar was too wide at that time).
- However, **monkeys** eventually took over the niche that lemurs had on the **African continent and drove lemurs to extinction there.**

EVOLUTION

ENVIRONMENTAL CONDITIONS AND SELECTIVE PRESSURES

- Selective pressures by the environment can lead to extirpation and extinction of species.
- i.e. Climate Change causing the extinction and extirpation of coral reefs.

EVOLUTION

- EXIT CARD 13

EVOLUTIONARY THEORY AND CONTRIBUTORS

EVOLUTION

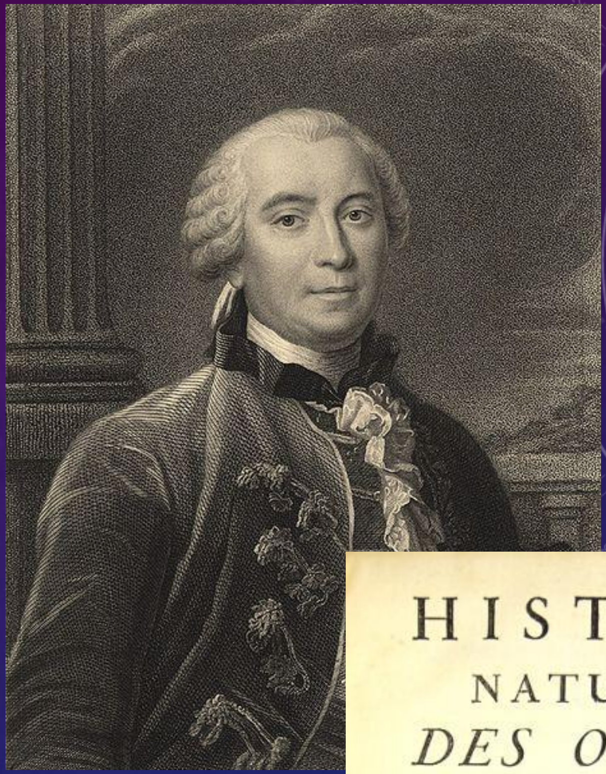
- Plato (427–347 B.C.E.) and Aristotle (384–322 B.C.E.), believed that all life existed in a perfected and unchanging form. This view of life prevailed in Western culture for over 2000 years.

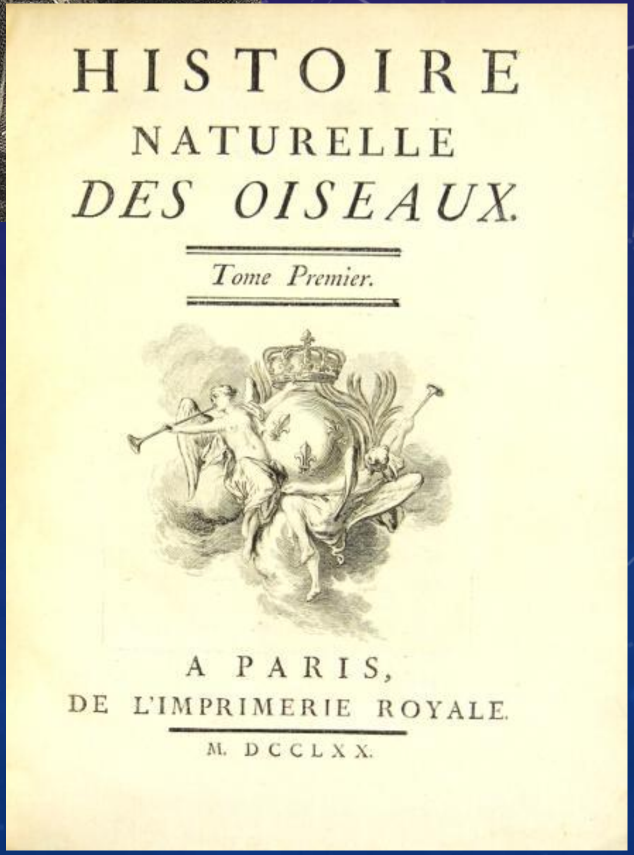
- By the sixteenth century the predominant **paradigm** in western culture was that **all species of organisms came into existence at the same time and remained unchanged**

- **We now know this to be untrue**

EVOLUTION

- French naturalist **Georges-Louis Leclerc, Comte de Buffon** (1707–1788). In 1749, he published the 44-volume ***Histoire Naturelle***, which compiled his understandings of the natural world
- In this work, Buffon noted the **similarities between humans and apes**, and speculated that they might have a common ancestor
- In other writings, Buffon suggested that **Earth was much older than 6000 years**, as was commonly believed.





HISTOIRE
NATURELLE
DES OISEAUX.

Tome Premier.

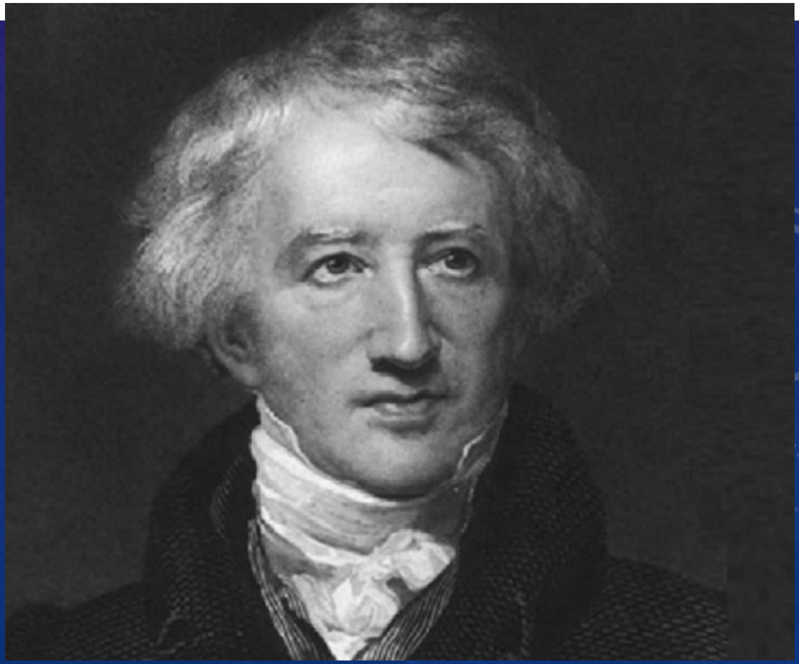
A PARIS,
DE L'IMPRIMERIE ROYALE.
M. DCCLXX.

EVOLUTION

- **Mary Anning** unearthed the ancient remains of a prehistoric fish called Ichthyosaurus, the specimen looked unlike any animal known to be living during Anning's time.
- Anning's discoveries made people question a widely believed idea—that all forms of life came into existence at the same time and had never changed. **But fossils provided good evidence that many life forms of the past no longer existed.**

EVOLUTION

- **Georges Cuvier** (1769– 1832) is largely credited with developing the science of **paleontology**, the study of ancient life through the examination of fossils. Cuvier found that each stratum (layer of rock) is characterized by a unique group of fossil species. He also found that the deeper (older) the stratum, the more dissimilar the species are from modern life. As Cuvier worked from stratum to stratum, **he found evidence that new species appeared and others disappeared over the passage of time. This evidence showed that species could become extinct.** Proposed the idea that Earth experienced many destructive natural events, such as floods and volcanic eruptions, in the past. These catastrophic events, which he called ***revolutions***, were violent enough to have killed numerous species each time they occurred.



EVOLUTION

- **Catastrophism** the theory that changes in the earth's crust during geological history have resulted chiefly from sudden violent and unusual events.

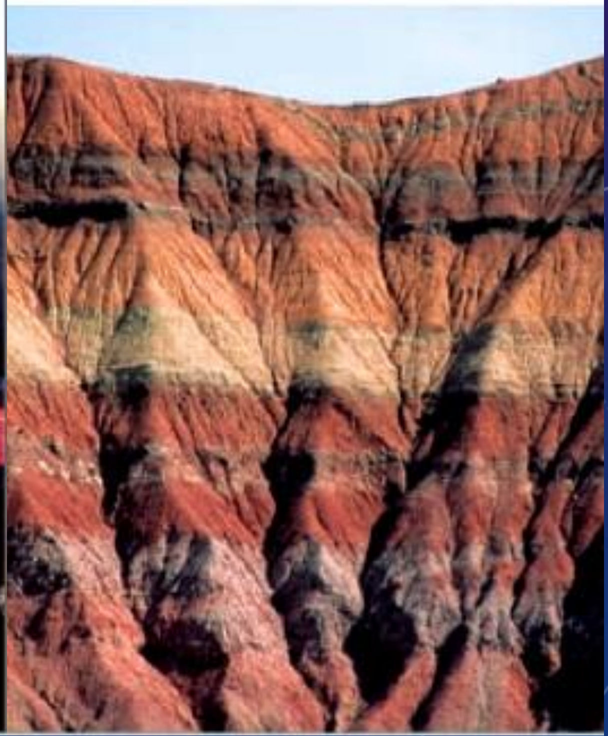
- The term **catastrophism** is often used to describe Cuvier’s ideas about the powerful forces that led to the extinction of species in Earth’s past.

EVOLUTION

- Scottish geologist **Charles Lyell** (1797–1875) rejected the idea of revolutions. He proposed, instead, **that geological processes operated at the same rates in the past as they do today.**
- He reasoned that if geological changes are slow and continuous rather than catastrophic, then Earth might be more than 6000 years old.
- As well, Lyell theorized that **slow, subtle processes could happen over a long period of time and could result in substantial changes.**
- **Wrote the book Principles of Geology**

- Lyell said that geological processes operated at the same rates in the past as they do today. He **rejected** Cuvier's idea of irregular, unpredictable, catastrophic events shaping Earth's history.
- He proposed the idea of **Uniformitarianism,** the theory that changes in the earth's crust during geological history have resulted from the action of continuous and uniform processes.

CATASTROPHISM	UNIFORMITARIANISM
Volcanoes, floods, and earthquakes are examples of catastrophic events that were once believed responsible for mass extinctions and the formation of all landforms.	Rock strata demonstrate that geologic processes, which are still occurring today, add up over long periods of time to cause great change.

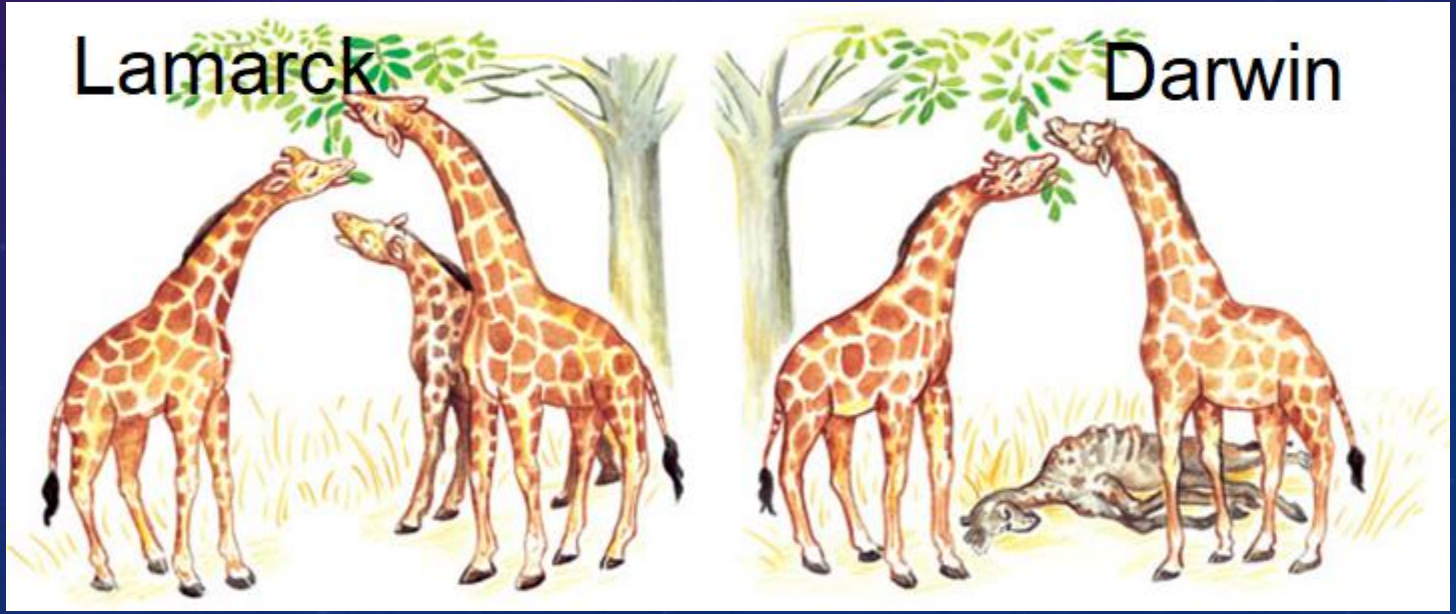


EVOLUTION

- French naturalist **Jean-Baptiste Lamarck** (1744–1829) **outlined his ideas about changes in species over time.** By comparing current species of animals with fossil forms, **Lamarck observed what he interpreted as a "line of descent,"** or progression, in which a series of fossils (from older to more recent) led to a modern species. **He thought that species increased in complexity over time, until they achieved a level of perfection.**

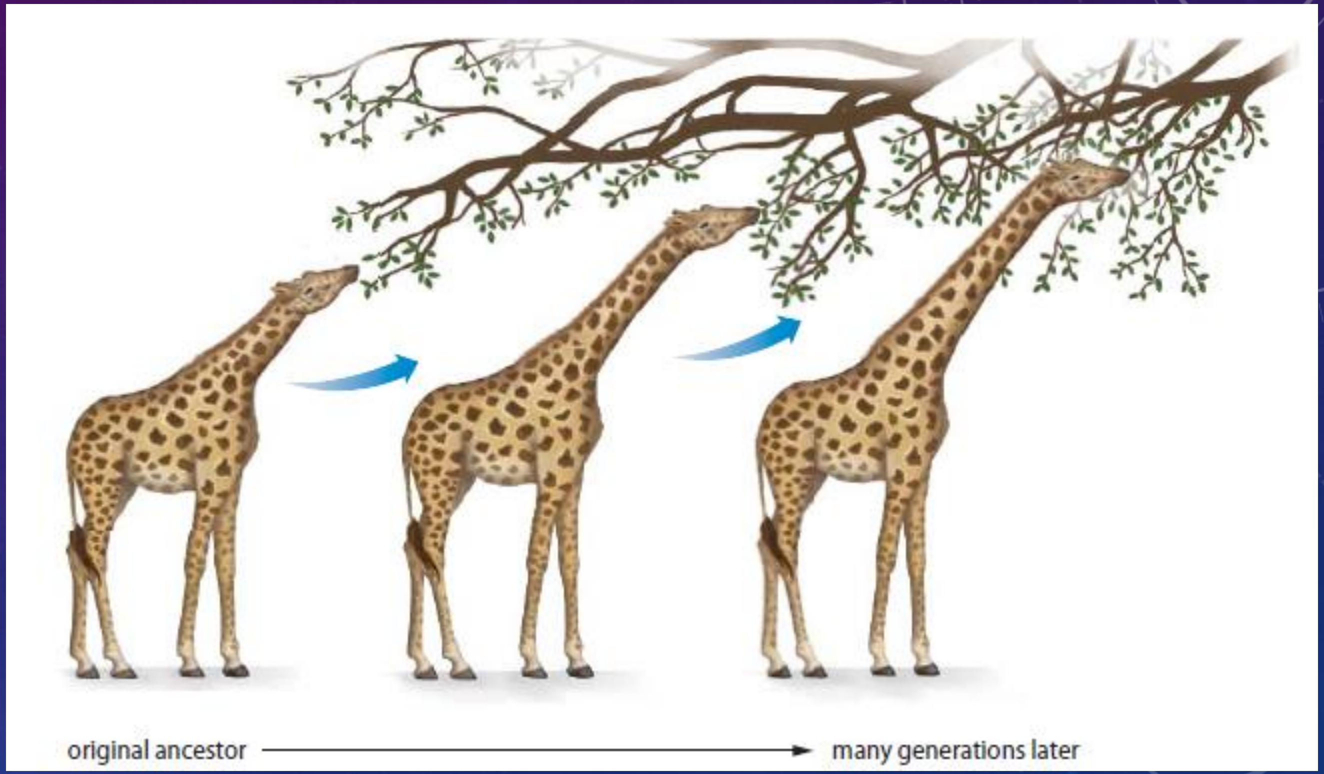
EVOLUTION

- Lamarck also thought that characteristics, such as large muscles, that were acquired during an organism's lifetime could be passed on to its offspring. Lamarck called this concept the inheritance of acquired characteristics.
- inheritance of acquired characteristics idea that characteristics acquired during an organism's lifetime could be passed down to its offspring THIS IS NOT A THING, YOU DO NOT GAIN SKILLS THAT YOUR PARENTS HAD OR THE TRAITS THEY GAIN THROUGH USE.
- if an adult giraffe stretched its neck to reach foliage high in the trees, then it would pass down the trait for a long neck to its offspring



EVOLUTION

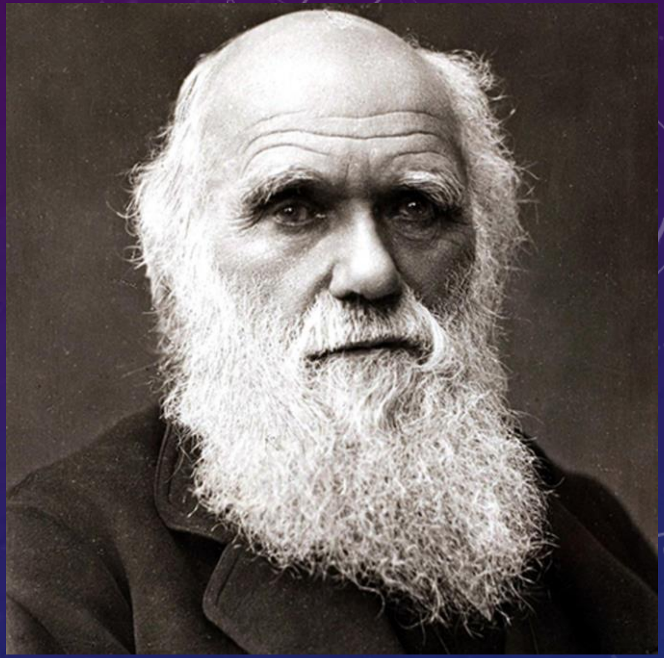
- Lamarck **provided a hypothesis for how the heredity of characteristics from one generation to the next might happen.**
- More importantly, he noted that an organism's **adaptations to the environment resulted in characteristics that could be inherited by offspring.**

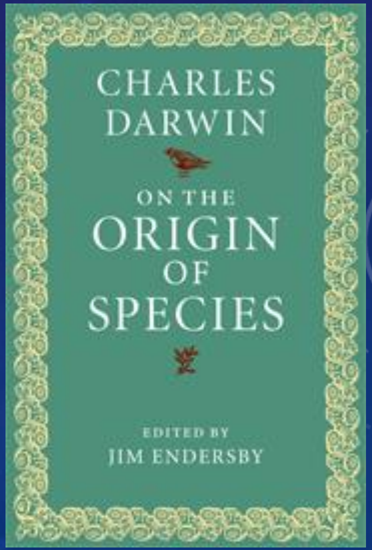


EVOLUTION

DARWIN

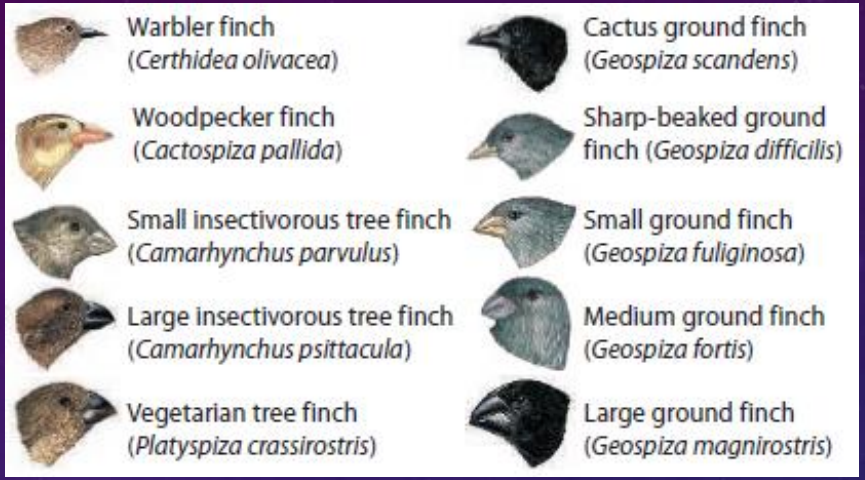
- In 1831, 22-year-old **Charles Darwin** left England on the HMS *Beagle*, a British survey ship.
- Charles Darwin was not the only person to organize his and others' observations and ideas into a comprehensive theory to **explain how species changed over time.**
- Darwin called this process **natural selection.**
- Darwin proposed two main ideas in ***On the Origin of Species***:
- 1. Present forms of life have arisen by descent and modification from an ancestral species.
- 2. The mechanism for modification is natural selection working for long periods of time.

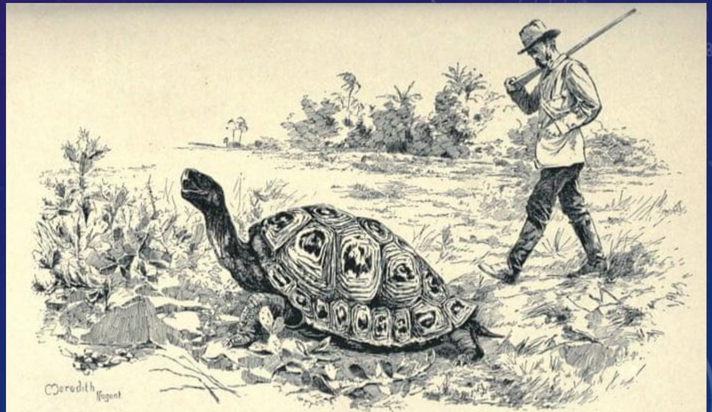




EVOLUTION

- Many of Darwin's observations surprised him. For example, he observed **finch species** on the **Galápagos Islands** that looked similar and yet distinct from one another and from any finch species on continental South America. He encountered **marine iguanas and giant tortoises**..

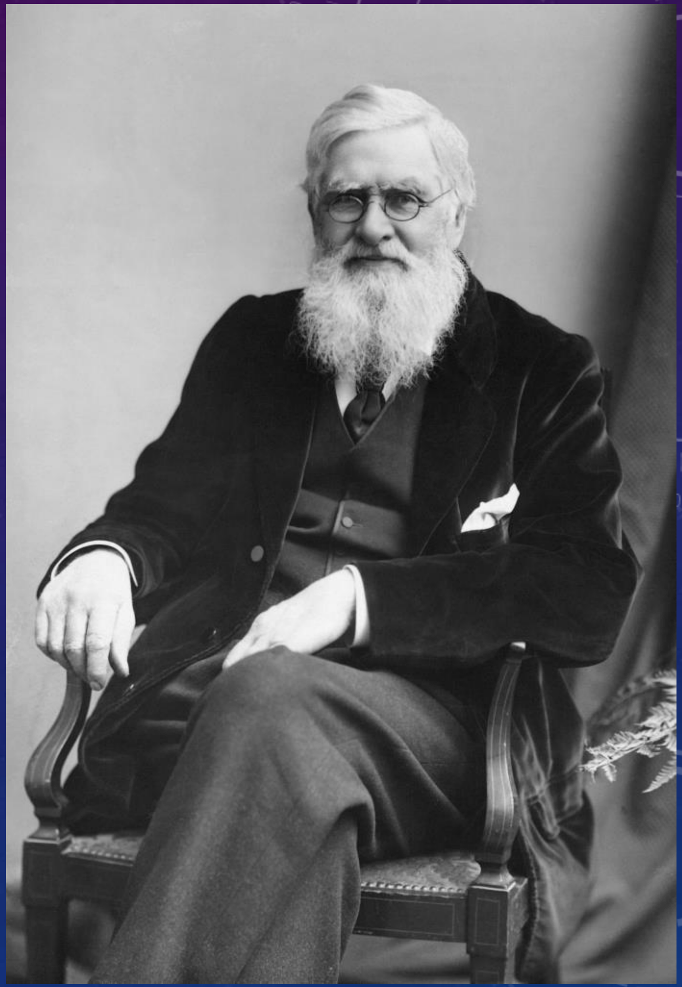




DARWIN TESTING THE SPEED OF AN ELEPHANT TORTOISE (GALAPAGOS ISLANDS).

EVOLUTION

- **Alfred Russel Wallace** (1823–1913), another British naturalist, independently reached conclusions that were similar to Darwin's.
- As a result of his studies in a group of islands near Indonesia (Maluku Islands), Wallace had reached a **conclusion similar to Darwin's.** In the paper, Wallace outlined an **essentially identical theory of evolution by natural selection.**
- **Charles Lyell presented Wallace's paper and parts of Darwin's unpublished 1844 essay to the scientific community on July 1, 1858.**



EVOLUTION

- An essay by economist **Thomas Malthus** (1766–1834), called An Essay on the Principles of Population, provided them with a key idea.
- Malthus had proposed that populations produced far more offspring than their environments (for example, their food supply) could support and were eventually reduced by starvation or disease.

EVOLUTION

- Malthus's vision of struggle and crowding helped Darwin and Wallace reasoned that **competition** for limited resources among individuals of the same species **would select for individuals with favourable traits**—traits that **increased** their chances of **surviving** to **reproduce.**

Charles Darwin & Alfred Russel Wallace

Thomas Malthus

DARWIN'S OBSERVATIONS

- **1.** The flora and fauna of the different regions the *Beagle* visited were distinct from those Darwin had studied in England and Europe. For example, the rodents in South America were structurally similar to one another but were quite different from the rodents Darwin had observed on other continents.

- If all organisms originated in their present forms during a single event, Darwin wondered, **why was there a distinctive clustering of similar organisms in different regions of the world?**

- **Why were all types of organisms not randomly distributed?**

EVOLUTION

- **2.** Darwin observed fossils of extinct animals, such as the armadillo-like glyptodont, that looked very similar to living animals.

- **Why would living and fossilized organisms that looked similar be found within the same region?**


Glyptodont, an ancient 4 m, 2 t animal from South America


Modern armadillo from South America (1.5 m)

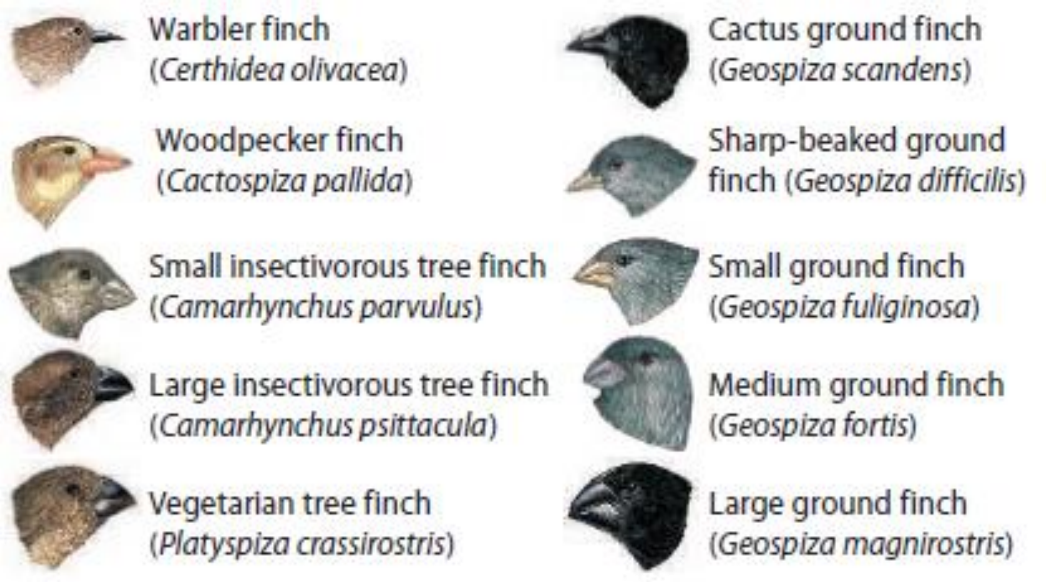
- **3.** The finches and other animals Darwin saw on the Galápagos Islands closely resembled animals he had observed on the west coast of South America.

- **Why did the Galápagos species so closely resemble organisms on the adjacent South American coastline?**

The Galápagos Islands, shown in this satellite image, include more than 20 small volcanic islands located approximately 1000 km off the coast of Ecuador.

