BIOL2107, Spring '23

Lecture 6

Natural Selection: "the gradual process by which heritable biological traits become either more or less common in a population as a function of the effect of inherited traits on the differential reproductive success of organisms interacting with their environment"

Genetic drift: a random change in allelic frequency over time and appreciate this as being a key mechanism of evolutionary change.

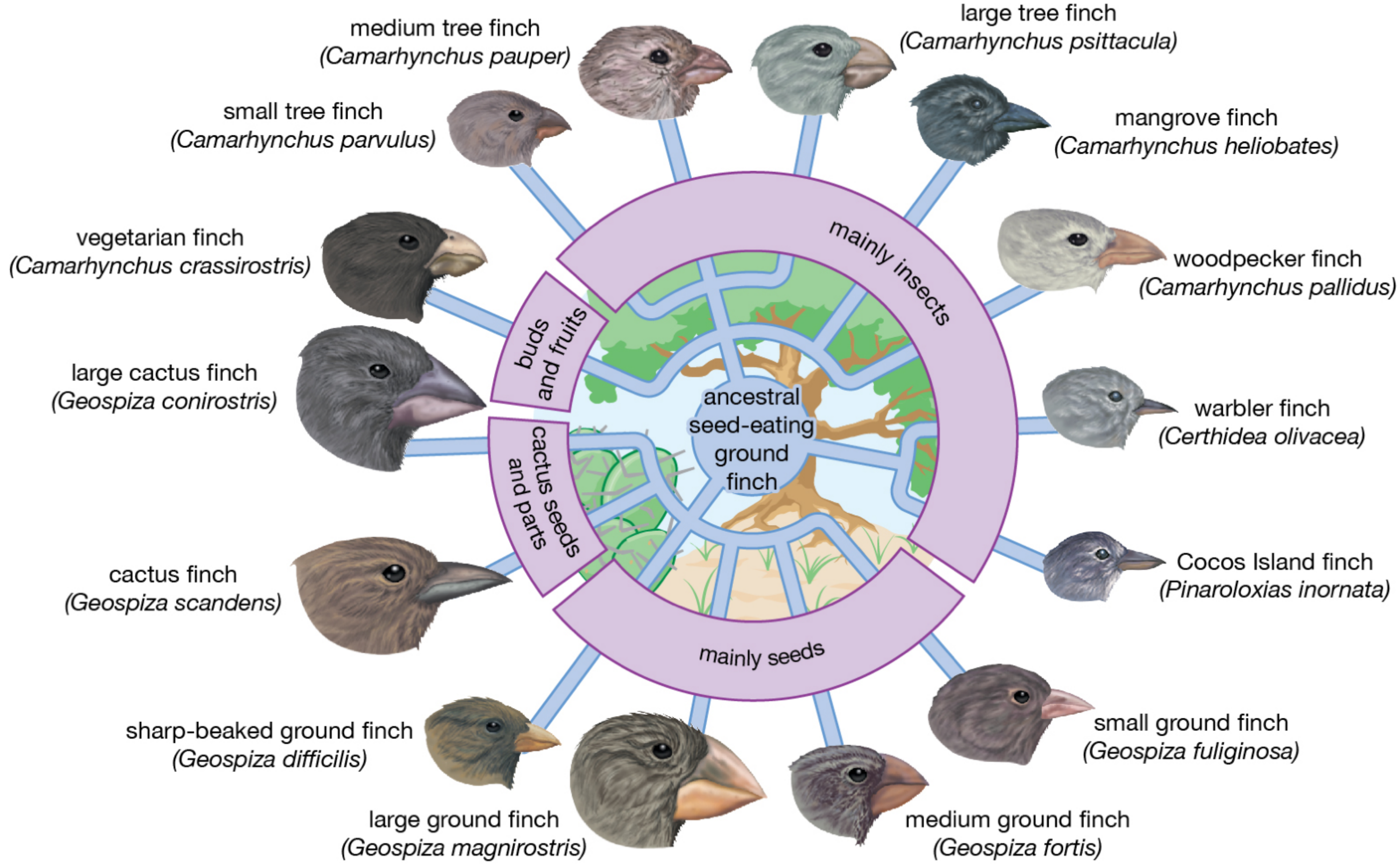
Gene flow is the intermingling of separate traits among similar, but distinct, populations. This increase occurs because individuals from other populations will bring in alleles that would otherwise be absent or rare (may be even lost) from the population that is being observed. In other words, gene flow **adds** variety to the gene pool.

Mutations: localized changes in the DNA blueprint that may or may not change the phenotypic characteristics, ultimately providing small changes in genes /alleles -see Genetic Drift

Variation in Speciation Rates.

Adaptive radiation is **a rapid increase in the number of species with a common ancestor**, characterized by great ecological and morphological diversity. The driving force behind it is the adaptation of organisms to new ecological contexts.

Adaptive radiation in Galapagos finches

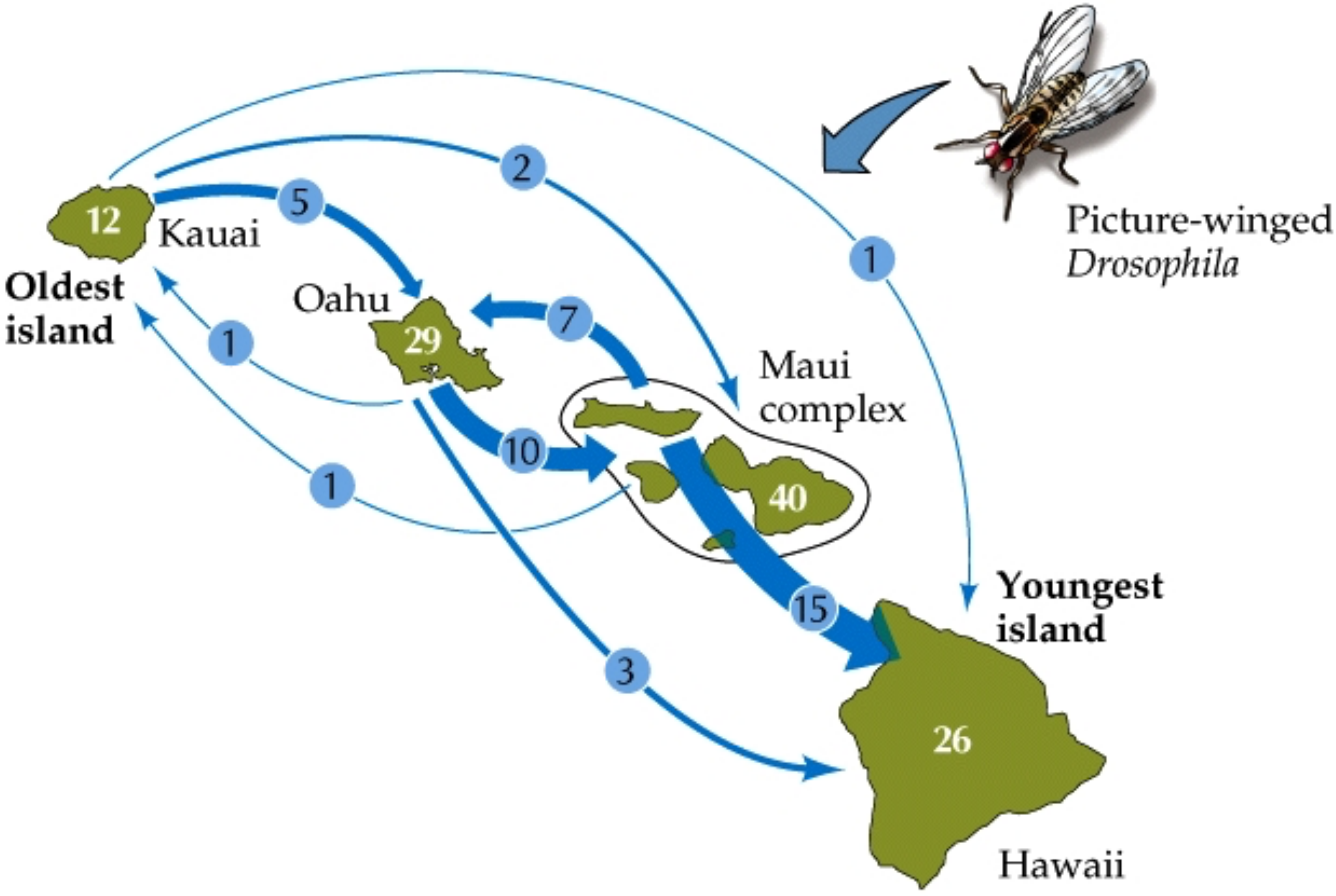


Variation in Speciation Rates.

Species need not be very different and may differ in relatively few genes.

Hawaiian Fruit Flies

Variation in Speciation Rates.



Variation in Speciation Rates.

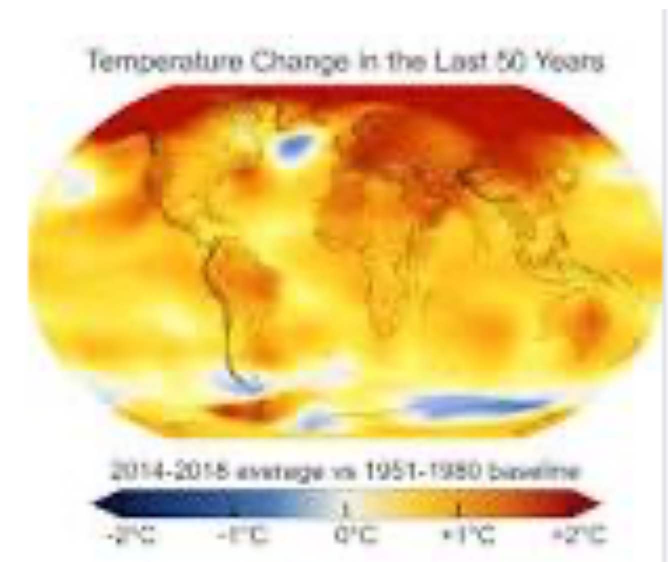
Behaviour may influence speciation rates

Populations of land snails may be separated by barriers as narrow as city streets, which -for the common garden snail- can be quite impressive barriers. Animals with complex behavior may speciate at a high rate because of choices of mates. Indeed, mate selection is probably a major contributor to rapid evolution as a consequence of reproductive isolation between species. Moreover. extremes of sexual selection: complex mating rituals, for example, may differentiate potential partners...parapatric speciation perhaps?

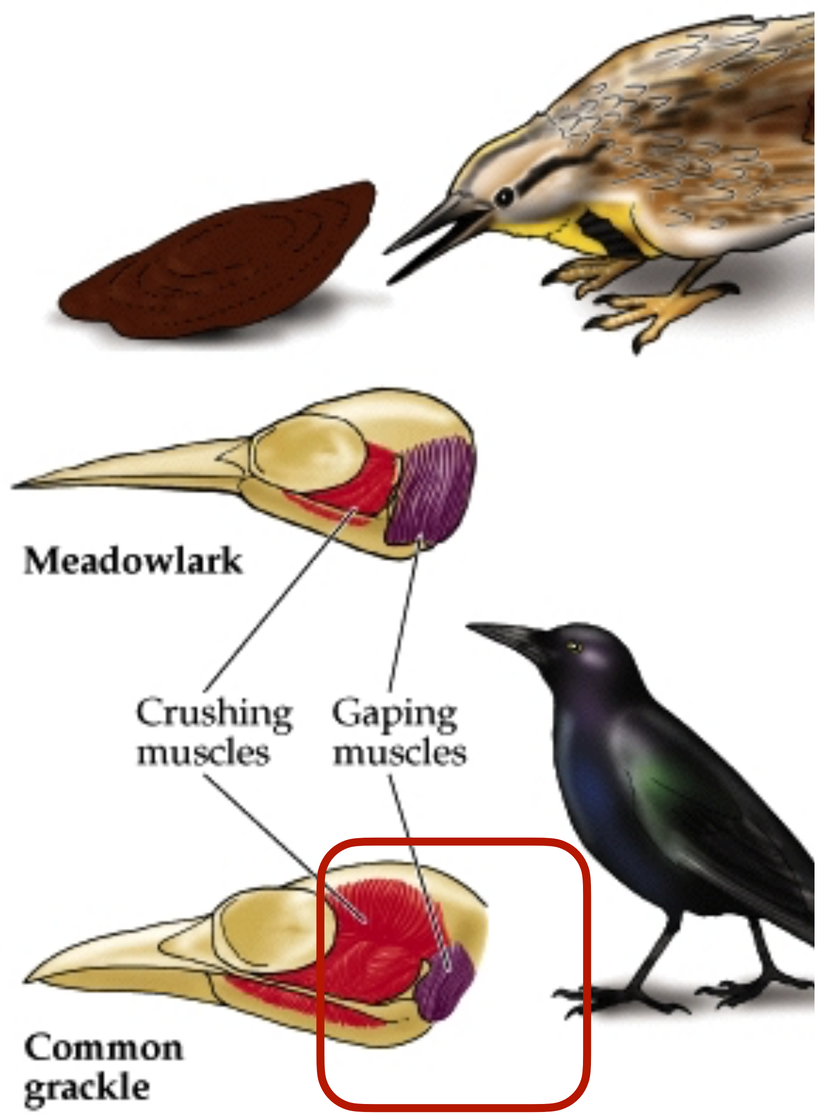
Population bottlenecks: the significant alteration in the gene pool, resulting form a **"bottlenecks"** or **"founder-effects"** change, may result in new adaptive changes (within the population) that result in more rapid speciation.

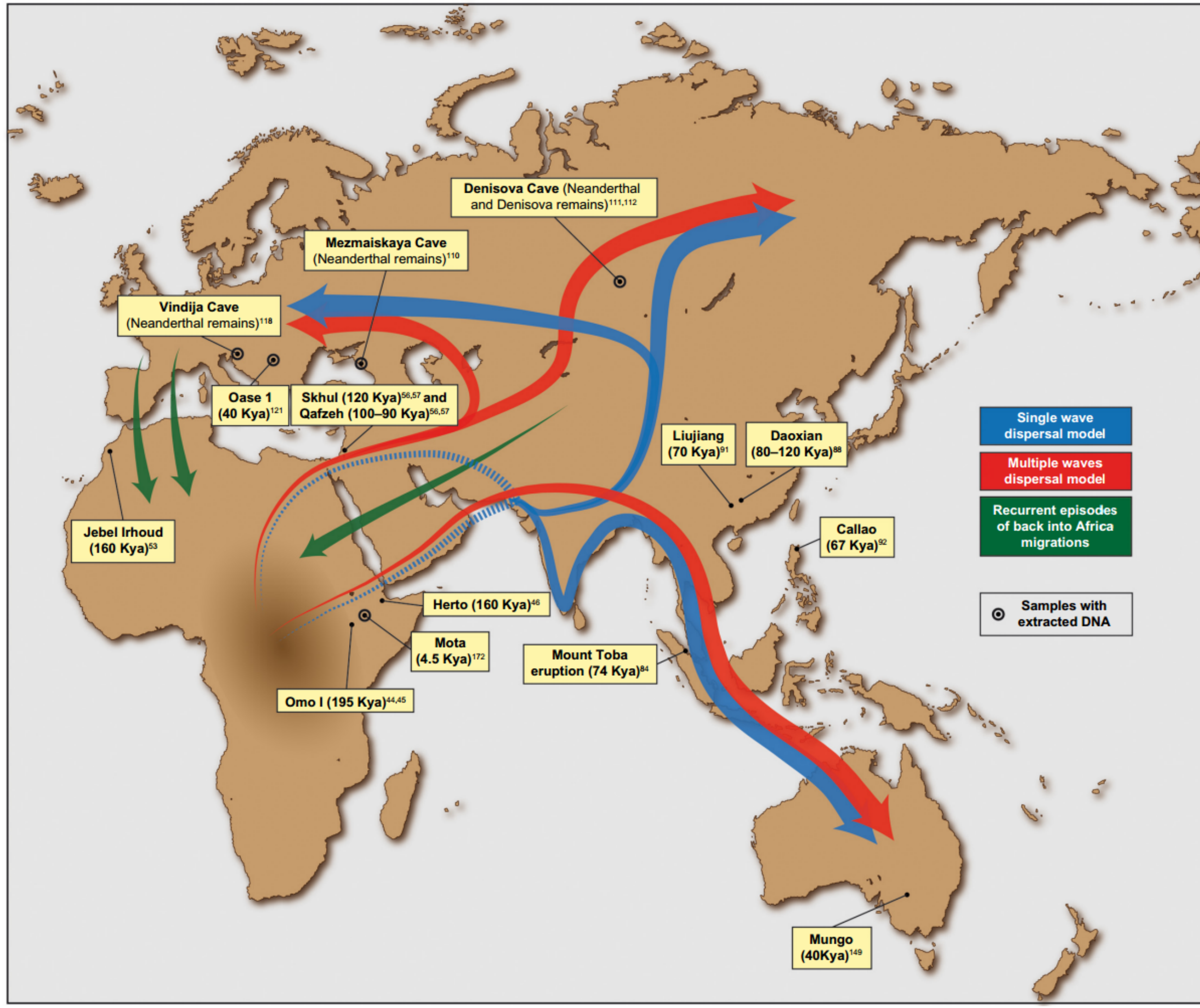
Environmental changes: may trigger high speciation rates. A climatic change in Africa from warm/wet to more rapid oscillations between warm/wet and cooler/drier conditions may result in a burst of changes.

Global warming



Variation in Speciation





Evolutionary lineages may al
to use the environment in a ne

Putative migration waves out of Africa and back migrations into the continent, as well as the locations of major ancient human remains and archeological sites (López et al.2015).

Variation in Speciation Rates.

Evolution of the Horseshoe Crab

Evolution

The horseshoe crab *(Limulus polyphemus)*, is the oldest living fossil in Maryland. Horseshoe Crabs evolved much earlier than humans or the Chesapeake Bay. **Fossils** of horseshoe crabs have been dated at 445 million years old.

They evolved in the shallow seas of the Paleozoic Era (540-248 million years ago) with other primitive **arthropods** called trilobites, a long extinct close relative of the horseshoe crab.

The age of the dinosaurs, Mezozoic Era, began about 200 million years ago. During this period, dinosaurs dominated the landscape as most species of marine reptiles became extinct. Also, the first mammals appeared.

At this time, the shallow seas around Europe were considered the dispersal point for ancestors of our modern day horseshoe crab species. At the end of the Era, a major **extinction** of the dinosaurs and about half of the planet's marine **invertebrates** occurred.

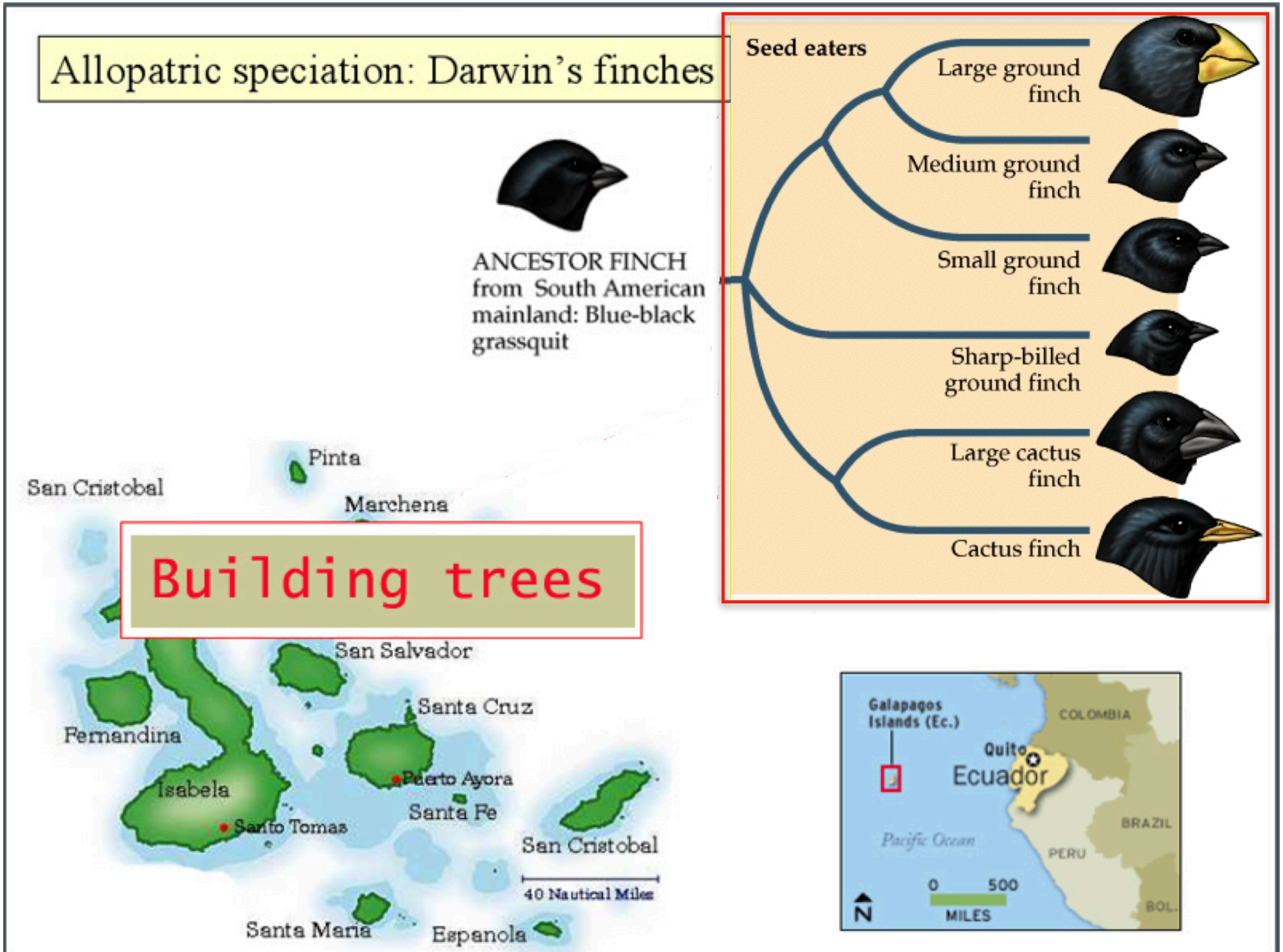
The Horseshoe Crab survived this time of change.

The Cenozoic Era ushered in the age of Mammals and Flowering Plants. Terrestrial and marine mammals evolved as did our large diversity of flowering plants. This era experienced several ice ages and the continents took their current form. Humans have flourished and still the horseshoe crab survives to this day.

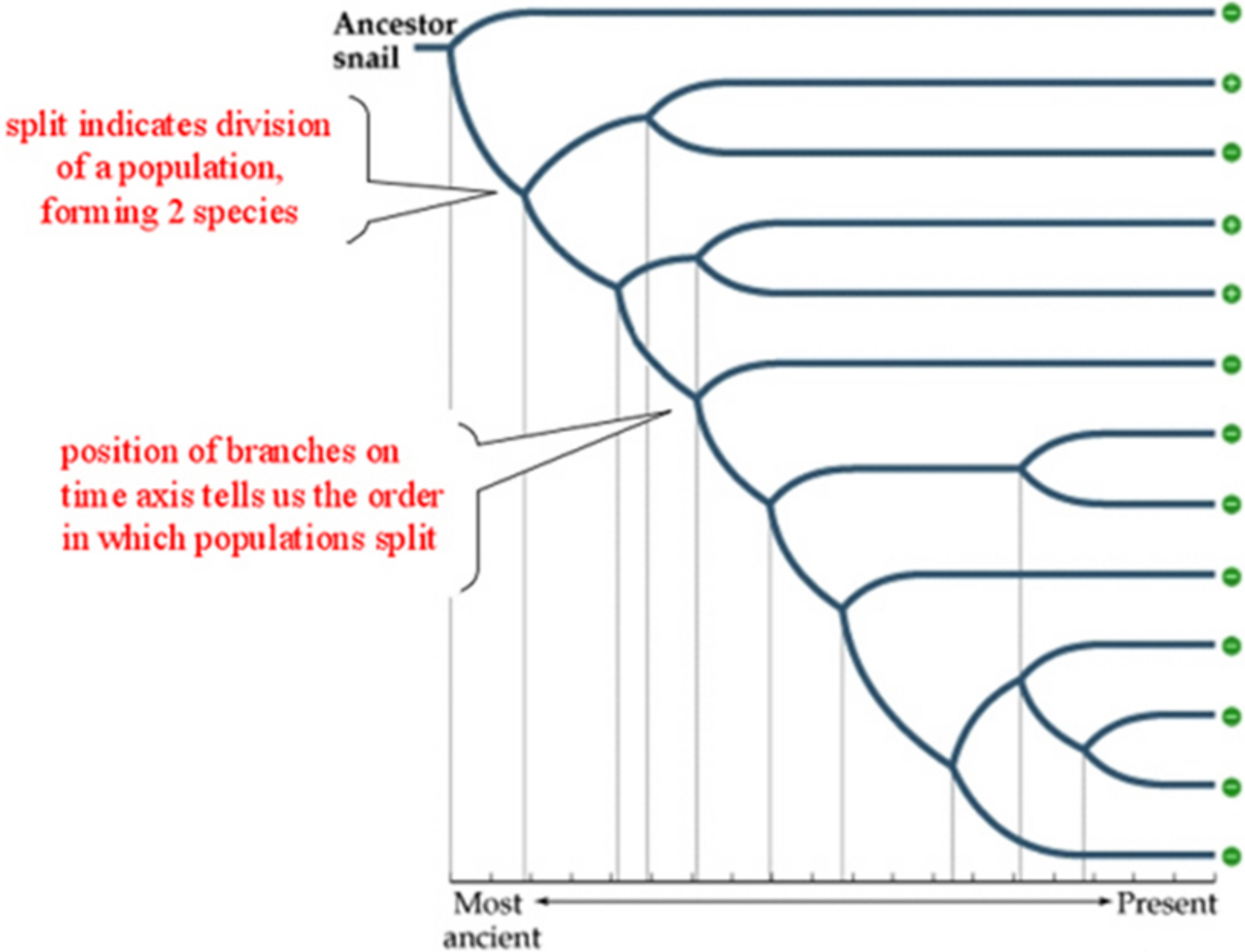
To learn more, visit the links on the left.