EVOLUTION

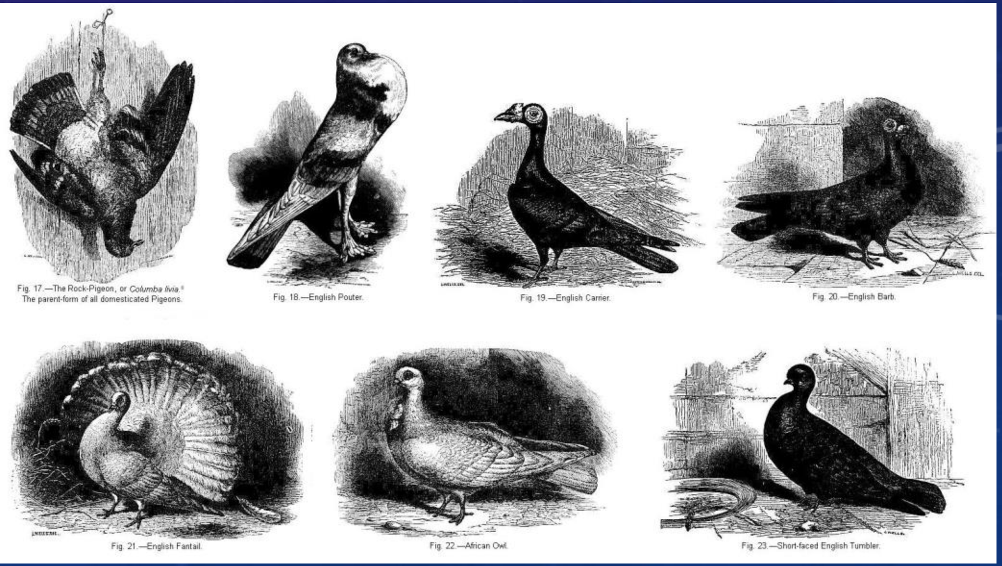
- **4.** Galápagos species (such as tortoises and finches) looked identical at first, but actually varied slightly between islands. Each type of Galápagos finch, for example, was adapted to eating a different type of food based on the size and shape of its beak.
- **Why was there such a diversity of species in such a small area?**
- **Could these species have been modified from an ancestral form that arrived on the Galápagos Islands shortly after the islands were formed?**



EVOLUTION

- **5.** Through his experience in breeding pigeons and studying breeds of dogs and varieties of flowers, Darwin knew that it was possible for traits to be passed on from parent to offspring, and that sexual reproduction resulted in many variations within a species.

- **Could a process similar to artificial selection also operate in nature?**



EVOLUTION

- (Activity 16.3, *NL Biology*, p. 649).

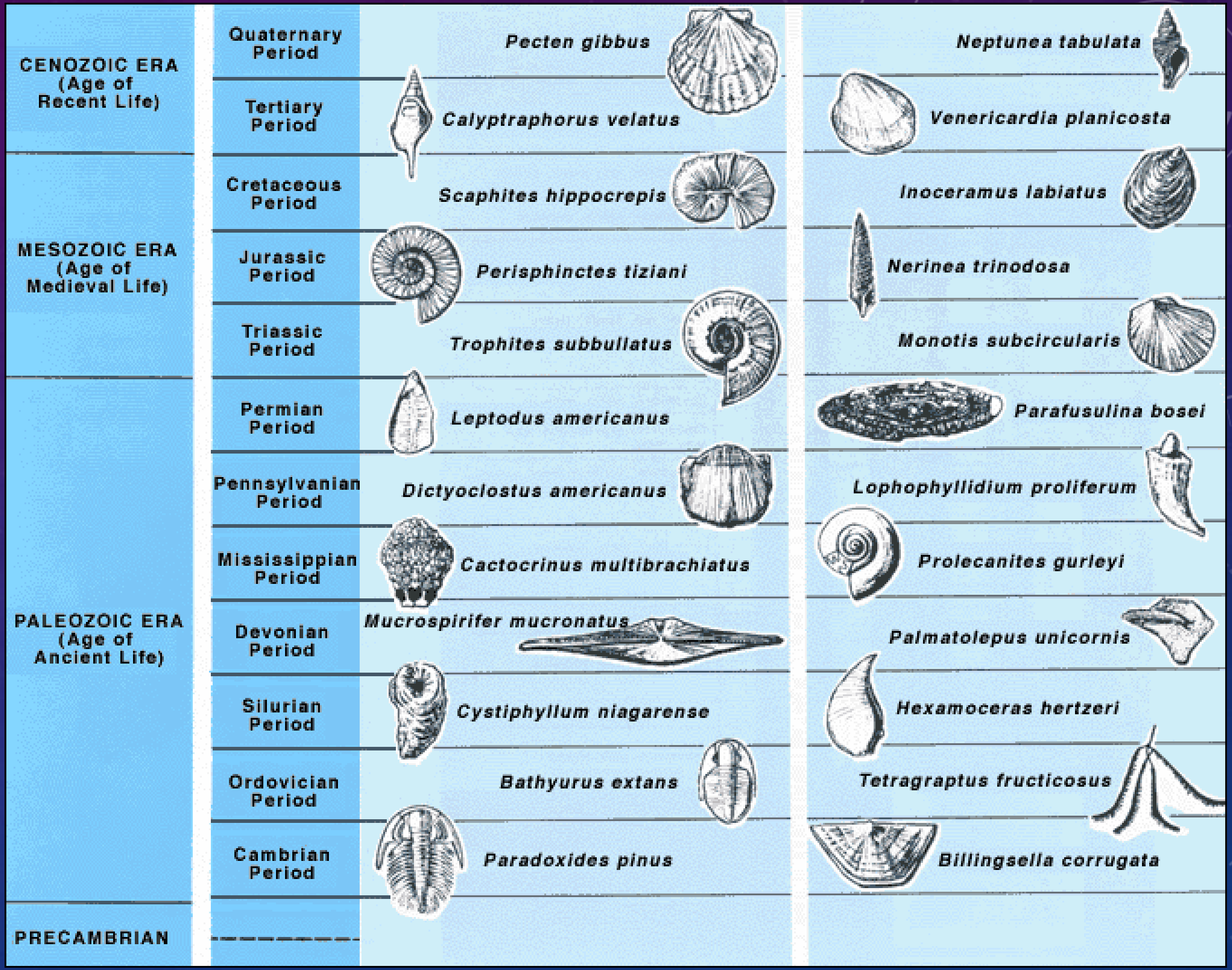
- (Debating Science, *NL Biology*, pp. 668-669).

EVOLUTION

FURTHER EVIDENCE OF EVOLUTION

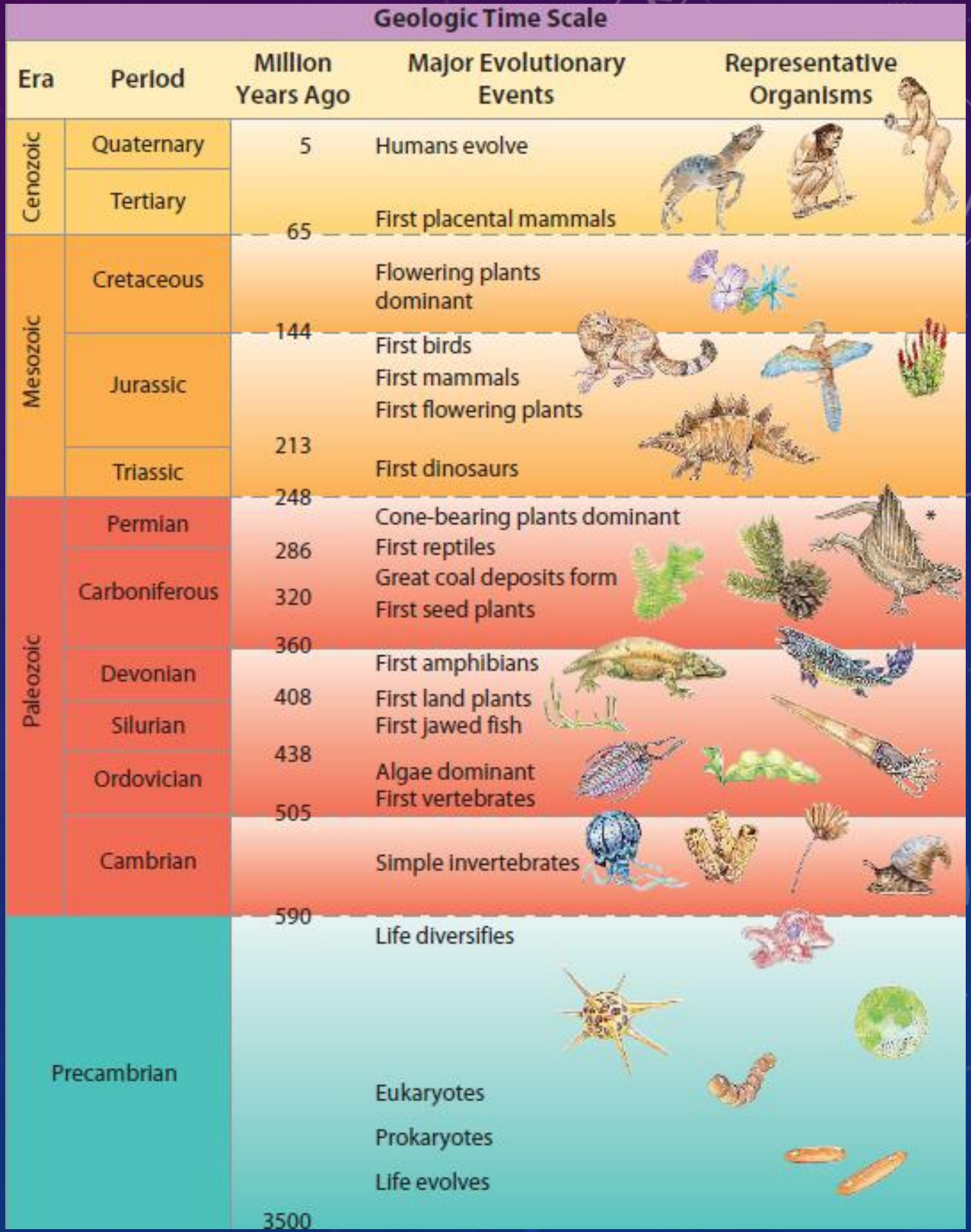
- **fossil record** remains or traces of past life preserved in sedimentary rock, which reveal the history of life on Earth

- **index fossils** fossils that are known to be common during a particular time, and so indicate the age of the rock they are found in



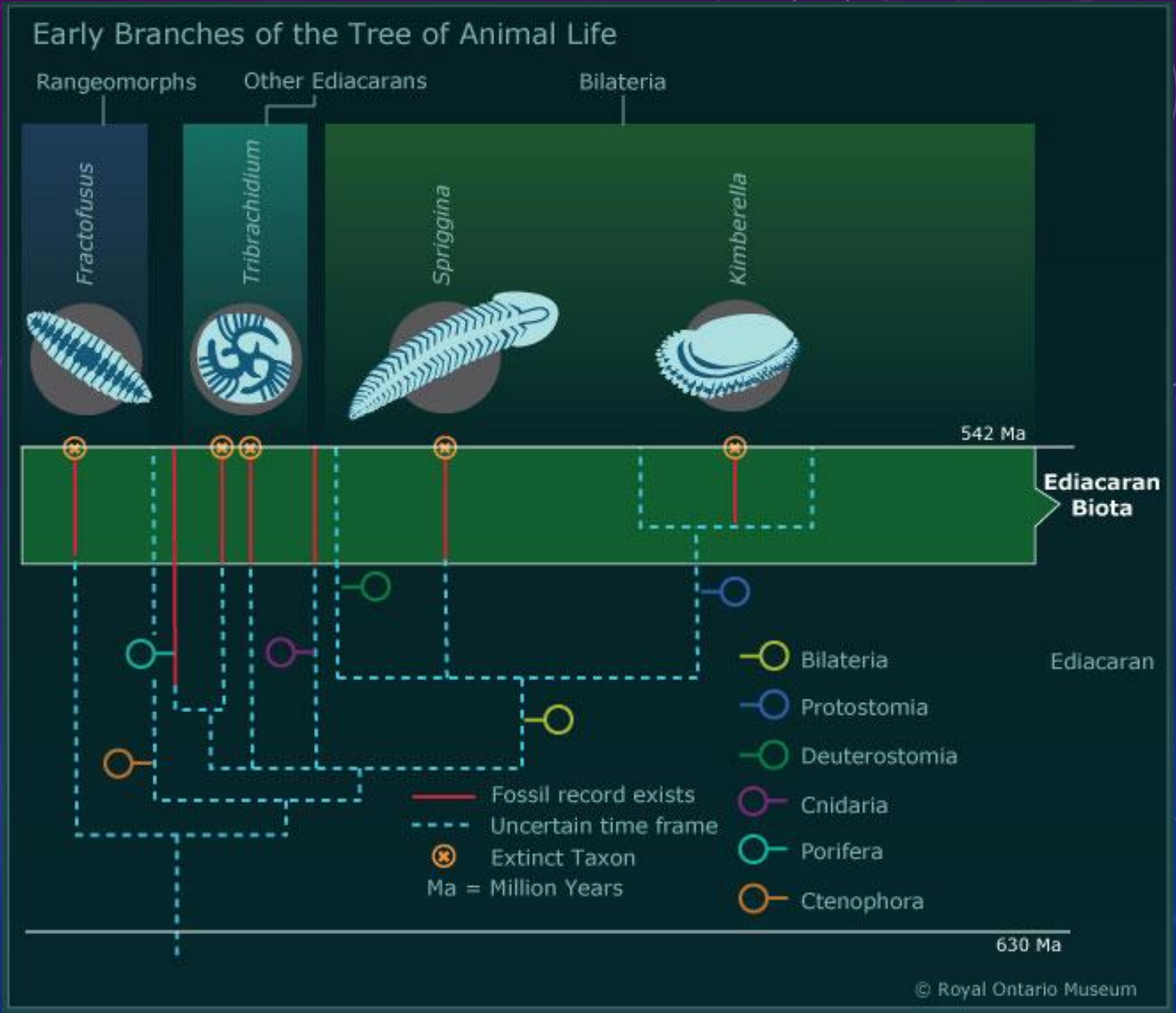
EVOLUTION

- 1. Fossils found in young layers of rock (from recent geological periods and usually closer to the surface) are much more **similar to species alive today** than fossils found in deeper, older layers of rock.
- 2. Fossils appear in **chronological order in the rock layers.** So, probable ancestors for a species are found in older rocks, which usually lie beneath the rock in which the later species is found.
- **3. Not all organisms appear in the fossil record at the same time.**



EVOLUTION

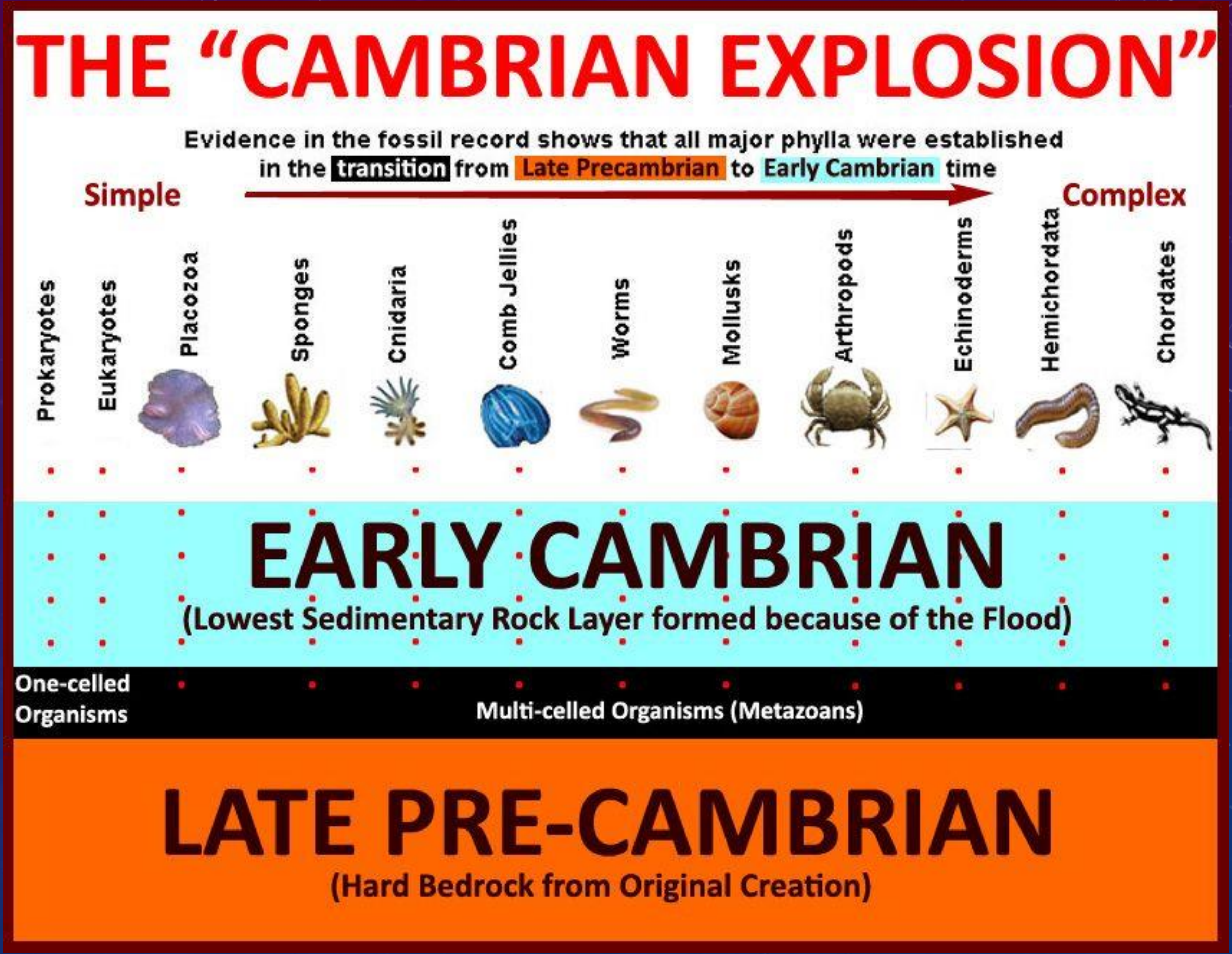
- The **Ediacaran Period** is a geological period that spans 94 million years from the end of the Cryogenian Period 635 million years ago (Mya), to the beginning of the Cambrian Period 541 Mya.
- **The Ediacaran Period produced some of the earliest known evidence of the evolution of multicellular animals (the metazoans).**



EVOLUTION

- The Cambrian Period was the first geological period of the Paleozoic Era, and of the Phanerozoic Eon. The Cambrian lasted 55.6 million years from the end of the Ediacaran Period 541 million years ago (mya) to the beginning of the Ordovician Period 485.4 mya.
- The Cambrian Period marks an **important** point in the history of life on Earth; **it is the time when most of the major groups of animals first appear in the fossil record.** This event is sometimes called the **"Cambrian Explosion,"** because of the relatively short time over which this diversity of forms appears.

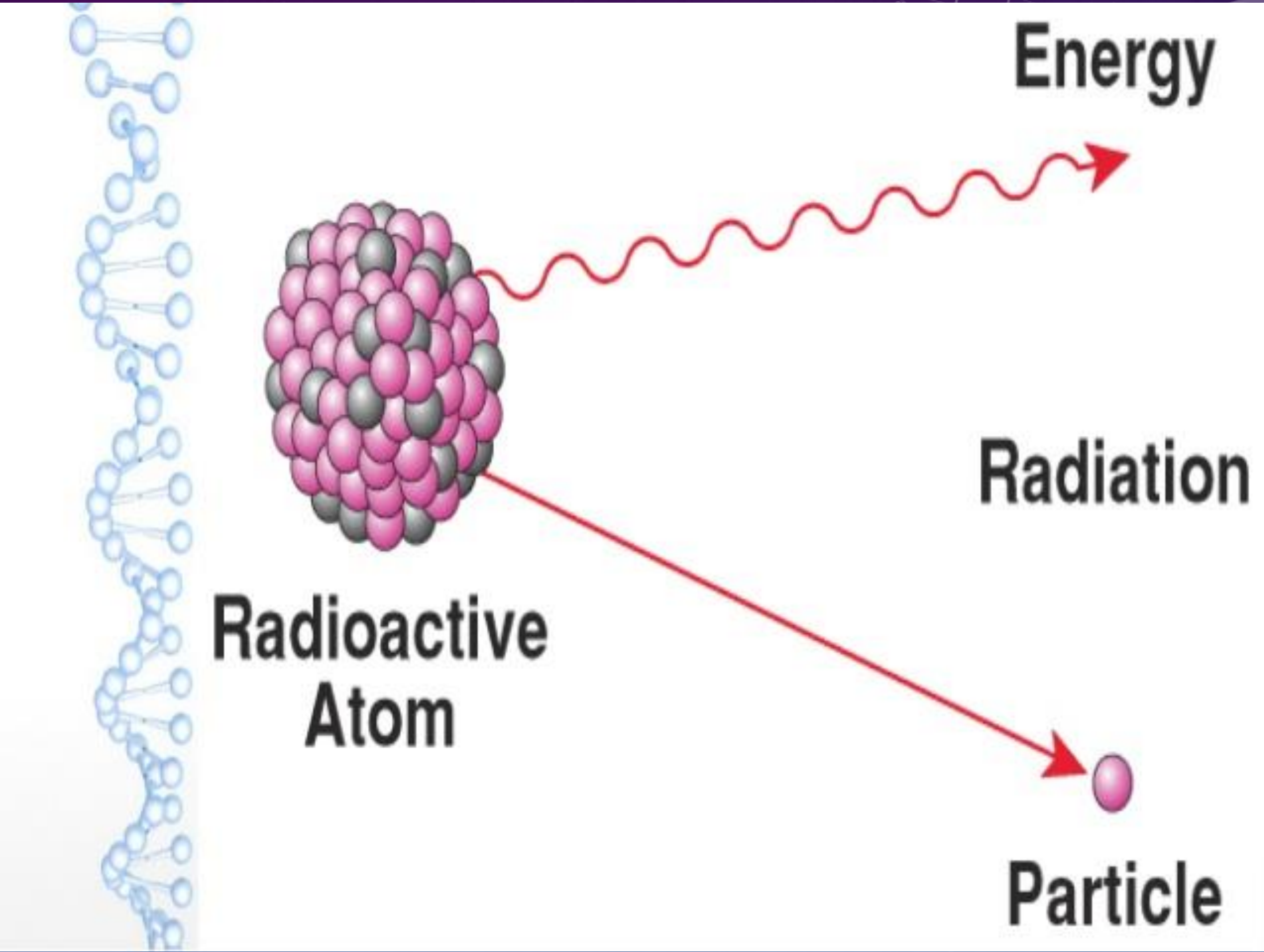
EVOLUTION



THE "CAMBRIAN EXPLOSION"
Evidence in the fossil record shows that all major phylla were established
in the transition from Late Precambrian to Early Cambrian time
Simple
Complex
Prokaryotes
Eukaryotes
Placozoa
Sponges
Cnidaria
Comb Jellies
Worms
Mollusks
Arthropods
Echinoderms
Hemichordata
Chordates
EARLY CAMBRIAN
(Lowest Sedimentary Rock Layer formed because of the Flood)
One-celled Organisms
Multi-celled Organisms (Metazoans)
LATE PRE-CAMBRIAN
(Hard Bedrock from Original Creation)

EVOLUTION

- **radiometric dating** method of dating rocks and minerals that uses measurements of certain radioactive isotopes to calculate absolute age in years

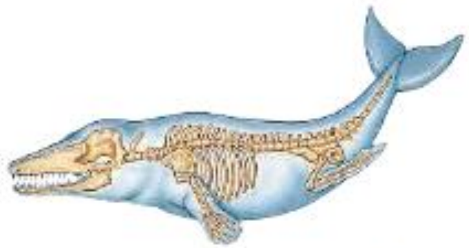


EVOLUTION

- **transitional fossils** fossils that show intermediary links between groups of organisms
- **Transitional fossils link the past with the present.** For example, scientists have found fossilized whales that lived 36 to 55 million years ago. These fossils link present-day whales to terrestrial ancestors. The ***Basilosaurus*** and ***Dorudon*** were ancient whales that had tiny hind limbs, but led an entirely aquatic life. *Dorudon* was about the size of a large dolphin, about 5 m long. It had a tiny pelvis (located near the end of its tail) and 10 cm legs, both of which would have been useless to an animal that lived an aquatic life. A more recently discovered transitional form, ***Ambulocetus,*** had heavier leg bones. Scientists hypothesize that it lived both on land and in water.

1. *Pakicetus attocki* lived on land, but its skull had already evolved features characteristic of whales.

2. *Ambulocetus natans* likely walked on land (as modern sea lions do) and swam by flexing its backbone and paddling with its hind limbs (as modern otters do).



3. *Rodhocetus kasranii's* small hind limbs would not have helped it swim, much less walk.

4. Modern toothed whales

EVOLUTION

- ***Archaeopteryx*** show a transitional stage in the fossil record because this species had characteristics of both reptiles (dinosaurs) and birds. *Archaeopteryx* had feathers, but, unlike any modern bird, it also had teeth, claws on its wings, and a bony tail.

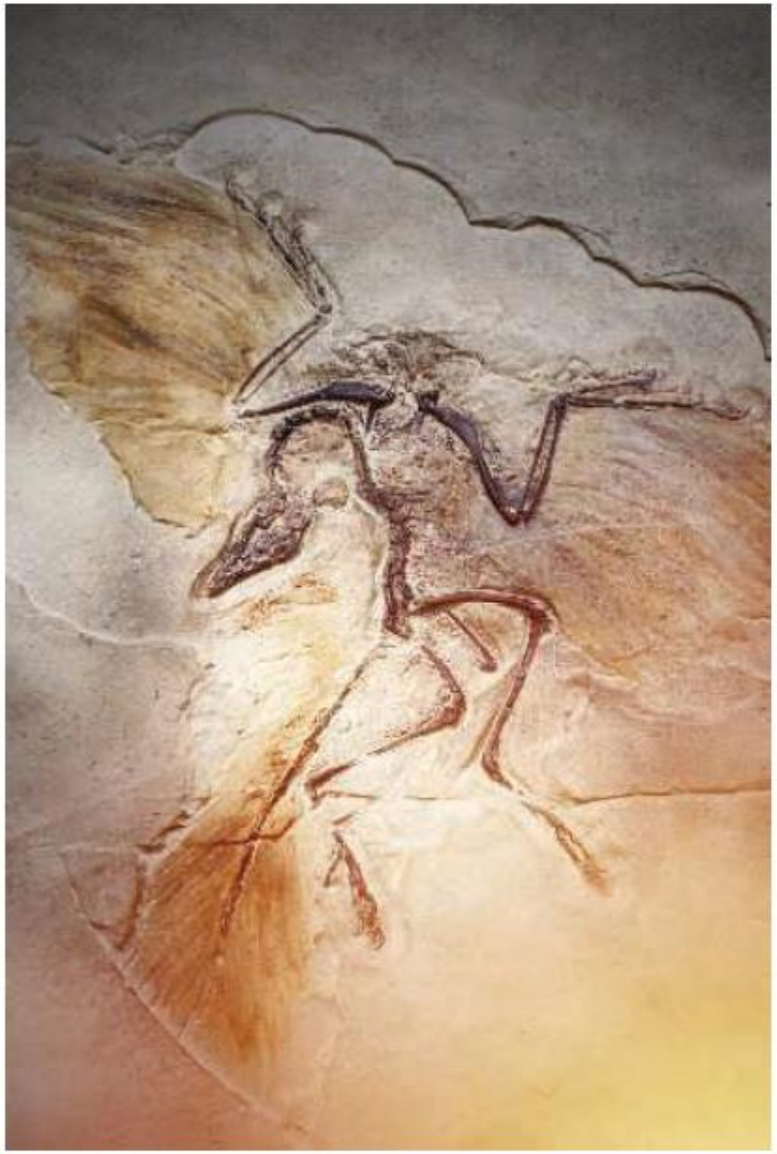


Figure 16.13 *Archeopteryx* had characteristics of non-avian dinosaurs as well as birds. It was probably able to fly.