SPORT FISH RESTORATION

Peripatric ?

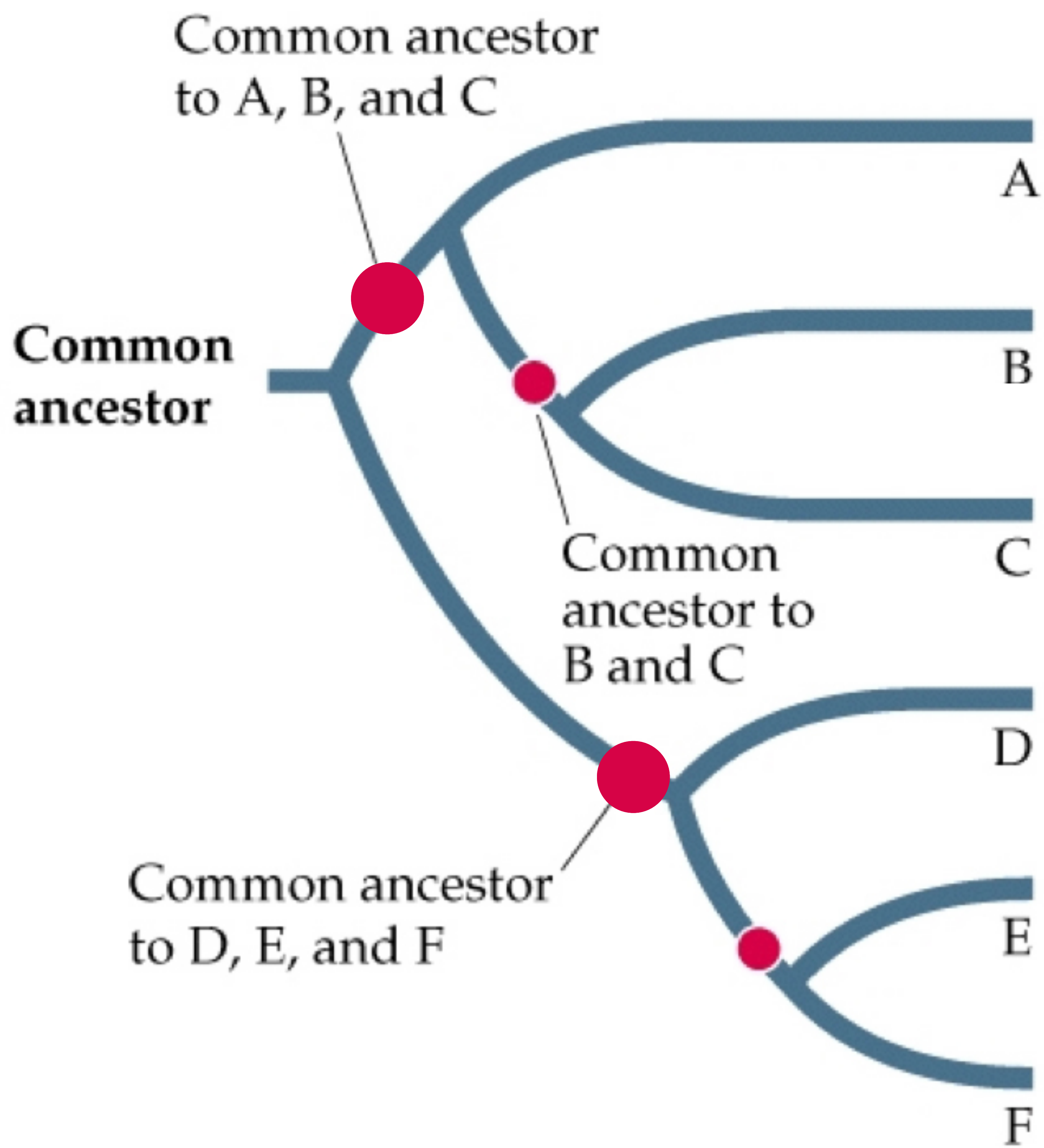


Allopatric speciation: Darwin's finches
ANCESTOR FINCH from South American mainland: Blue-black grassquit
Seed eaters
Large ground finch
Medium ground finch
Small ground finch
Sharp-billed ground finch
Large cactus finch
Cactus finch
Building trees
Pinta
San Cristobal
Marchena
San Salvador
Santa Cruz
Fernandina
Isabela
Puerto Ayora
Santo Tomas
Santa Fe
San Cristobal
40 Nautical Miles
Santa Maria
Espanola
Galapagos Islands (Ec.)
Quito
Ecuador
COLOMBIA
BRAZIL
PERU
Pacific Ocean
0 500
MILES
N
BOL.


Ancestor snail
split indicates division of a population, forming 2 species
position of branches on time axis tells us the order in which populations split
Most ancient
Present

Reading Phylogenies

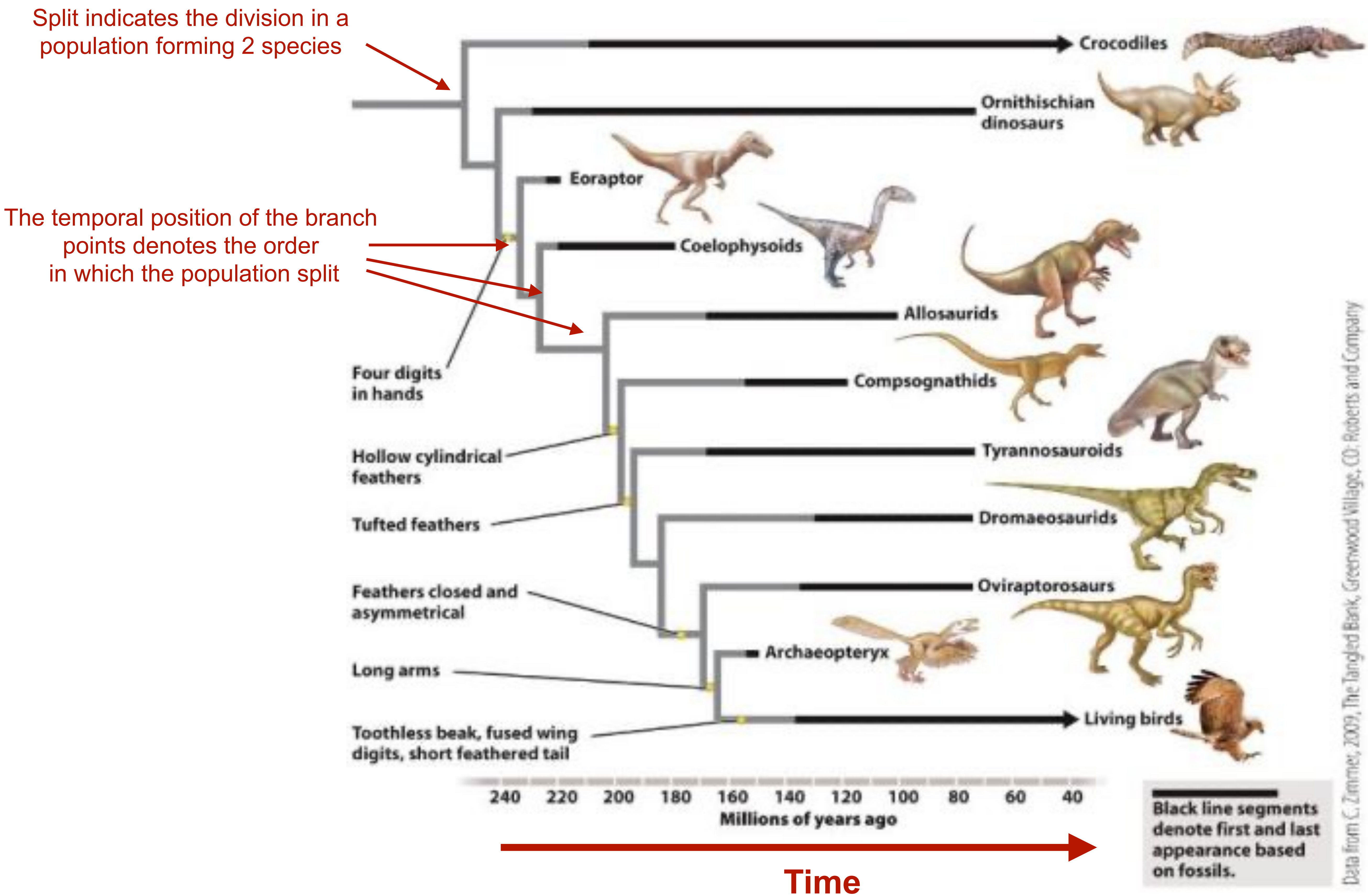
The evolutionary relationships among groups of organisms are commonly depicted as a branching tree called a phylogeny.



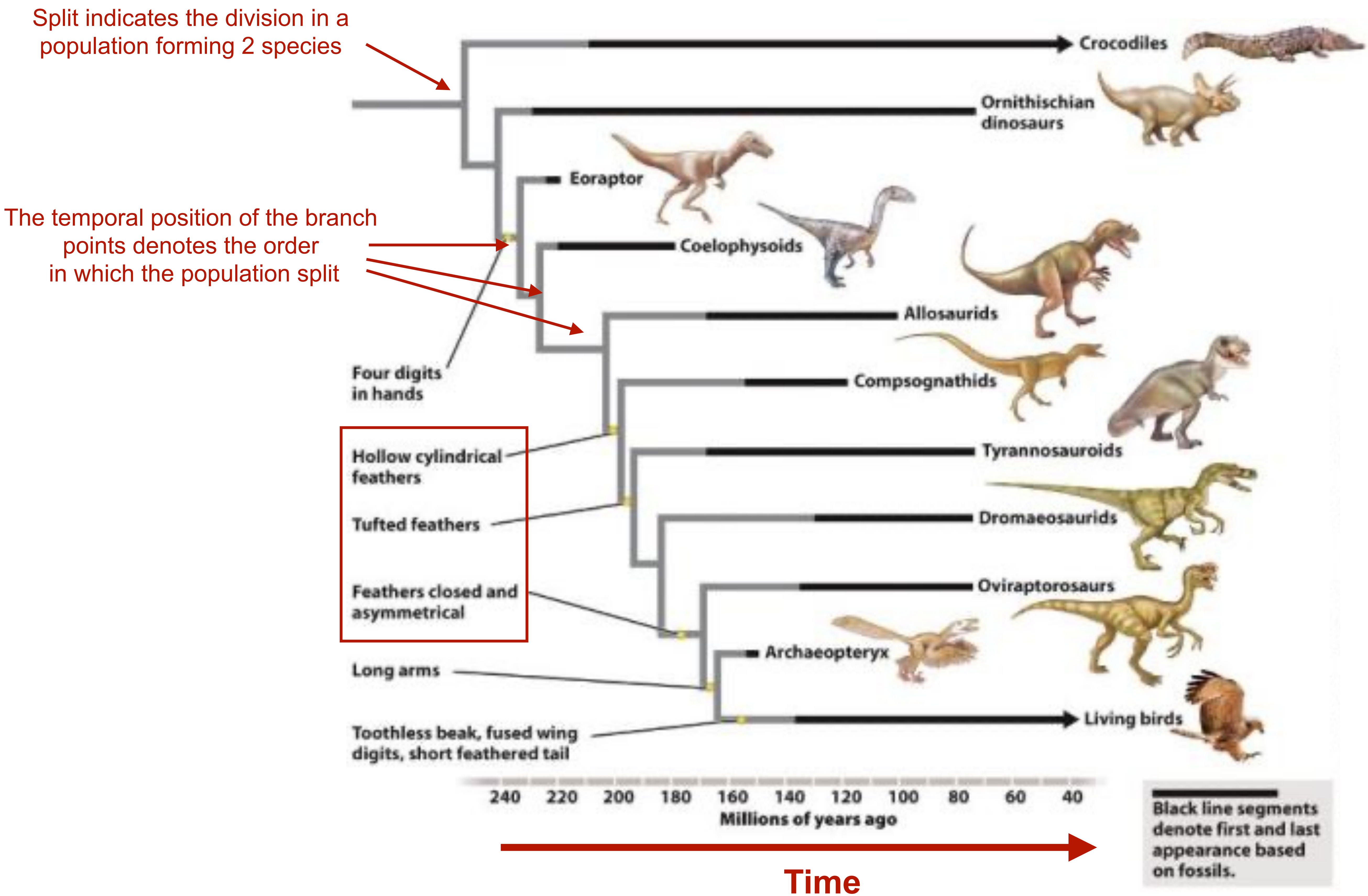
paraphyletic taxon: includes some but not all descendants of a single ancestor

polyphyletic taxon: contains members with more than one recent common ancestor

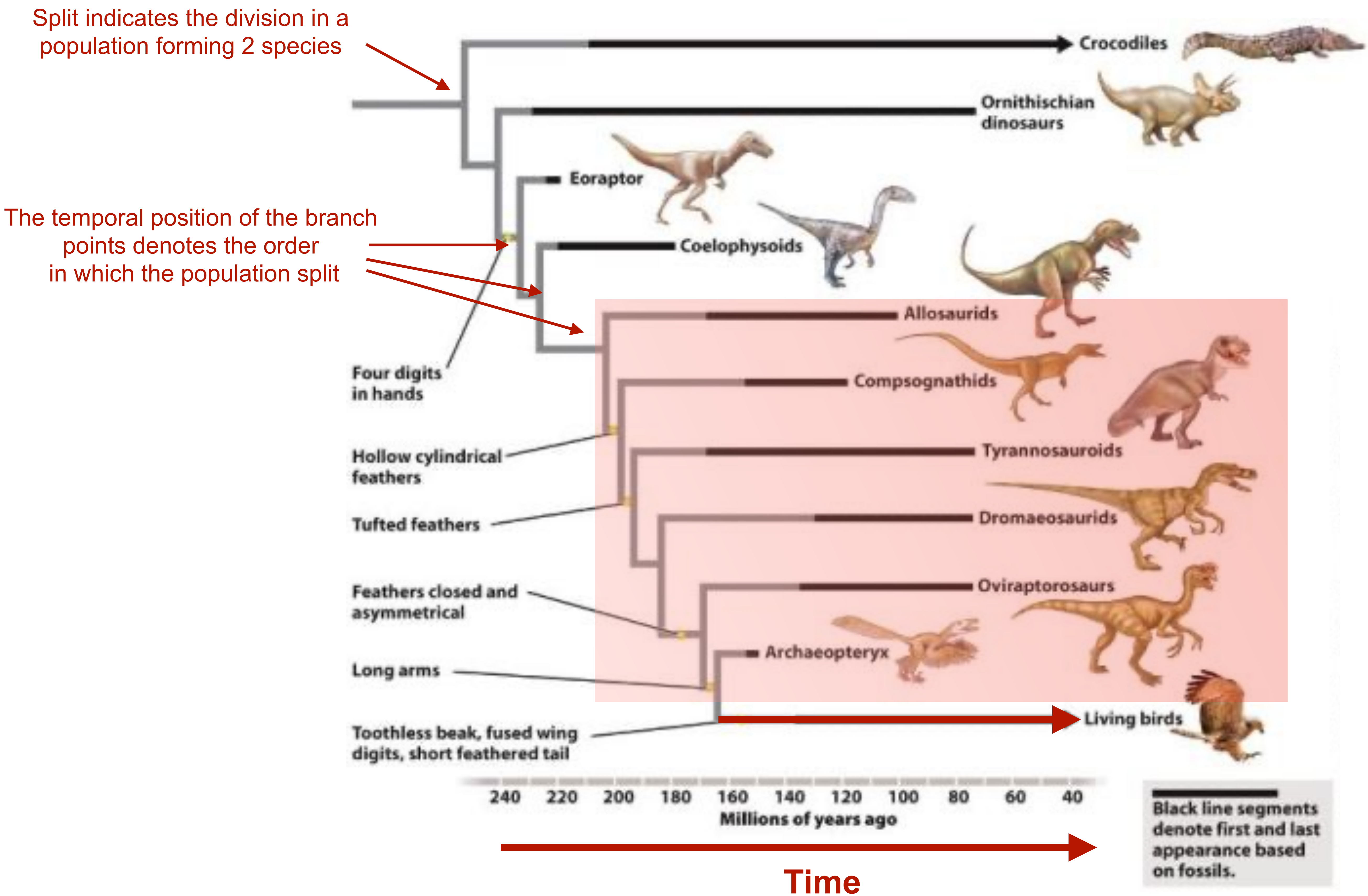
monophyletic taxon: includes all descendants of a single ancestor



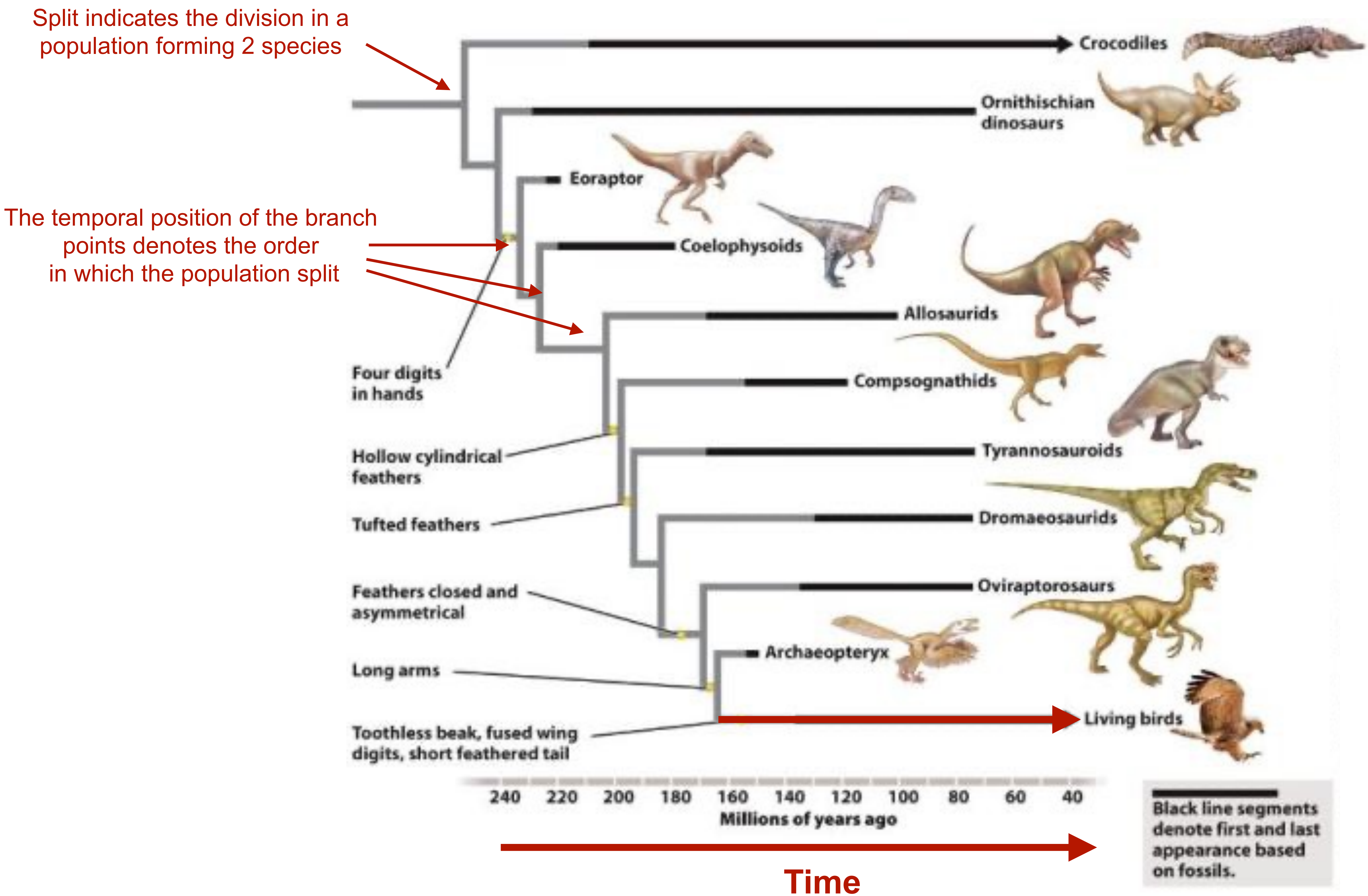
Dinosaur and Bird Phylogeny



Dinosaur and Bird Phylogeny (1 of 2)



Dinosaur and Bird Phylogeny (1 of 2)



Dinosaur and Bird Phylogeny (1 of 2)


Charmeleon

23.1 *Eight Vertebrates Ordered According to Unique Shared Derived Traits*

	DERIVED TRAIT[a]						
TAXON	JAWS	LUNGS	CLAWS OR NAILS	FEATHERS	FUR	MAMMARY GLANDS	FOUR-CHAMBERED HEART
Hagfish	–	–	–	–	–	–	–
Perch	+	–	–	–	–	–	–
Salamander	+	+	–	–	–	–	–
Lizard	+	+	+	–	–	–	–
Crocodile	+	+	+	–	–	–	+
Pigeon	+	+	+	+	–	–	+
Mouse	+	+	+	–	+	+	+
Chimpanzee	+	+	+	–	+	+	+

[a] A plus sign indicates the trait is present, a minus sign that it is absent.

"Operational Taxonomic Unit"… OTU

23.1 Eight Vertebrates Ordered According to Unique Shared Derived Traits

TAXON	DERIVED TRAIT[a]						
	JAWS	LUNGS	CLAWS OR NAILS	FEATHERS	FUR	MAMMARY GLANDS	FOUR-CHAMBERED HEART
Hagfish	–	–	–	–	–	–	–
Perch	+	–	–	–	–	–	–
Salamander	+	+	–	–	–	–	–
Lizard	+	+	+	–	–	–	–
Crocodile	+	+	+	–	–	–	+
Pigeon	+	+	+	+	–	–	+
Mouse	+	+	+	–	+	+	+
Chimpanzee	+	+	+	–	+	+	+

[a] A plus sign indicates the trait is present, a minus sign that it is absent.

"Operational Taxonomic Unit"… OTU

23.1 Eight Vertebrates Ordered According to Unique Shared Derived Traits

TAXON	DERIVED TRAIT[a] JAWS	LUNGS	CLAWS OR NAILS	FEATHERS	FUR	MAMMARY GLANDS	FOUR-CHAMBERED HEART
Hagfish	–	–	–	–	–	–	–
Perch	+	–	–	–	–	–	–
Salamander	+	+	–	–	–	–	–
Lizard	+	+	+	–	–	–	–
Crocodile	+	+	+	–	–	–	+
Pigeon	+	+	+	+	–	–	+
Mouse	+	+	+	–	+	+	+
Chimpanzee	+	+	+	–	+	+	+

[a]A plus sign indicates the trait is present, a minus sign that it is absent.

"Operational Taxonomic Unit"… OTU

23.1 *Eight Vertebrates Ordered According to Unique Shared Derived Traits*

TAXON	DERIVED TRAIT[a]						
	JAWS	LUNGS	CLAWS OR NAILS	FEATHERS	FUR	MAMMARY GLANDS	FOUR-CHAMBERED HEART
Hagfish	–	–	–	–	–	–	–
Perch	+	–	–	–	–	–	–
Salamander	+	+	–	–	–	–	–
Lizard	+	+	+	–	–	–	–
Crocodile	+	+	+	–	–	–	+
Pigeon	+	+	+	+	–	–	+
Mouse	+	+	+	–	+	+	+
Chimpanzee	+	+	+	–	+	+	+

[a]A plus sign indicates the trait is present, a minus sign that it is absent.

"Operational Taxonomic Unit"… OTU

23.1 *Eight Vertebrates Ordered According to Unique Shared Derived Traits*

	DERIVED TRAIT[a]						
TAXON	JAWS	LUNGS	CLAWS OR NAILS	FEATHERS	FUR	MAMMARY GLANDS	FOUR-CHAMBERED HEART
Hagfish	–	–	–	–	–	–	–
Perch	+	–	–	–	–	–	–
Salamander	+	+	–	–	–	–	–
Lizard	+	+	+	–	–	–	–
Crocodile	+	+	+	–	–	–	+
Pigeon	+	+	+	+	–	–	+
Mouse	+	+	+	–	+	+	+
Chimpanzee	+	+	+	–	+	+	+

[a]A plus sign indicates the trait is present, a minus sign that it is absent.

"Operational Taxonomic Unit"… OTU

23.1 *Eight Vertebrates Ordered According to Unique Shared Derived Traits*

TAXON	DERIVED TRAIT[a]						
	JAWS	LUNGS	CLAWS OR NAILS	FEATHERS	FUR	MAMMARY GLANDS	FOUR-CHAMBERED HEART
Hagfish	–	–	–	–	–	–	–
Perch	+	–	–	–	–	–	–
Salamander	+	+	–	–	–	–	–
Lizard	+	+	+	–	–	–	–
Crocodile	+	+	+	–	–	–	+
Pigeon	+	+	+	+	–	–	+
Mouse	+	+	+	–	+	+	+
Chimpanzee	+	+	+	–	+	+	+

[a] A plus sign indicates the trait is present, a minus sign that it is absent.

"Operational Taxonomic Unit"… OTU

23.1 Eight Vertebrates Ordered According to Unique Shared Derived Traits

TAXON	JAWS	LUNGS	CLAWS OR NAILS	FEATHERS	FUR	MAMMARY GLANDS	FOUR-CHAMBERED HEART
	DERIVED TRAIT[a]						
Hagfish	–	–	–	–	–	–	–
Perch	+	–	–	–	–	–	–
Salamander	+	+	–	–	–	–	–
Lizard	+	+	+	–	–	–	–
Crocodile	+	+	+	–	–	–	+
Pigeon	+	+	+	+	–	–	+
Mouse	+	+	+	–	+	+	+
Chimpanzee	+	+	+	–	+	+	+

[a] A plus sign indicates the trait is present, a minus sign that it is absent.