EVOLUTION

BIOGEOGRAPHY

- **biogeography** the study of the past and present geographical distribution of species

EVOLUTION

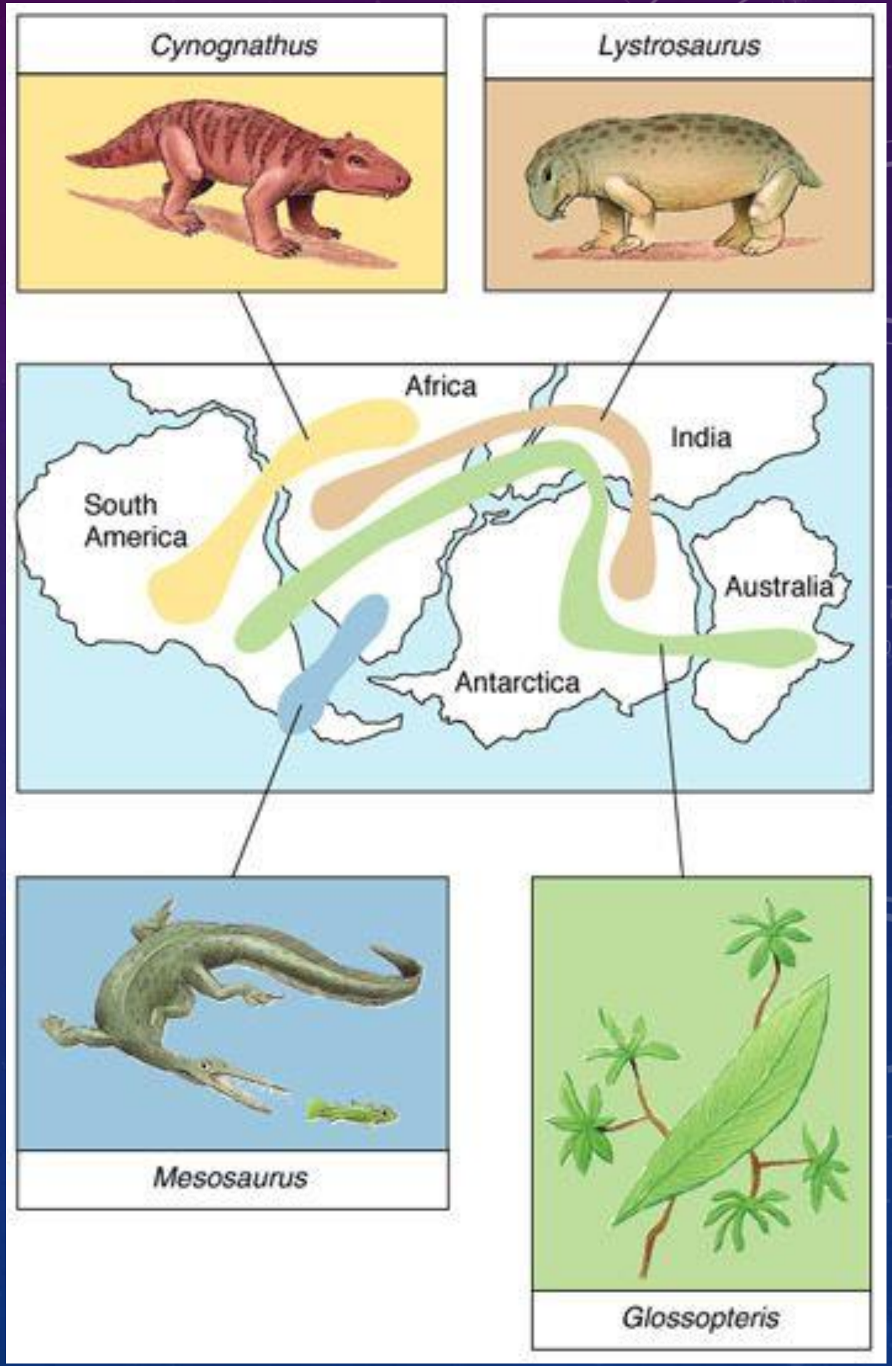
- Many of the observations that **Darwin and Wallace** used to develop their theories were based on biogeography. **Darwin and Wallace hypothesized that species evolve in one location and then spread out to other regions.**
- 1. **Geographically close environments are more likely to be populated by related species** than are locations that are geographically separate but environmentally similar.
- So, for instance, most species of **cacti** are native only to the deserts of North, Central, and South America. They are not naturally found in other deserts in the world, such as those in Australia or Africa.

EVOLUTION

- **2. Animals found on islands often closely resemble animals found on the closest continent.** This suggests that animals on islands have evolved from mainland migrants, with populations becoming adapted over time as they adjust to the environmental conditions of their new home. For example**, the lizards found on the Canary Islands, off the northwest coast of Africa, are very similar to the lizards found in west Africa.**

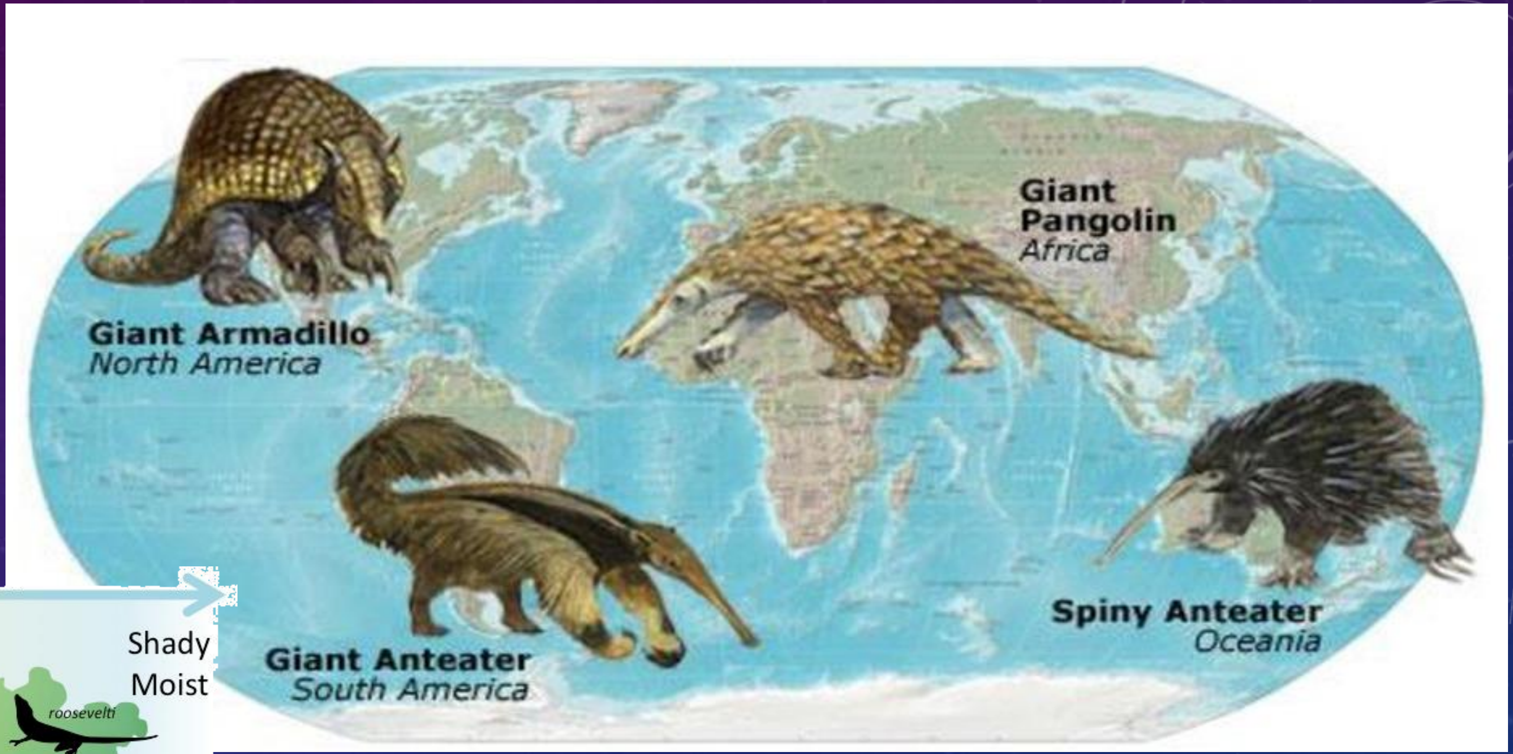
EVOLUTION

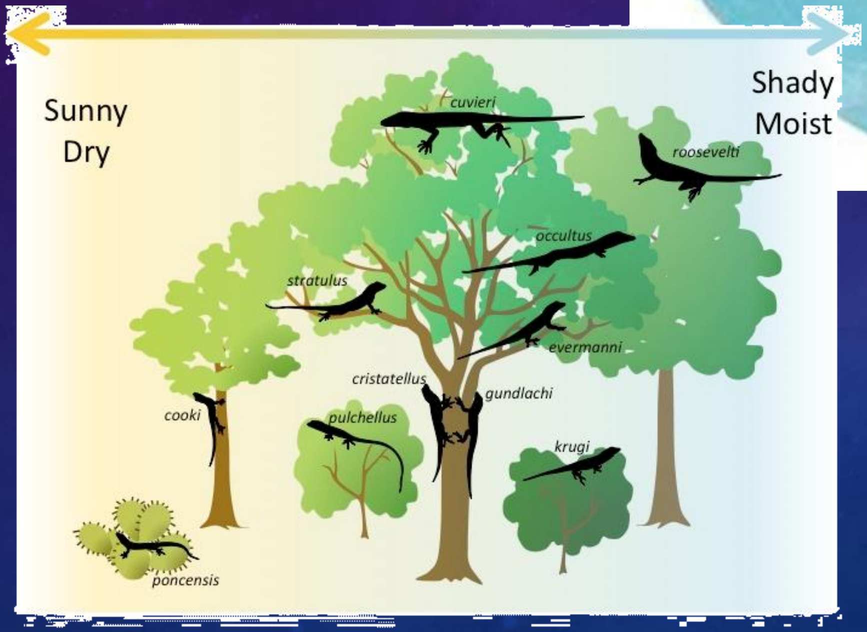
- **3. Fossils of the same species can be found on the coastlines of neighbouring continents.** For example, fossils of the **reptile *Cynognathus*** have been found in Africa and South America. The theory of plate tectonics explains these observations. The locations of continents are not fixed; continents are slowly moving away from one another. At one time, the continents of Africa and South America were joined in one "supercontinent."



EVOLUTION

- 4. Closely related species are almost never found in exactly the same location or habitat.

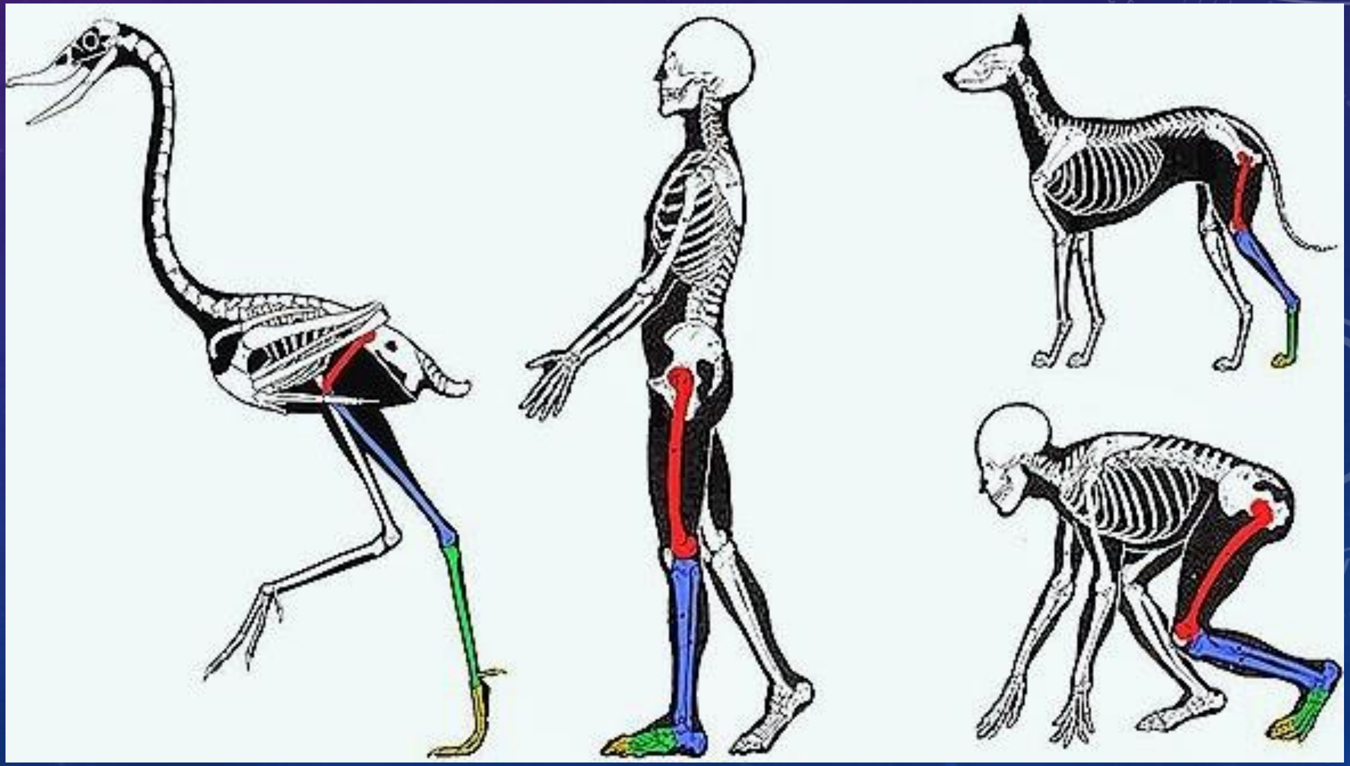




COMPARATIVE ANATOMY

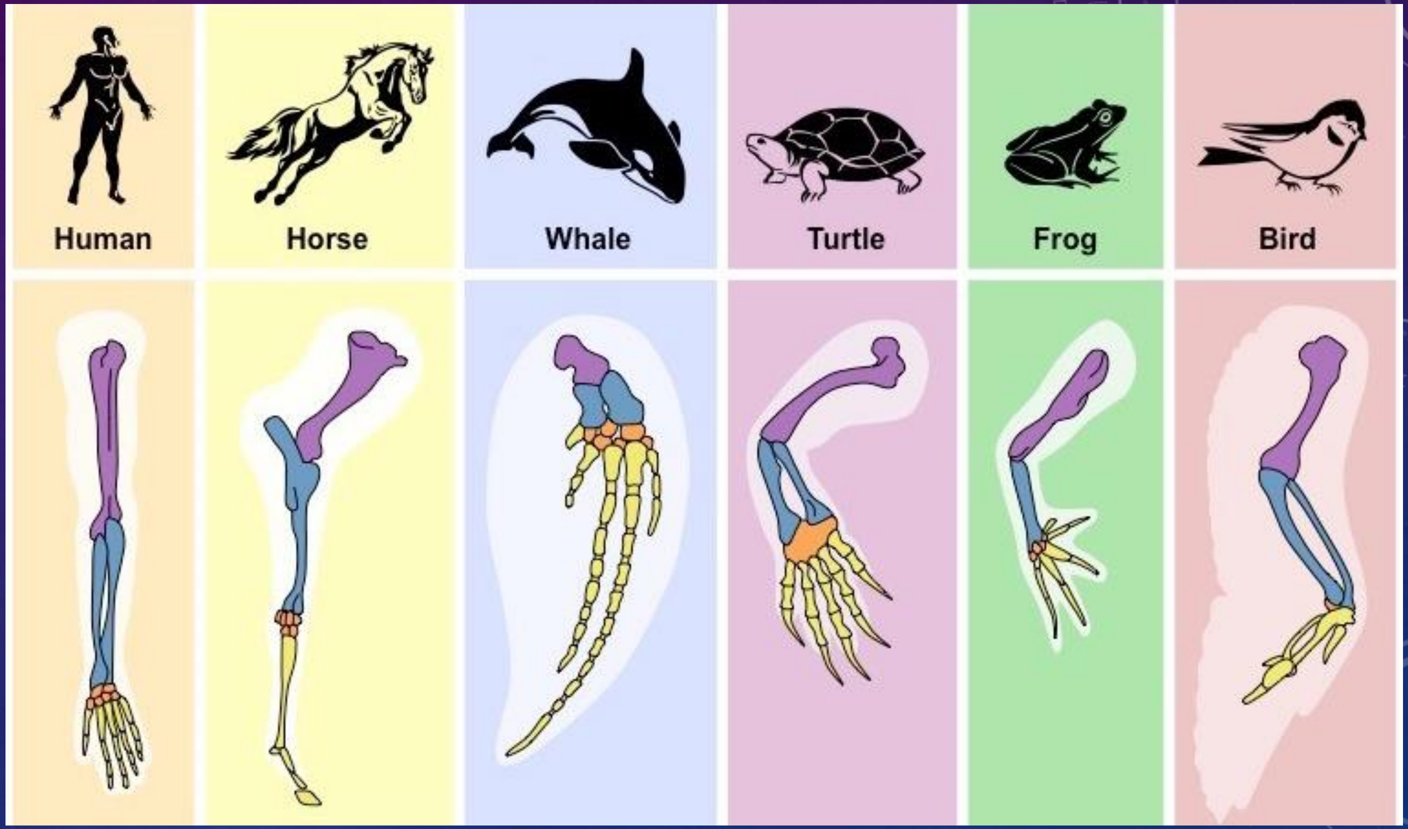
EVOLUTION

- **Comparative anatomy** the comparative study of the body structures of different species of animals in order to understand the adaptive changes they have undergone in the course of evolution from common ancestors.
- Despite their different functions, however, all vertebrate forelimbs contain the same set of bones, organized in similar ways.
- How is this possible?
  - **The most plausible explanation is that the basic vertebrate forelimb originated with a common ancestor.**



EVOLUTION

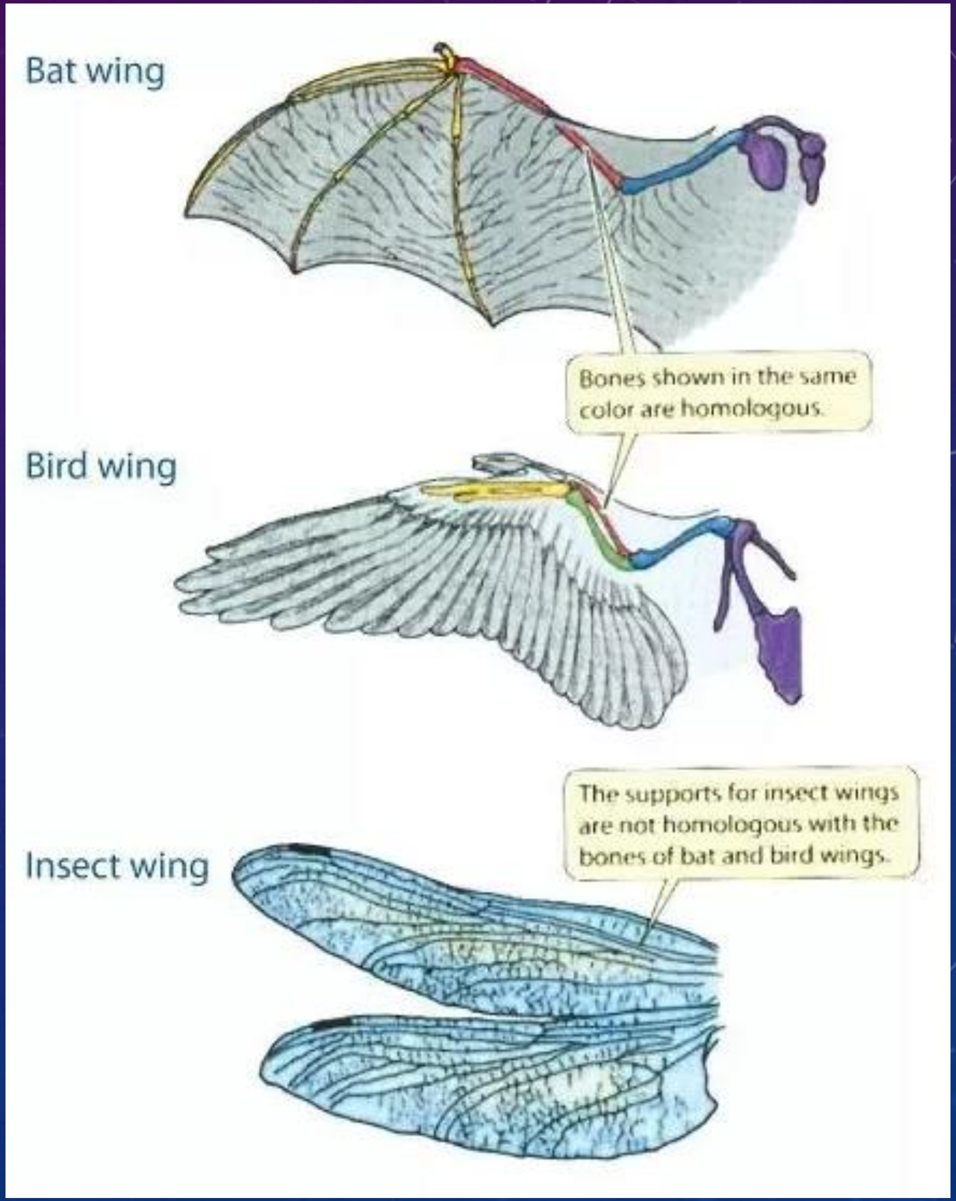
- **homologous structures** physical features with the same evolutionary origin and underlying structural elements, but that may have different functions



EVOLUTION

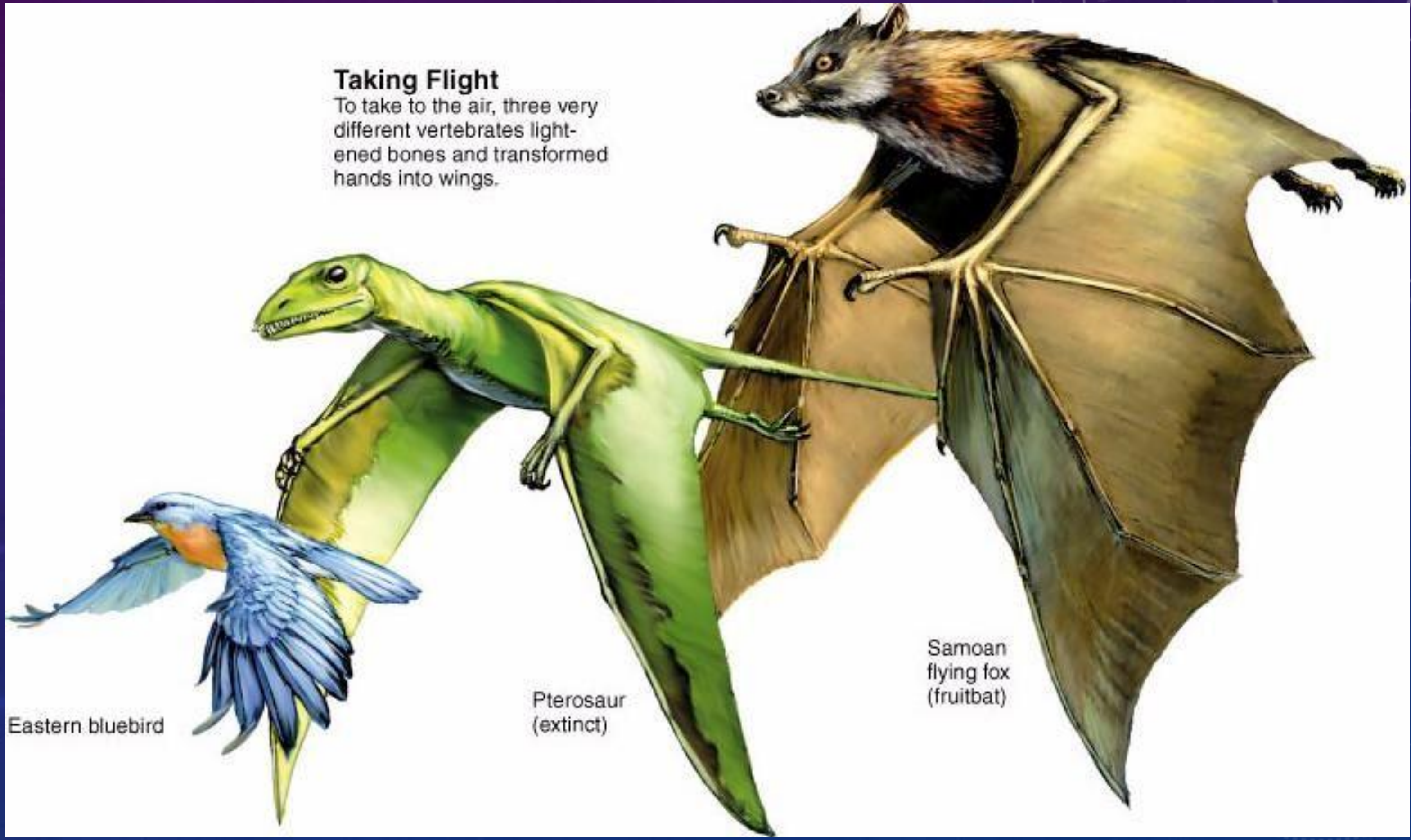
- **analogous structures** physical features that evolved separately but perform similar functions in different types of organisms

- Functional similarity in anatomy, however, does not necessarily mean that species are closely related.
- The wings of **insects, birds, bats, and pterosaurs** are similar in function, but not in structure. (For example, **bones** support bird wings, whereas a tough material called **chitin** makes up insect wings.)



EVOLUTION

- **convergent evolution** tendency among species that are not closely related to develop similar body plans when living under the same conditions



EVOLUTION

- **vestigial structures** anatomical features that no longer retain their function

- Some species have anatomical features that appear to serve no function, such as **cave fish that have eye sockets but no eyes.** Vestigial structures are homologous to functioning structures of other species.

- Some large **snakes and whales have vestigial hip bones**. Their small, unused hip bones are homologous to the hip bones that support the hind limbs of other vertebrates.