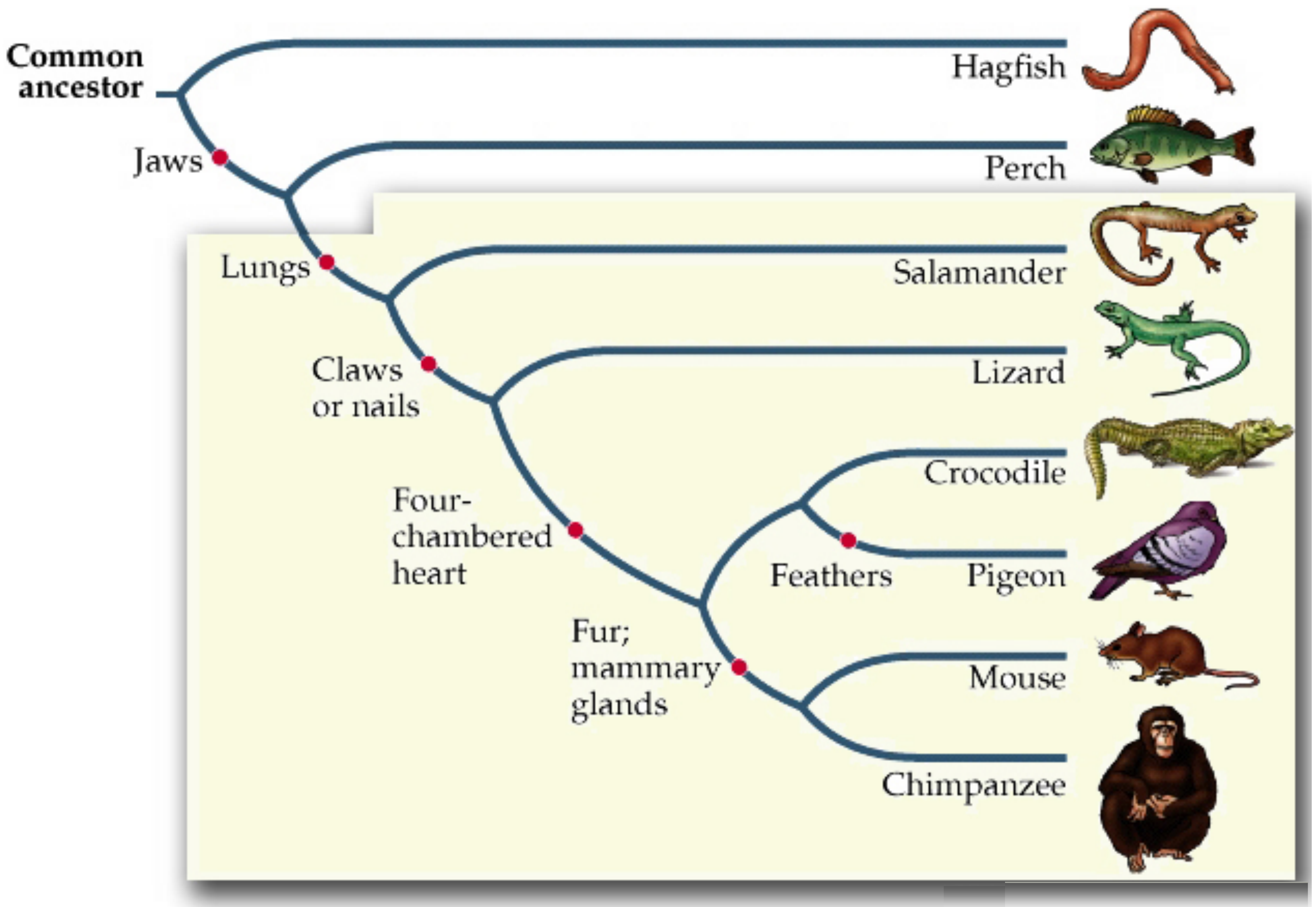
"Operational Taxonomic Unit"… OTU

23.1 Eight Vertebrates Ordered According to Unique Shared Derived Traits

TAXON	DERIVED TRAIT[a]						
	JAWS	LUNGS	CLAWS OR NAILS	FEATHERS	FUR	MAMMARY GLANDS	FOUR-CHAMBERED HEART
Hagfish	–	–	–	–	–	–	–
Perch	+	–	–	–	–	–	–
Salamander	+	+	–	–	–	–	–
Lizard	+	+	+	–	–	–	–
Crocodile	+	+	+	–	–	–	+
Pigeon	+	+	+	+	–	–	+
Mouse	+	+	+	–	+	+	+
Chimpanzee	+	+	+	–	+	+	+

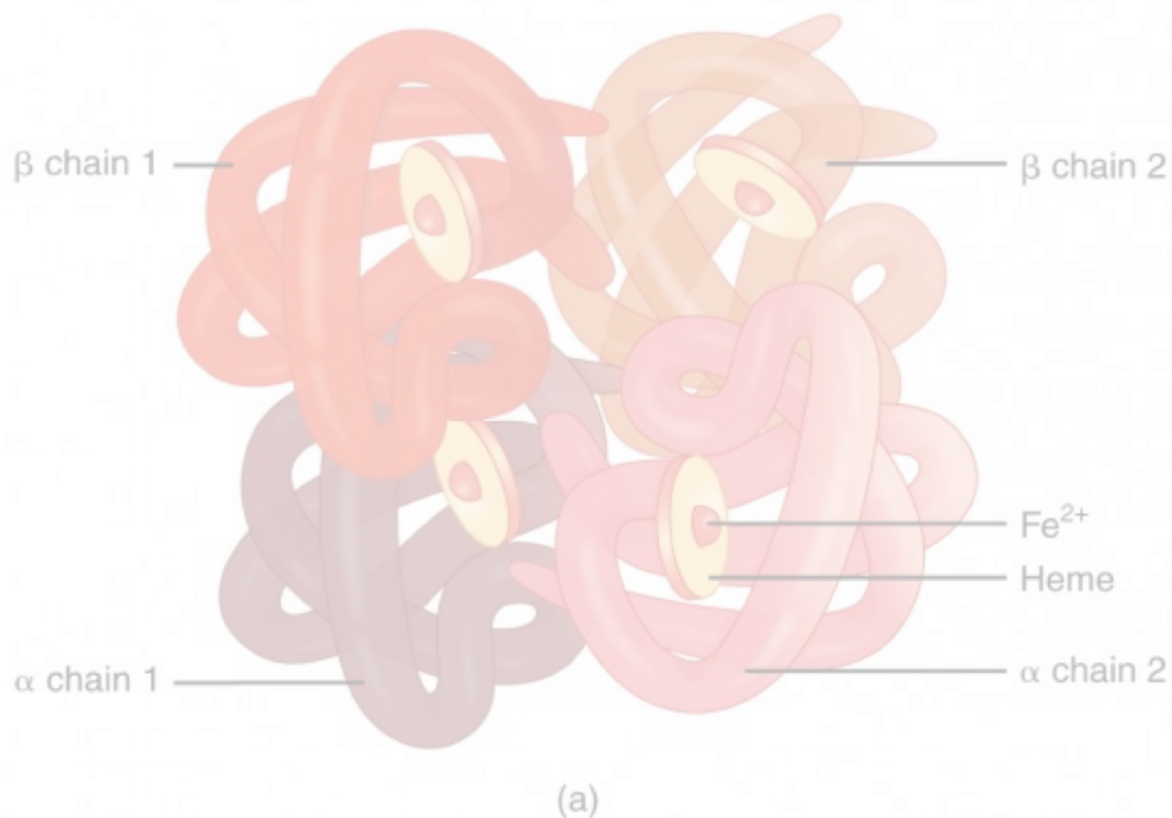
[a]A plus sign indicates the trait is present, a minus sign that it is absent.