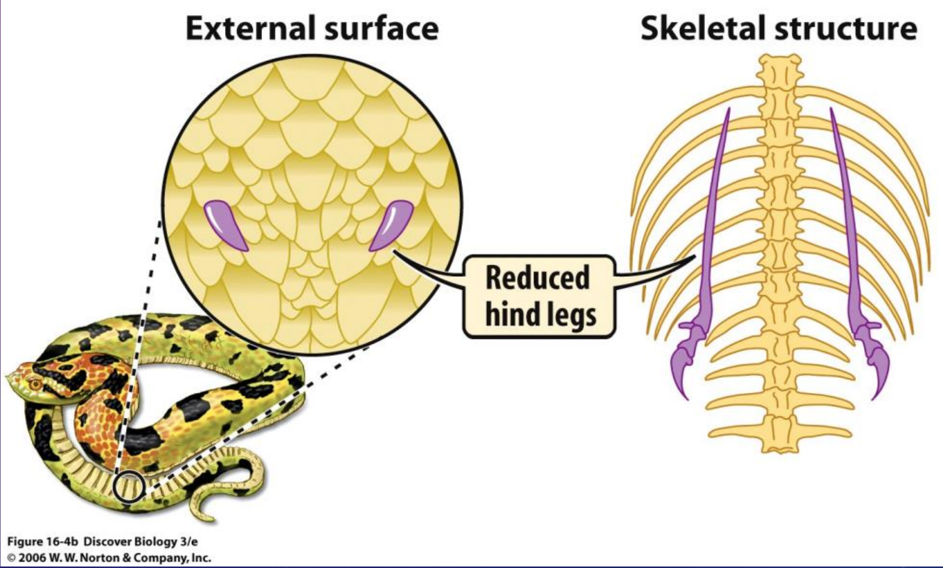


Figure 16-4b Discover Biology 3/e
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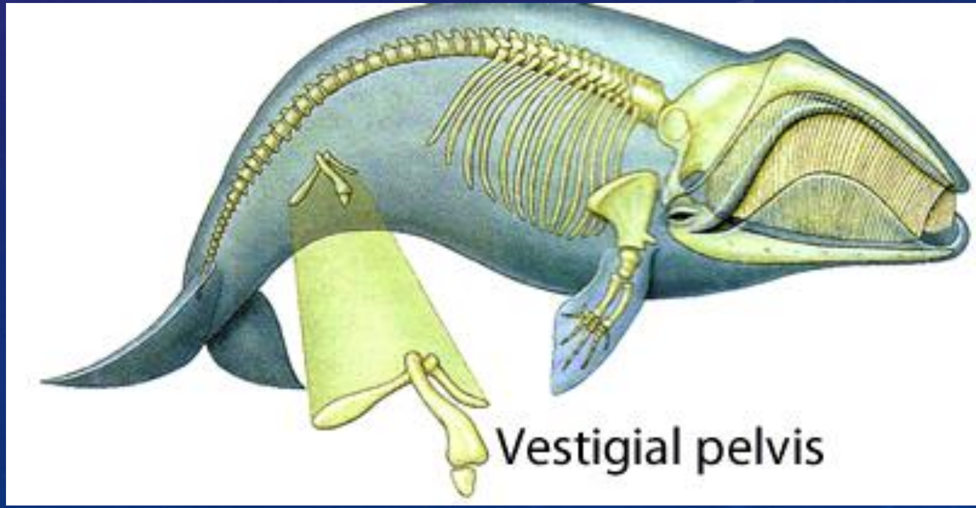
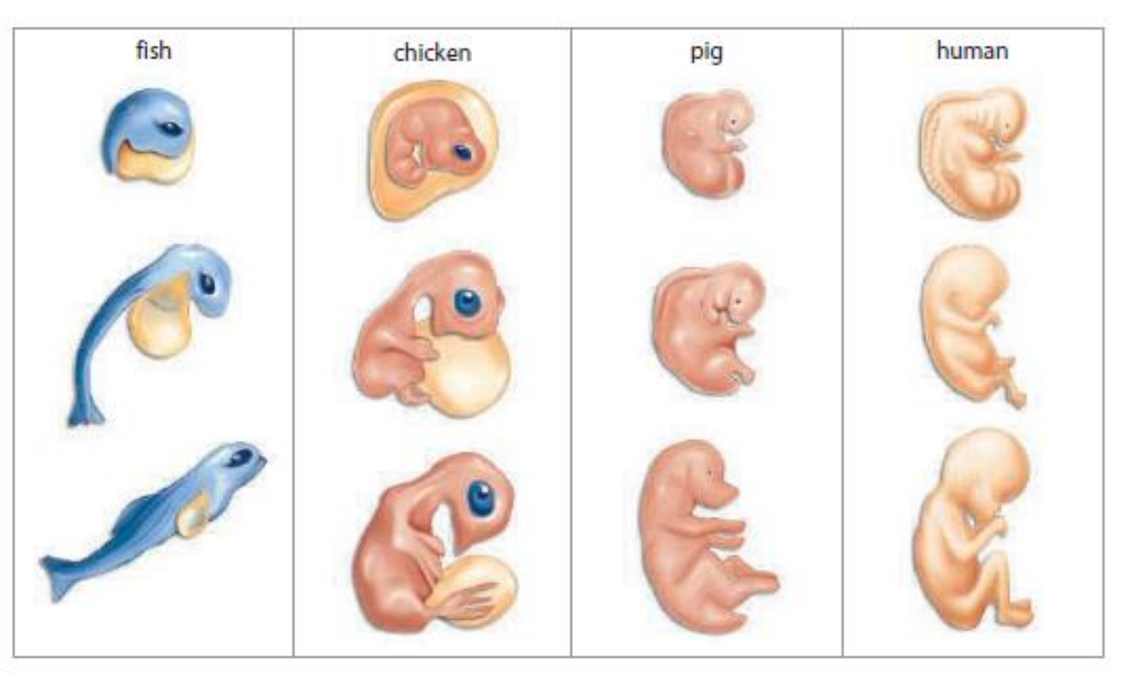


EMBRYOLOGY

- The embryos of different groups of organisms exhibit similar stages of embryonic development.
- All **vertebrate embryos** have paired **pouches, or out-pocketings of the throat.**
- In **fish** and some **amphibians**, the pouches develop into **gills**.
- In **humans**, the pouches become parts of the **ears and throat**.
- The similarities among embryos in related groups (such as vertebrates) point to a **common ancestral origin.**

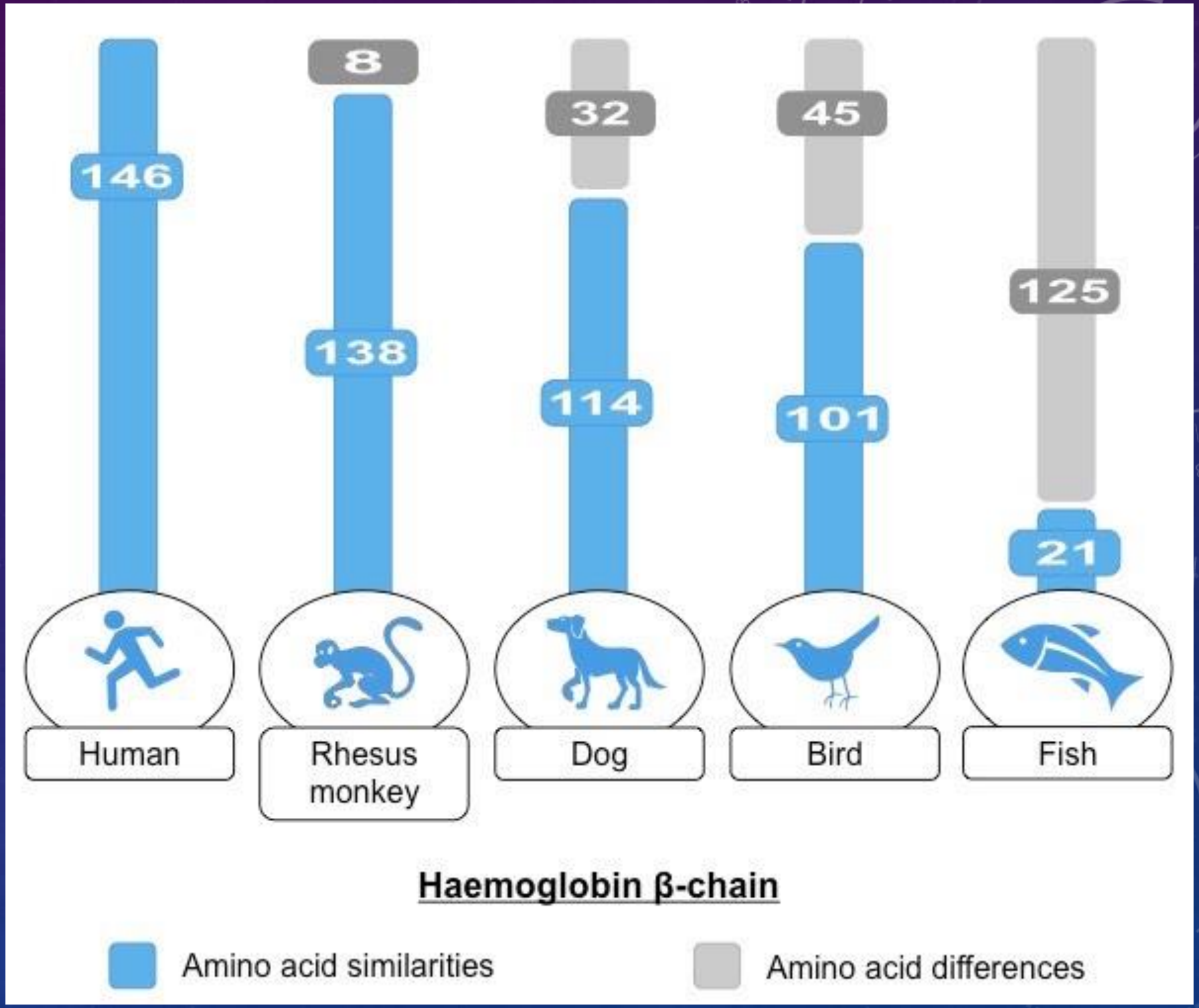


EVOLUTION

EVOLUTION

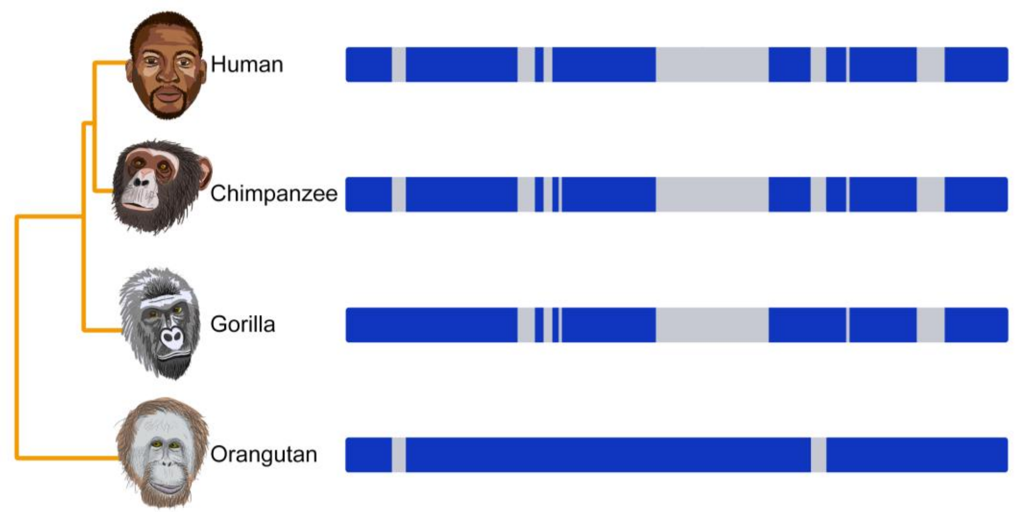
MOLECULAR BIOLOGY AND GENETICS

- The evolutionary relationships among species are reflected in their DNA and proteins.
- The field of **molecular biology** developed as technologies to identify molecules such as **DNA and proteins** developed.
- **This field has provided evidence that helps to support the idea of common ancestry and evolution through natural selection.**



EVOLUTION

- The fact that all organisms use DNA as their genetic material supports the idea that all life has a common ancestor.
- Even seemingly unrelated species share some of the same genes. The chimpanzee (*Pan troglodytes*) and the potato (*Solanum tuberosum*), for example, have 2700 genes in common.
- **Scientists can infer how closely related two species are by comparing sequences in amino acids, RNA, and DNA, or by comparing chromosomes as a whole.**



EVOLUTION

- For example, **human chromosome number 5** and its chimpanzee counterpart show the same pattern of bands, except for an inverted portion near the centromere. **Chimpanzees are our closest living evolutionary relative.**

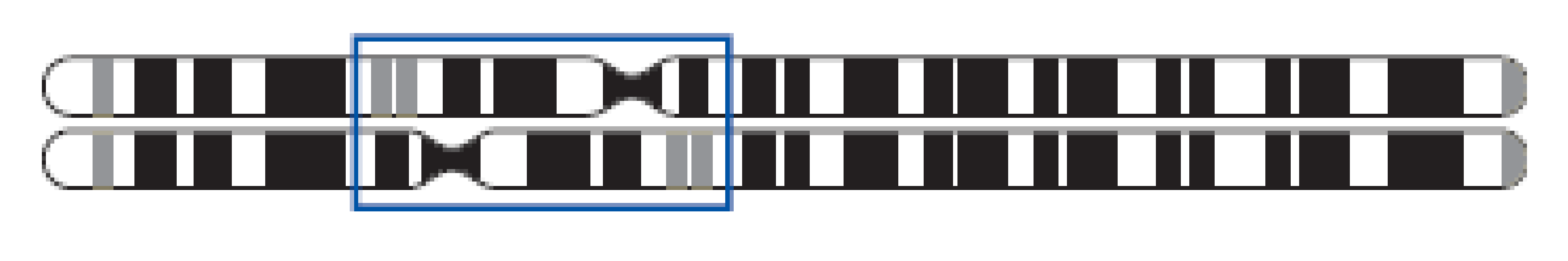
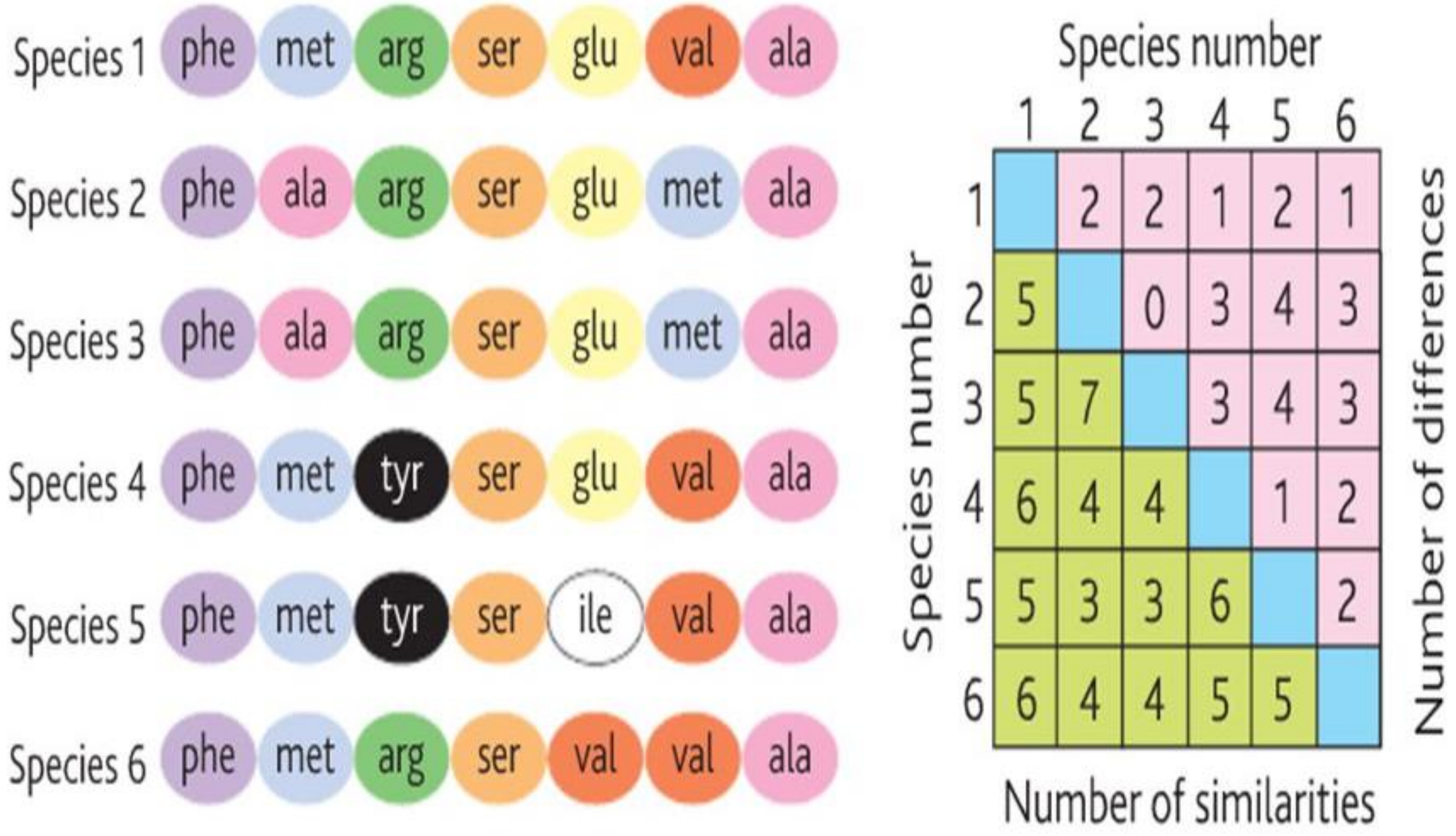


Figure 16.16 This diagram shows the similar banding patterns in human chromosome number 5 (bottom) and a chimpanzee chromosome (top).

EVOLUTION



Species number	1	2	3	4	5	6
1		2	2	1	2	1
2	5		0	3	4	3
3	5	7		3	4	3
4	6	4	4		1	2
5	5	3	3	6		2
6	6	4	4	5	5	

Figure 2 *Comparison of amino acid sequence in part of the same protein in six species*

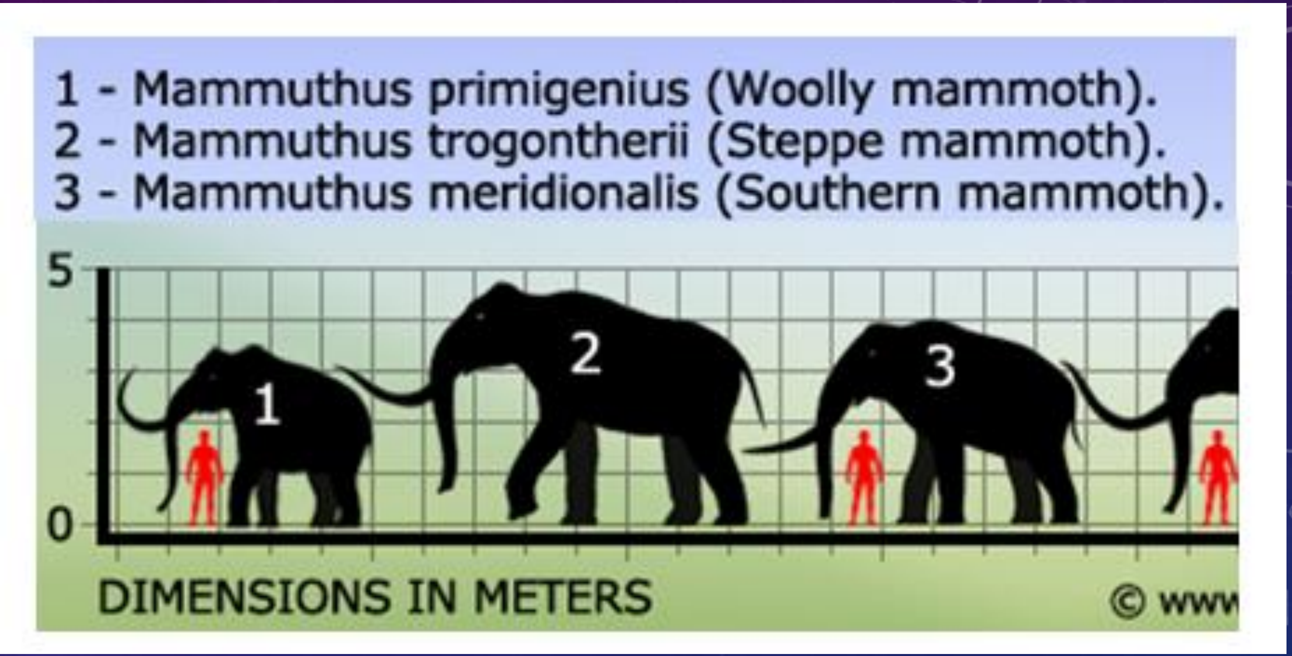
- Exit Card 14

EVOLUTION

THE EVOLUTION OF NEW SPECIES

- **speciation** the formation of new species

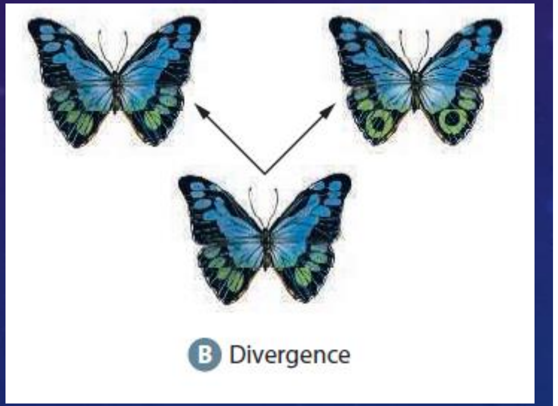
- ***Transformation*** a new species gradually develops as a result of mutation and adaptation to changing environmental conditions, and the old species is gradually replaced.

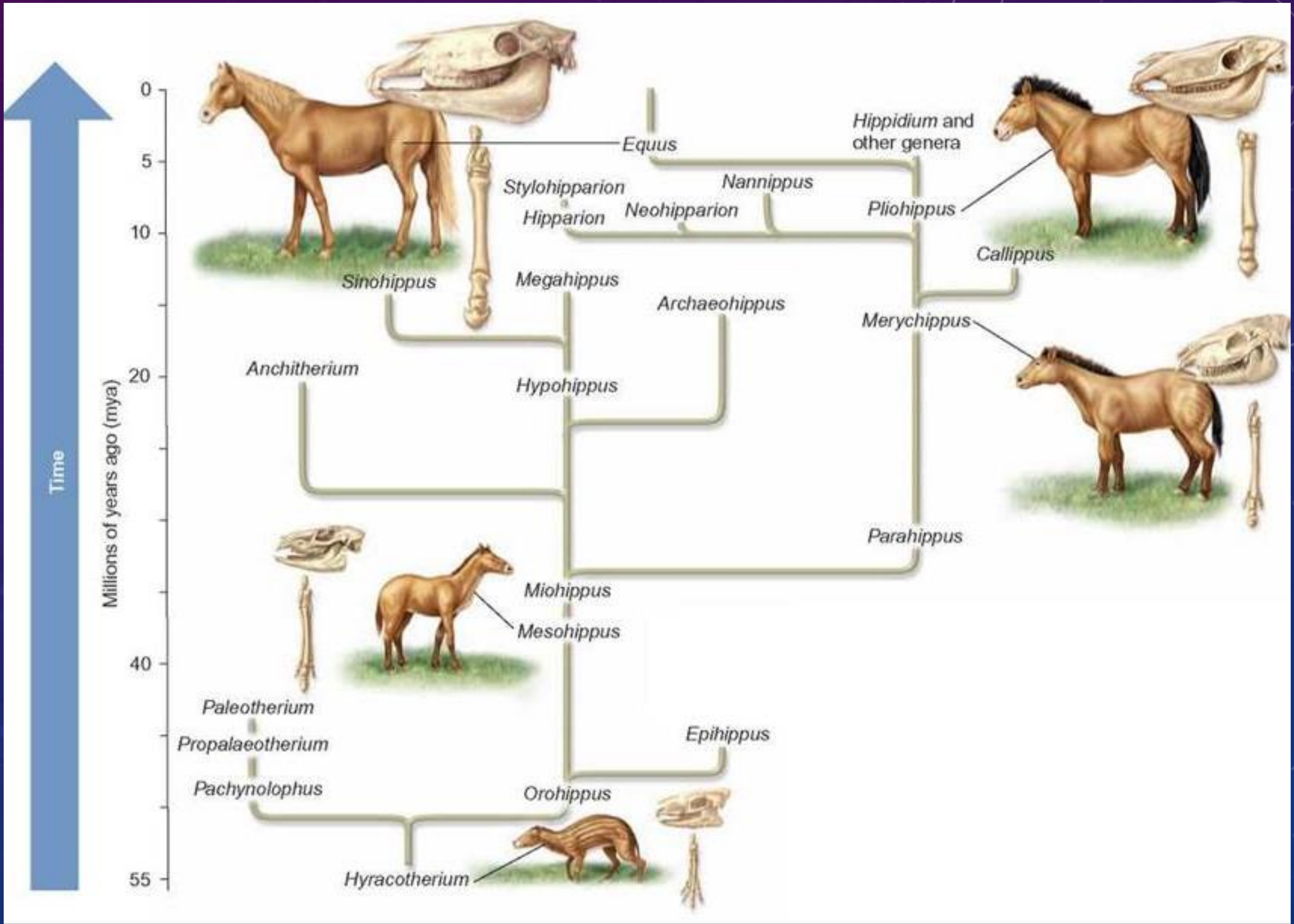


The evolution of mammoths followed this pathway. The ancestral mammoth lived approximately 2.6 million to 700 000 years ago. It slowly evolved into the steppe mammoth that lived 700 000 to 500 000 years ago, and finally into the woolly mammoth that lived 350 000 to 10 000 years ago.

EVOLUTION

- **Divergence (adaptative radiation)** one or more species arise from a parent species that continues to exist.

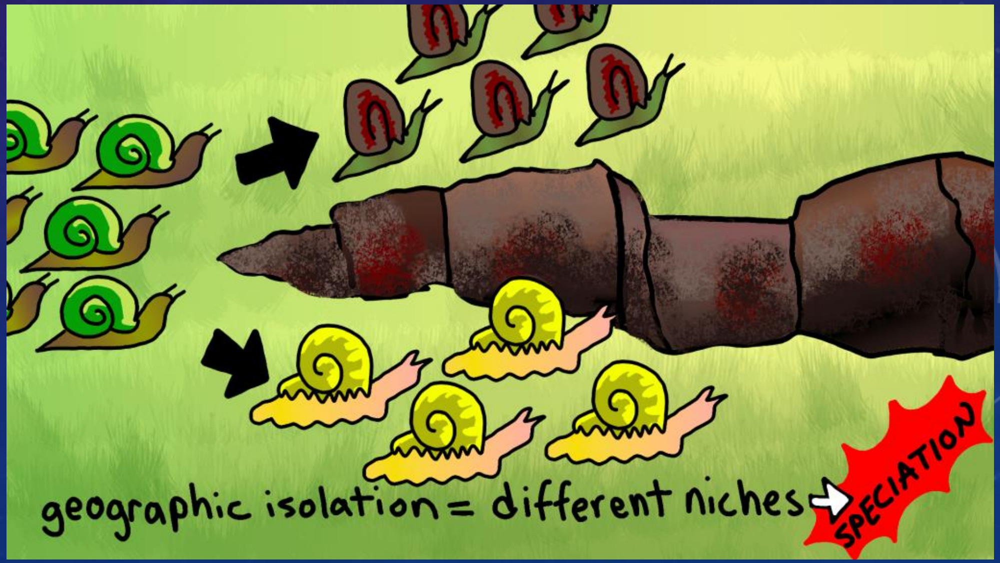




EVOLUTION

KEEPING POPULATIONS SEPARATE

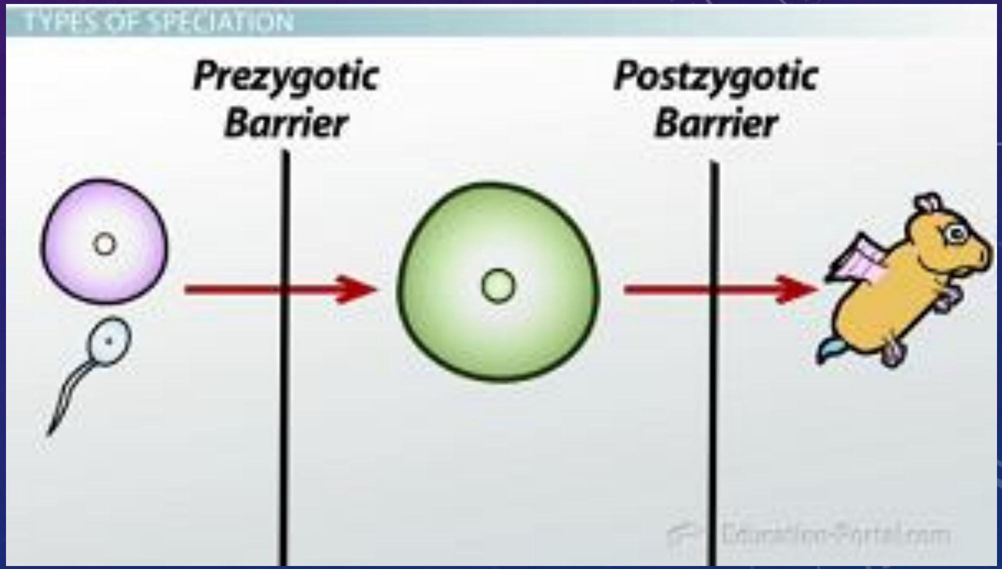
- **geographical barrier** feature such as mountain that physically separates populations and so prevents them from interbreeding
- Lava flow may isolate populations, changes in ocean levels may turn a peninsula into an island, or a few colonizers may reach a geographically separate habitat
- After a long period of time, speciation will occur. The separated populations will no longer be able to mate and reproduce successfully with other members of the original population.



EVOLUTION

- **biological barrier** features of different populations that keep them *reproductively isolated*, even when they exist in the same geographic area

- **Reproductively Isolated** the inability of a species to breed successfully with related species due to geographical, behavioral, physiological, or genetic barriers or differences.

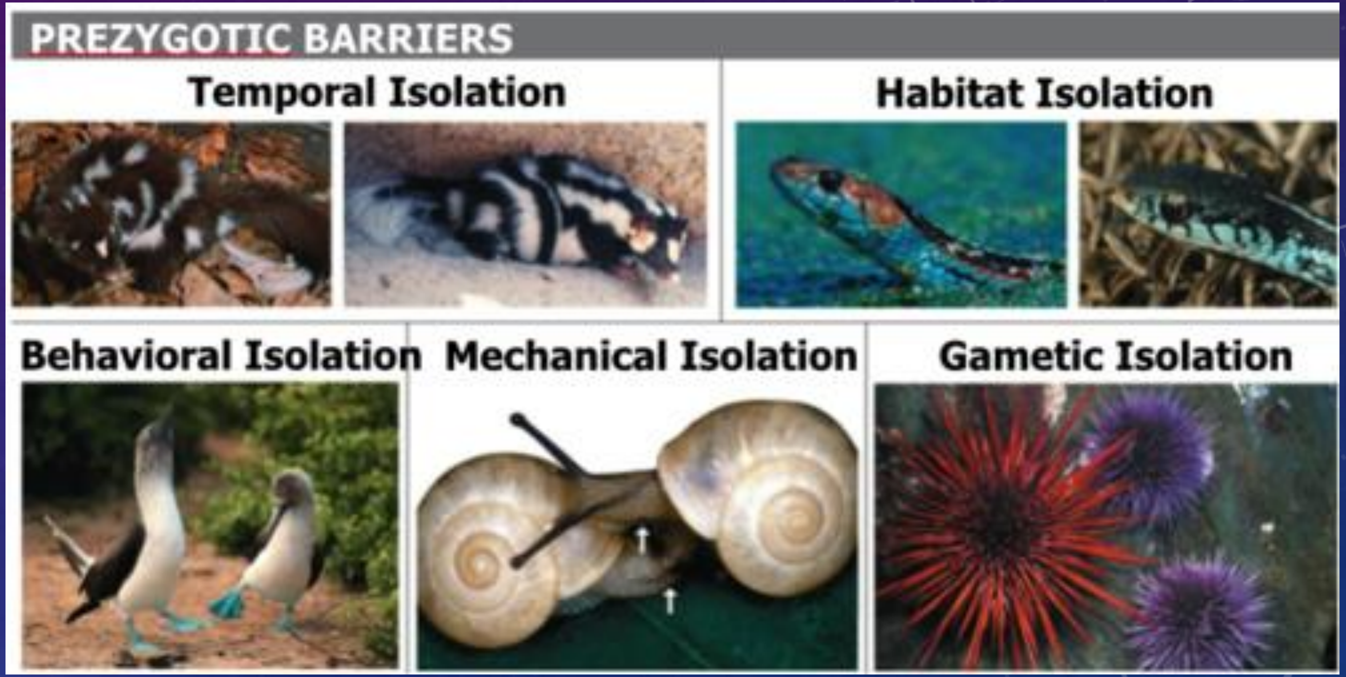


EVOLUTION

- Scientists studying the **cichlids** hypothesize that many of the species in the lake today originated after the **lake dried to just a few small pools of water** about 14 000 years ago.
- Populations were isolated in these pools of water until the water level rose again. The speciation of cichlids has produced a remarkable variety of cichlids with a fascinating **diversity of teeth, jaws, mating behaviours, and coloration.**

EVOLUTION

- **prezygotic barrier** a mechanism that blocks reproduction from taking place by preventing fertilization.



- **Behavioural isolation**
- **Ecological/habitat isolation**
- **Temporal isolation**
- **Mechanical Isolation**
- **Gametic isolation**

EVOLUTION

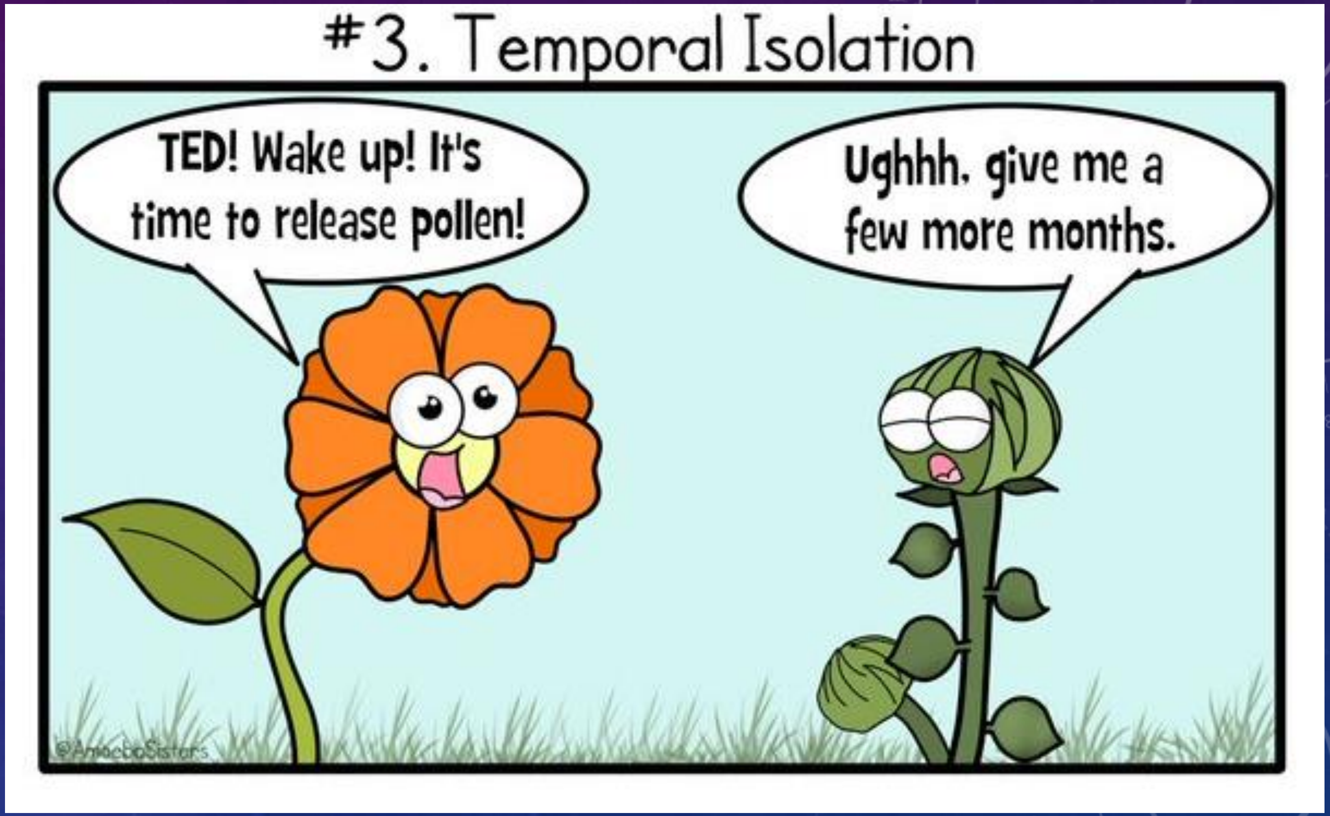
- **behavioural isolation** biological barrier in which species-specific signals or behaviours prevent interbreeding with closely related species
- Male birds use distinct calls that are recognized by other birds of the same species during their mating season.
- Their calls are different enough from the calls of neighbouring species to provide a biological barrier to reproduction.
- Female spiders use pheromones (chemical signals) to attract mates of the same species.
- Some male spiders use specific movements to identify themselves to the females.

EVOLUTION

- **Ecological/habitat isolation** biological barrier in which different species live in the same general area, but use different habitats, and so rarely encounter each other
- The **blackspotted stickleback** builds nests in brackish waters, where seawater and fresh water mix; the **three-spined stickleback** builds nests in fresh water. Habitat isolation is different from a geographical barrier, because there is no physical impediment that keeps the populations apart.

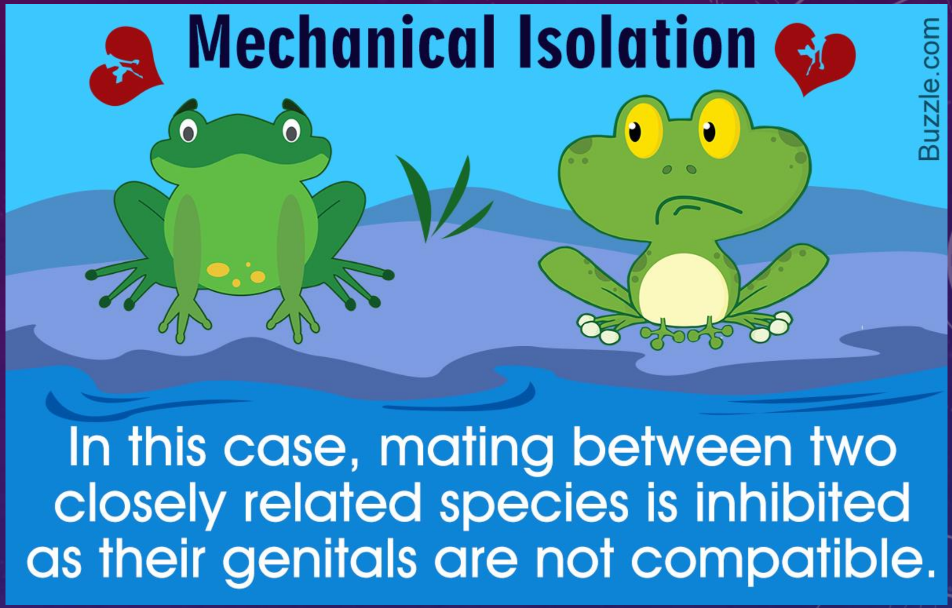
EVOLUTION

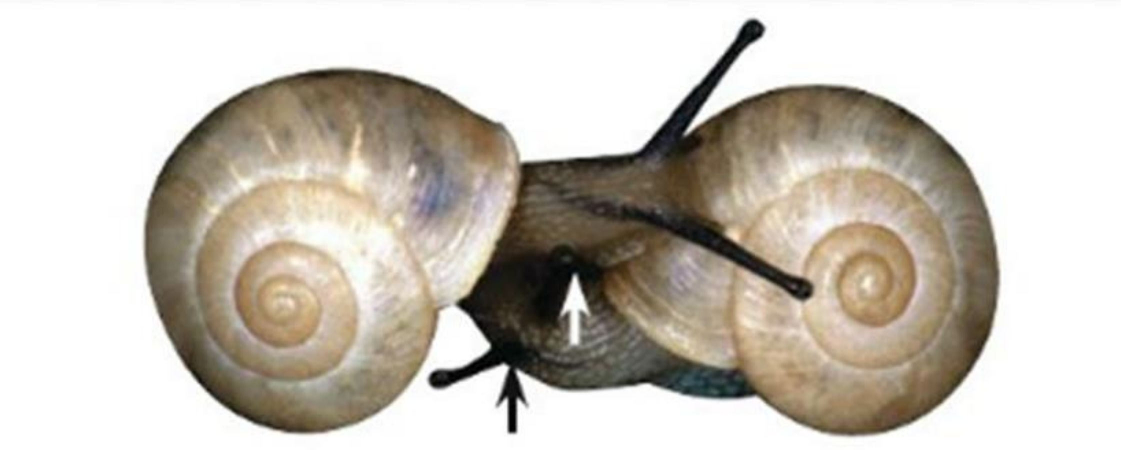
- **temporal isolation** timing barriers that prevent species in the same habitat from interbreeding; species may mate or flower at different times of the day, in different seasons, or in different years



EVOLUTION

- **mechanical isolation** biological barrier in which closely related species have incompatible reproductive structures, and so either cannot mate, or, in the case of plants, cannot be pollinated by the same species of pollinator
- Pollen may be carried on the backs or wings of bees and flowers may have different anatomy for pollination.
- Insects have very distinct locations of their genital anatomy.



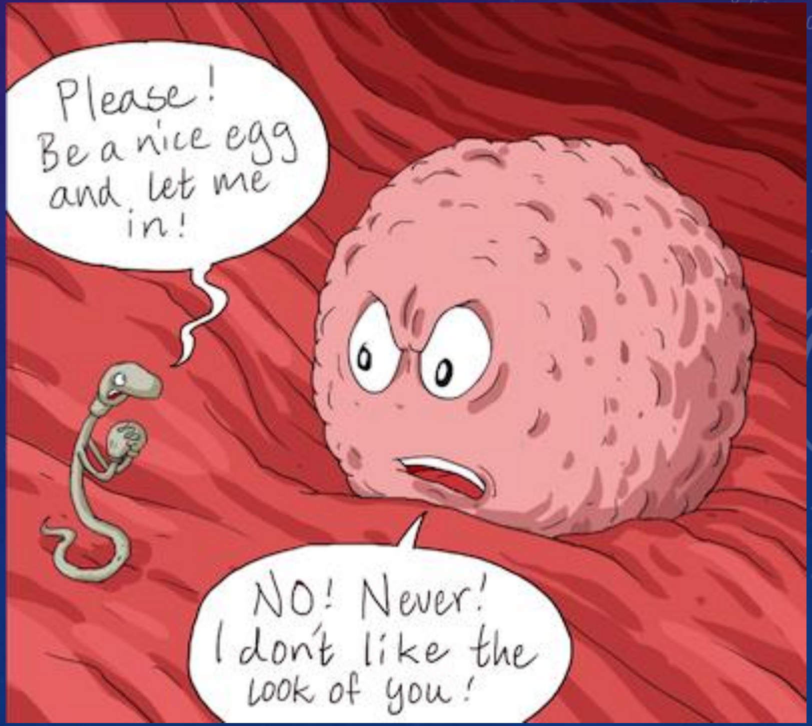


▲ **Figure 14.3E** **Mechanical isolation:** The genital openings (indicated by arrows) of these snails are not aligned, and mating cannot be completed.

EVOLUTION

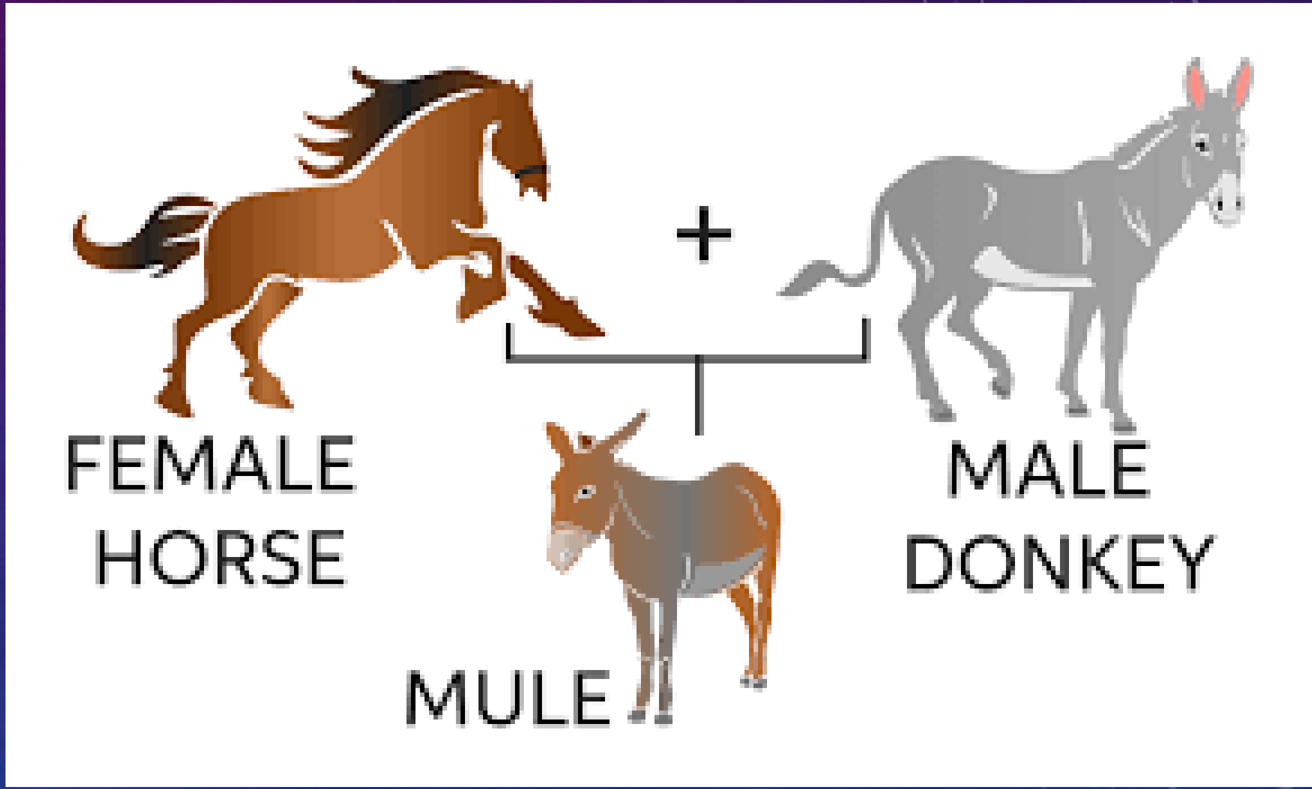
- **gametic isolation** biological barrier, such as a chemical marker on an egg, that prevents eggs and sperm from different species fusing to form a zygote

- Many marine animals, including corals, clams, and sea cucumbers, release their gametes into open water. The sperm recognize eggs of their own species through chemical markers on the surface of the eggs. The sperm will not recognize an egg of a different species, and so will not fertilize this egg.



EVOLUTION

- **postzygotic barrier** a mechanism that blocks reproduction after fertilization and zygote formation.



- **Hybrid inviability**
- **Hybrid sterility**
- **Hybrid breakdown**

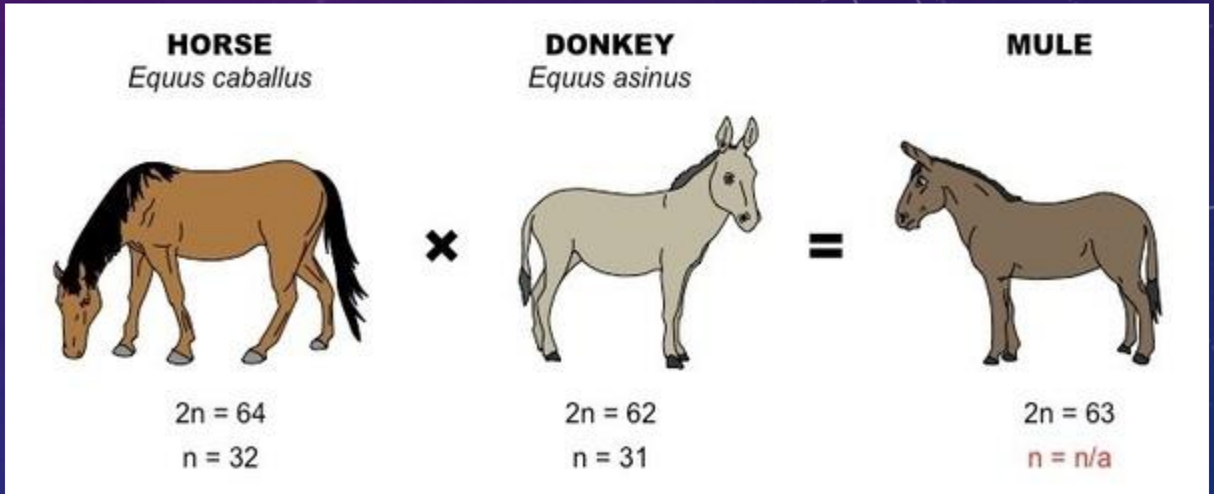
EVOLUTION

- **hybrid inviability** a genetic incompatibility of interbred species that stops development of the hybrid zygote during its development

- hybrid embryos between **sheep** and **goats die** in early **development before birth.**

EVOLUTION

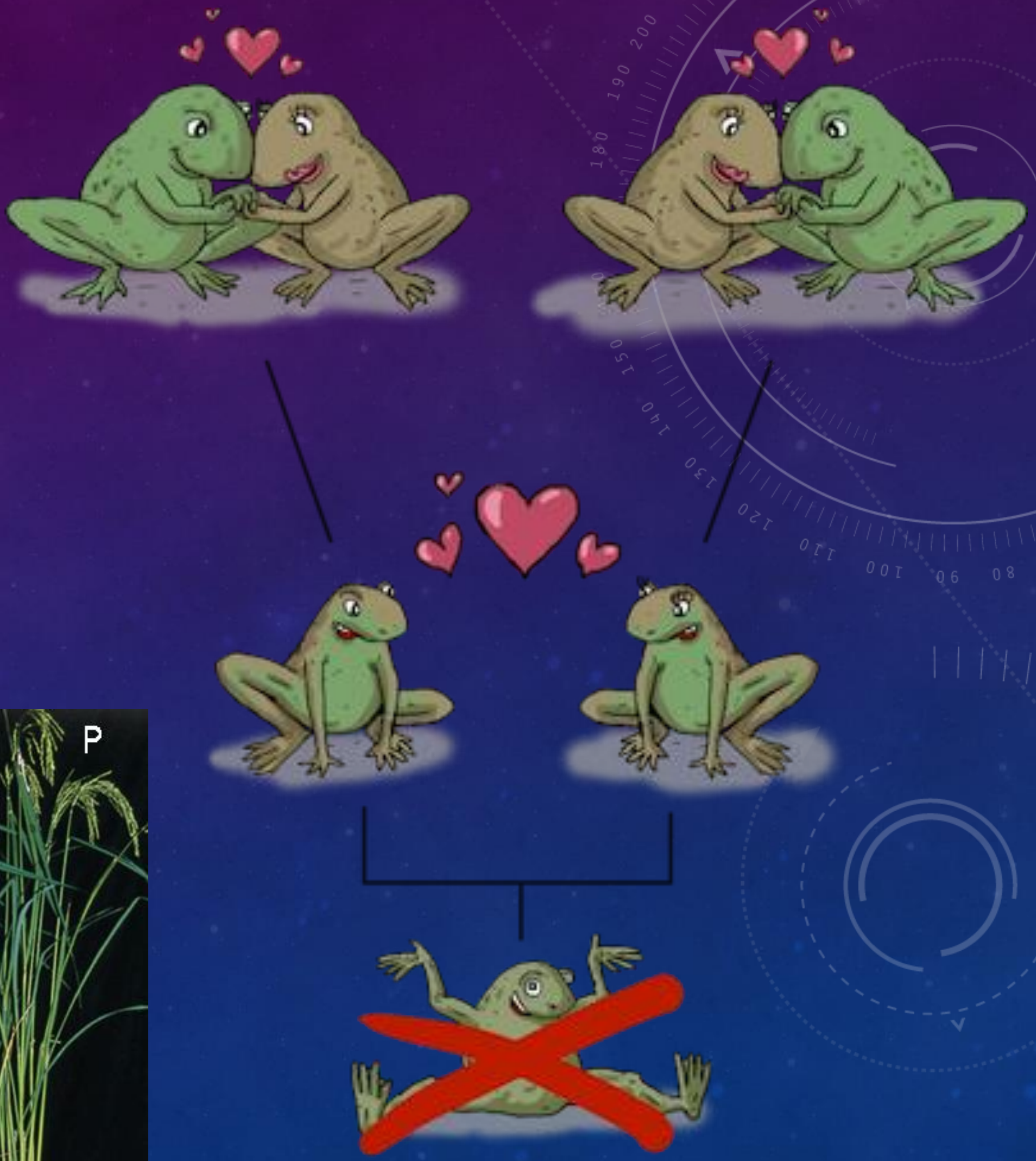
- **hybrid sterility** a biological barrier that exists between two species because, although they can mate and produce hybrid offspring, the offspring are sterile



- The offspring of a **horse** and a **donkey**.
- Meiosis fails to produce normal gametes in hybrid offspring.

EVOLUTION

- **hybrid breakdown** a biological barrier that occurs when first generation hybrids mate with each other or with an individual from either parent species, and the offspring are either sterile or weak.

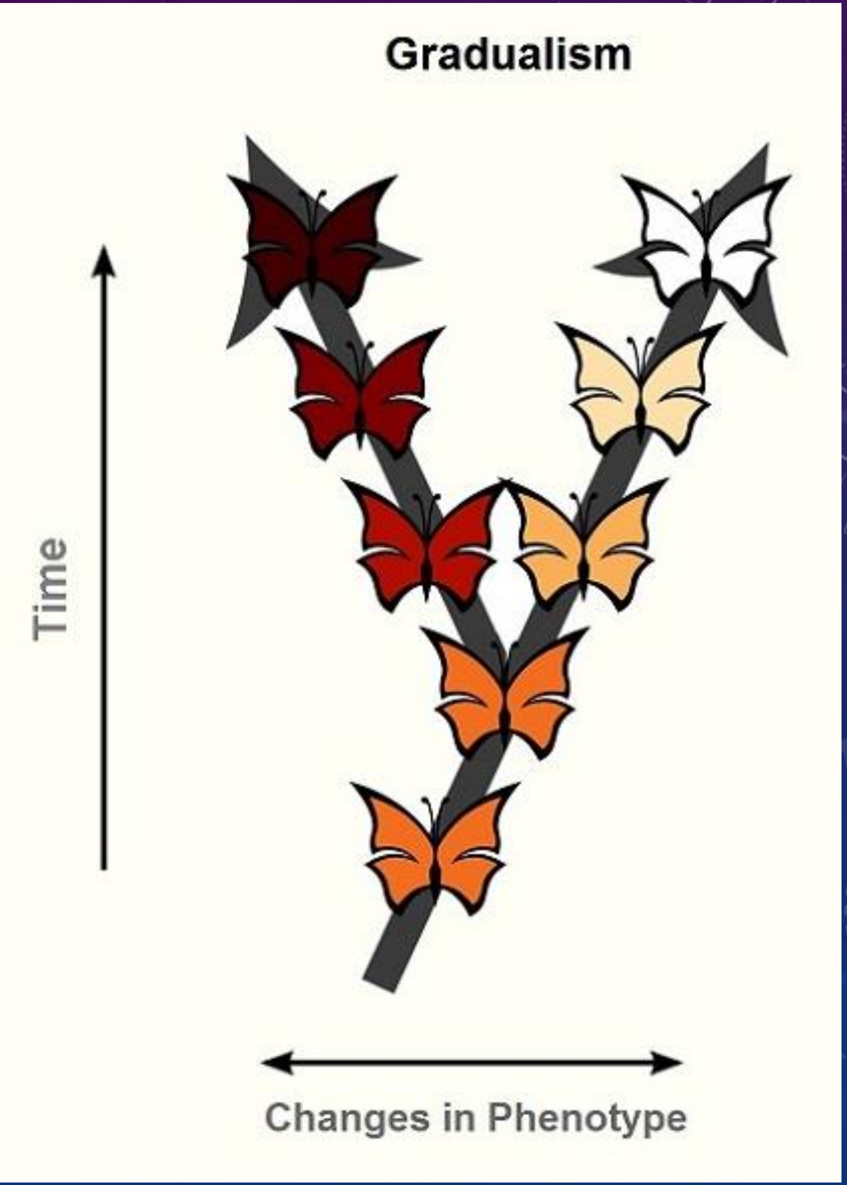


THE PACE OF EVOLUTION

EVOLUTION

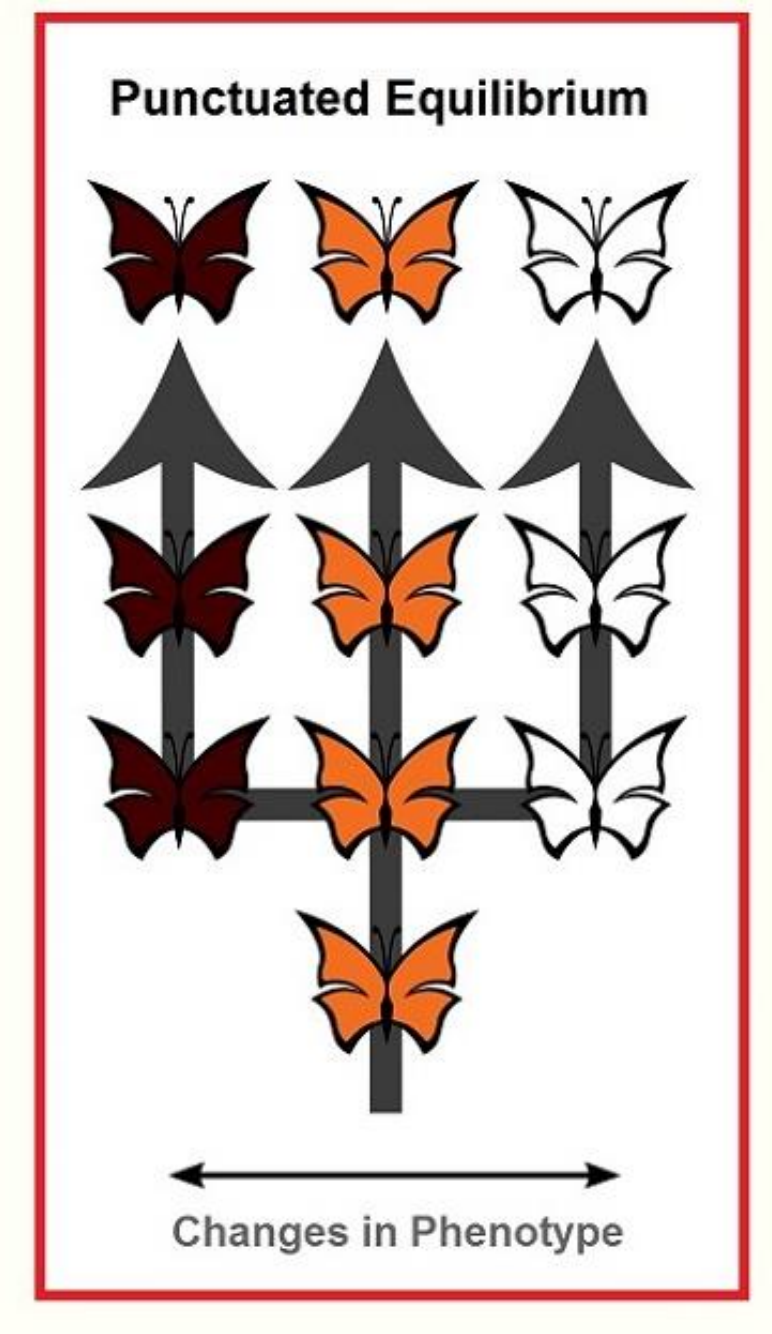
- **gradualism** model that describes evolution as slow, steady, and linear, with the accumulation of many small changes producing large changes

- According to this model, big changes (such as the evolution of a new species) occur as a result of many small changes.
- The fossil record, however, rarely reveals fossils that show this gradual transition but **not all organisms leave fossils.**



EVOLUTION

- **punctuated equilibrium** model that describes evolution as consisting of long periods of stasis, interrupted by periods of rapid change
- Evidence in the fossil record that show periods of rapid change happen after mass extinctions.