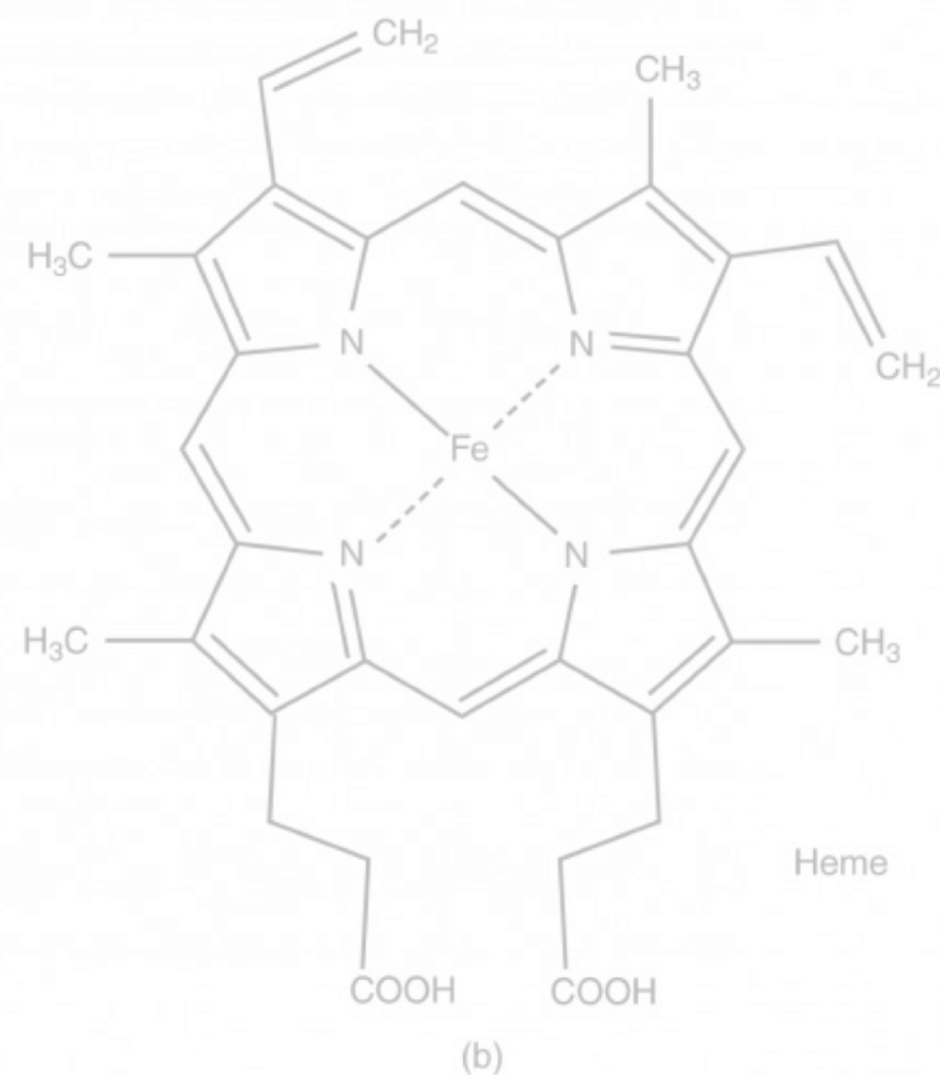
"Operational Taxonomic Unit"… OTU

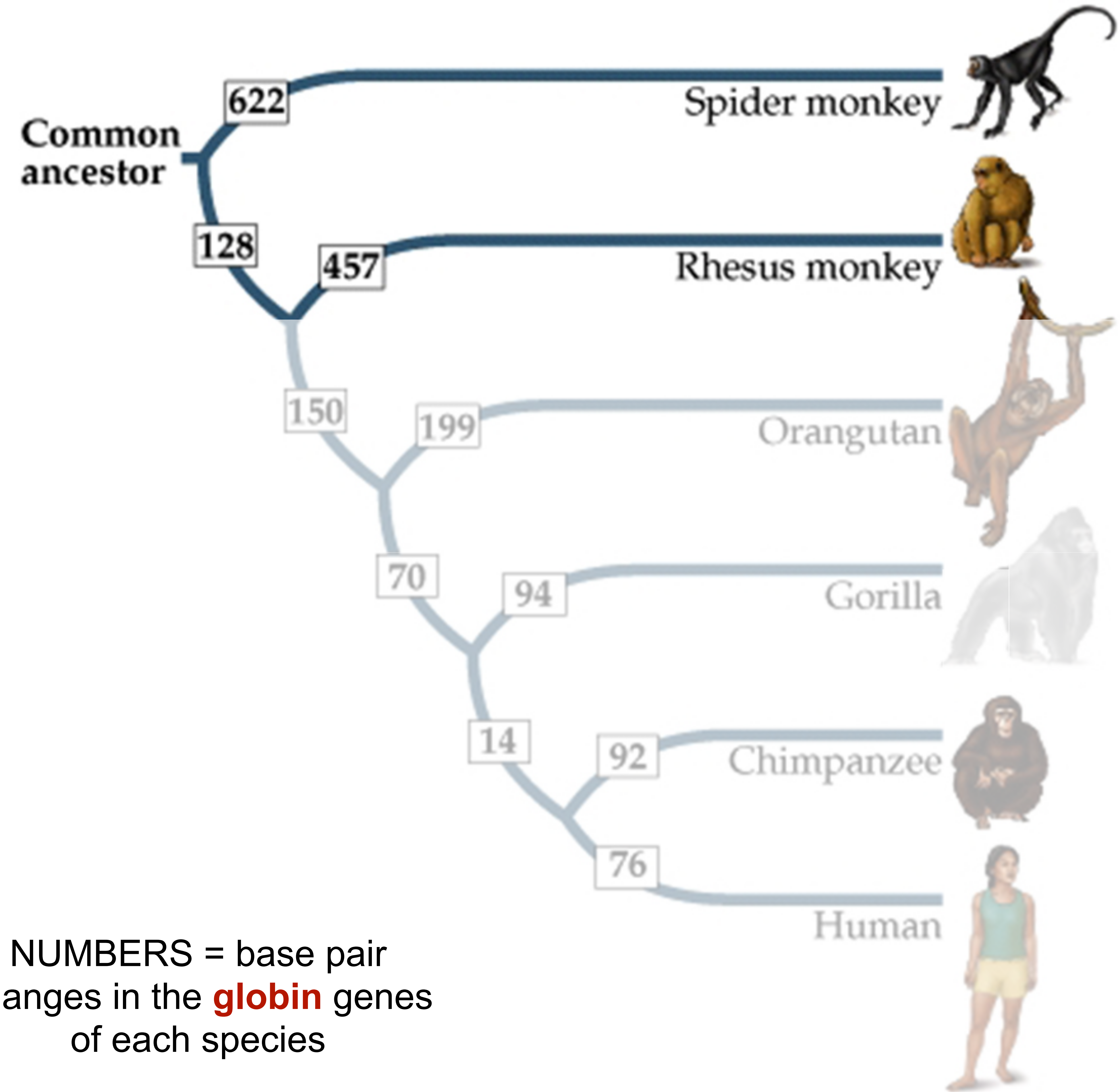


“Operational Taxonomic Unit”… OTU

"Operational Taxonomic Unit"… OTU



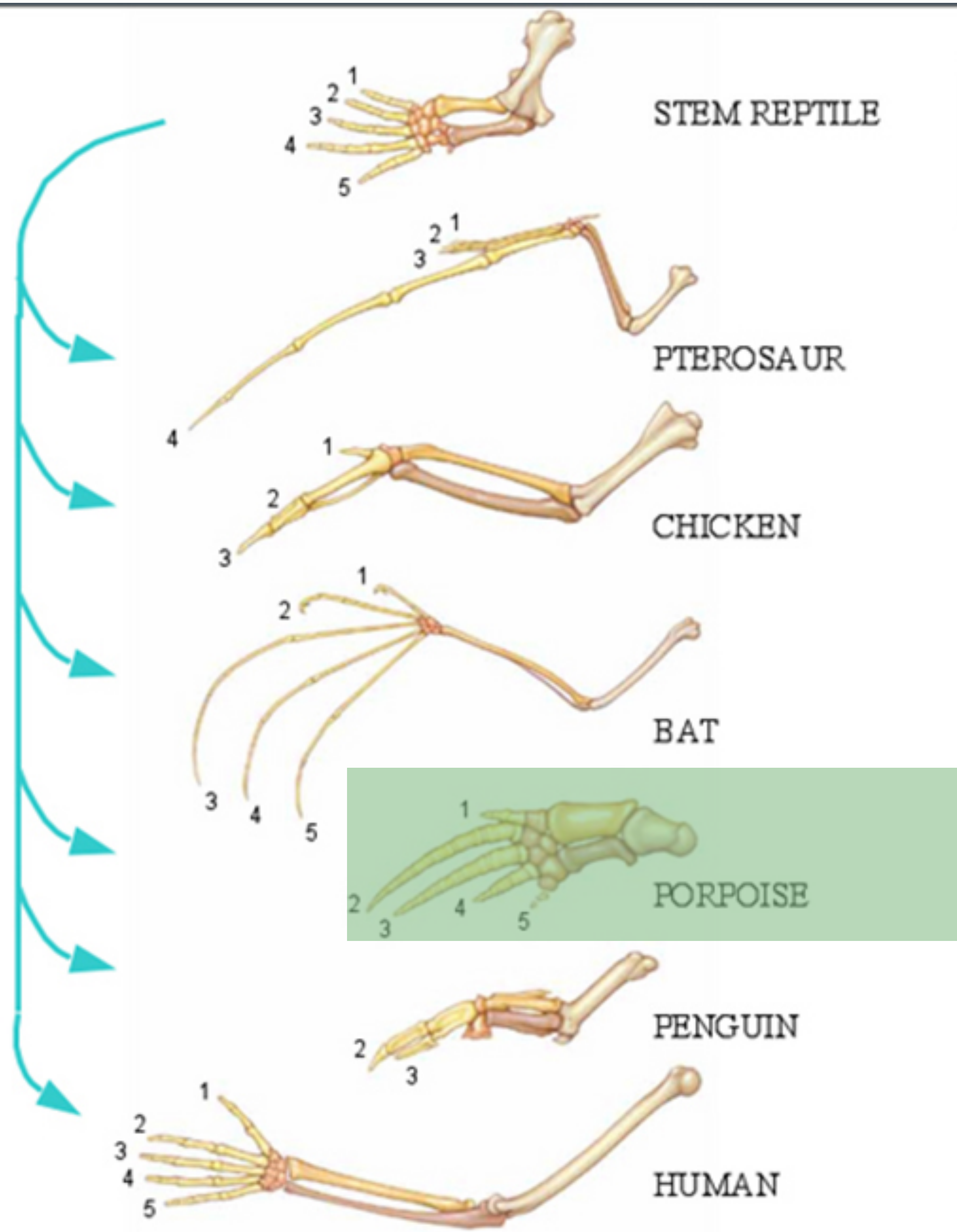


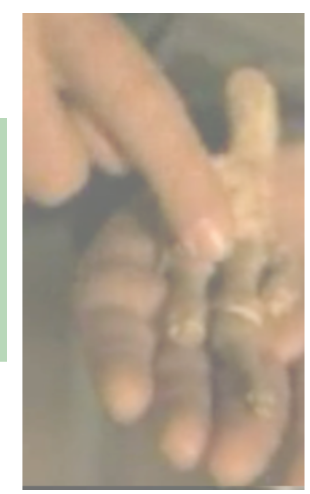


NUMBERS = base pair changes in the **globin** genes of each species

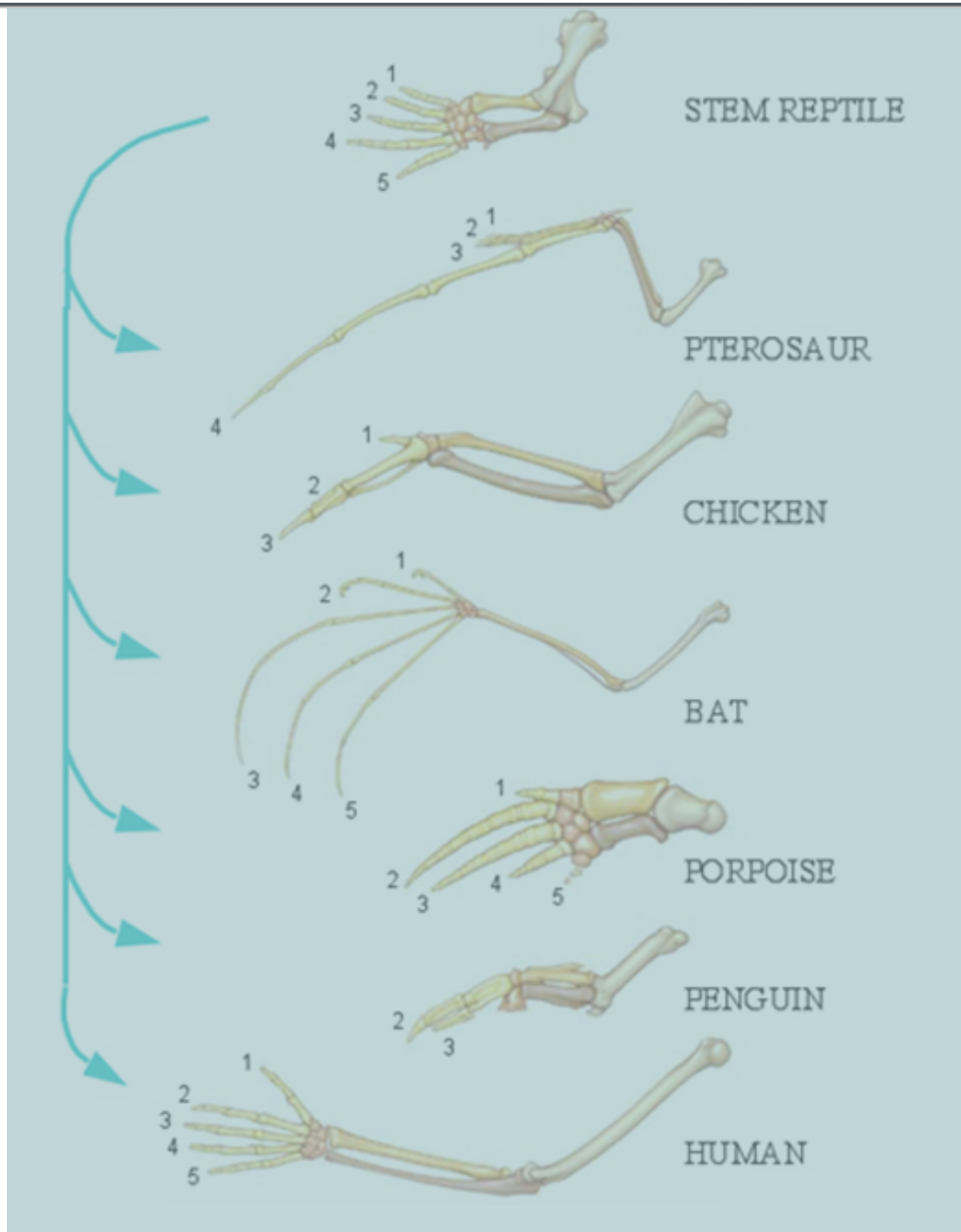
Fossil Records…

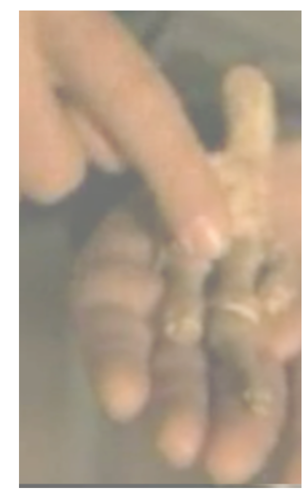
Divergent evolution



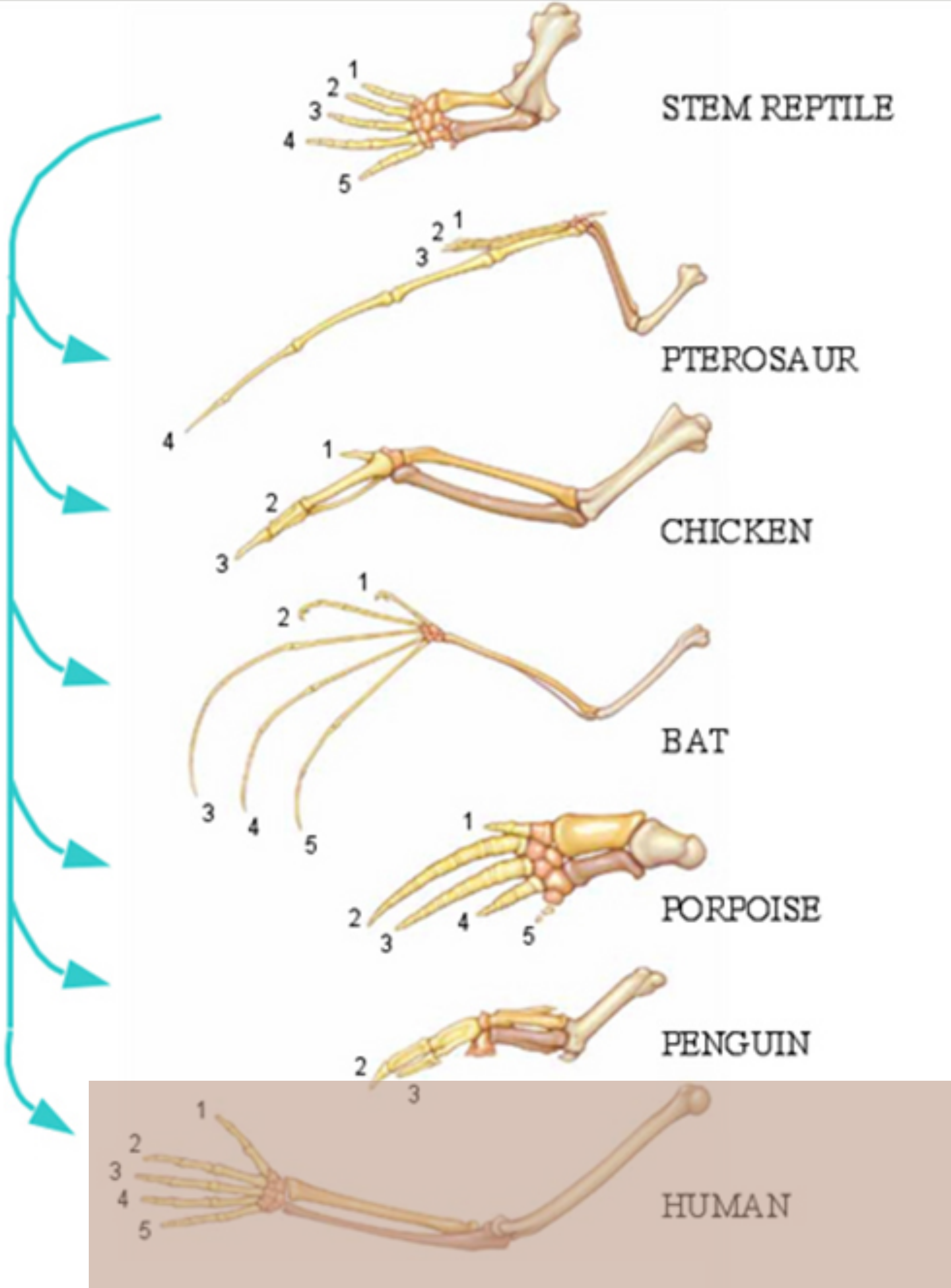


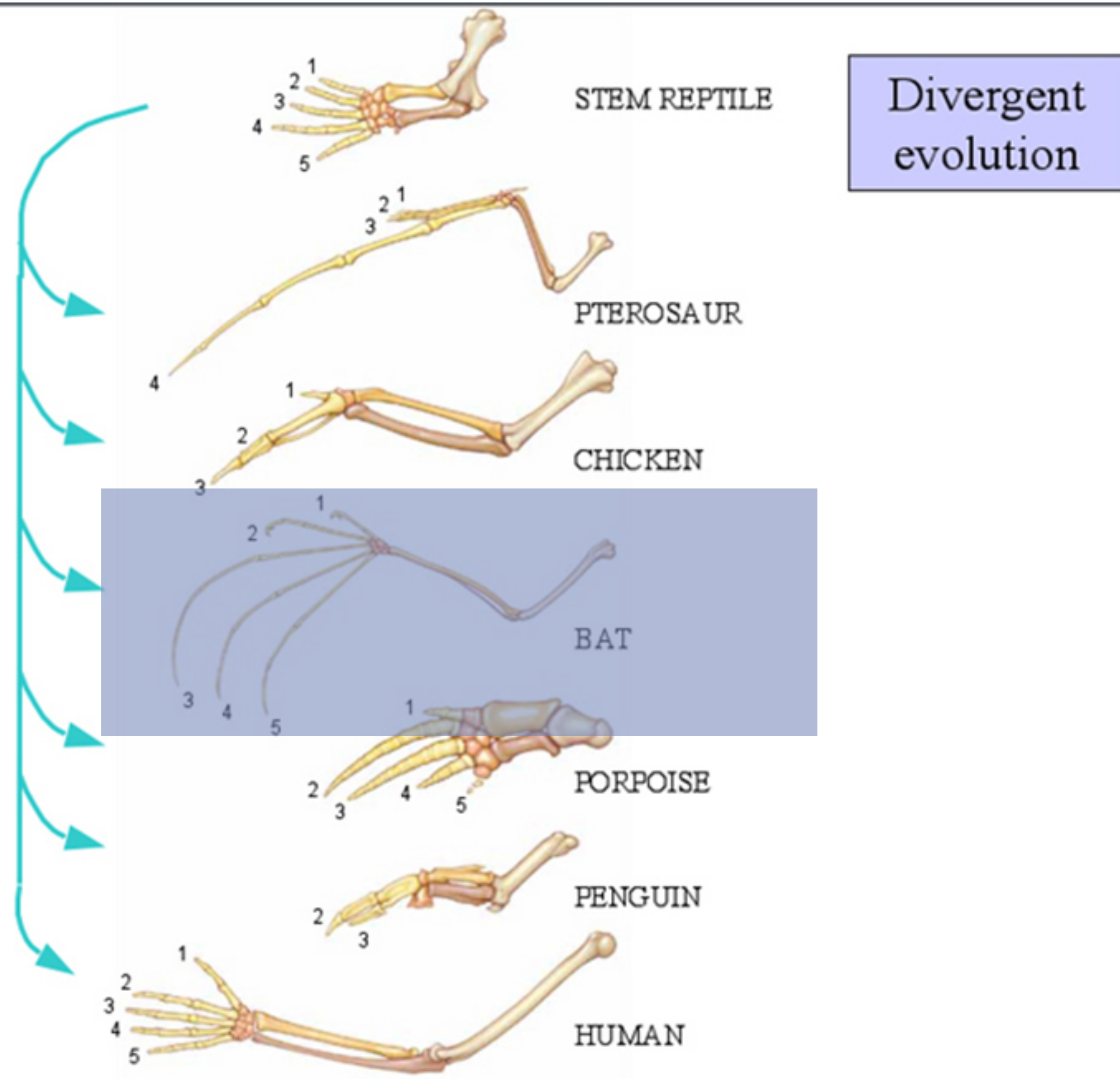
Divergent evolution



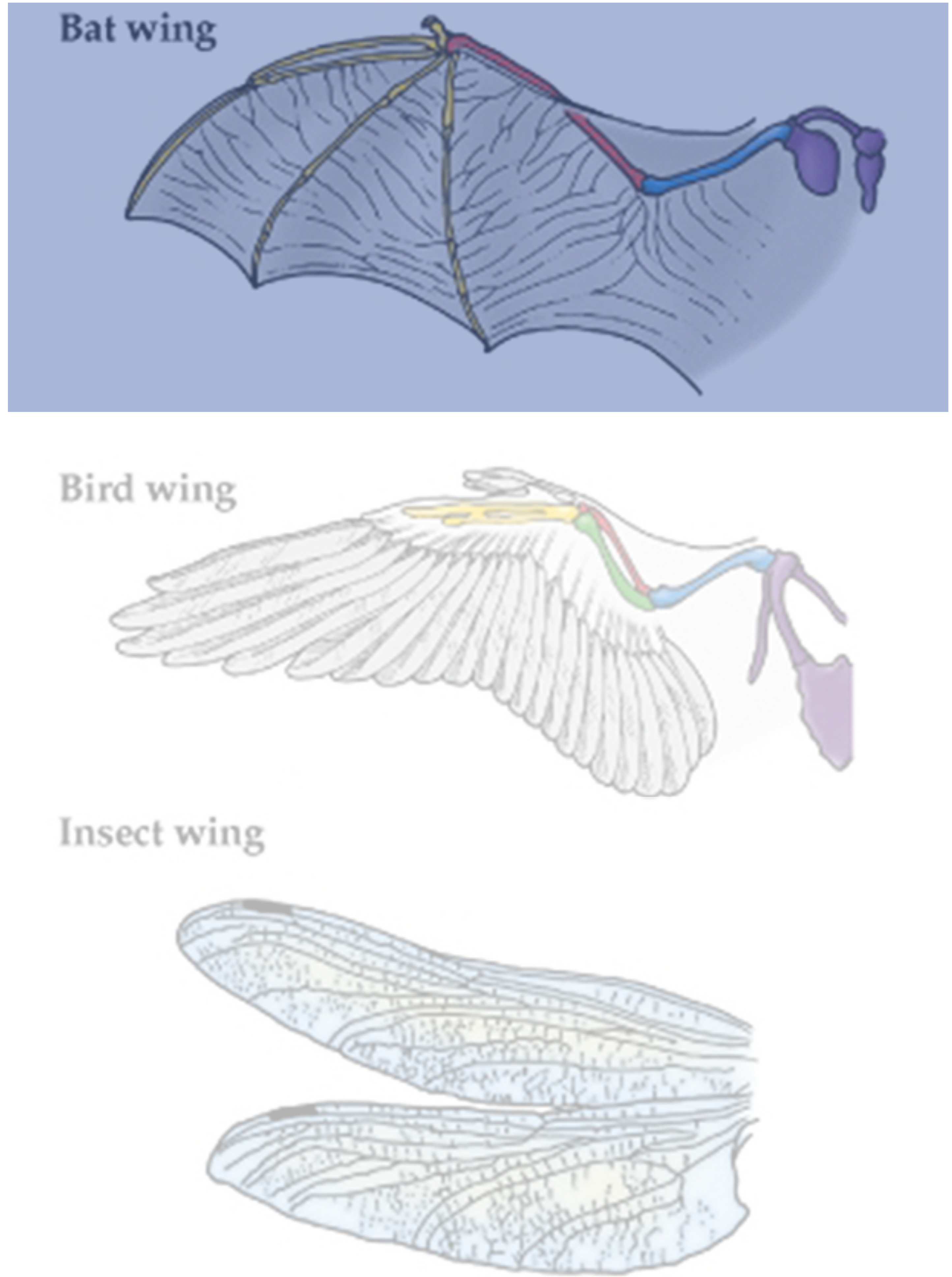


Divergent evolution

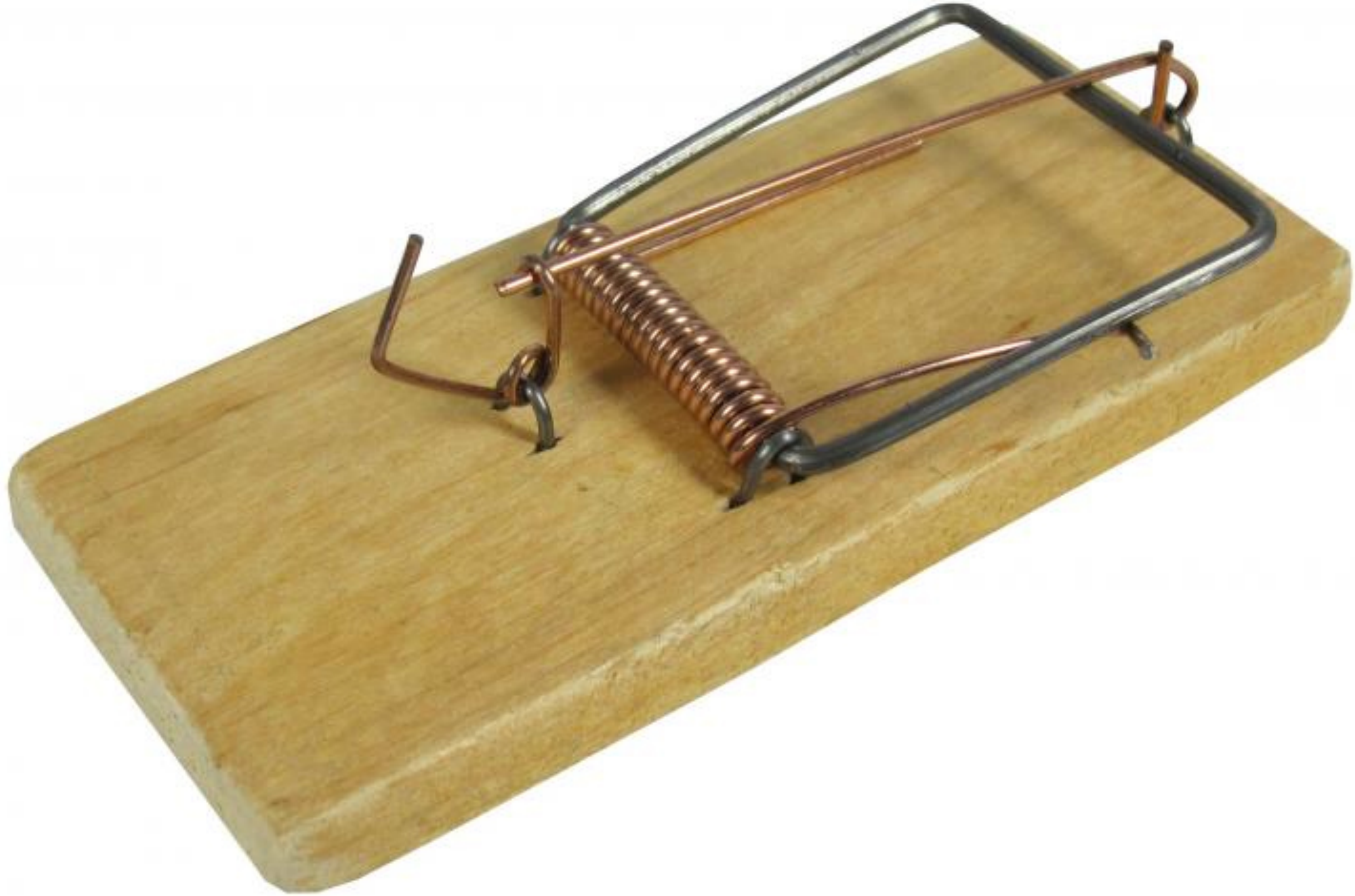




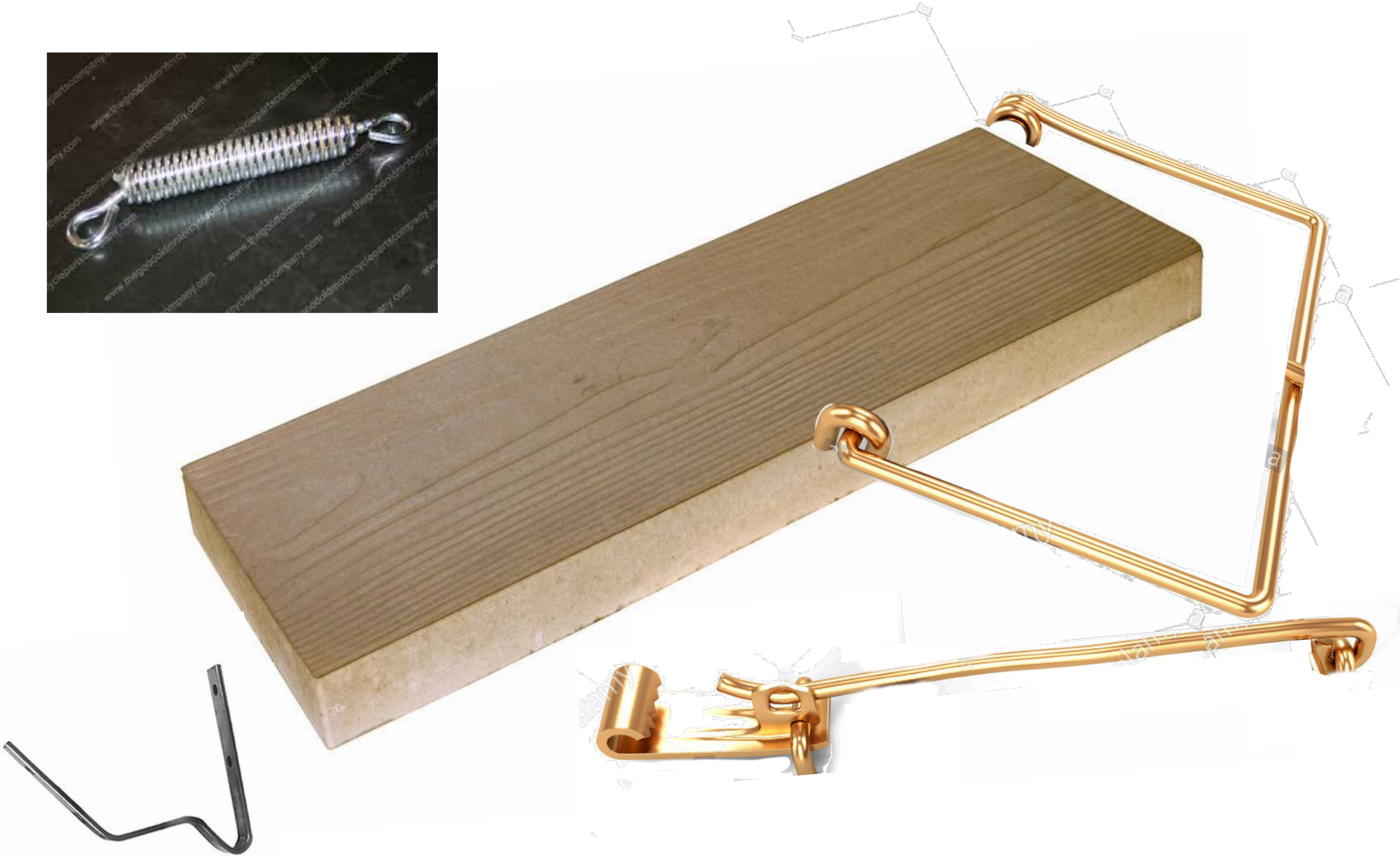
Divergent evolution
STEM REPTILE
PTEROSAUR
CHICKEN
BAT
PORPOISE
PENGUIN
HUMAN



Convergent Evolution

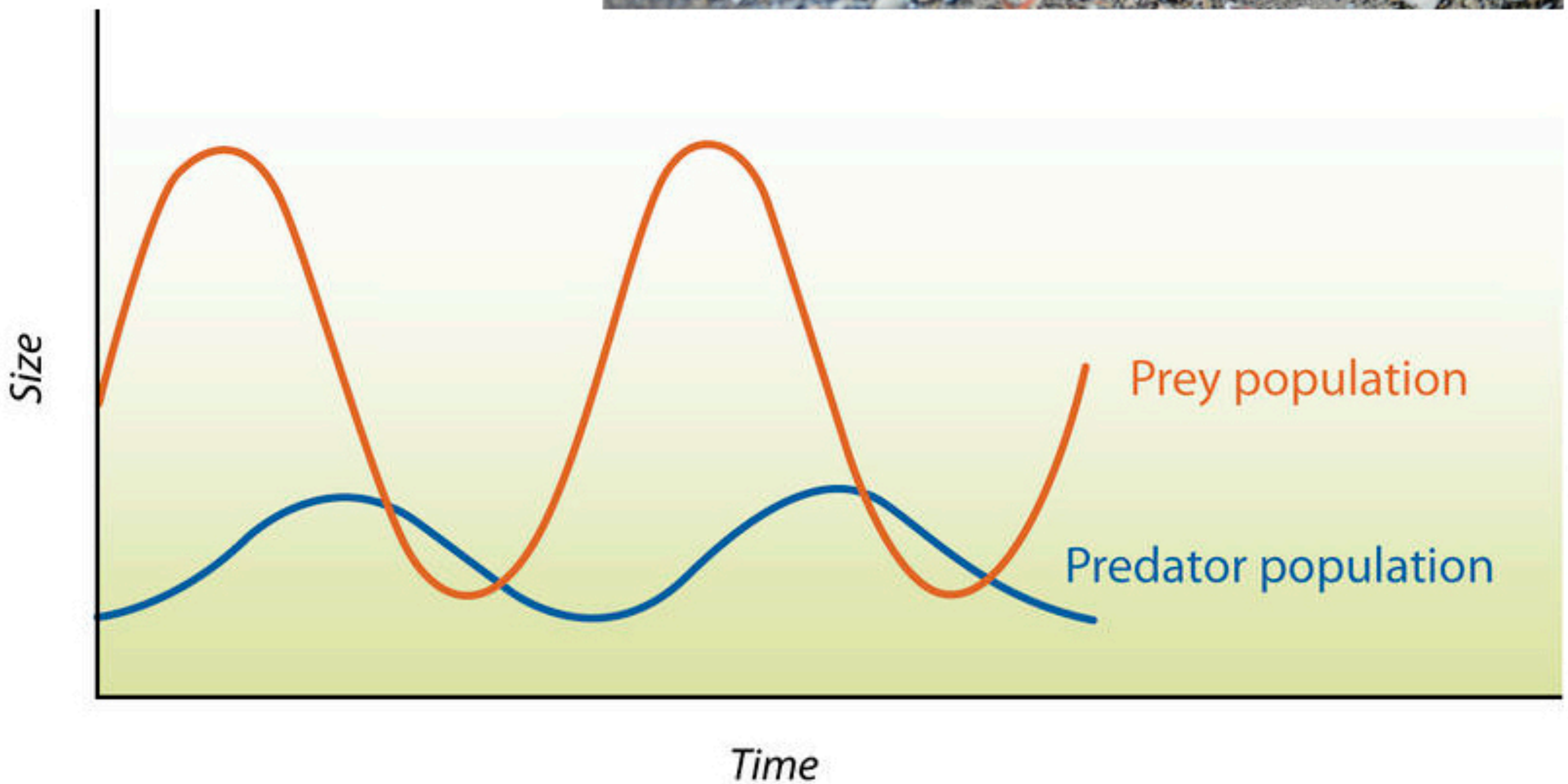


The Mouse Trap… argument



The Mouse Trap ???

Fundamentals of Eye evolution


Size
Prey population
Predator population
Time

Batesian Mimicry

Toxic Newts… escalating “arms race”

Population Variables

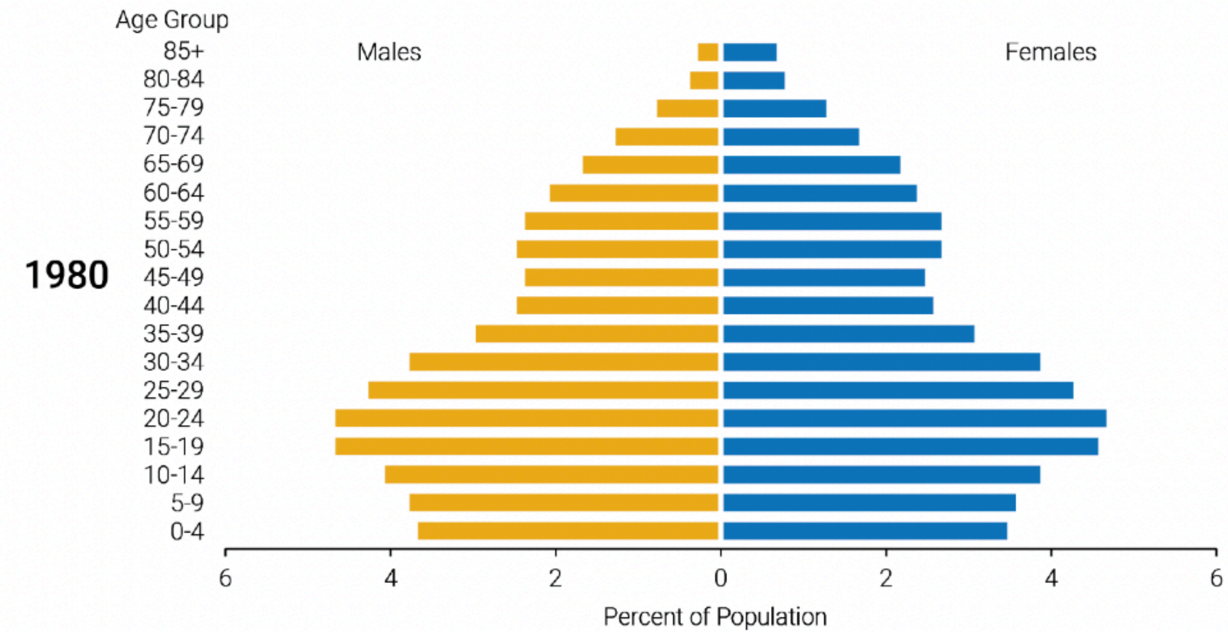
a) population density (Individuals in a population may have uniform, random, or clumped distributions)

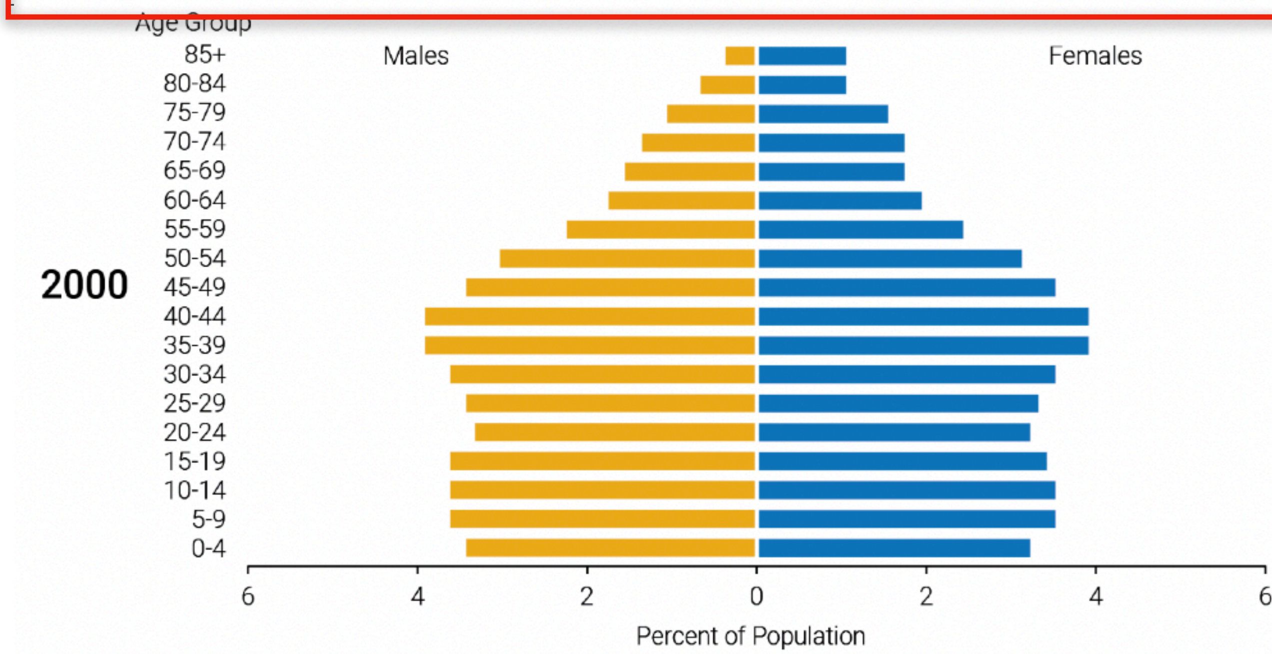
b) Births and Deaths: Births, deaths, immigration, and emigration drive changes in population density and distribution.

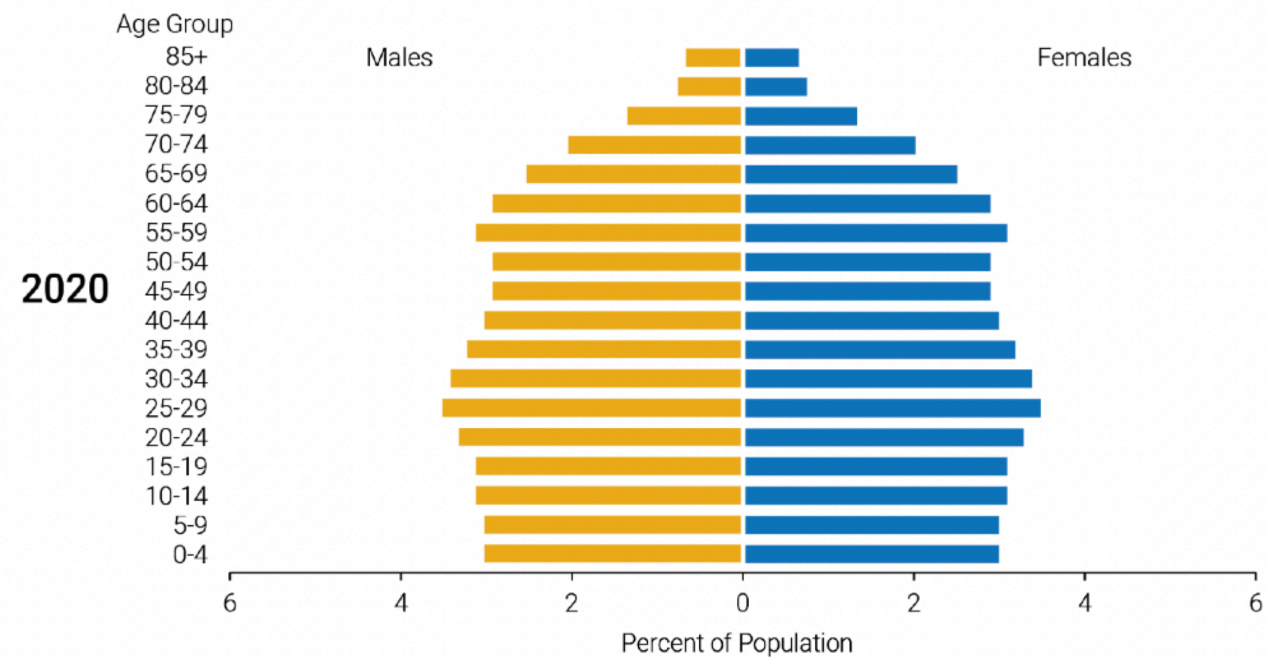
$$\mathbf{N}\text{umber} = \mathbf{N}_0 + \mathbf{B}\text{irths} - \mathbf{D}\text{eaths} + \underbrace{\mathbf{I}\text{mmigrants} + \mathbf{E}\text{mmigrants}}_{\text{Gene Flow}}$$

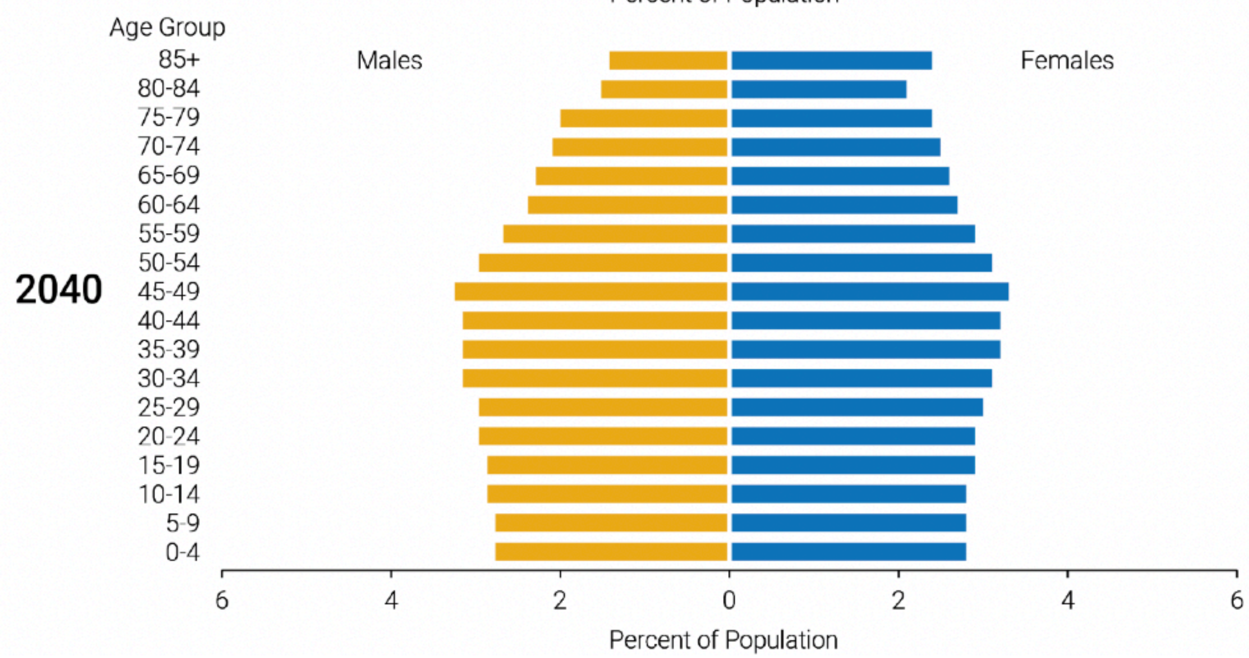
c) Age distribution (into “cohorts”) within a population, which reveals the recent history of births and deaths.