EVOLUTION

- **co-evolve** to evolve together, as occurs with closely associated species so that the evolution of one depends on the evolution of the other
- **Madagascar long-spurred orchid** has co-evolved with its only pollinator the **Hawk moth.**
- Darwin predicted that it must have evolved along with an insect pollinator that had a tongue long enough to reach the nectar in the orchid's spur.
- The giant hawkmoth, endemic to Madagascar, was **discovered in 1882**. Its existence, however, was **predicted 20 years earlier.**

EVOLUTION

- Exit Card 15

EVOLUTION

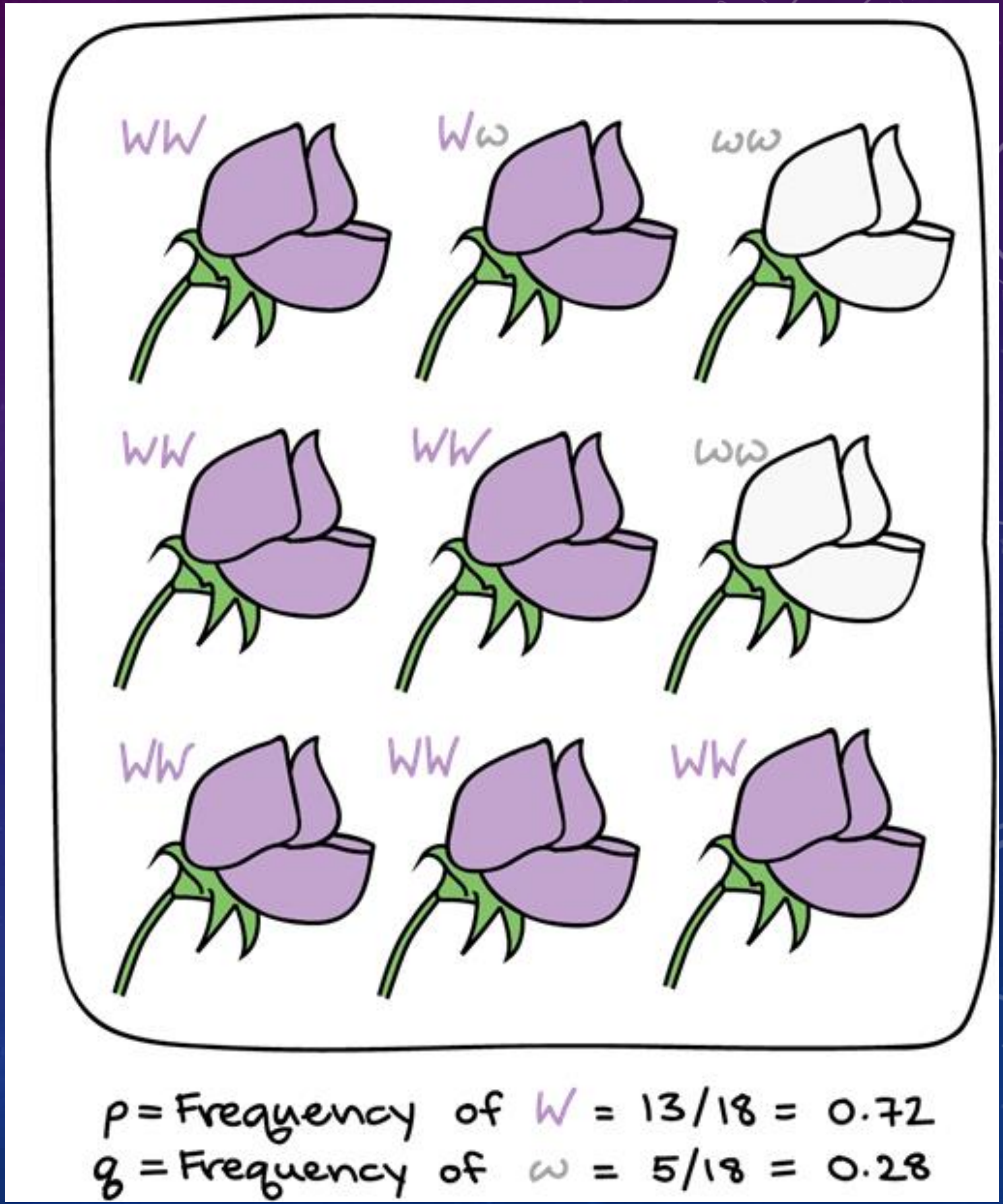
DESCRIBING GENETIC DIVERSITY IN POPULATIONS

- **population genetics** the study of genetic variation in populations

- **gene pool** sum of all alleles for all the genes in a population

EVOLUTION

- **genotype frequency** proportion of a population with a particular genotype, usually expressed as a decimal
- **phenotype frequency** proportion of a population with a particular phenotype, expressed as a decimal or percent
- **allele frequency** rate of occurrence of a particular allele in a population with respect to a particular gene

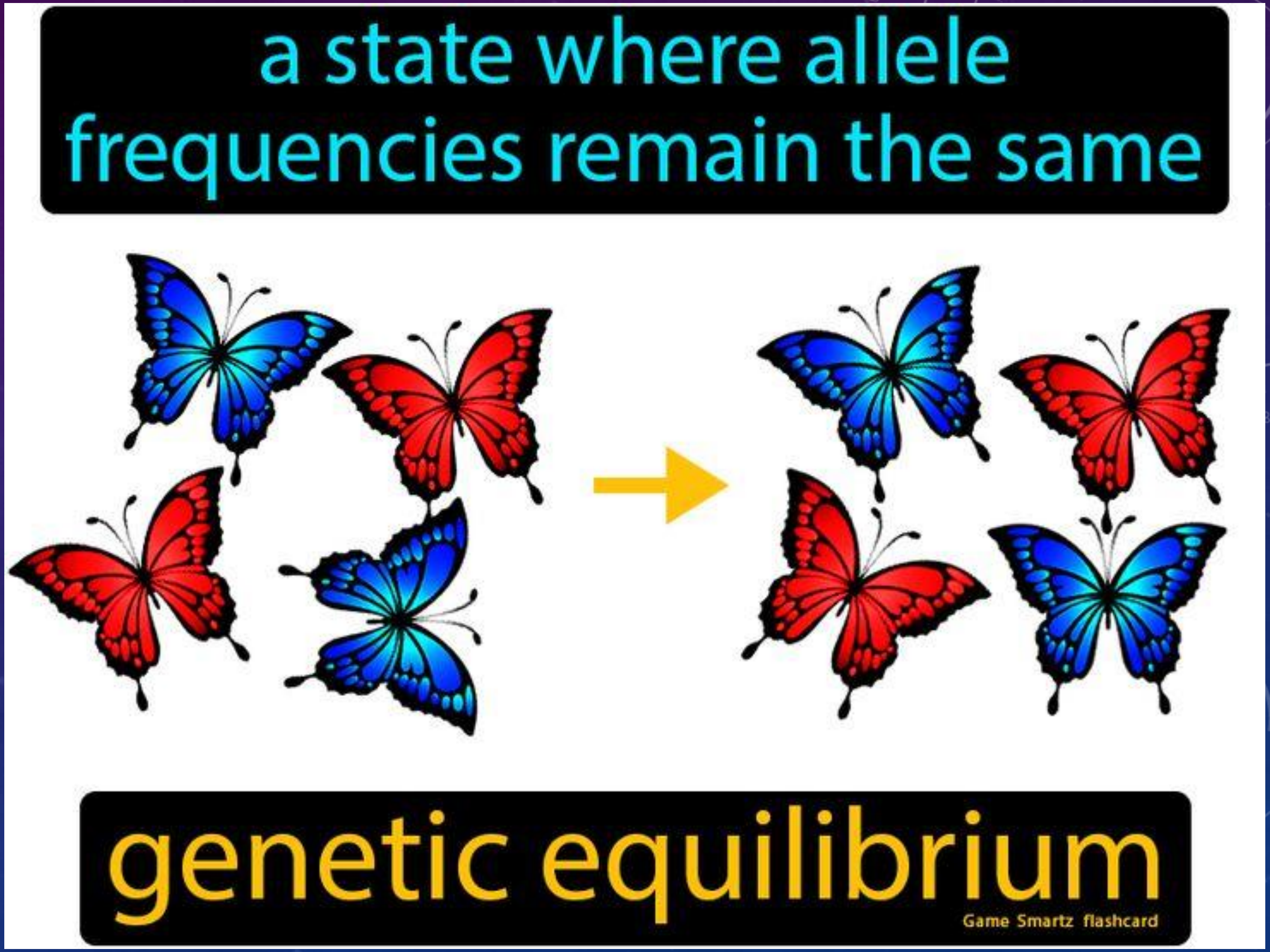


EVOLUTION

Phenotype			
Genotype	*BB*	*Bb*	*bb*
Number of mice (total = 200)	72	96	32
Genotype frequency	$\frac{72}{200} = 0.36$	$\frac{96}{200} = 0.48$	$\frac{32}{200} = 0.16$
Number of alleles in gene pool (total = 400)	$72 \times 2\ B = 144\ B$	$96 \times 1\ B = 96\ B$ $96 \times 1\ b = 96\ b$	$32 \times 2\ b = 64\ b$
Allele frequency	$\frac{240}{400} = 0.60$		$\frac{160}{400} = 0.40$

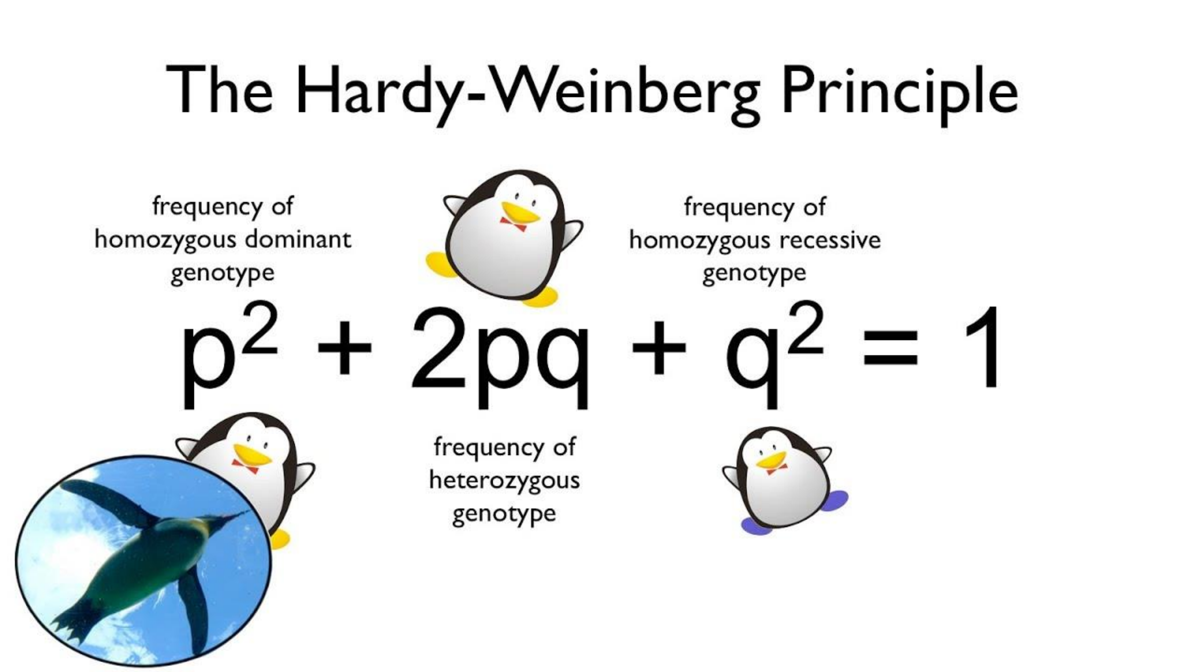
EVOLUTION

- **genetic equilibrium (*Hardy-Weinberg Equilibrium)*** condition of a gene pool in which allele frequencies remain constant over time, and therefore the population is not evolving



FIVE CONDITIONS OF THE HARDY-WEINBERG PRINCIPLE

- **1. The population is large enough that chance events will not alter allele frequencies.**
- **2. Mates are chosen on a random basis.**
- **3. There are no net mutations.**
- **4. There is no migration.**
- **5. There is no natural selection against any of the phenotypes.**



EVOLUTION

SOLVING HARDY-WEINBERG PROBLEMS

- $P^2 + 2pq + q^2 = 1$
- $p + q = 1$

- P^2 = frequency of homozygous dominant genotype (BB)
- q^2 = frequency of homozygous recessive genotype (bb)
- 2pq = frequency of heterozygous genotype

- p = frequency of dominant allele
- q = frequency of recessive allele

EVOLUTION

- Sixteen percent of a **population** is unable to taste the chemical PTC. These non-tasters are recessive for the tasting gene

The word **population** means P^2, 2pq, or q^2

The question is telling us q^2 = 0.16 always change to decimal form.

Always solve for p and q, in this case $\sqrt{q^2} = \sqrt{0.16} = 0.4$ which means p = 0.6

1.)What percentage of the population are tasters?

If 16% are non-tasters then 84% have to be tasters

2.) What is the frequency of the dominant allele and recessive allele?

The dominant allele is p so 0.6
The recessive allele is q so 0.4

3.) What percentage of the population are heterozygous for the trait?

The question is asking for 2pq so you need to calculate it

2pq = 2(0.6)(0.4) = 0.48 = 48%

EVOLUTION

- The delta-32 mutation, a **recessive gene**, gives humans protection from HIV infection. The **allele frequency** for a town in Sweden is 20%.

The question is telling us $q = 0.2$

So $p = 0.8$

1.) What percent of the population have two copies of the gene and are therefore immune to HIV?

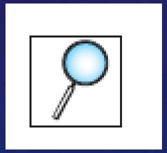
Question is asking for q^2 so $q^2 = 0.2^2 = 0.04$ or 4% are immune to HIV

2.) What percent of the population are less susceptible to HIV because they are heterozygous?

Question is asking about population so $2pq = 2(0.8)(0.2) = 0.32$ or 32%

EVOLUTION

- Investigation 17.B

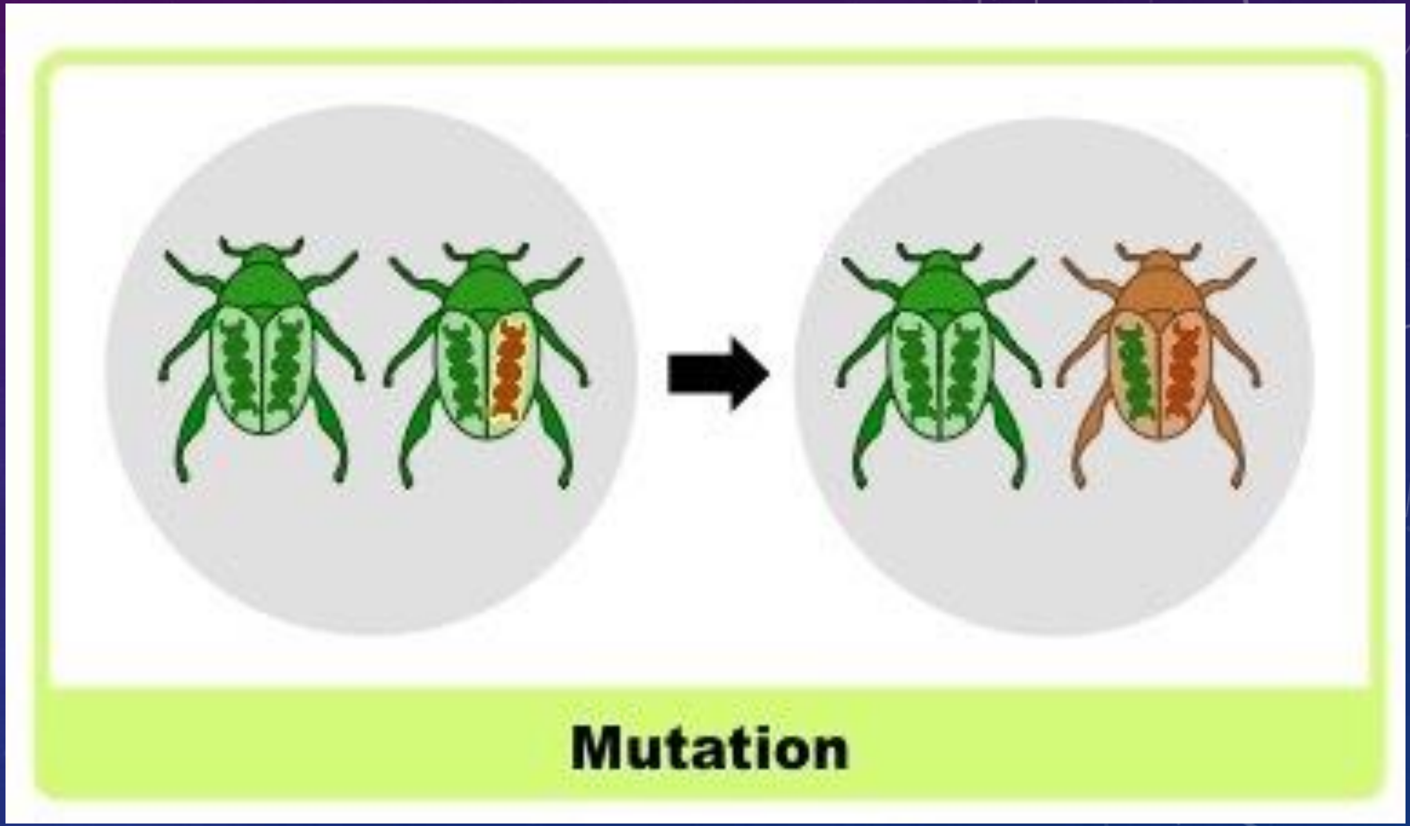


EVOLUTION

- Exit Card 16

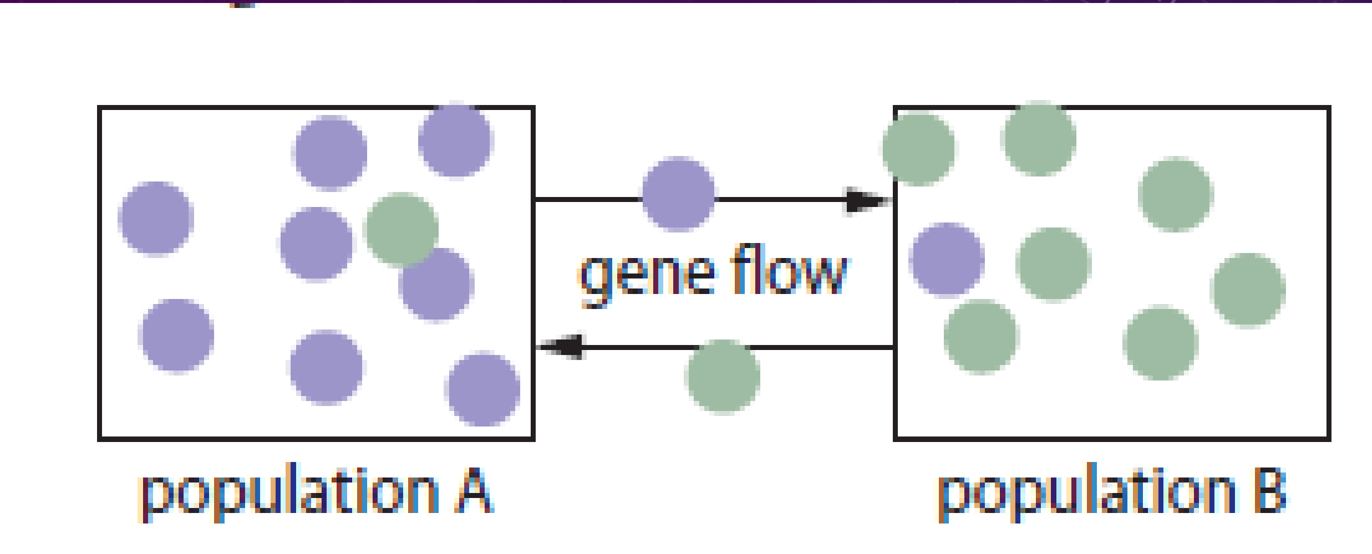
CAUSES OF GENE POOL CHANGES

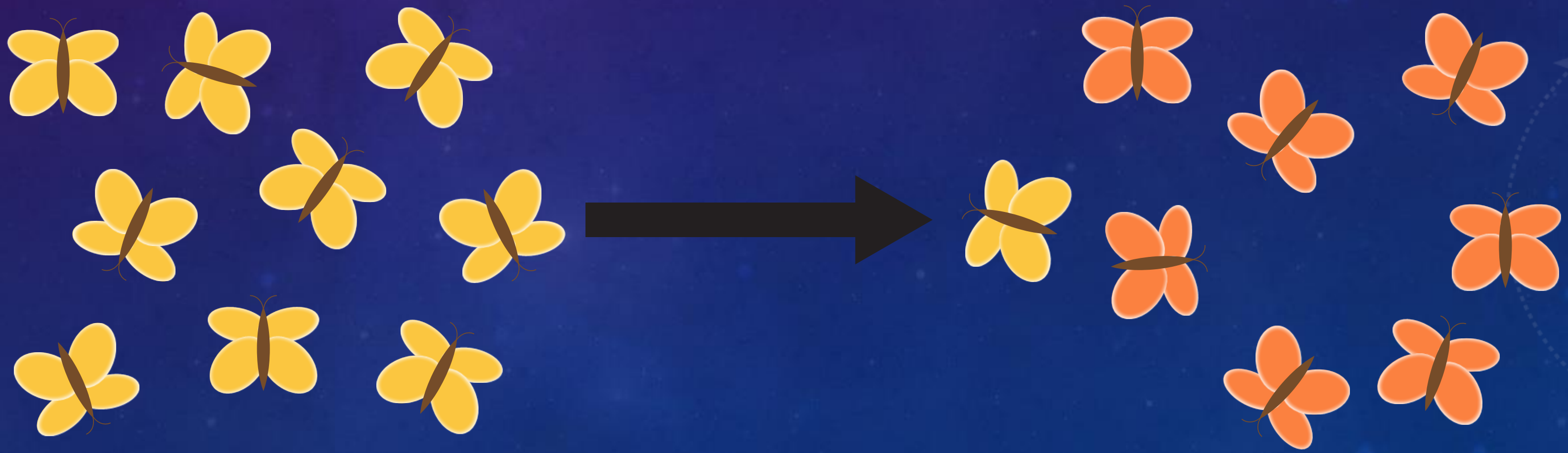
- **Mutations** an inheritable mutation has the potential to affect an entire gene pool. Recall that while most mutations are neutral, some are harmful and a few are even beneficial.



EVOLUTION

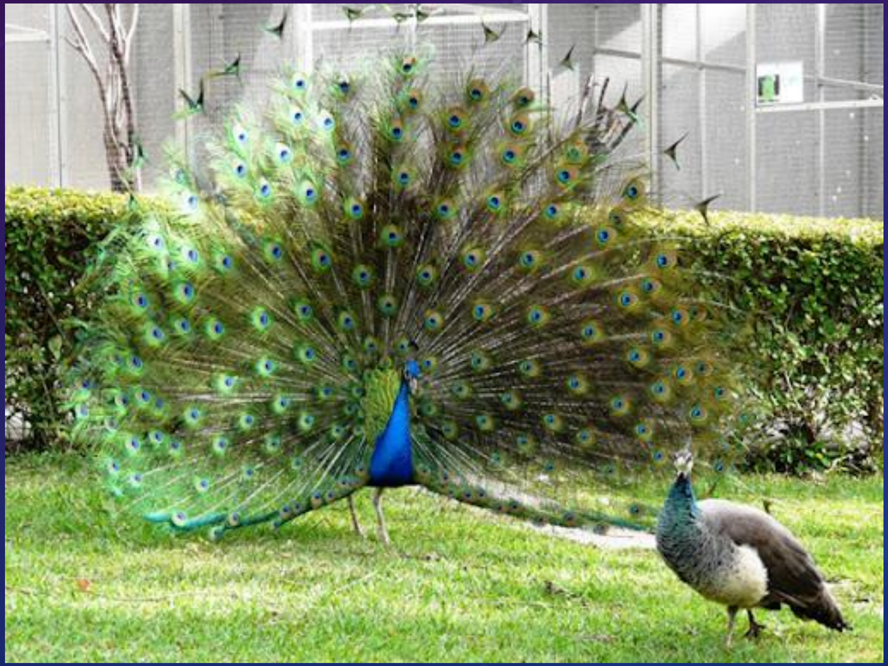
- **gene flow** net movement of alleles from one population to another due to the migration of individuals

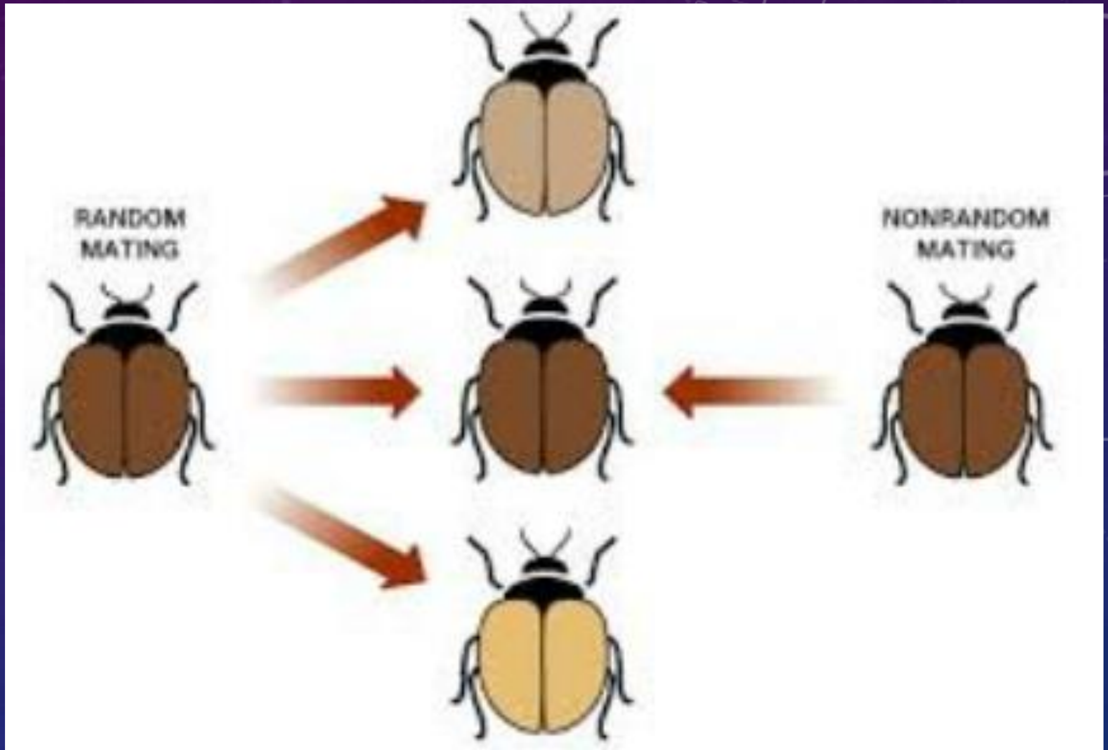




EVOLUTION

- **non-random mating**
  mating among individuals that prevents those with particular phenotypes from breeding, as in mate selection or inbreeding