Timing of these events may influence age distributions for many years

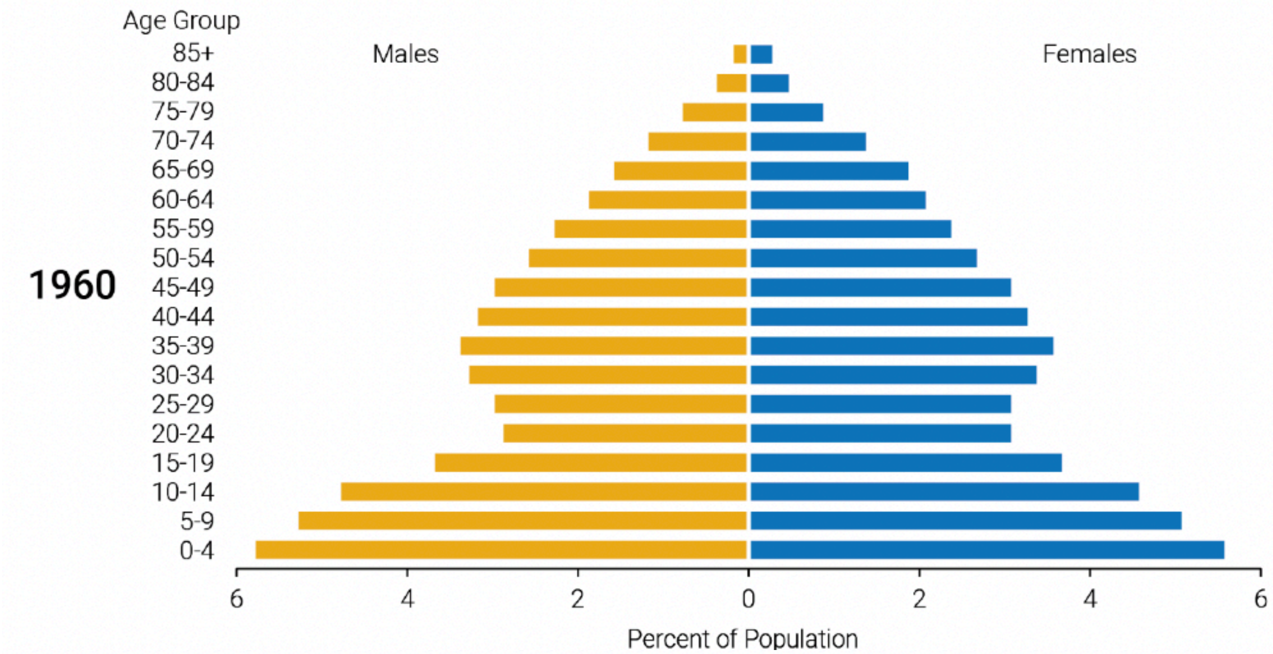


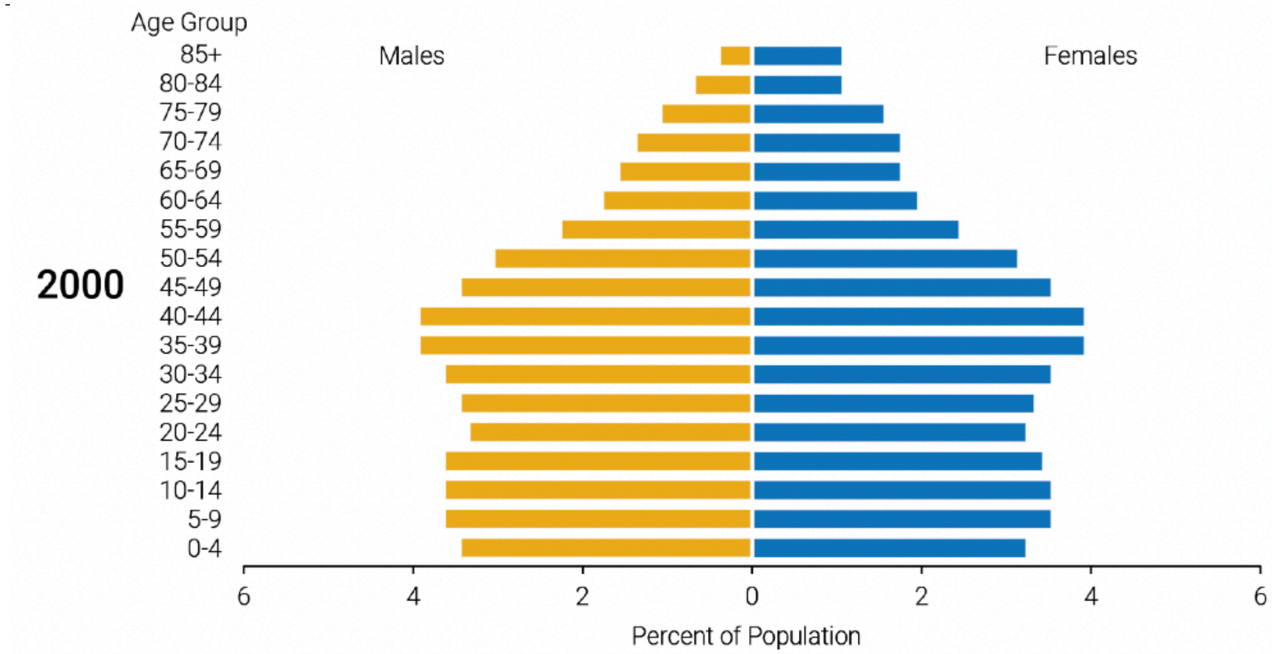


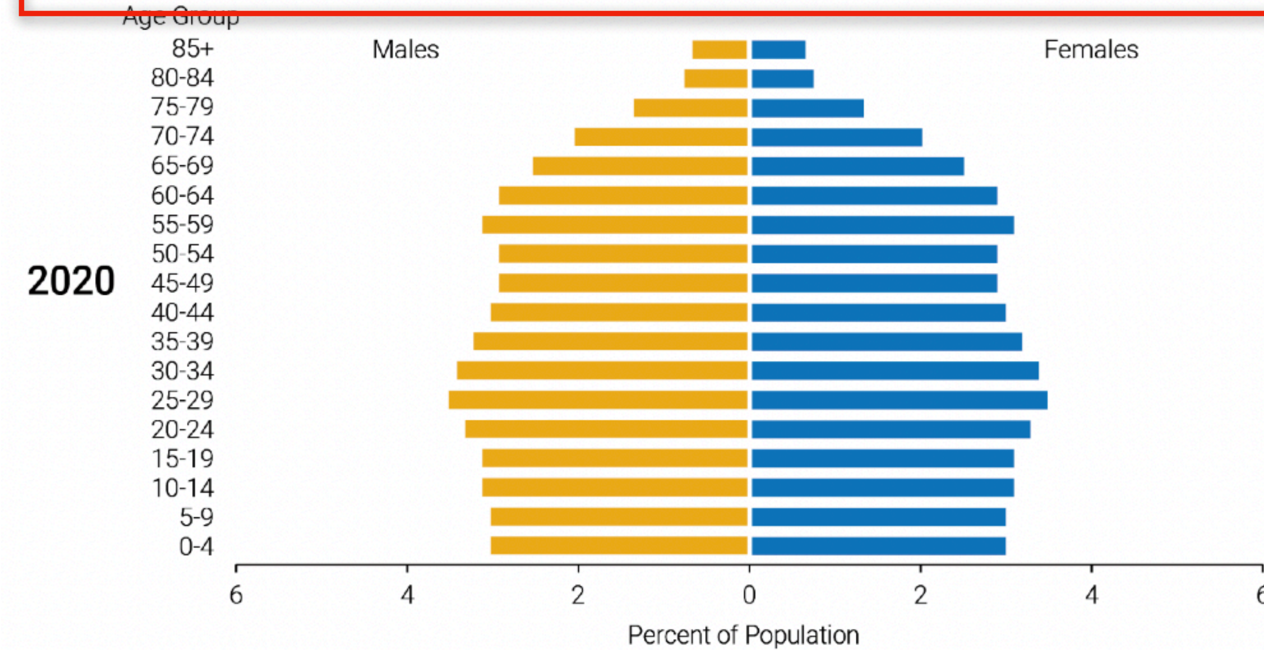


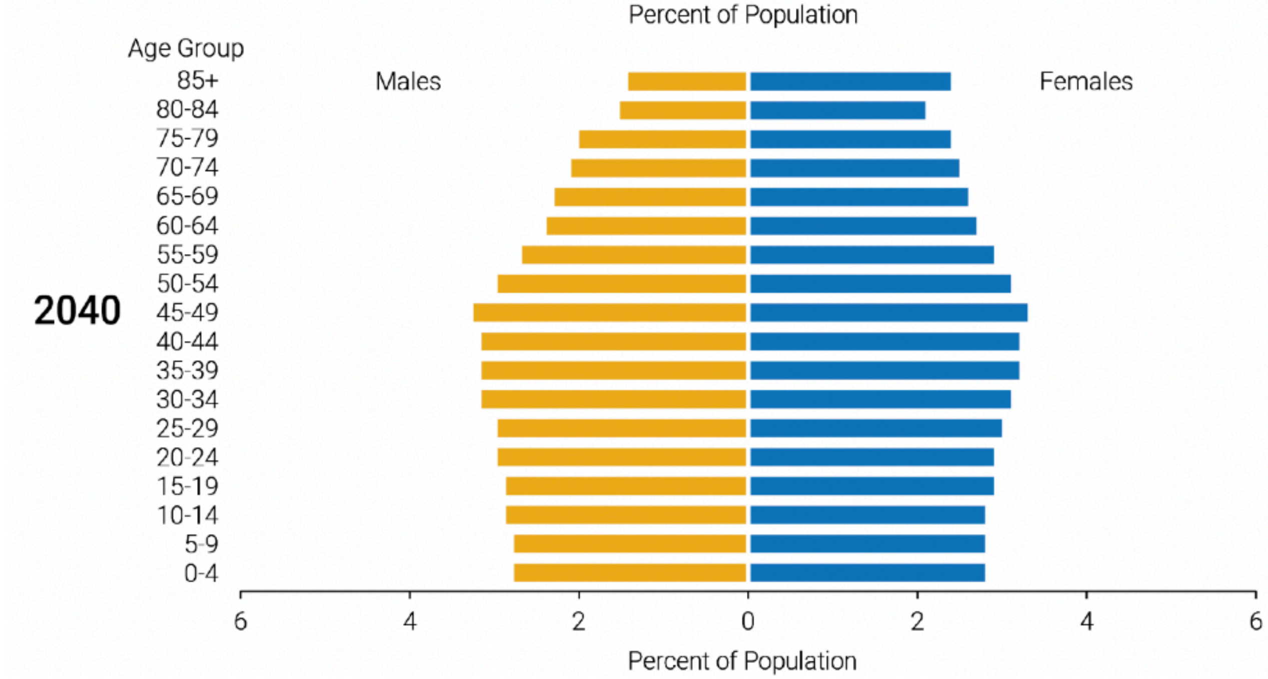


u-s-population-is-growing-older/

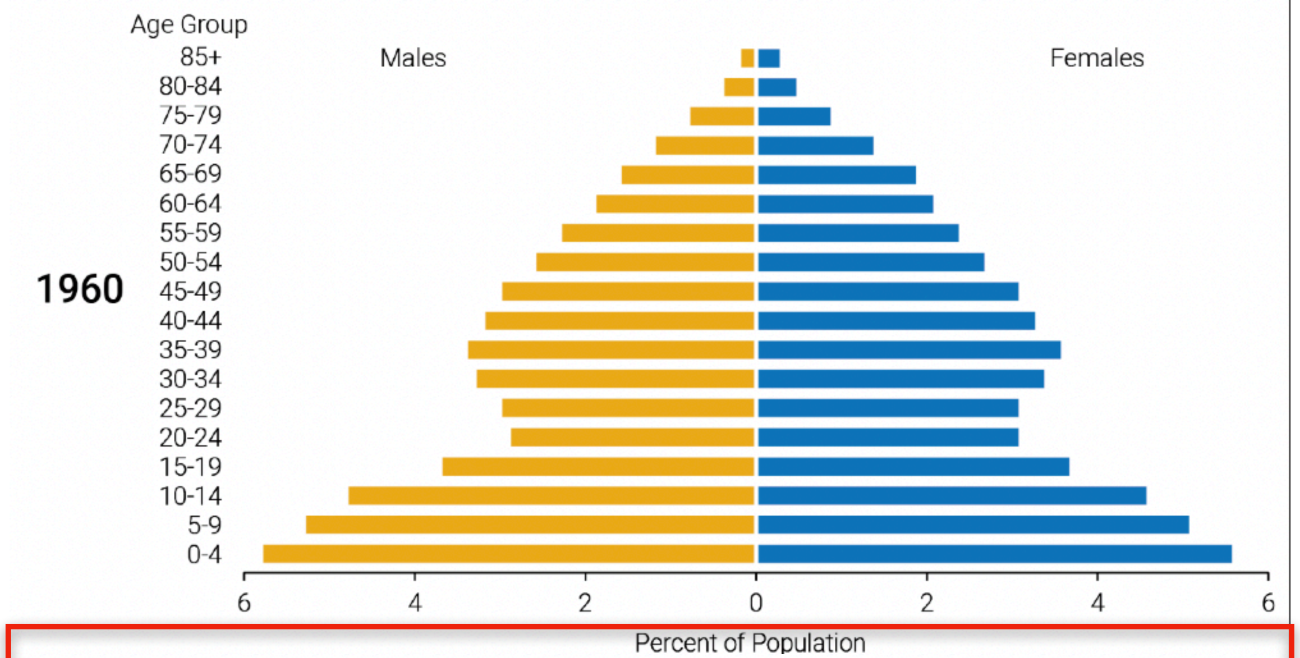


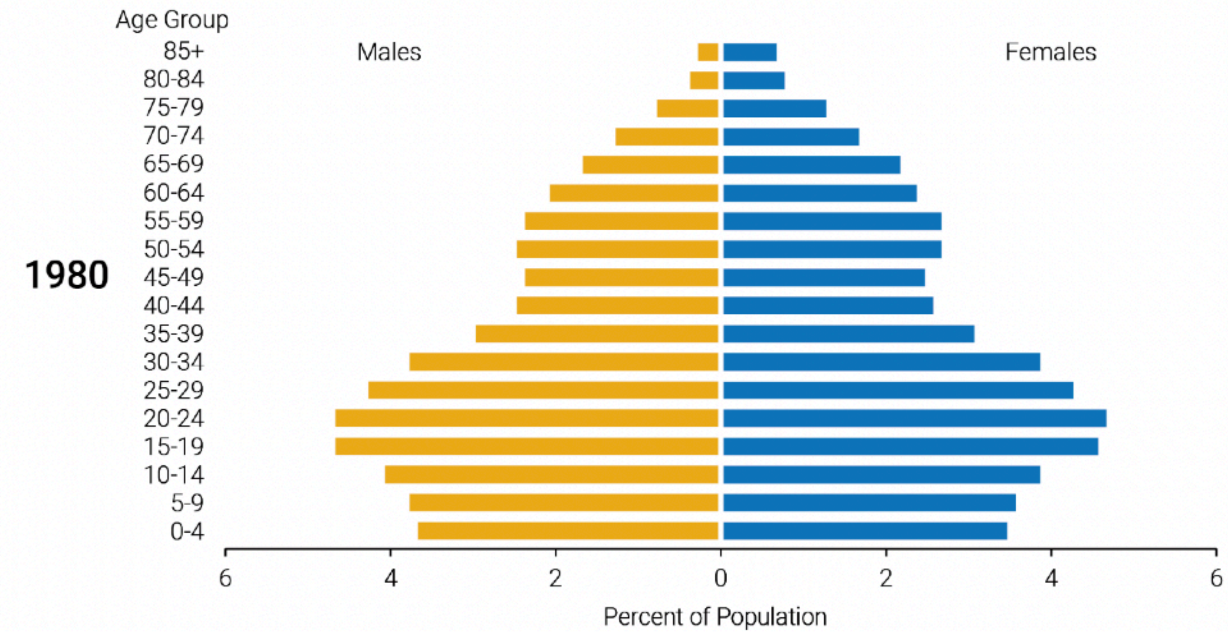


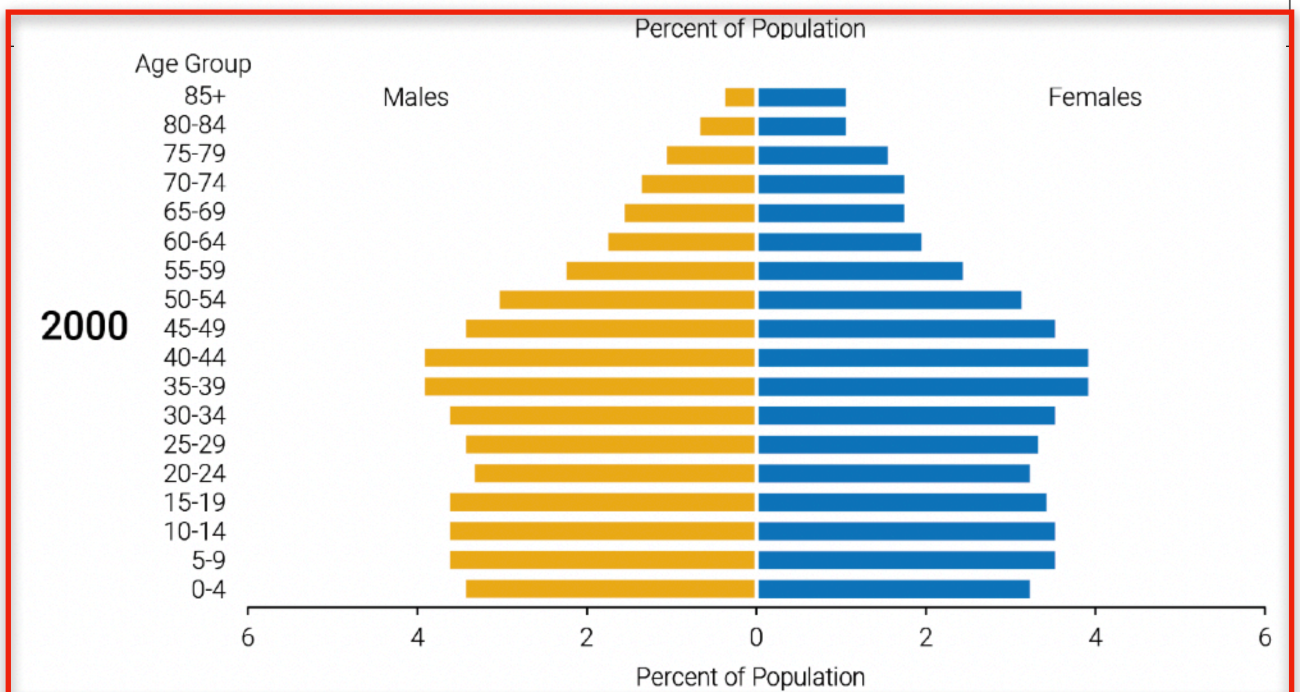


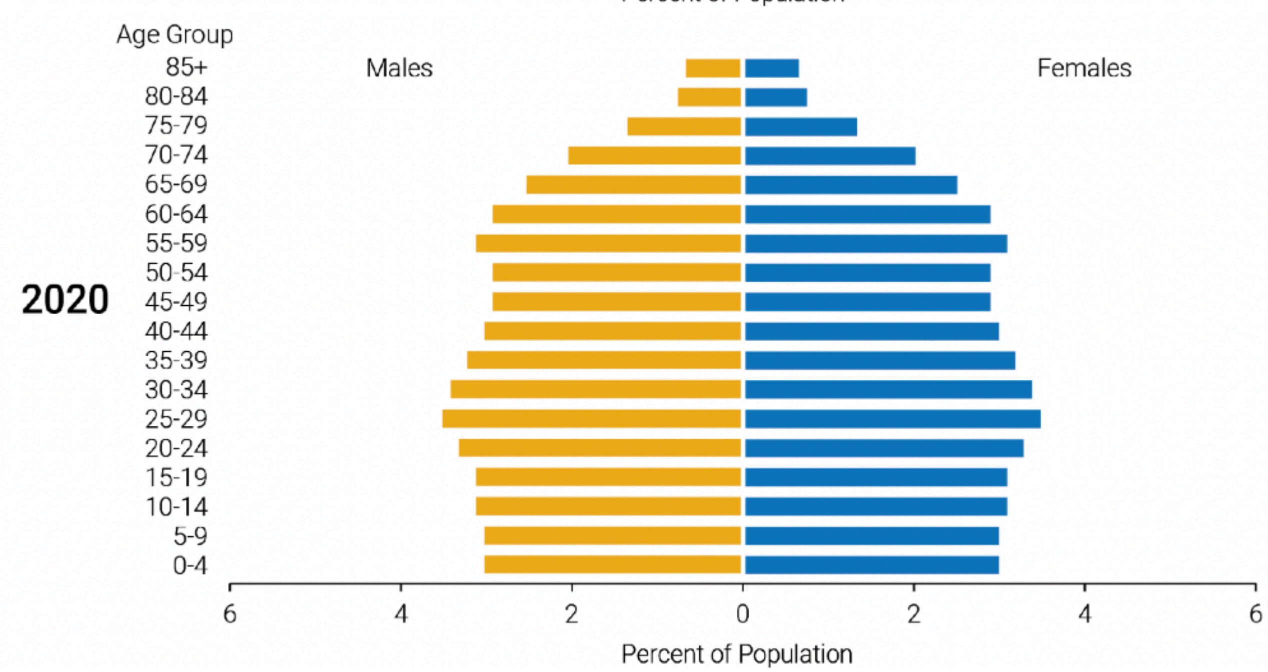


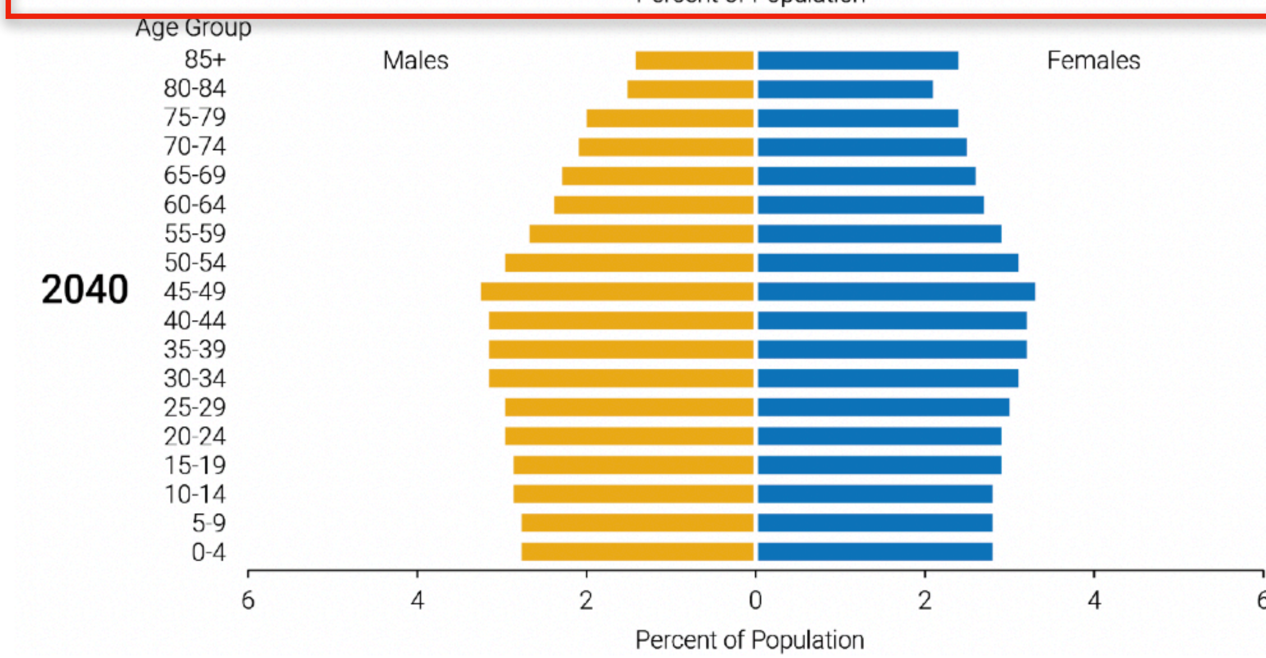
u-s-population-is-growing-older/



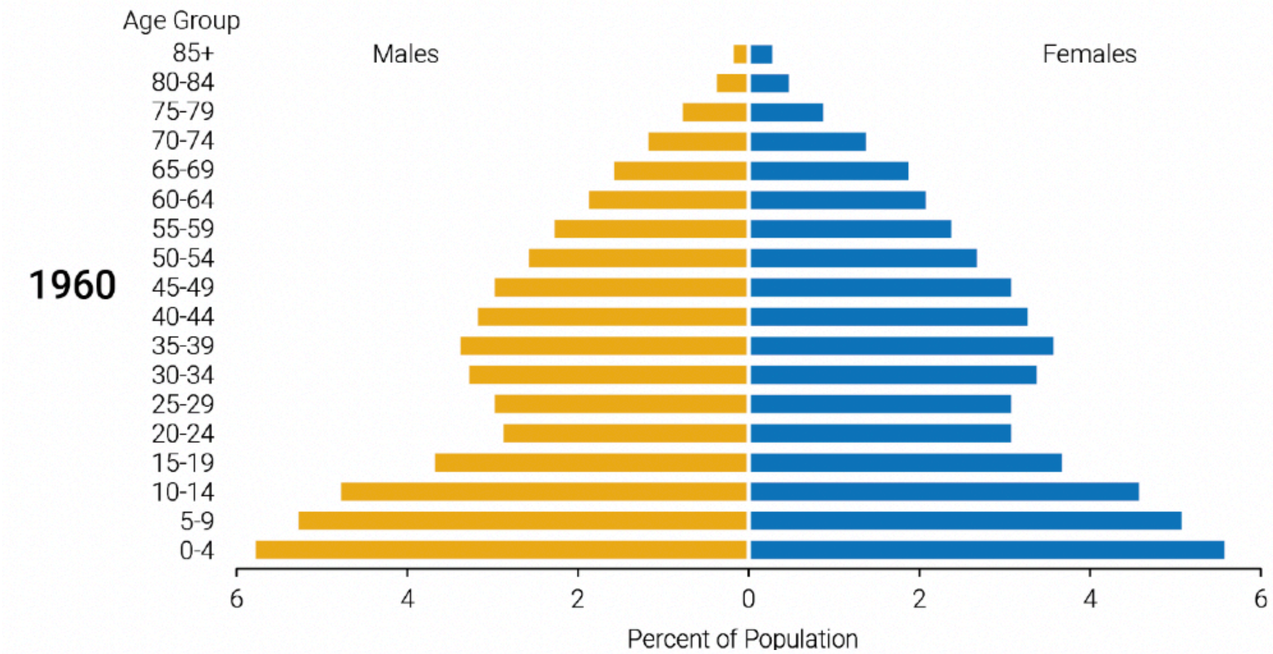


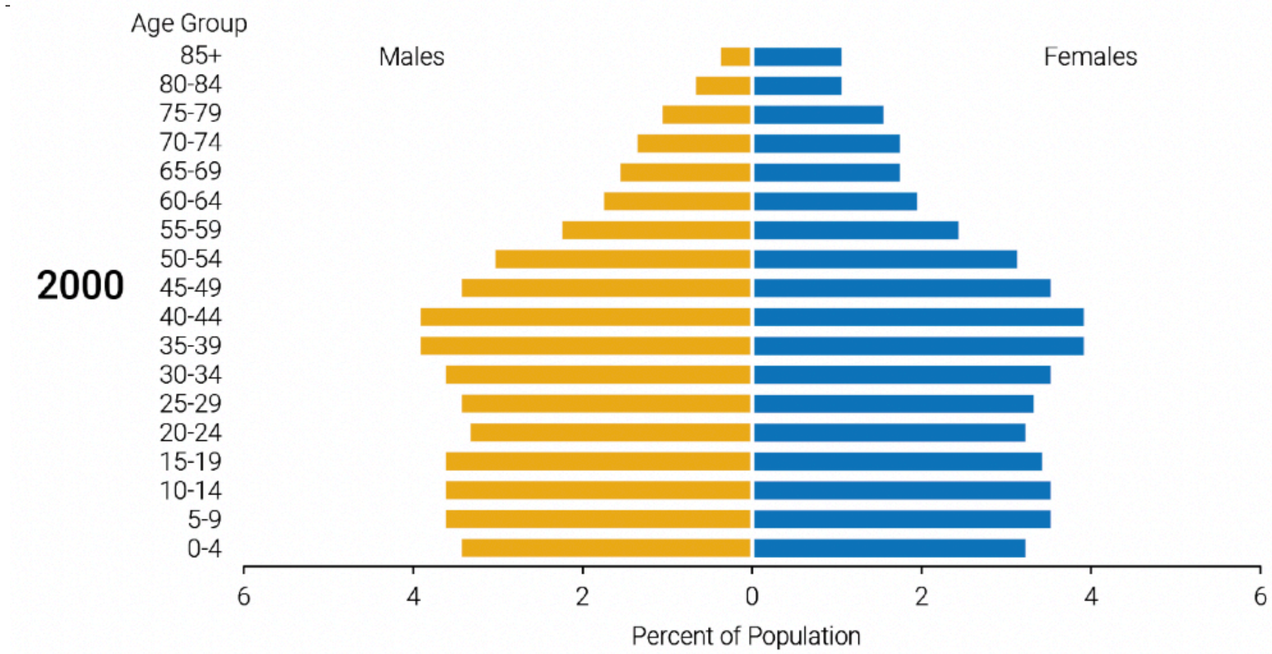


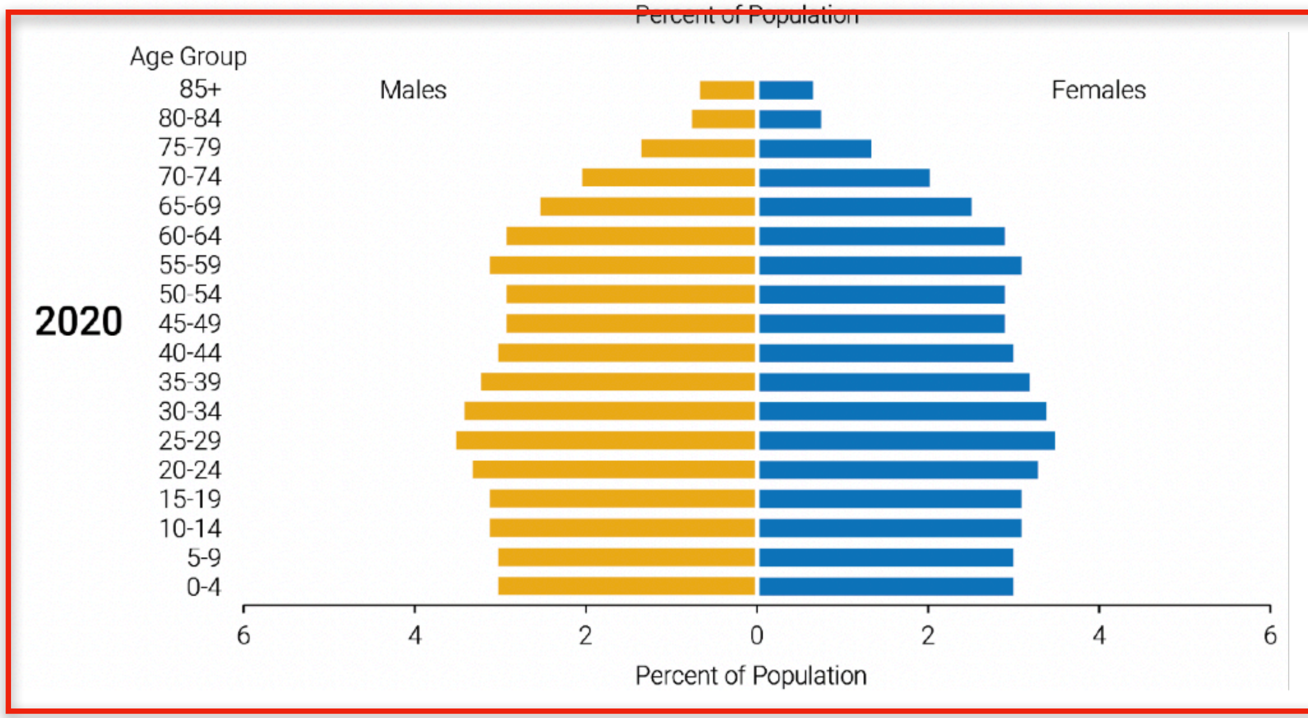


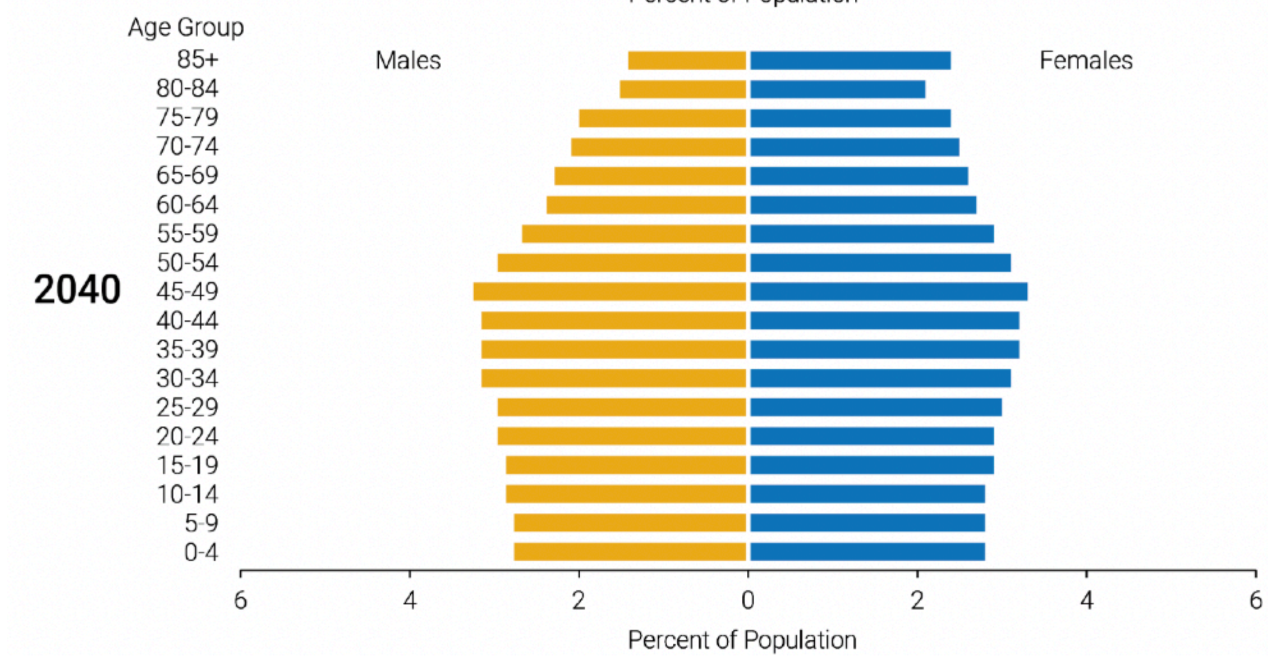


<u>**u-s-population-is-growing-older/**</u>

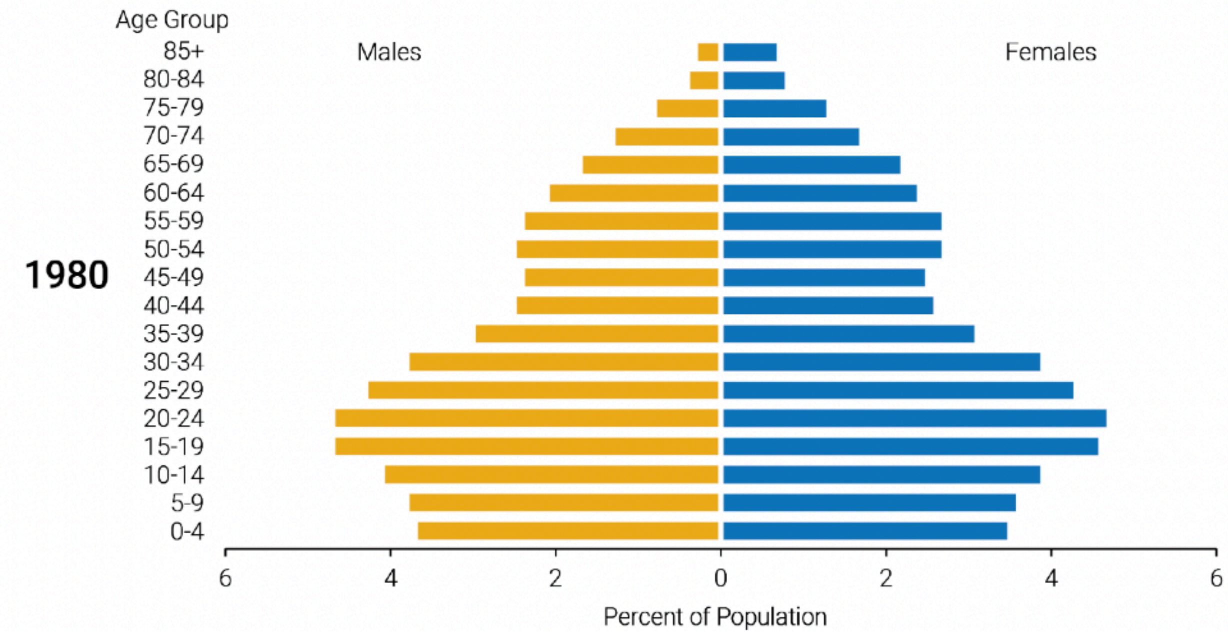


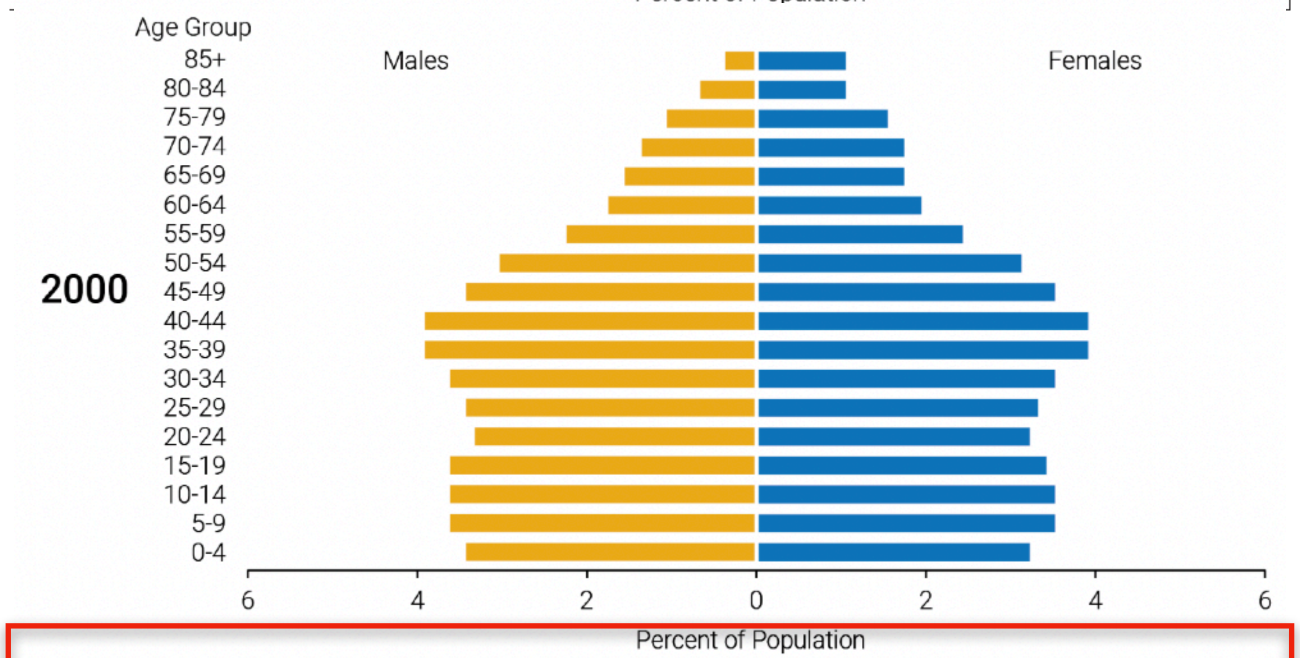


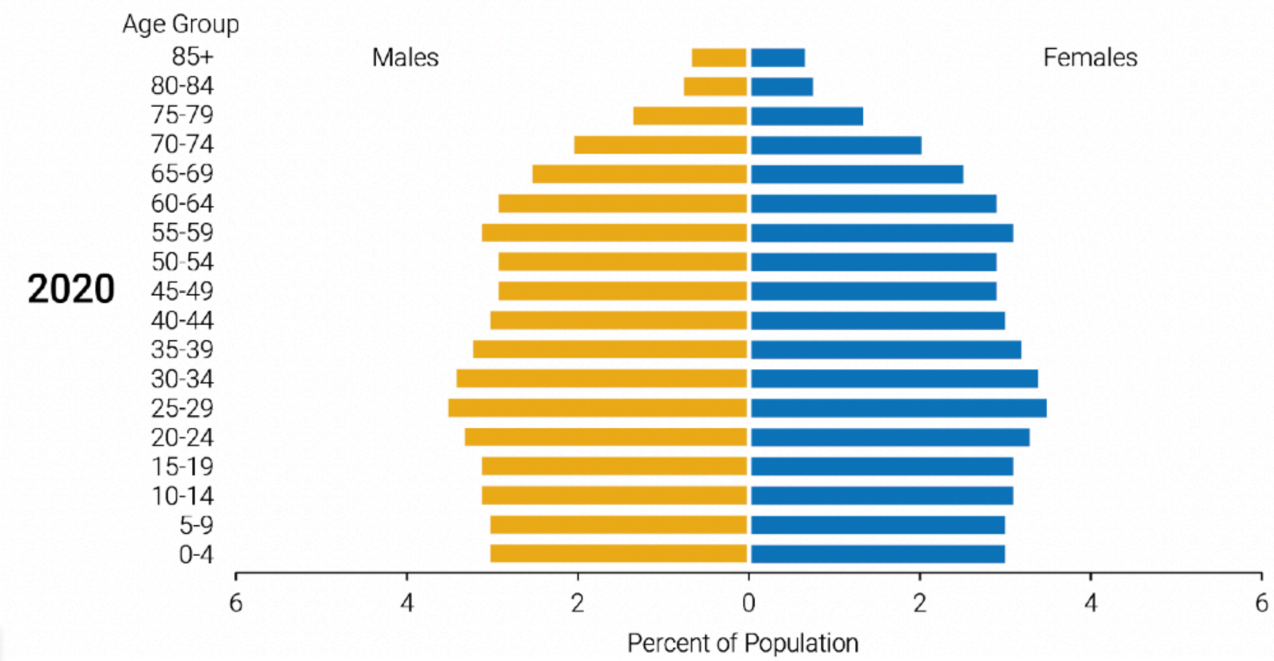


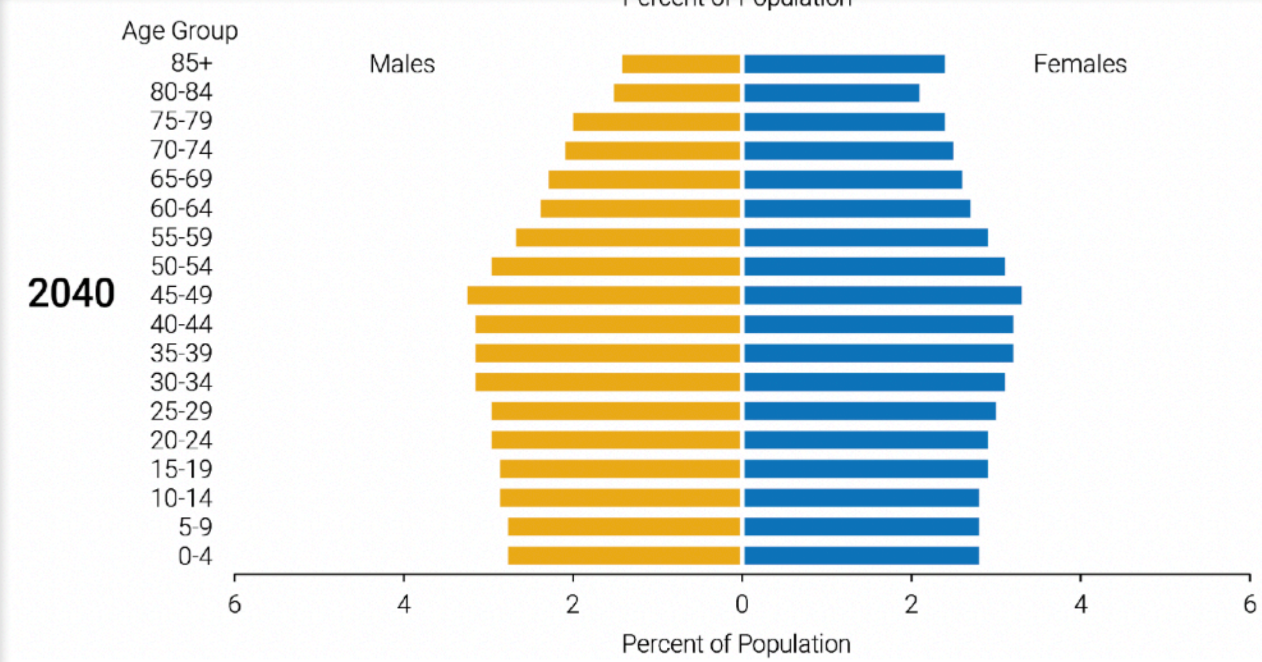


u-s-population-is-growing-older/

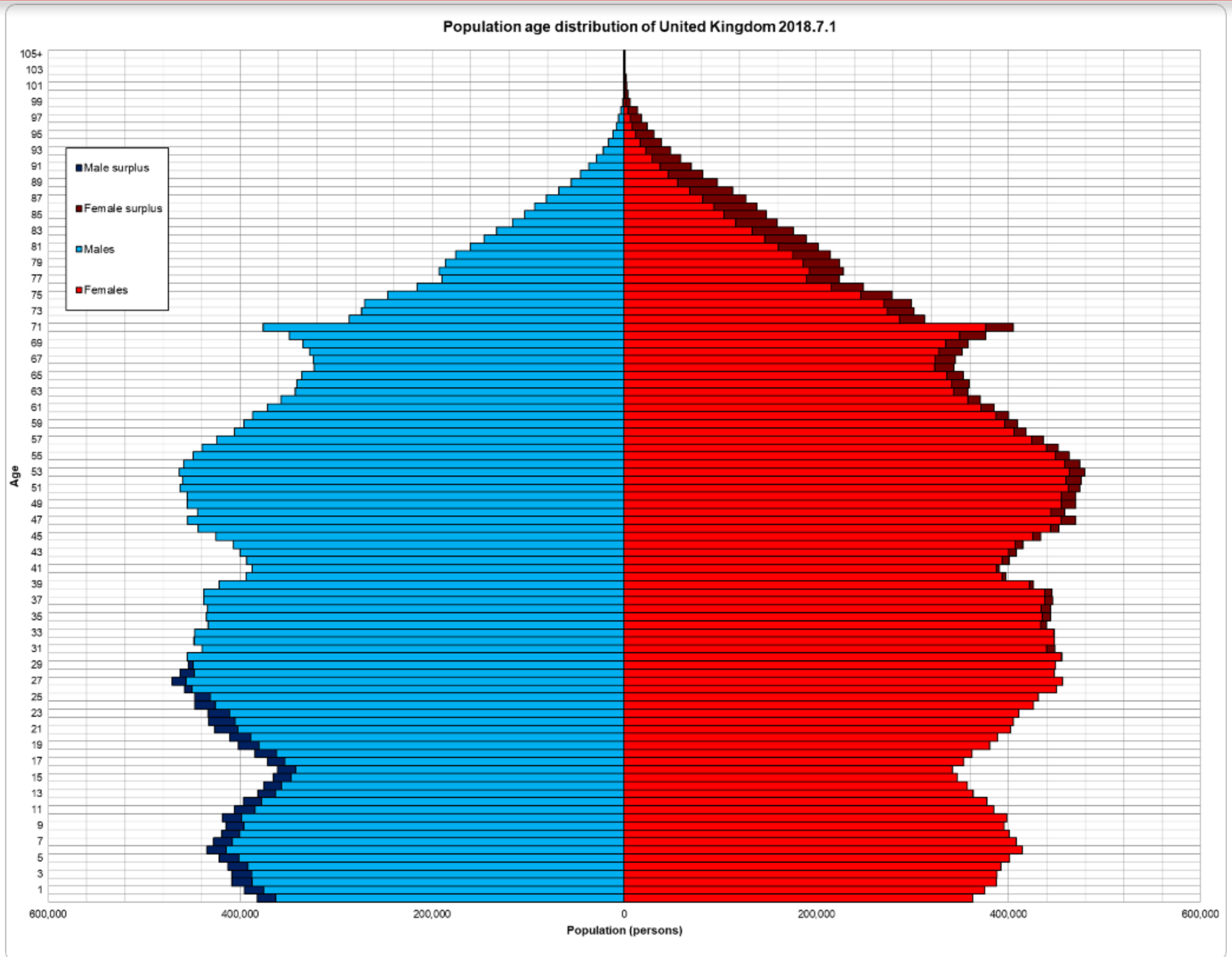






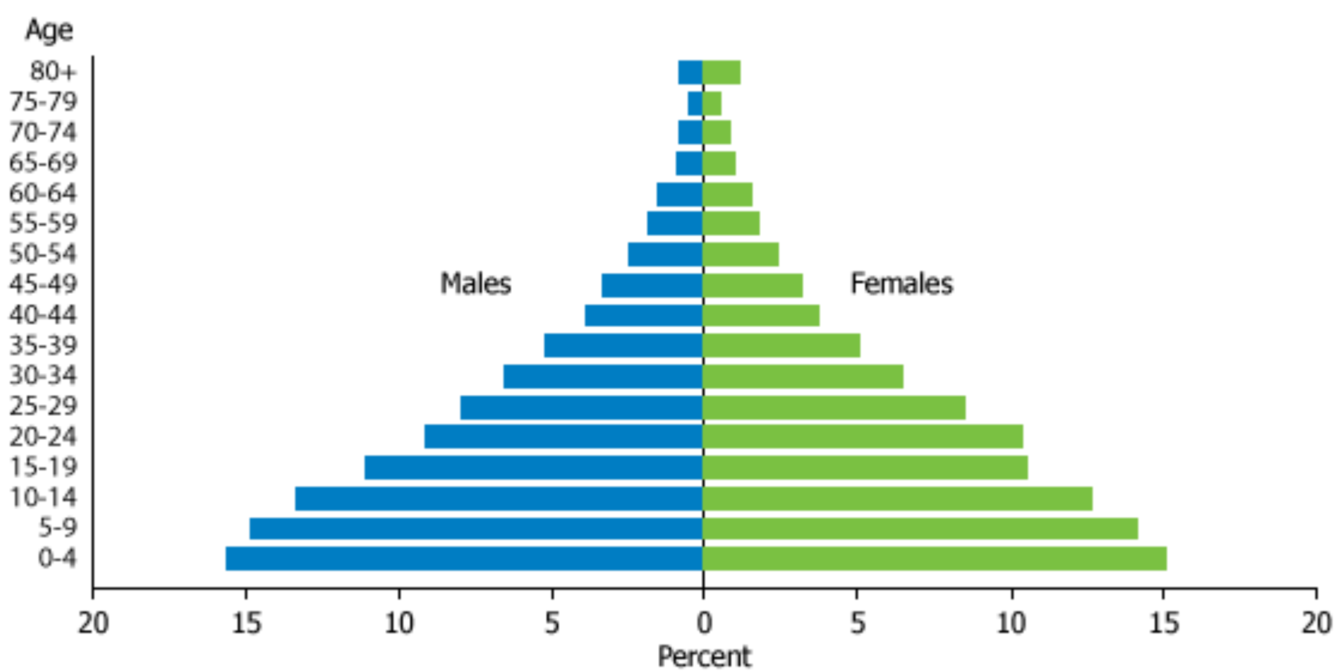


u-s-population-is-growing-older/

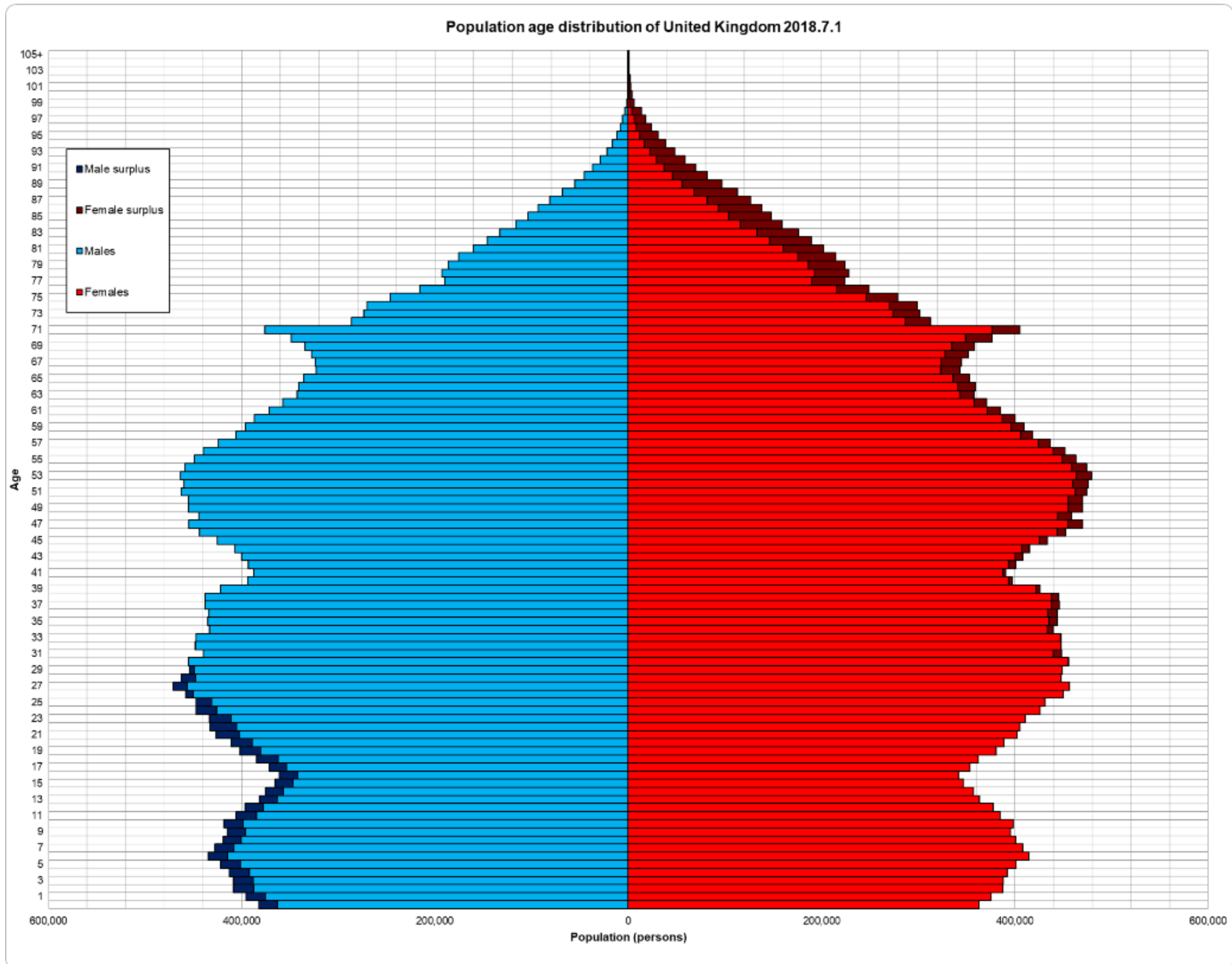


UK's Age and demographics ~ 2018

Kenya's Age and demographics ~ 2011

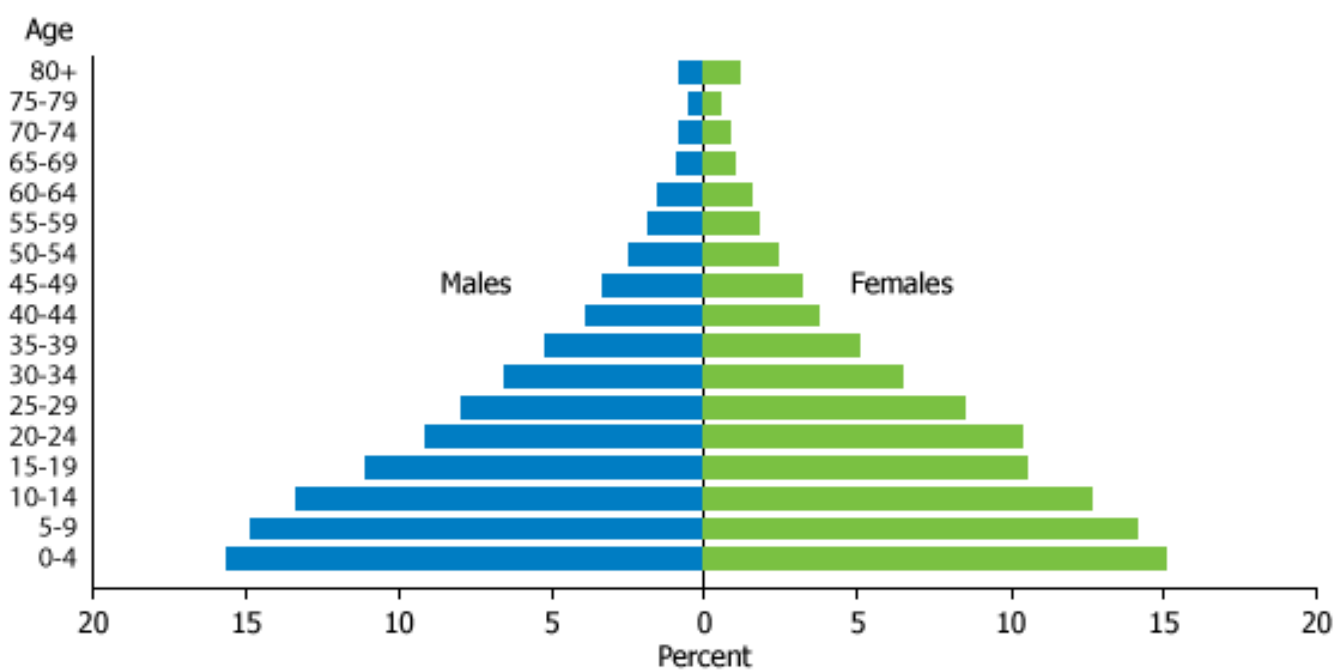


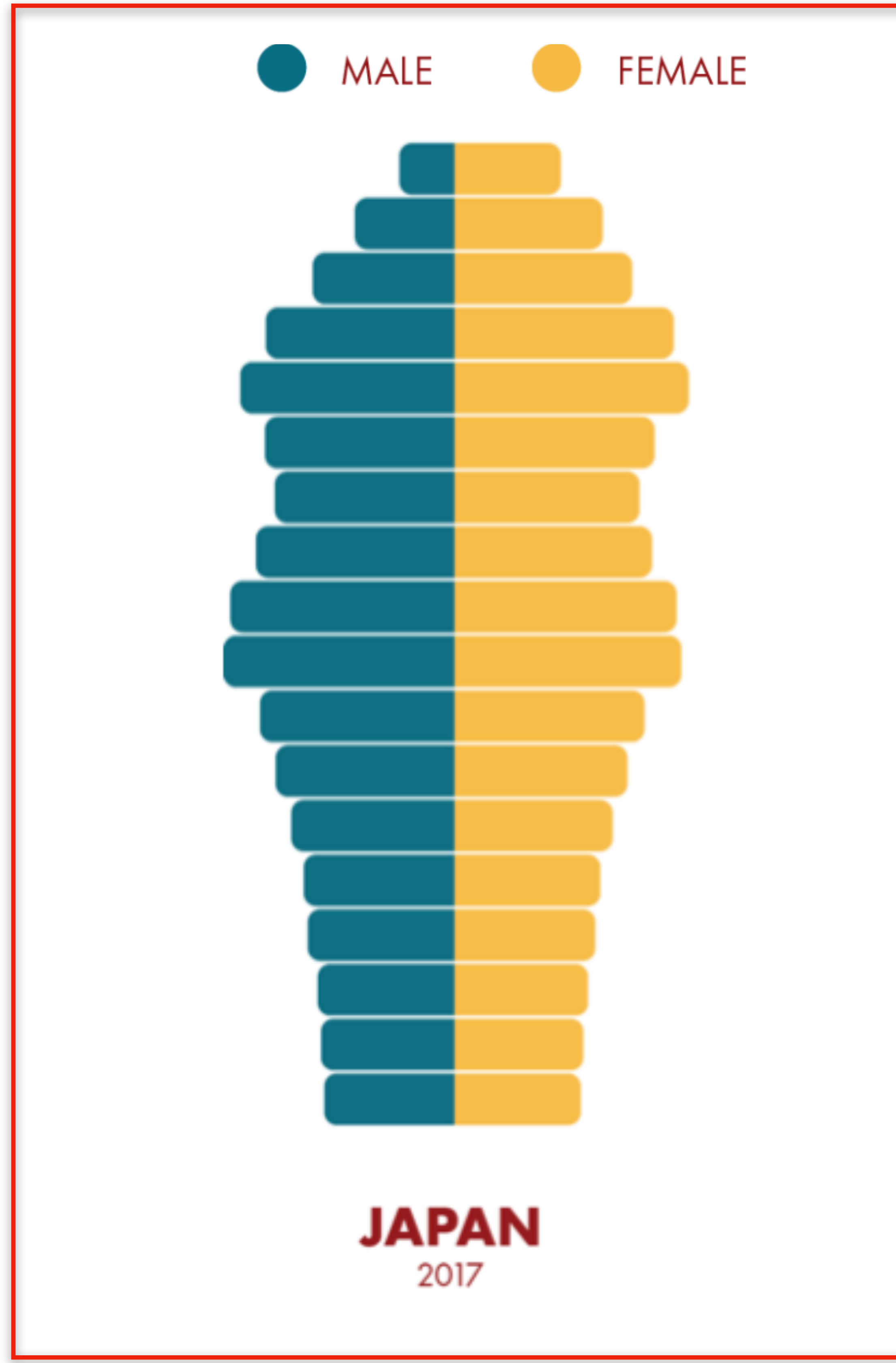
JAPAN
2017

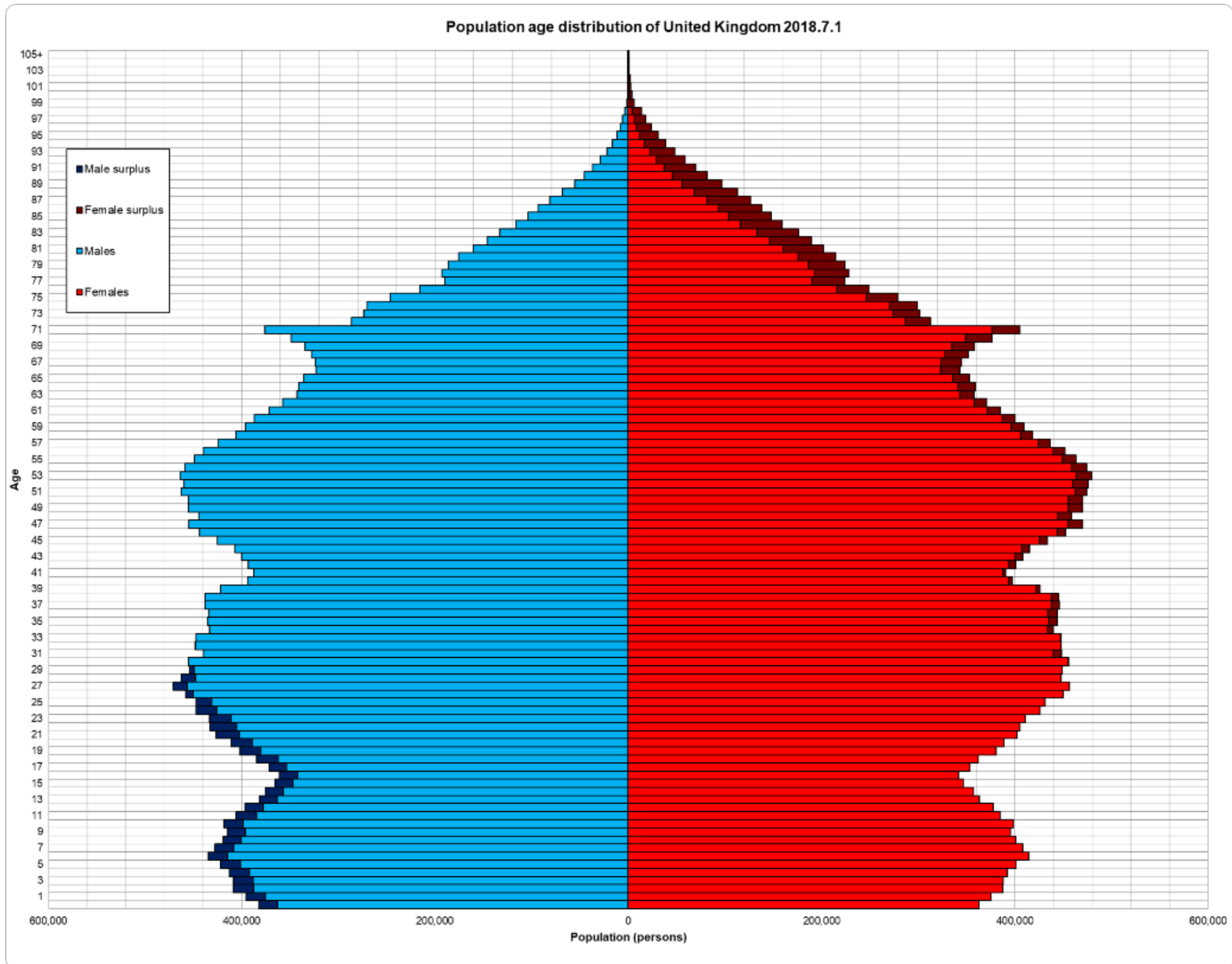


UK's Age and demographics ~ 2018

Kenya's Age and demographics ~ 2011

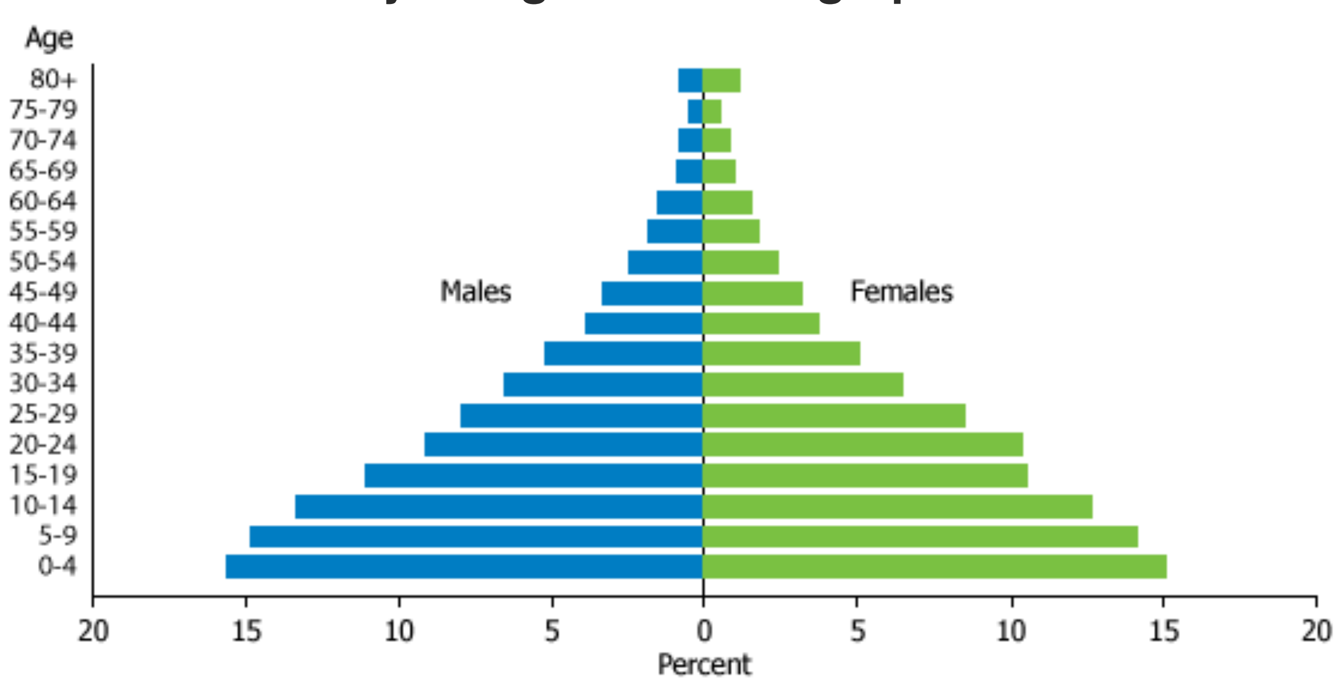




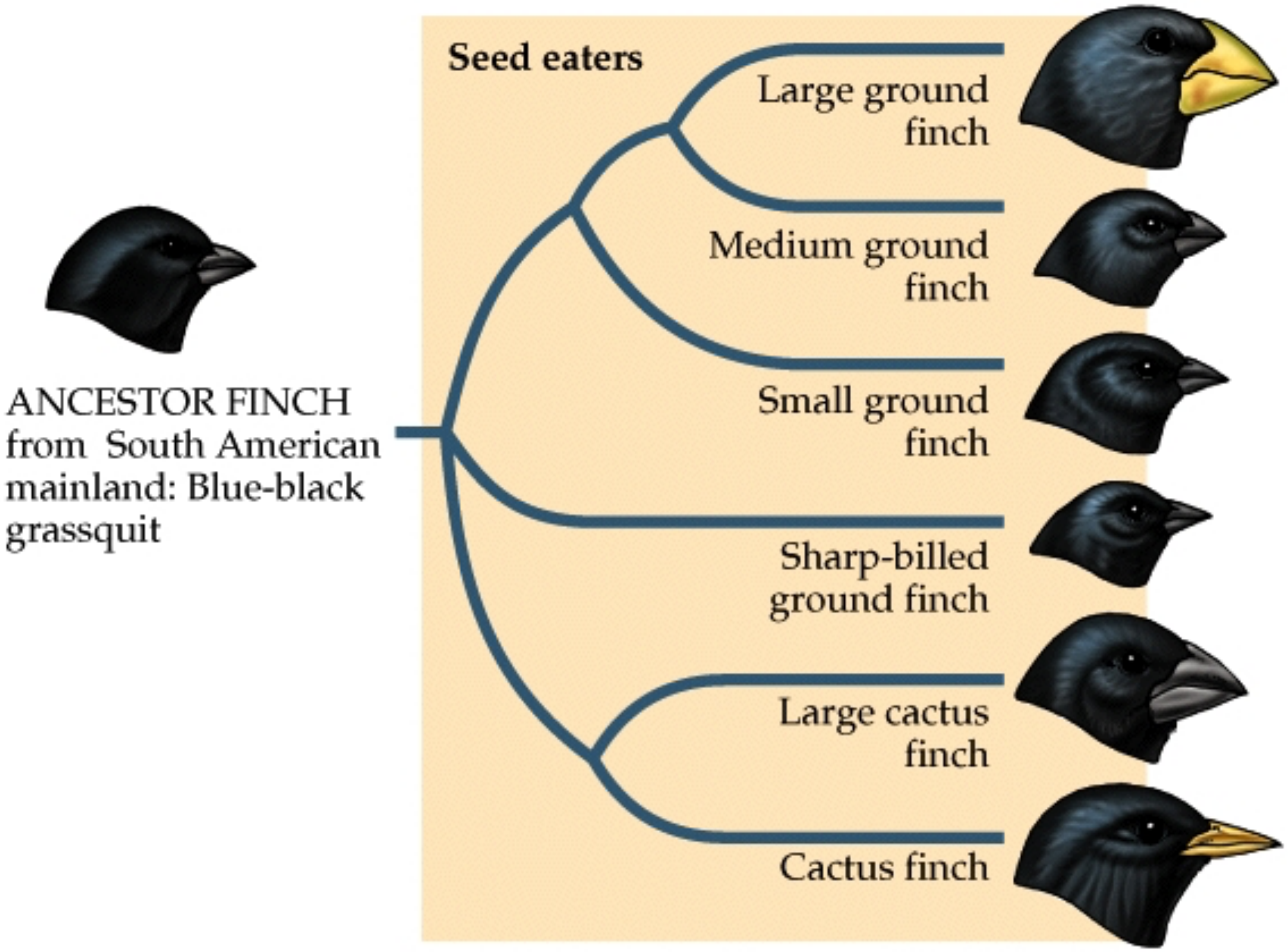


UK's Age and demographics ~ 2018

Kenya's Age and demographics ~ 2011



JAPAN
2017



n's Ground Finch

			RVIVAL RATE[b]	MORTALITY RATE[c]
			0.434	0.566
			0.855	0.143
			0.898	0.102
			0.928	0.072
			0.955	0.045
			0.678	0.322
			0.545	0.455
			0.651	0.349
			0.944	0.056
			0.776	0.224
10	11	0.052	0.923	0.077
11	10	0.048	0.396	0.604
12	4	0.019	0.737	0.263
13	3	0.014	0.714	0.004

[a]Survivorship = the proportion of newborns who survive to age x.
[b]Survival rate = the proportion of individuals of age x who survive to age $x + 1$.
[c]Mortality rate = the proportion of individuals of age x who die before the age of $x + 1$.