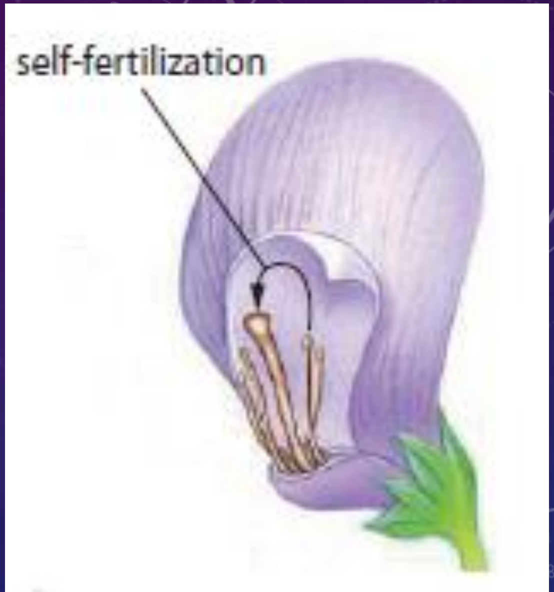


EVOLUTION

- **sexual selection** a special case of natural selection in which a particular phenotype improves an individual's chances of obtaining a mate – a form of non-random mating

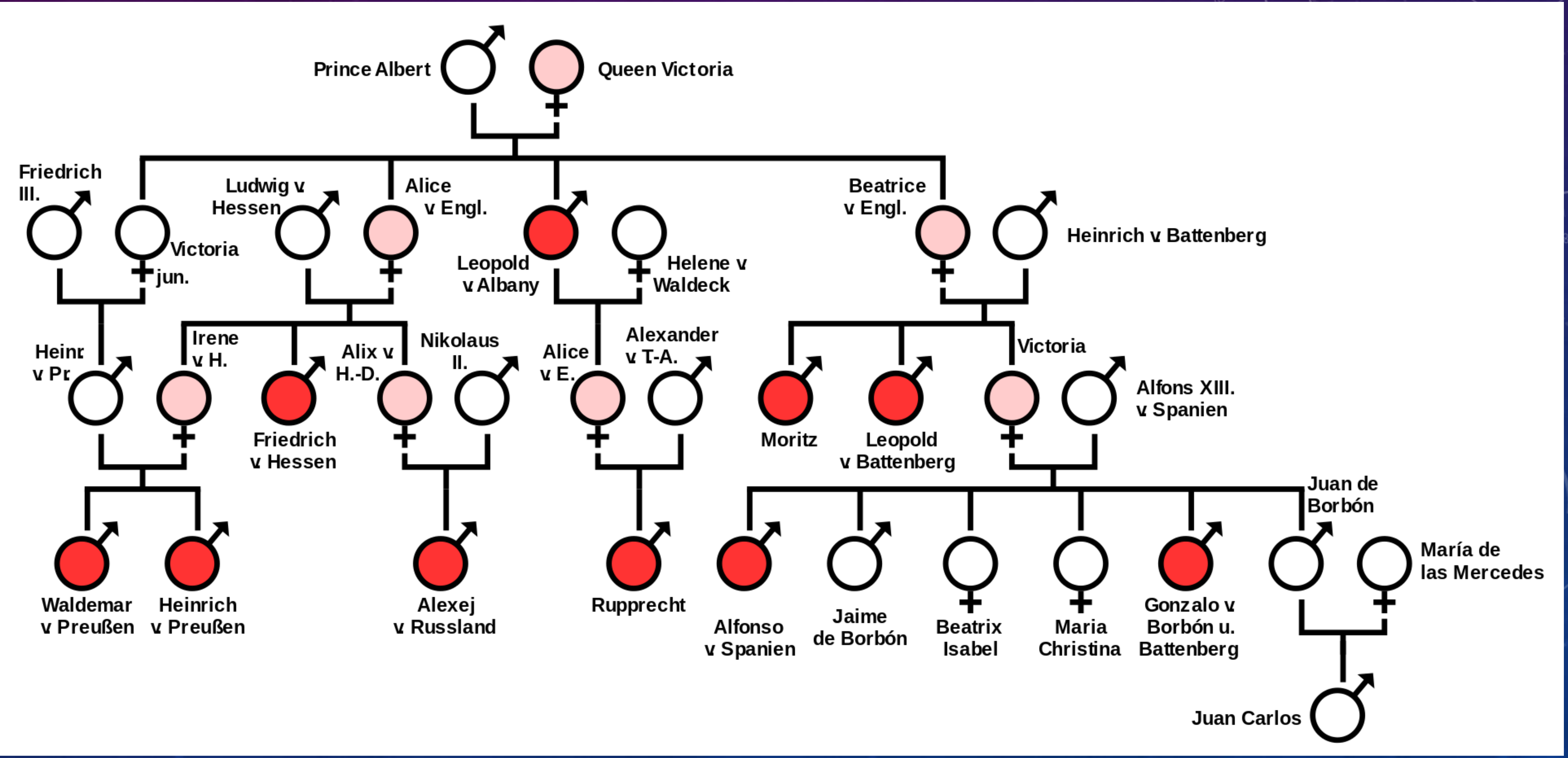
- Sexual selection generally involves competition among males through combat (as with rutting woodland caribou) or visual displays to females. A male ruffed grouse (Bonasa umbellus), for example, attempts to attract females by displaying—fluffing up his neck feathers and rapidly beating his wings to produce a drumming sound.

- **Inbreeding** occurs when closely related individuals breed together. – also non-random mating
- An extreme example of inbreeding is the self-fertilization of some flowers.
- Since close relatives share similar genotypes, inbreeding increases the frequency of homozygous genotypes.
- As homozygous genotypes become more common, harmful recessive alleles are more likely to be expressed.
- Inbreeding can also have a positive effect on a population, however. If homozygous recessive individuals fail to breed, and there are fewer heterozygous individuals each generation, harmful recessive alleles will be eliminated from the gene pool over time



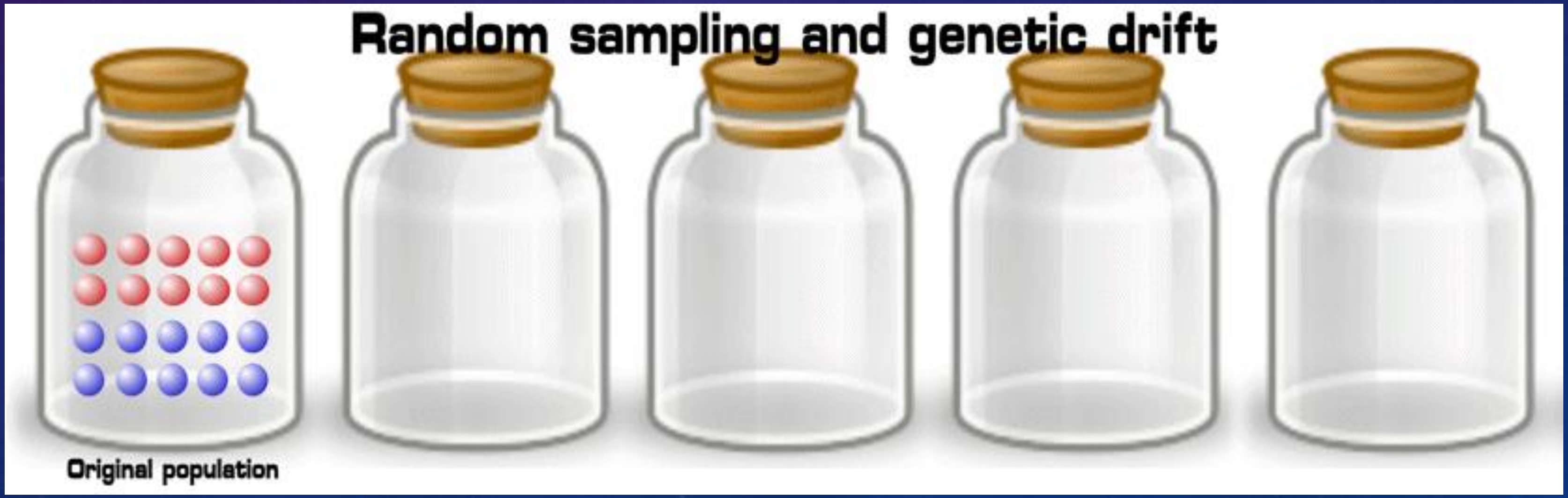
THE ROYAL FAMILY - HEMOPHILIA

- The presence of hemophilia B within the European royal families was well-known, with the condition once popularly known as "the royal disease".



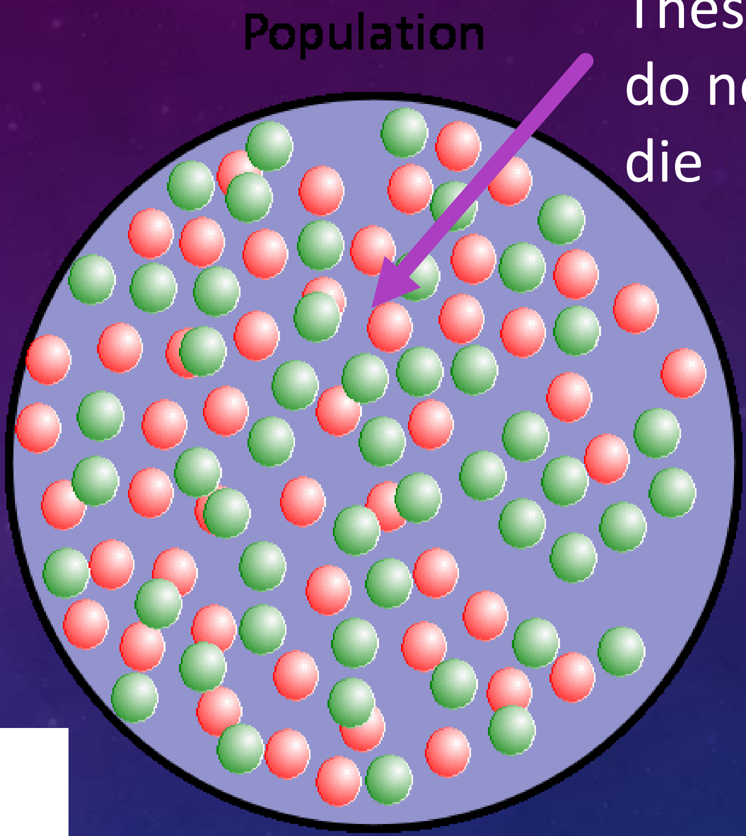
EVOLUTION

- **genetic drift** change in allele frequencies (gene pool) in a small breeding population due to chance events

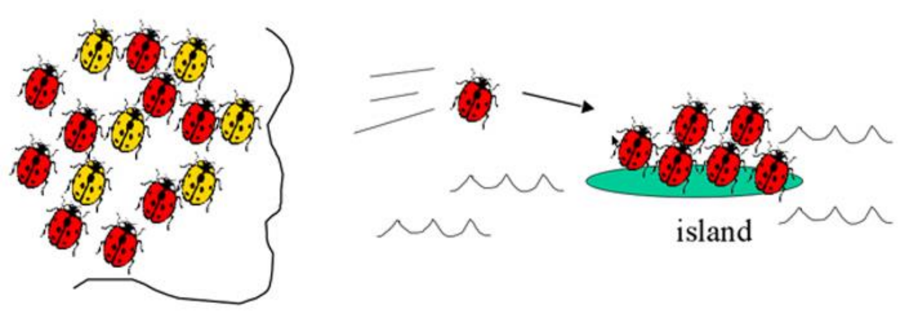


EVOLUTION

- **founder effect** gene pool change that occurs when a few individuals start a new, isolated population



These do not die

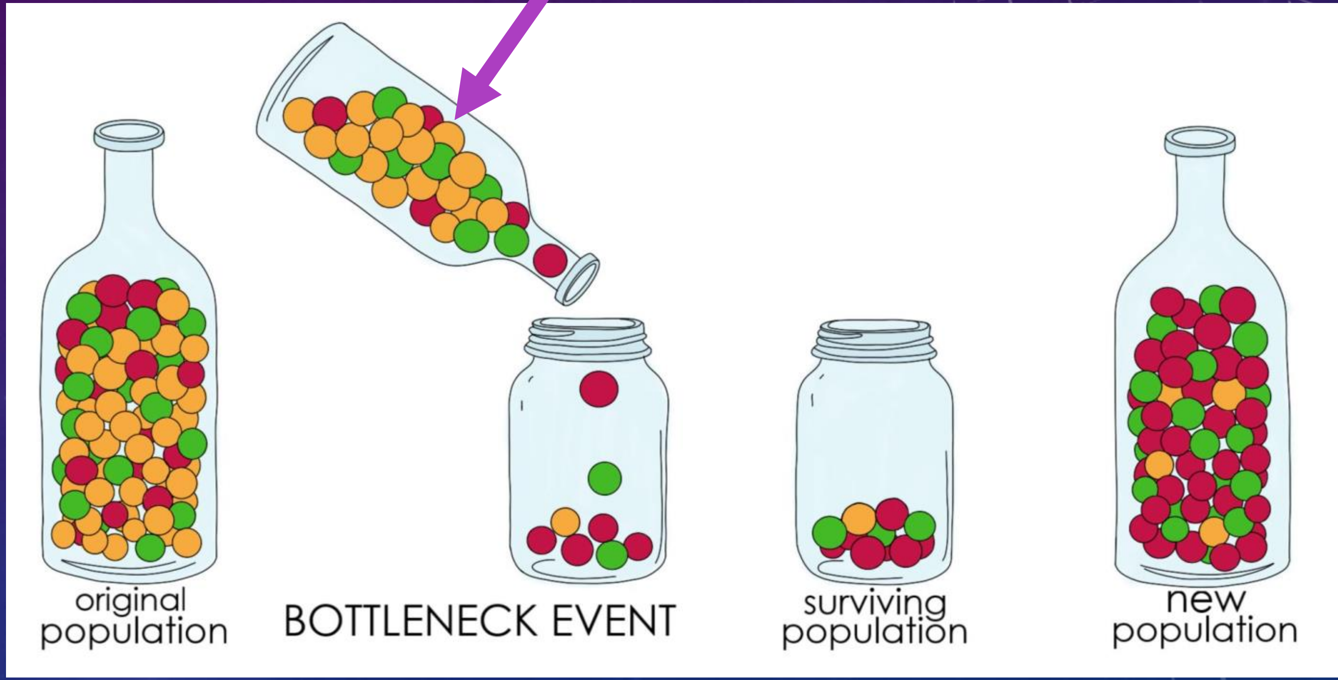


Ancestral population frequencies		
	Red	Green
Original	0.50	0.50
After split		
Generation 1		
Generation 2		
Generation 3		
Generation 4		
Generation 5		

EVOLUTION

- **bottleneck effect** gene pool change that results from a rapid decrease in population size

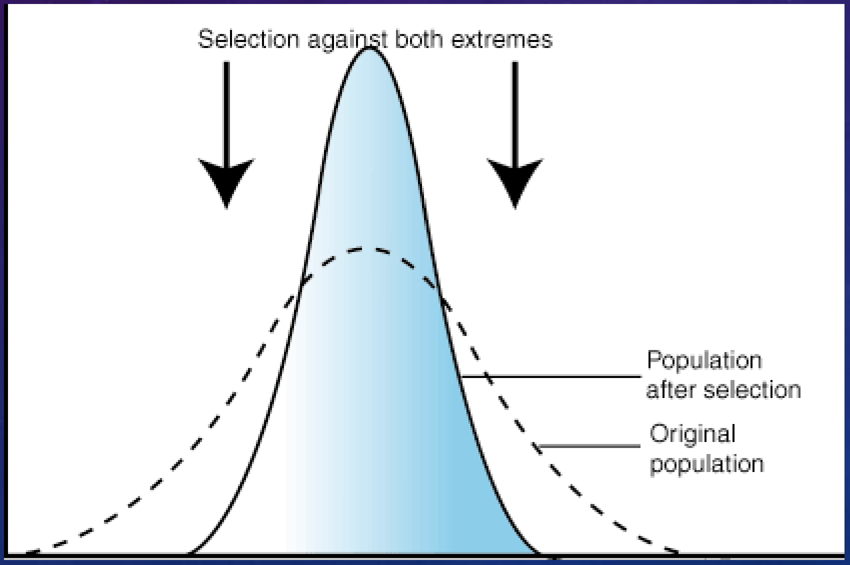
These die, different than founder effect

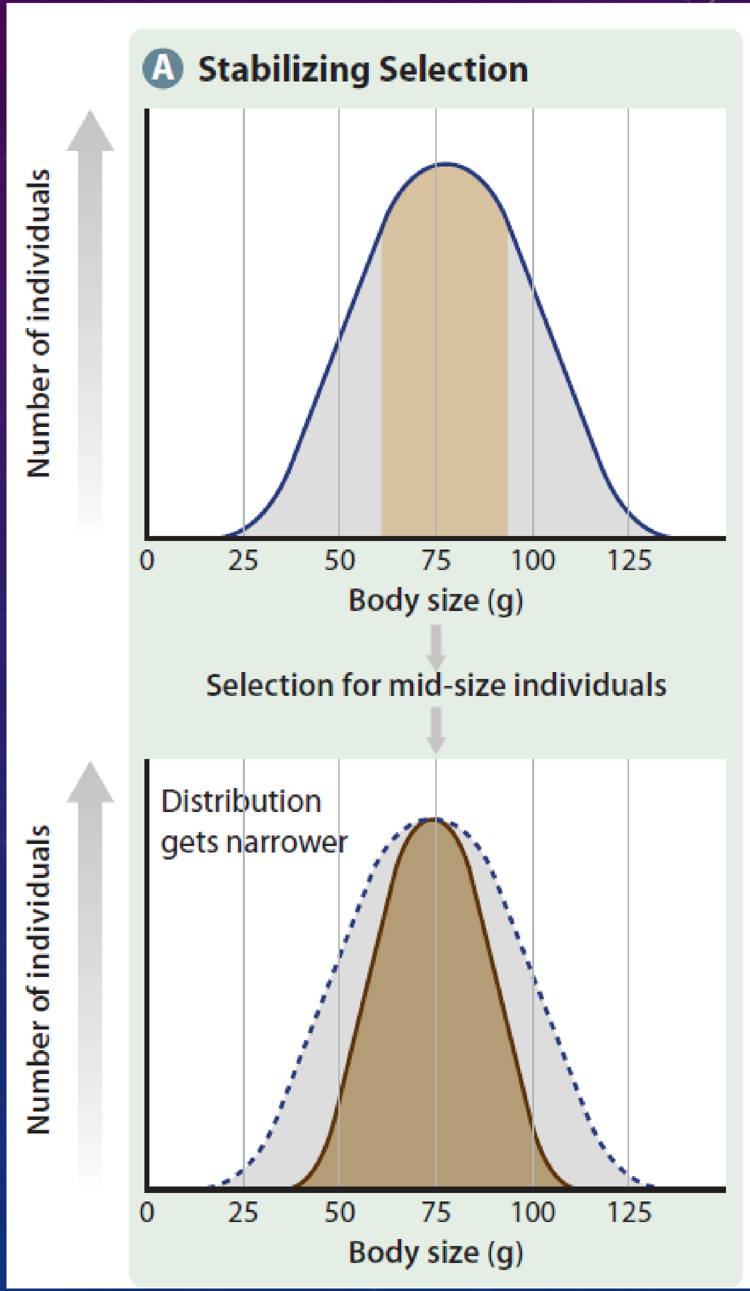


EVOLUTION

REMEMBER FROM BEFORE

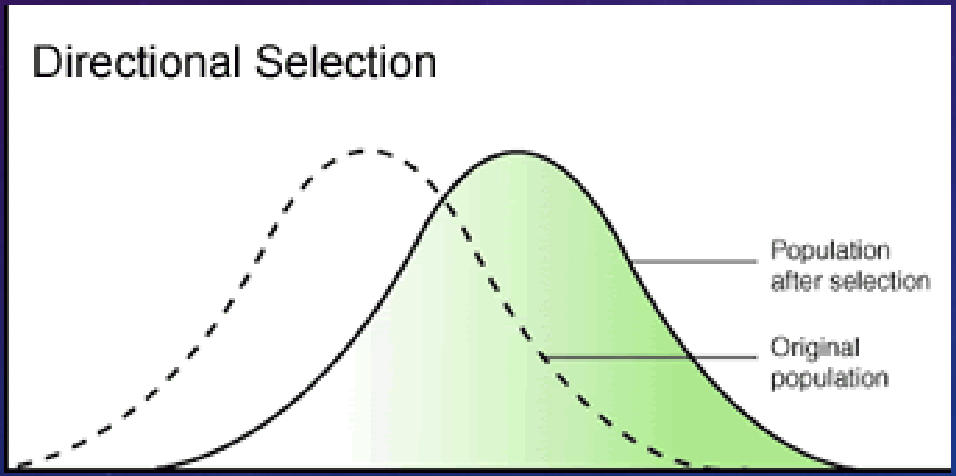
- **stabilizing selection** a form of natural selection that favours an intermediate phenotype and acts against extreme versions of the phenotype.

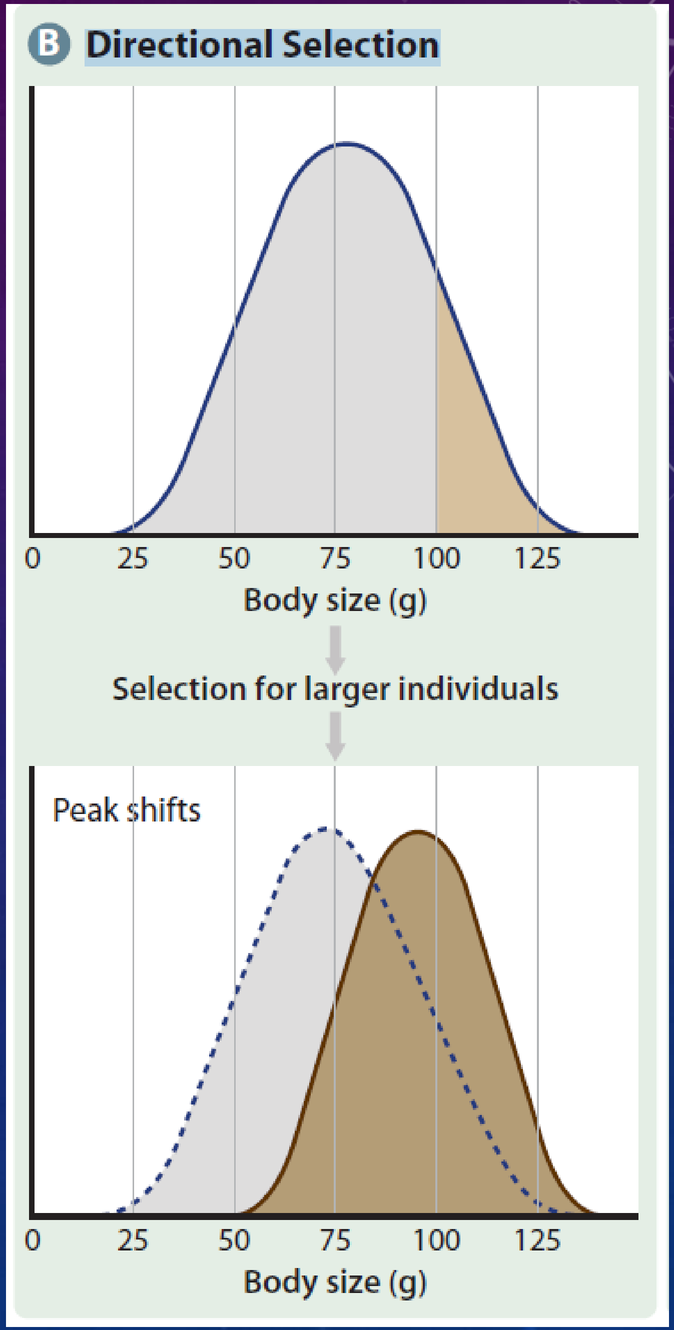




EVOLUTION

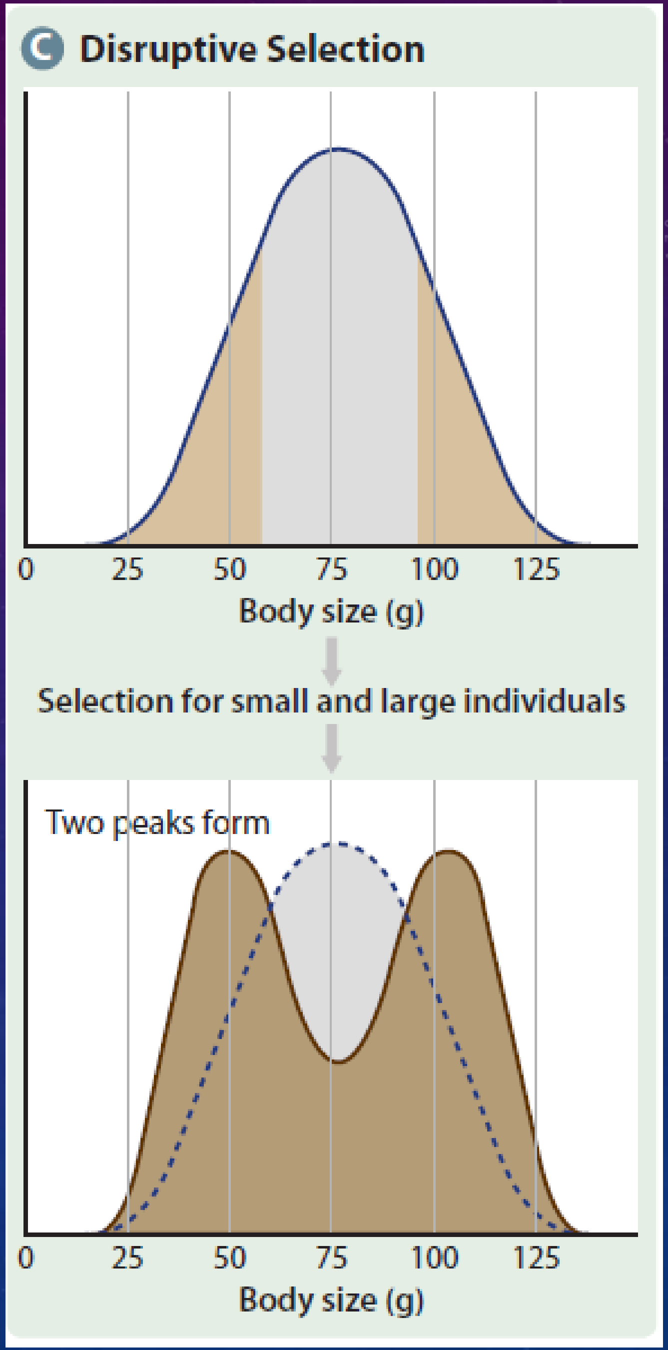
- **directional selection** a form of natural selection that favours the phenotype at one extreme over the other





EVOLUTION

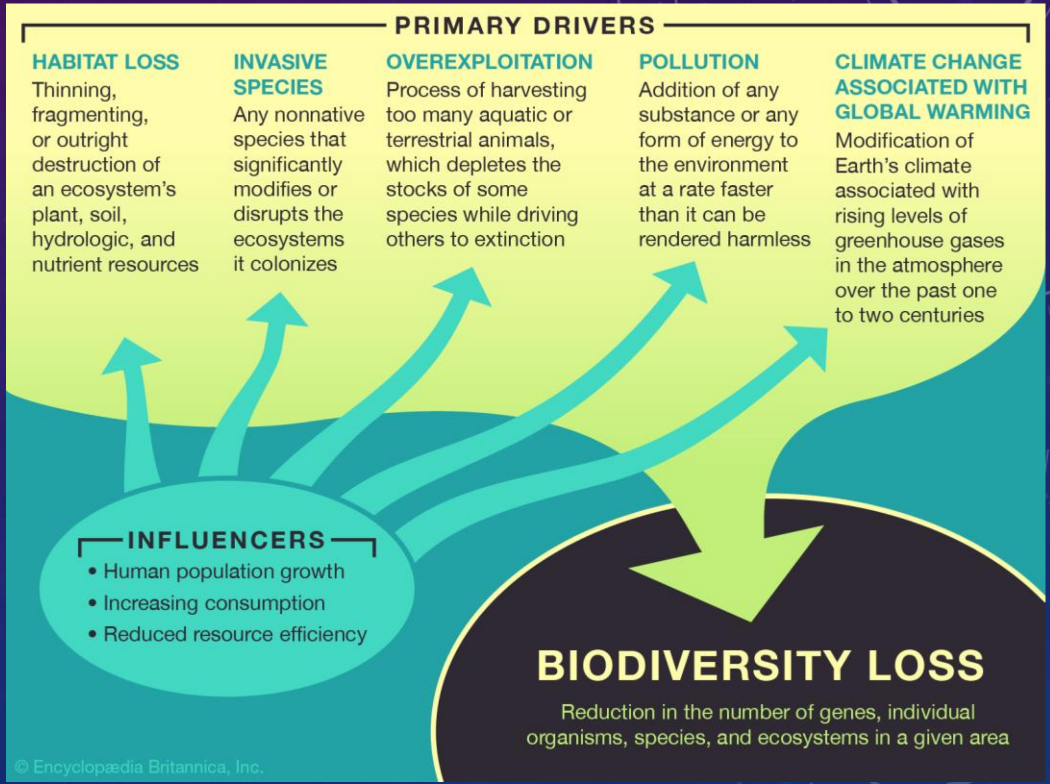
- **disruptive selection** a form of natural selection that favours the extremes of a range of phenotypes over intermediate phenotypes, and may eliminate intermediate phenotypes from the population



HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

EVOLUTION

- Human activities can affect the genetic diversity of populations in various ways.
  - commercial fishing
  - habitat loss
  - invasive species
  - over harvesting
  - dam/ road construction
  - climate change
  - selective hunting
  - insecticide/ herbicide us
  - antibiotic/antimicrobial cleaner use



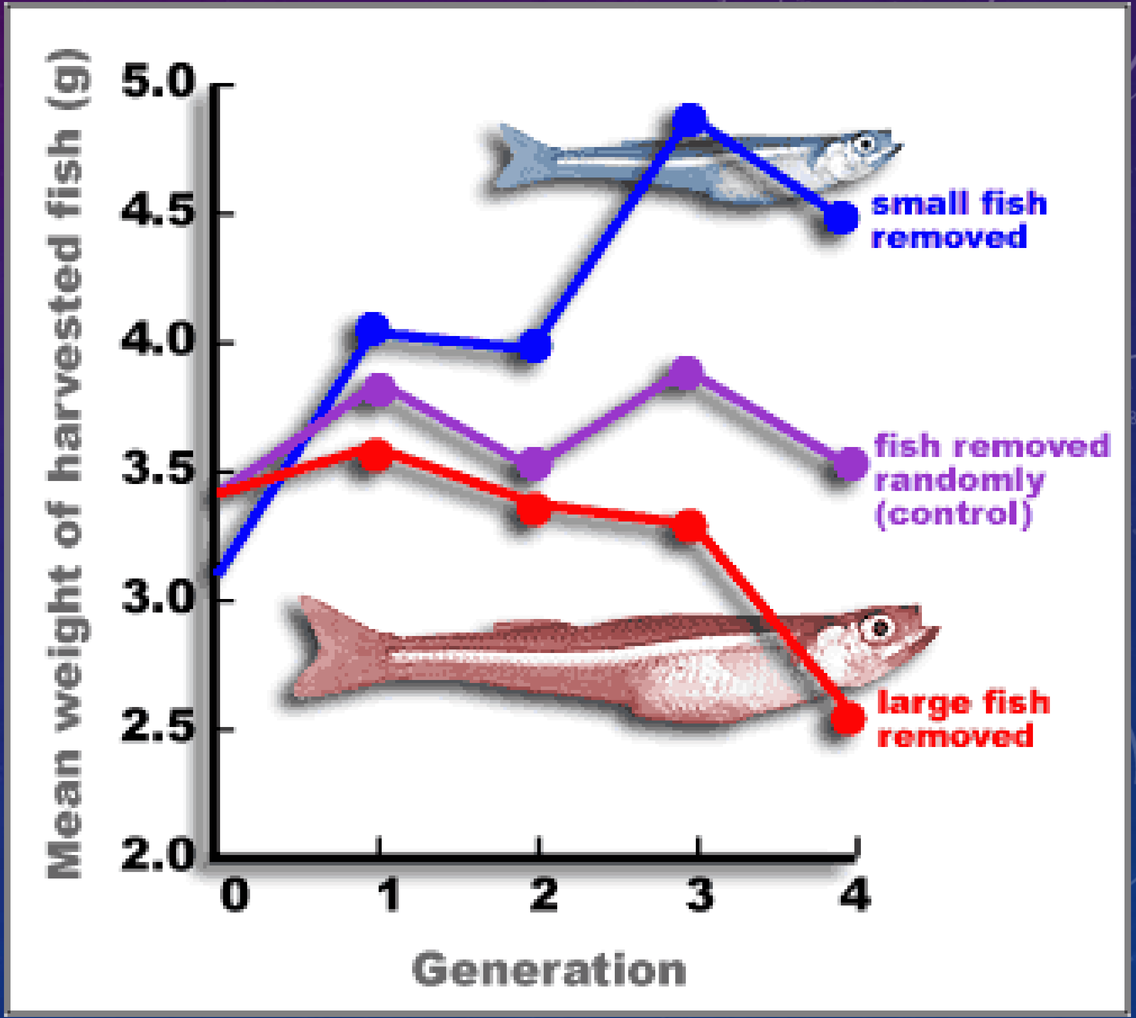
- **Due to genetic drift each population will likely have little genetic diversity within it.**

EVOLUTION

HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

- **Commercial Fishing** - For many marine species, fishing probably has the greatest impact of any human activity on the loss of within-species diversity, both within and among populations.

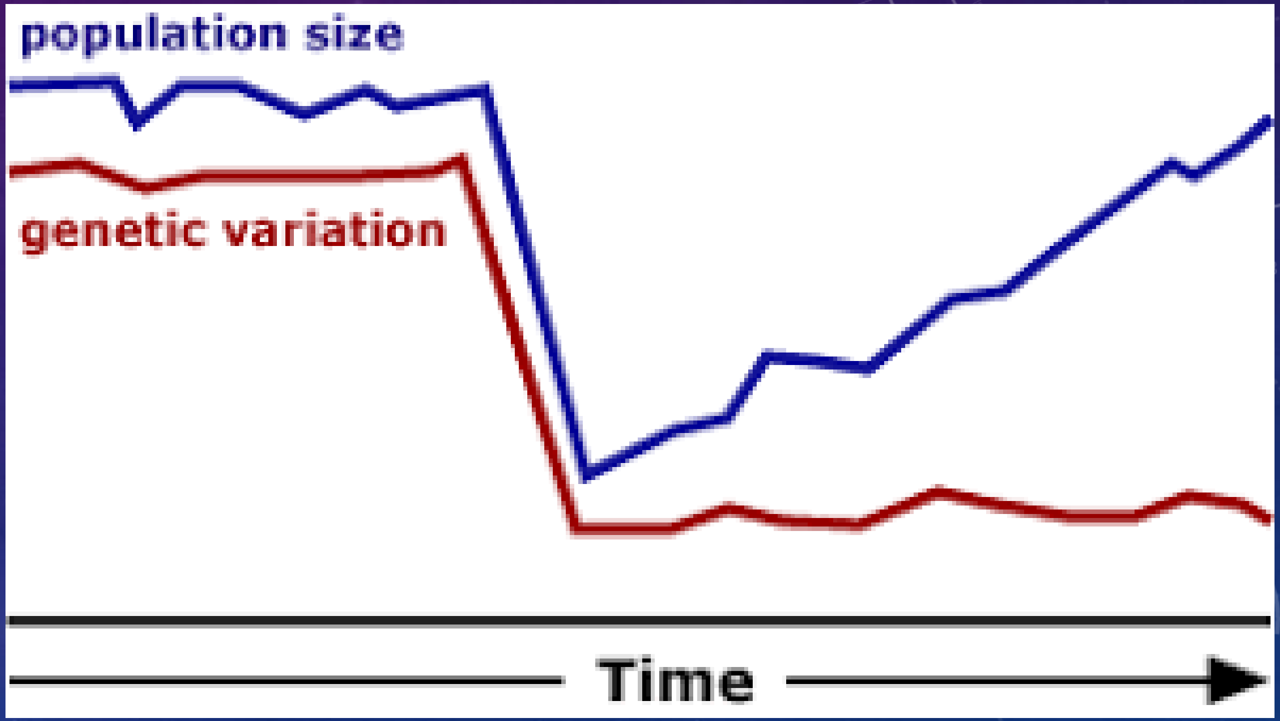
- Net mesh size/type can determine who is caught and who escapes
- Method of fishing can determine who is caught and who survives



HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

- **Habitat Loss** – degradation of habitat will eventually lead to less genetic diversity

- Any organisms that cannot withstand the change will die off leaving only a specific population to reproduce

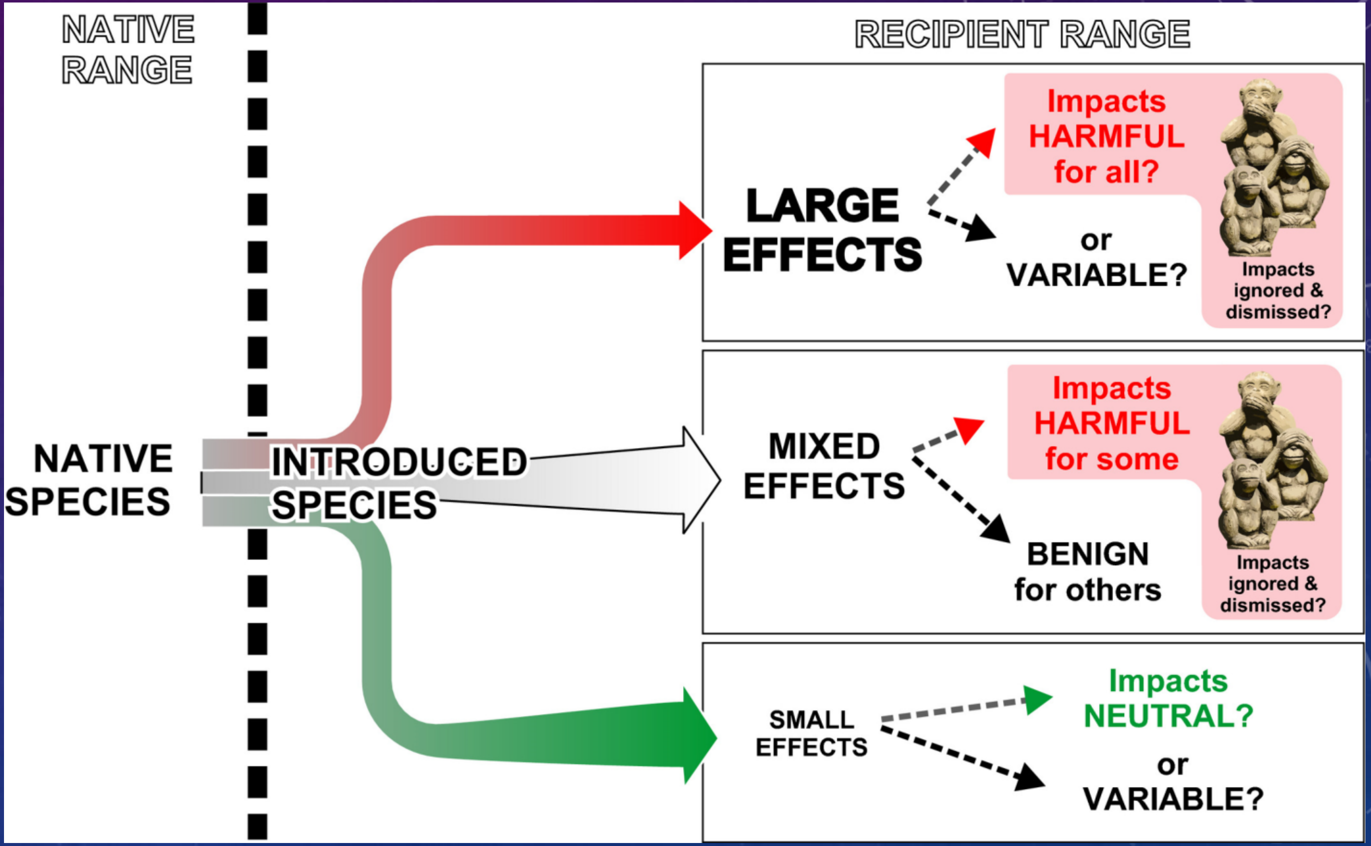


EVOLUTION

HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

EVOLUTION

- **Invasive Species** – move into an area and then the natural populations of some other organisms drop because they cannot handle the change.
- Often causes loss of genetic diversity
- Usually transported to a new area accidently by humans



EVOLUTION

HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

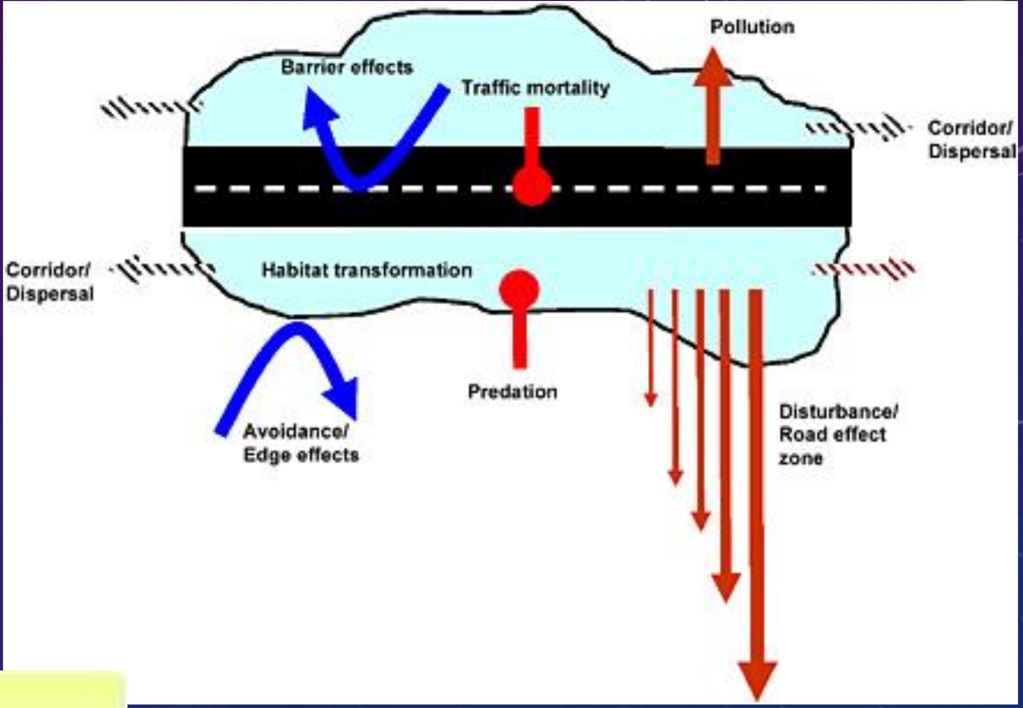
- **Over harvesting** – catching or harvesting to much of a resource can lead to loss of genetic diversity.

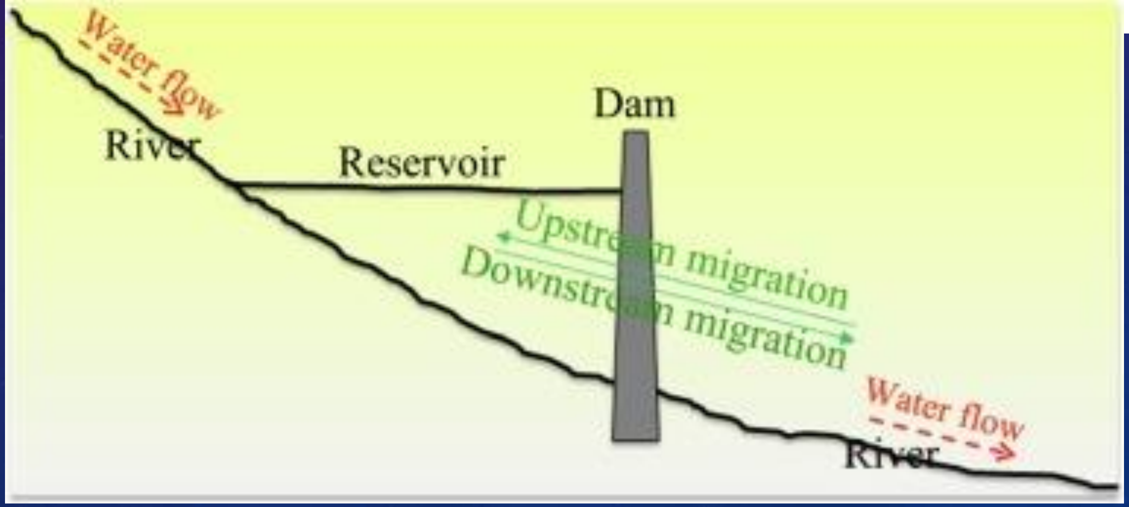
HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

EVOLUTION

- **Dam/road construction**

- Creates a barrier which stops individuals from mixing with one another.

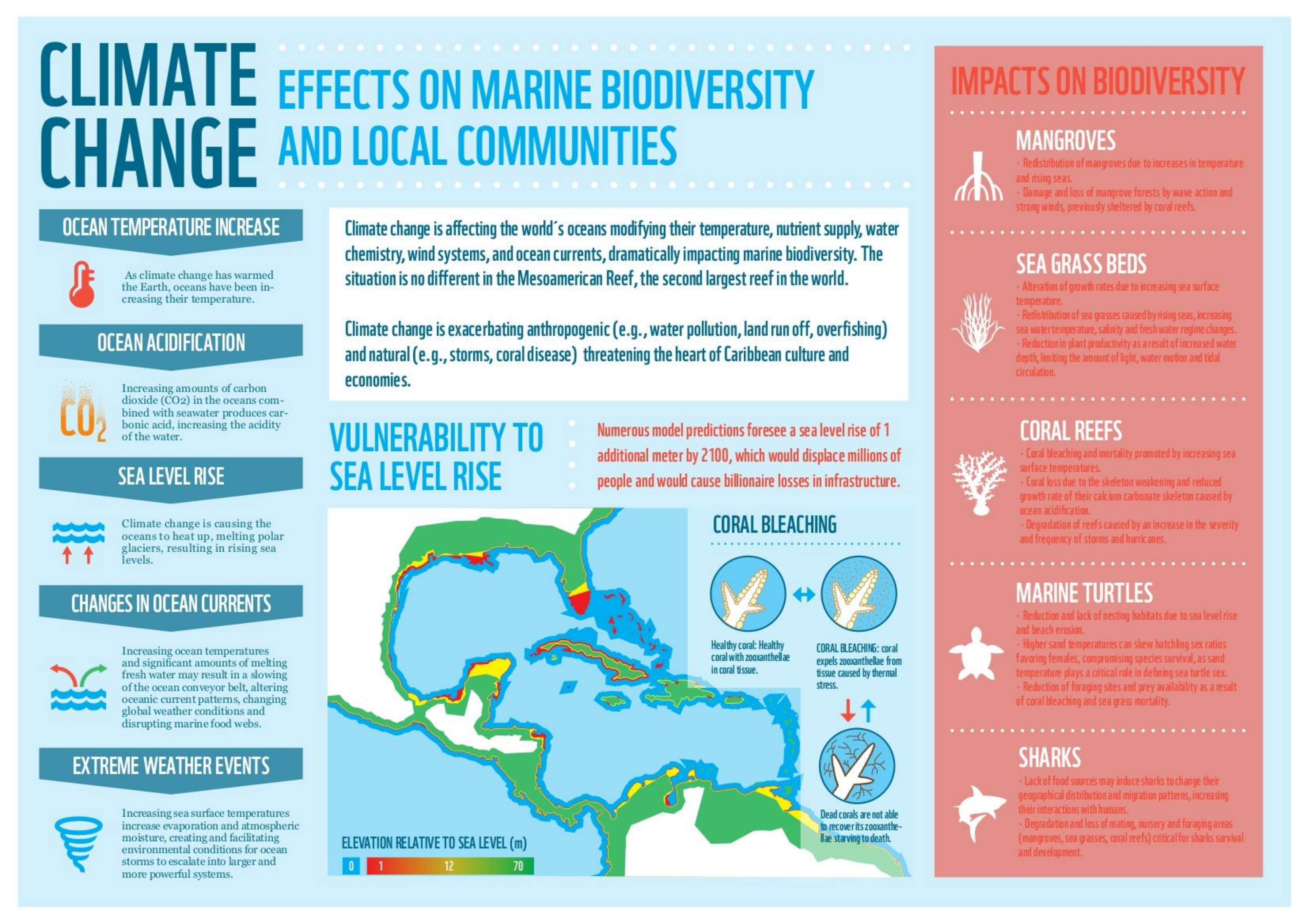




EVOLUTION

HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

- **Climate change**

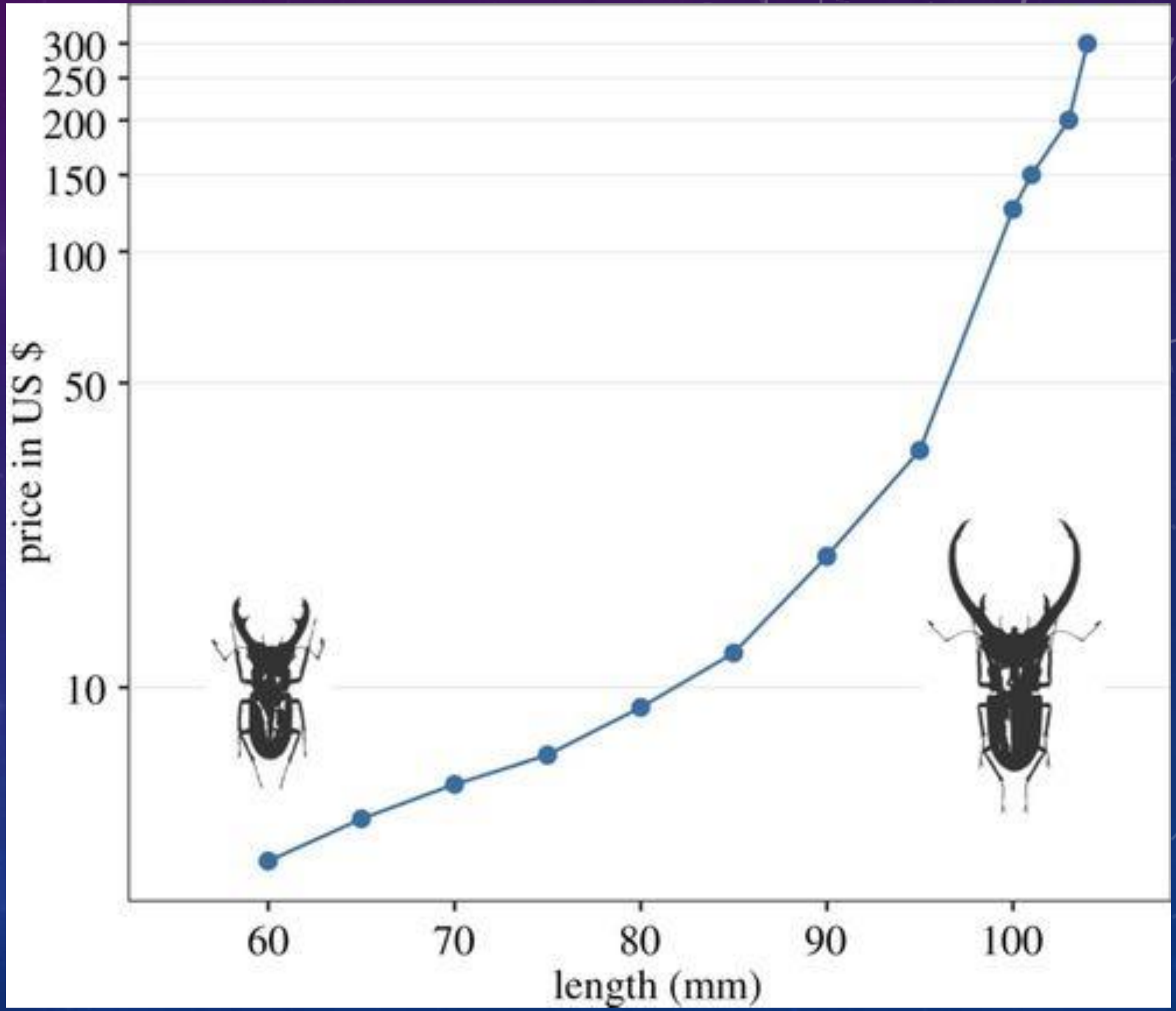


HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

EVOLUTION

- **Selective hunting**

- When selective hunting the trait that is being chosen is at risk of being lost, this leads to biodiversity loss.



HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

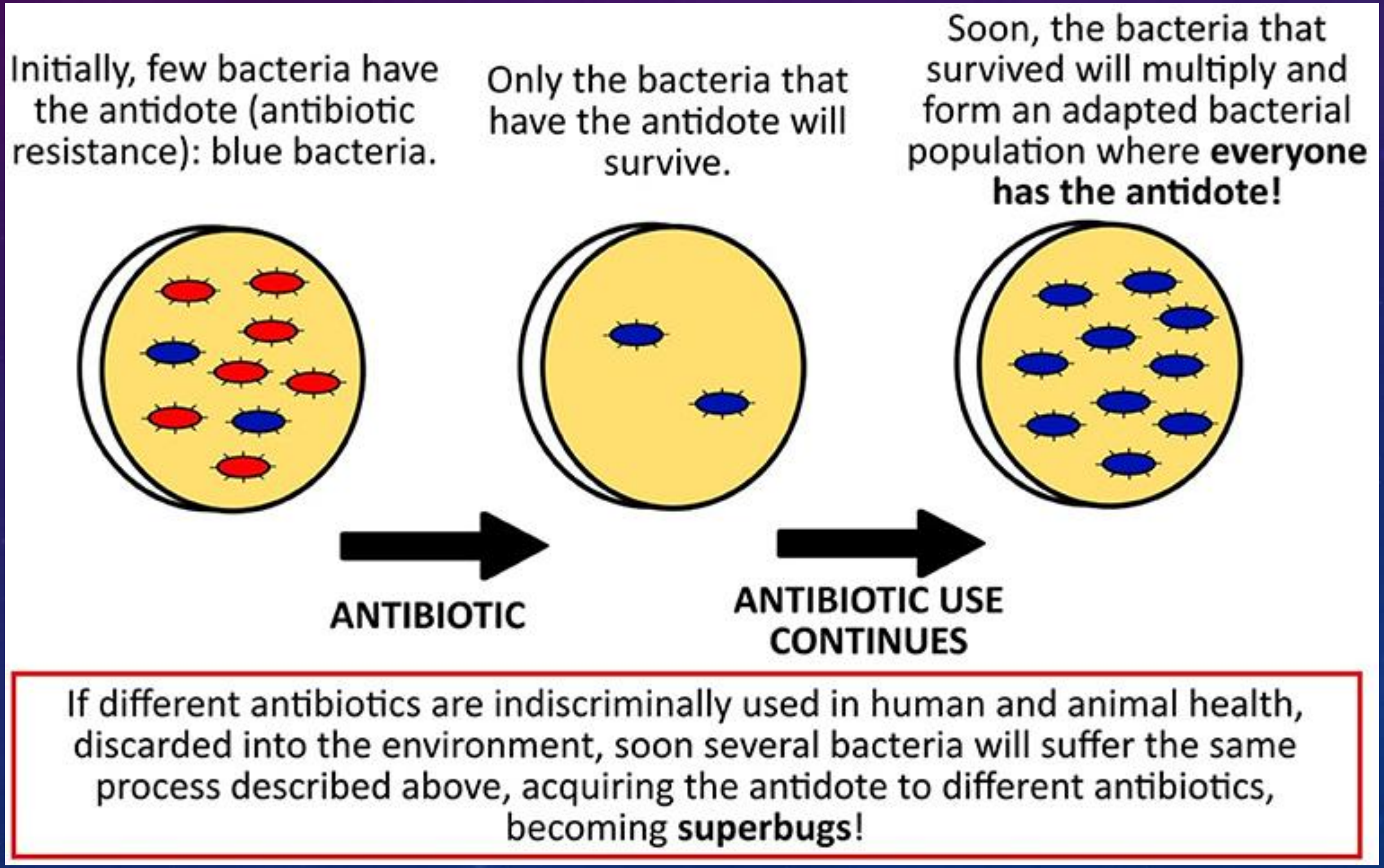
EVOLUTION

- **Insecticide/herbicide use**
- Insecticides or herbicides target specific organisms or traits and eliminate them.

EVOLUTION

HOW HUMANS AFFECT GENETIC DIVERSITY OF POPULATIONS

- **Antibiotic/antimicrobial cleaner use**



GENETIC ENGINEERING TECHNOLOGIES RISKS/BENEFITS

- CONNECTIONS + SOCIAL AND ENVIRONMENTAL CONTEXTS
  - STSE Biotechnology and Gene Pools
    - Artificial Selection
    - Transgenic Organisms
    - Cloning

EVOLUTION

- Test

EVOLUTION