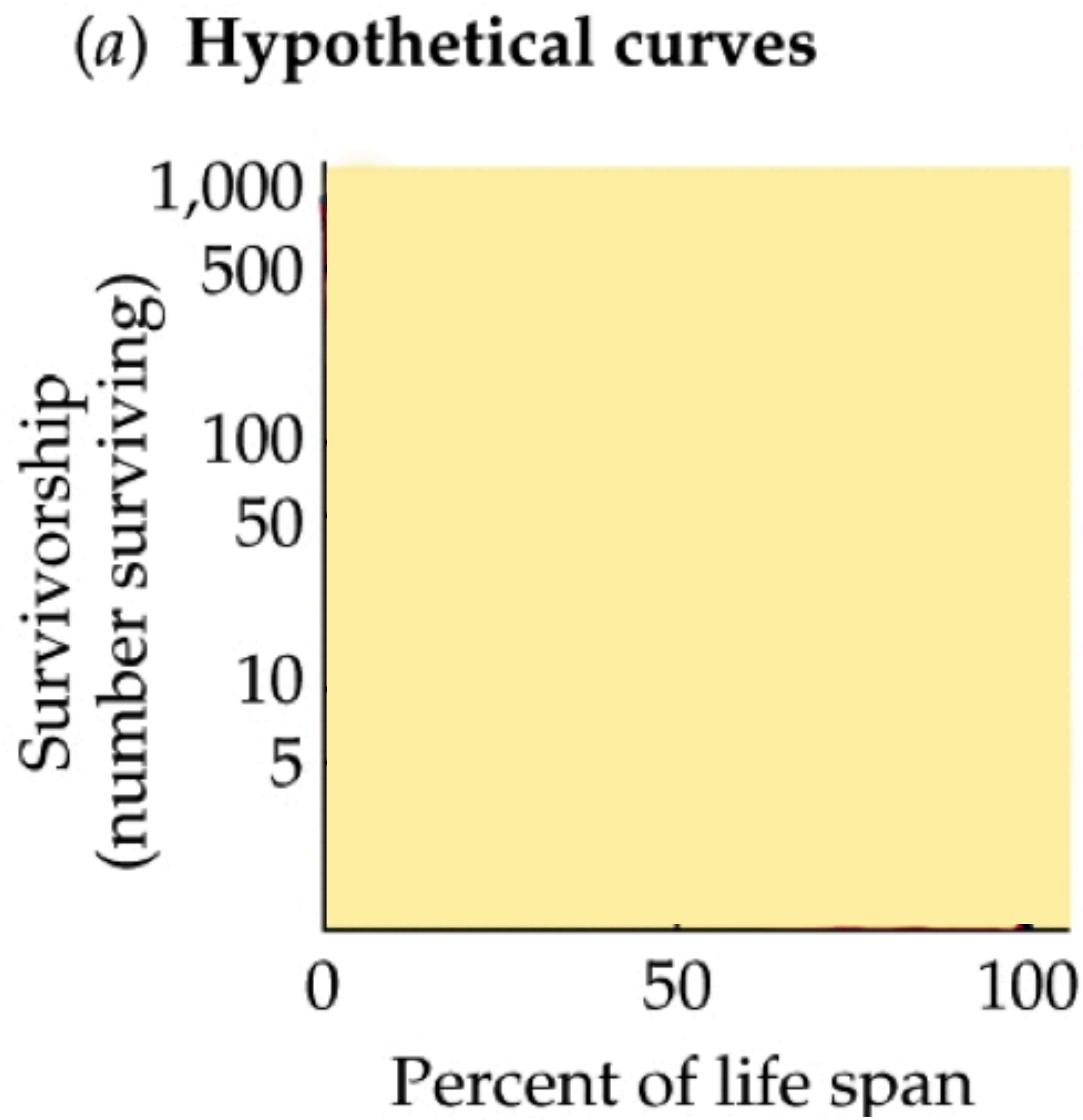
54.1 *Life Table of the 1978 Cohort of Darwin's Ground Finch* (Geospiza scandens) *on Isla Daphne*

AGE IN YEARS (*X*)	NUMBER ALIVE	SURVIVORSHIP[a]	SURVIVAL RATE[b]	MORTALITY RATE[c]
0	210	1.000	0.434	0.566
1	91	0.434	0.855	0.143
2	78	0.371	0.898	0.102
3	70	0.333	0.928	0.072
4	65	0.309	0.955	0.045
5	62	0.295	0.678	0.322
6	42	0.200	0.545	0.455
7	23	0.109	0.651	0.349
8	15	0.071	0.944	0.056
9	14	0.067	0.776	0.224
10	11	0.052	0.923	0.077
11	10	0.048	0.396	0.604
12	4	0.019	0.737	0.263
13	3	0.014	0.714	0.004

[a]Survivorship = the proportion of newborns who survive to age x.

[b]Survival rate = the proportion of individuals of age x who survive to age $x + 1$.

[c]Mortality rate = the proportion of individuals of age x who die before the age of $x + 1$.

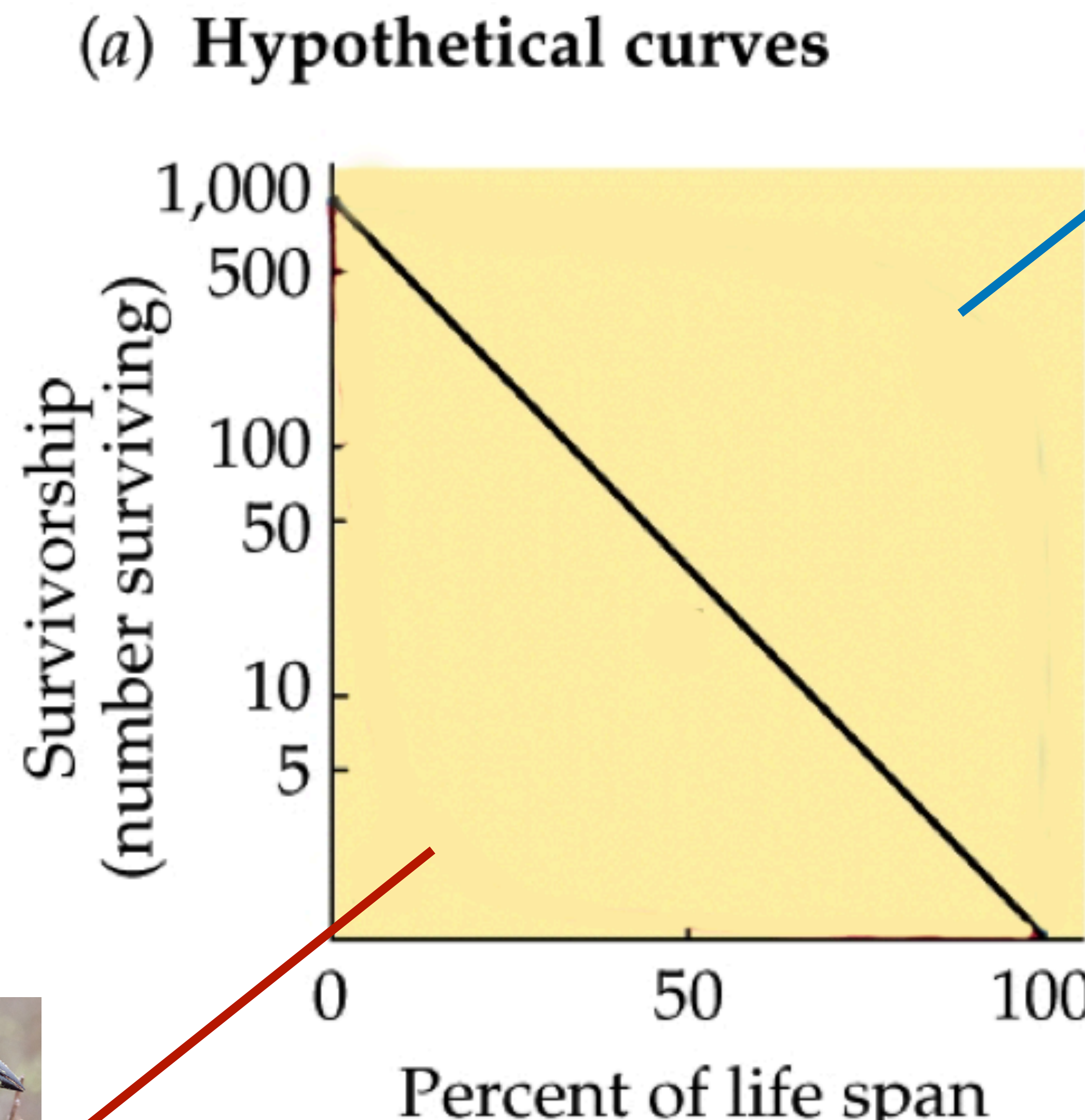


Survivorship

54.1 *Life Table of the 1978 Cohort of Darwin's Ground Finch* (Geospiza scandens) *on Isla Daphne*

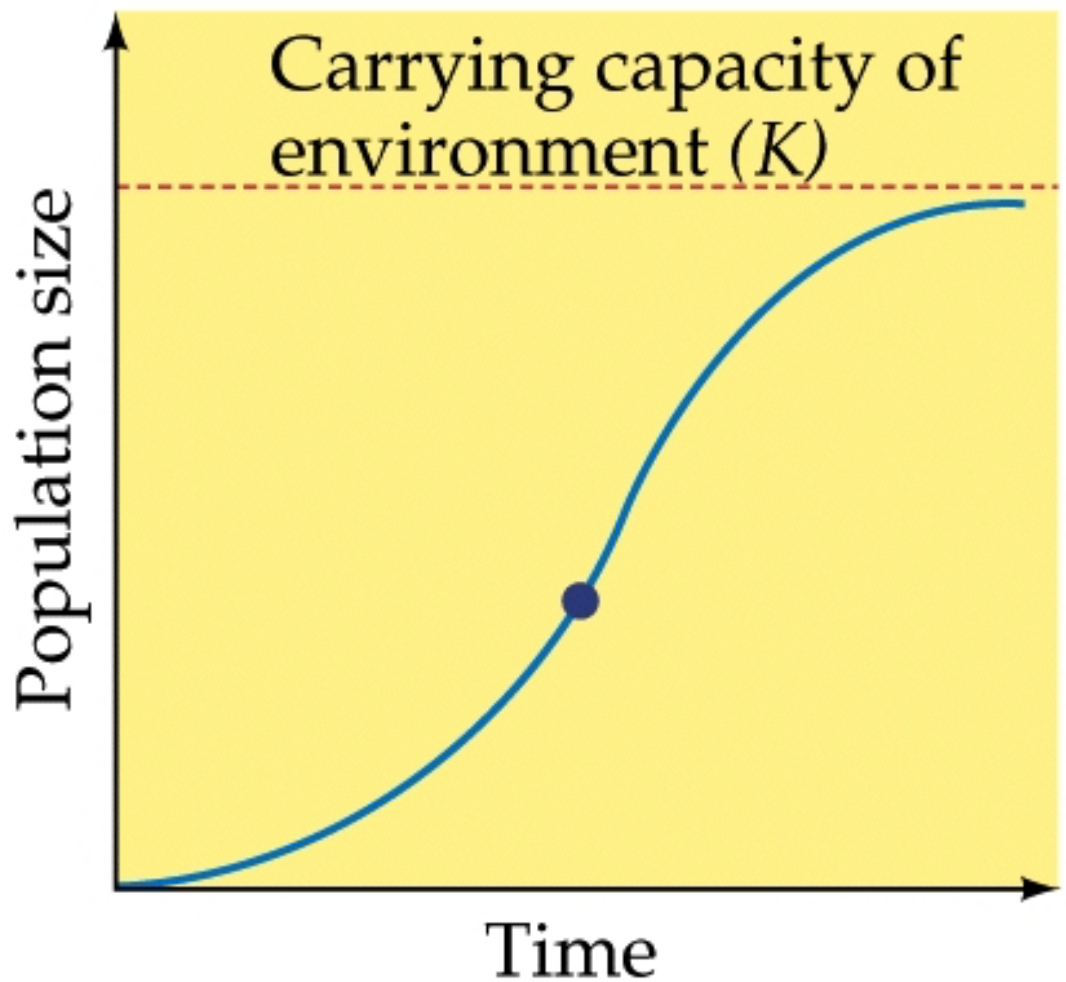
AGE IN YEARS (*X*)	NUMBER ALIVE	SURVIVORSHIP[a]	SURVIVAL RATE[b]	MORTALITY RATE[c]
0	210	1.000	0.434	0.566
1	91	0.434	0.855	0.143
2	78	0.371	0.898	0.102
3	70	0.333	0.928	0.072
4	65	0.309	0.955	0.045
5	62	0.295	0.678	0.322
6	42	0.200	0.545	0.455
7	23	0.109	0.651	0.349
8	15	0.071	0.944	0.056
9	14	0.067	0.776	0.224
10	11	0.052	0.923	0.077
11	10	0.048	0.396	0.604
12	4	0.019	0.737	0.263
13	3	0.014	0.714	0.004

[a]Survivorship = the proportion of newborns who survive to age x.
[b]Survival rate = the proportion of individuals of age x who survive to age $x + 1$.
[c]Mortality rate = the proportion of individuals of age x who die before the age of $x + 1$.

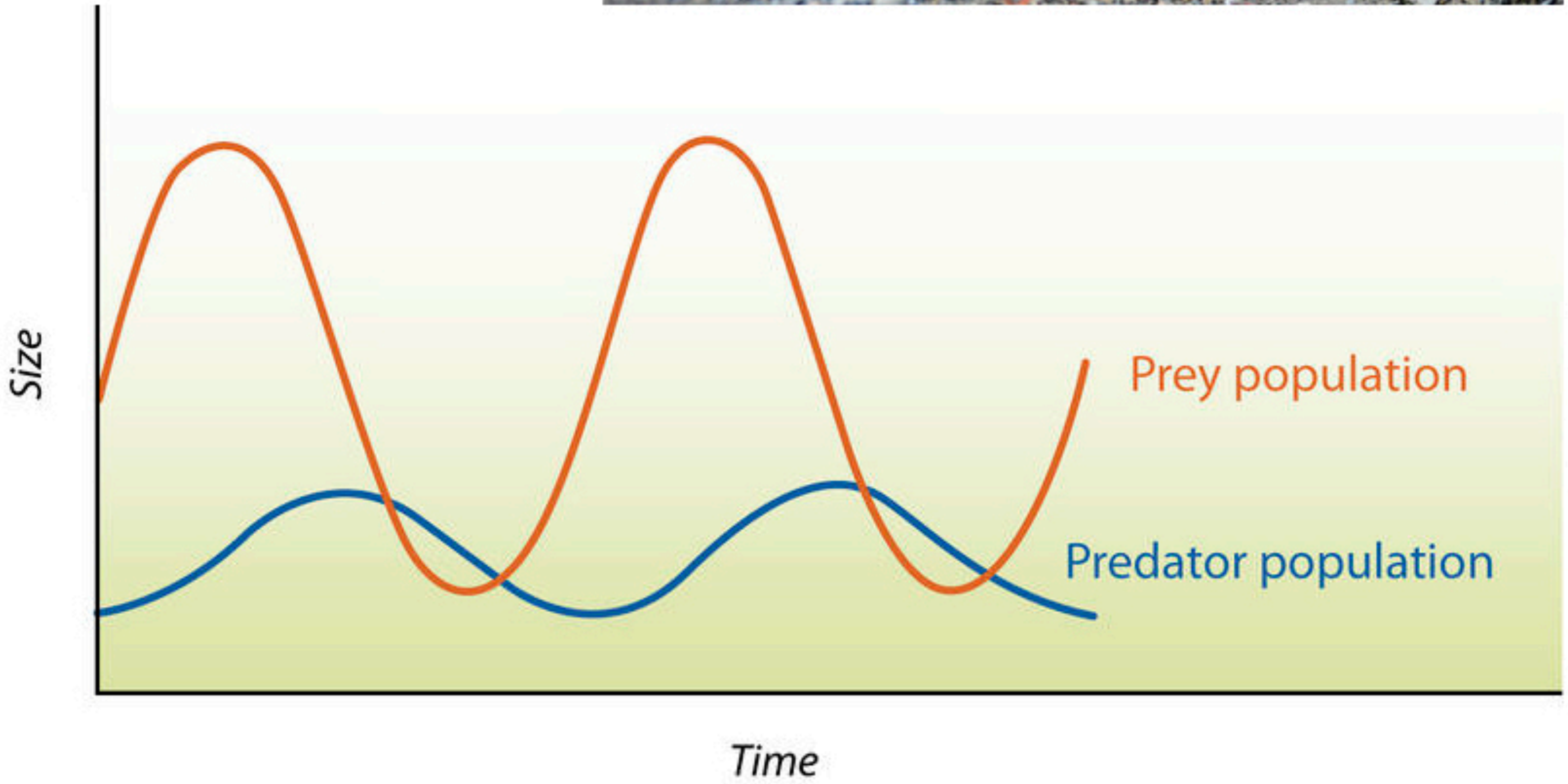


Geospiza scandens

Survivorship



Theoretical Population Growth
-with No limitations.


Size
Time
Prey population
Predator population

https://www.worldometers.info/world-population/

Current World Population

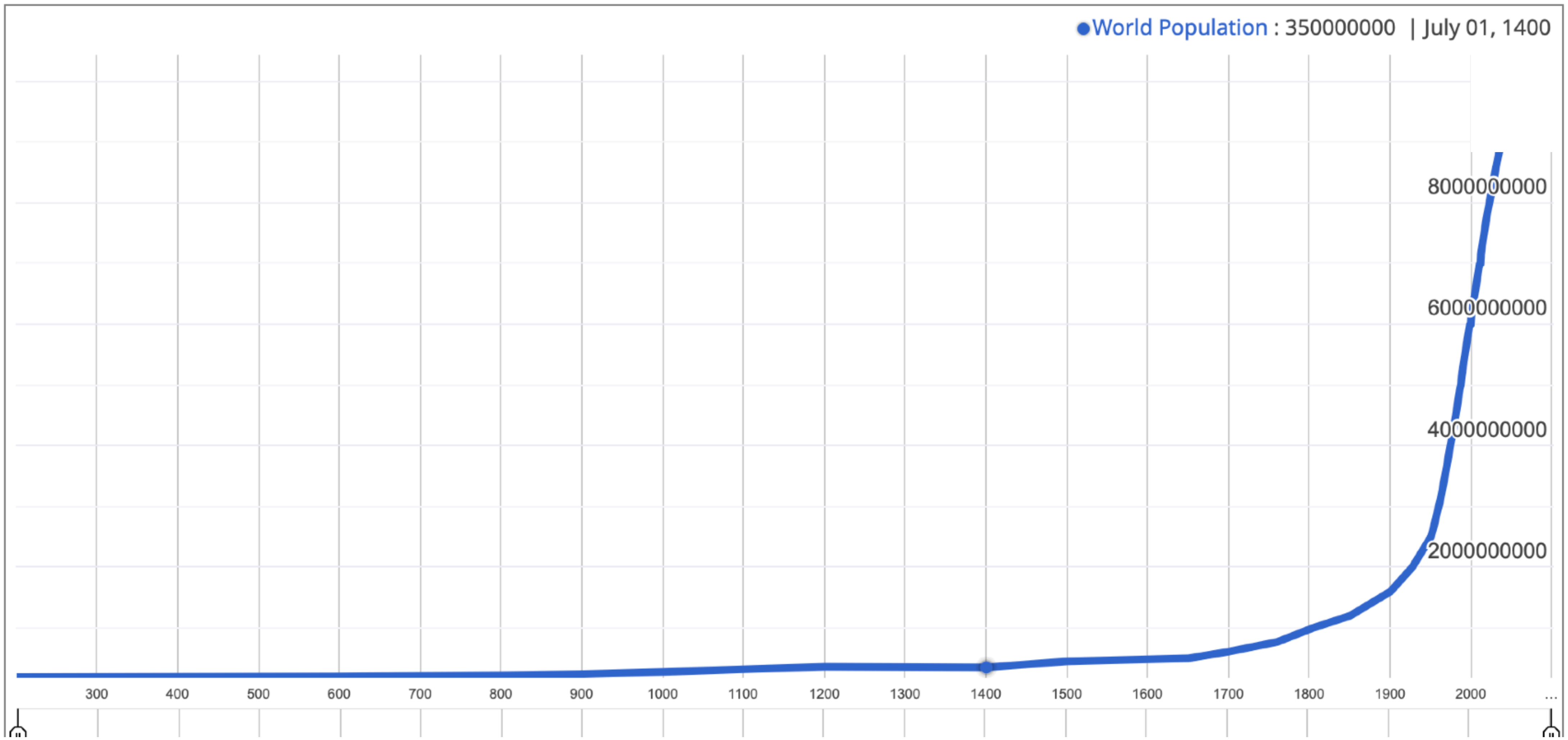
8,058,945,833

view all people on 1 page >

World Population: Past, Present, and Future

(move and expand the bar at the bottom of the chart to navigate through time)

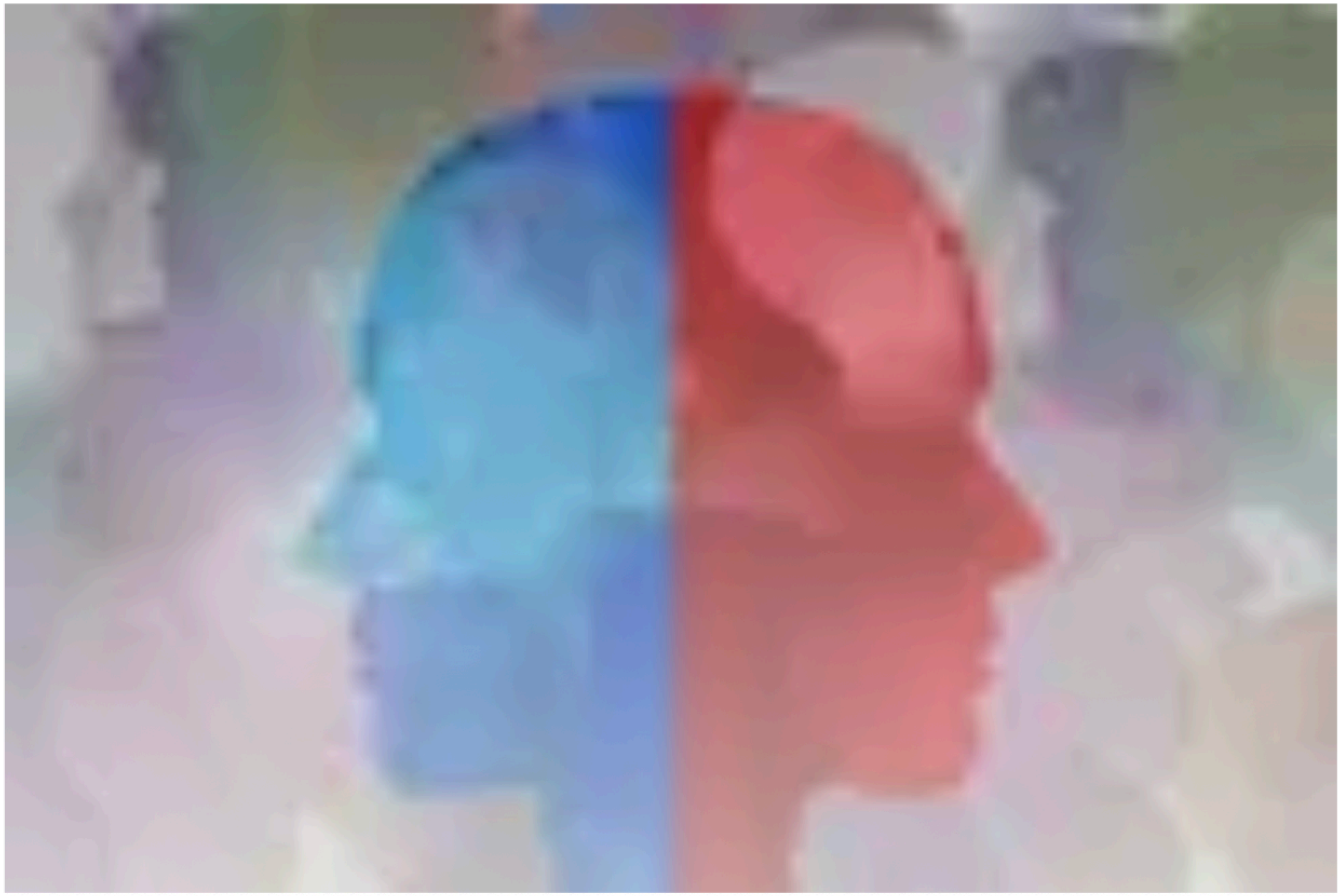
back to top ↑



The chart above illustrates how world population has changed throughout history. View the full tabulated data.

Could humans evolve into two different species in the future?

22 September 2021



Brain light/Alamy

Would it be possible for humans to evolve into two different species in the future?

NewScientist