

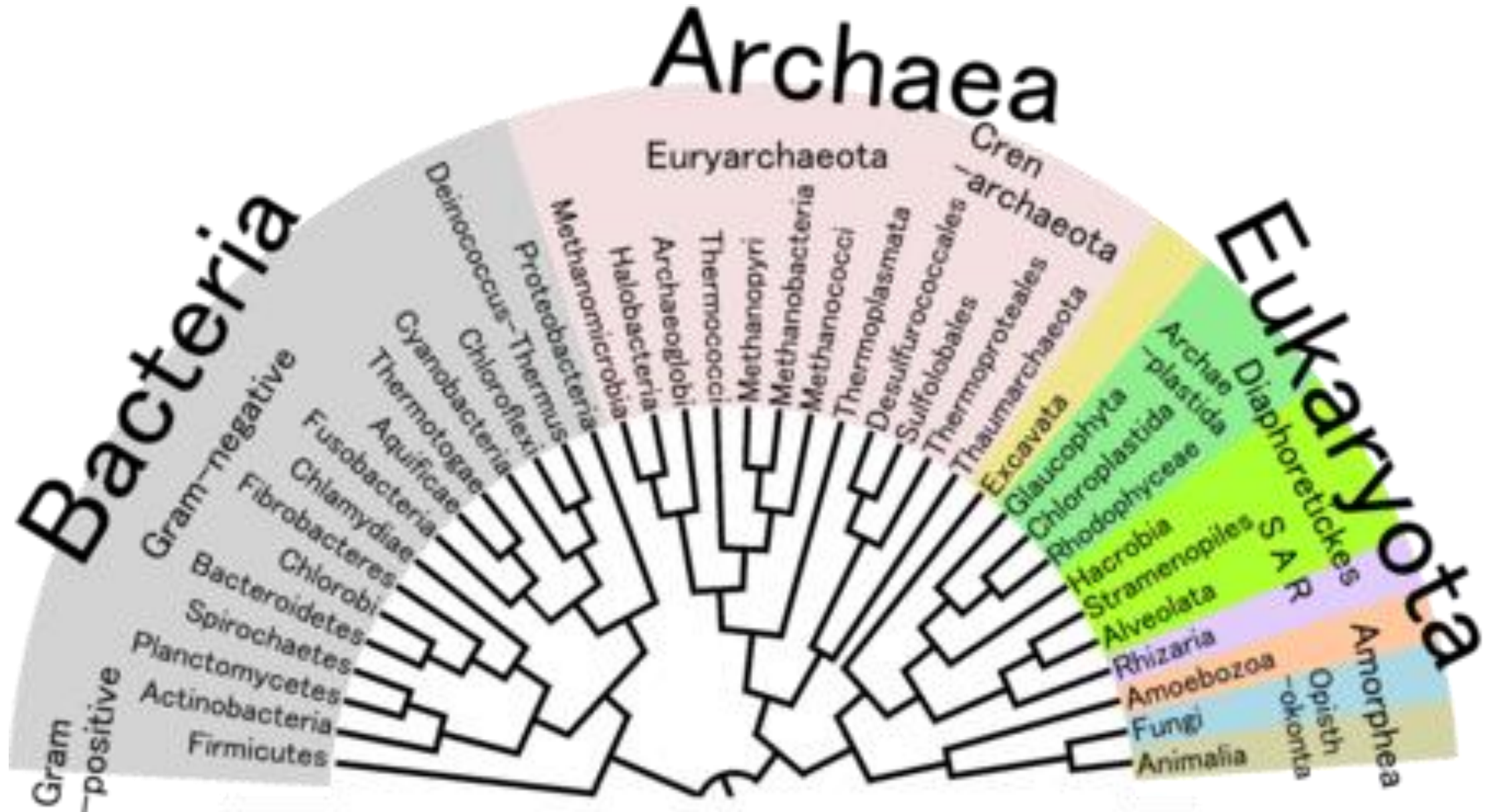
Lesson 1

Evidence of Evolution

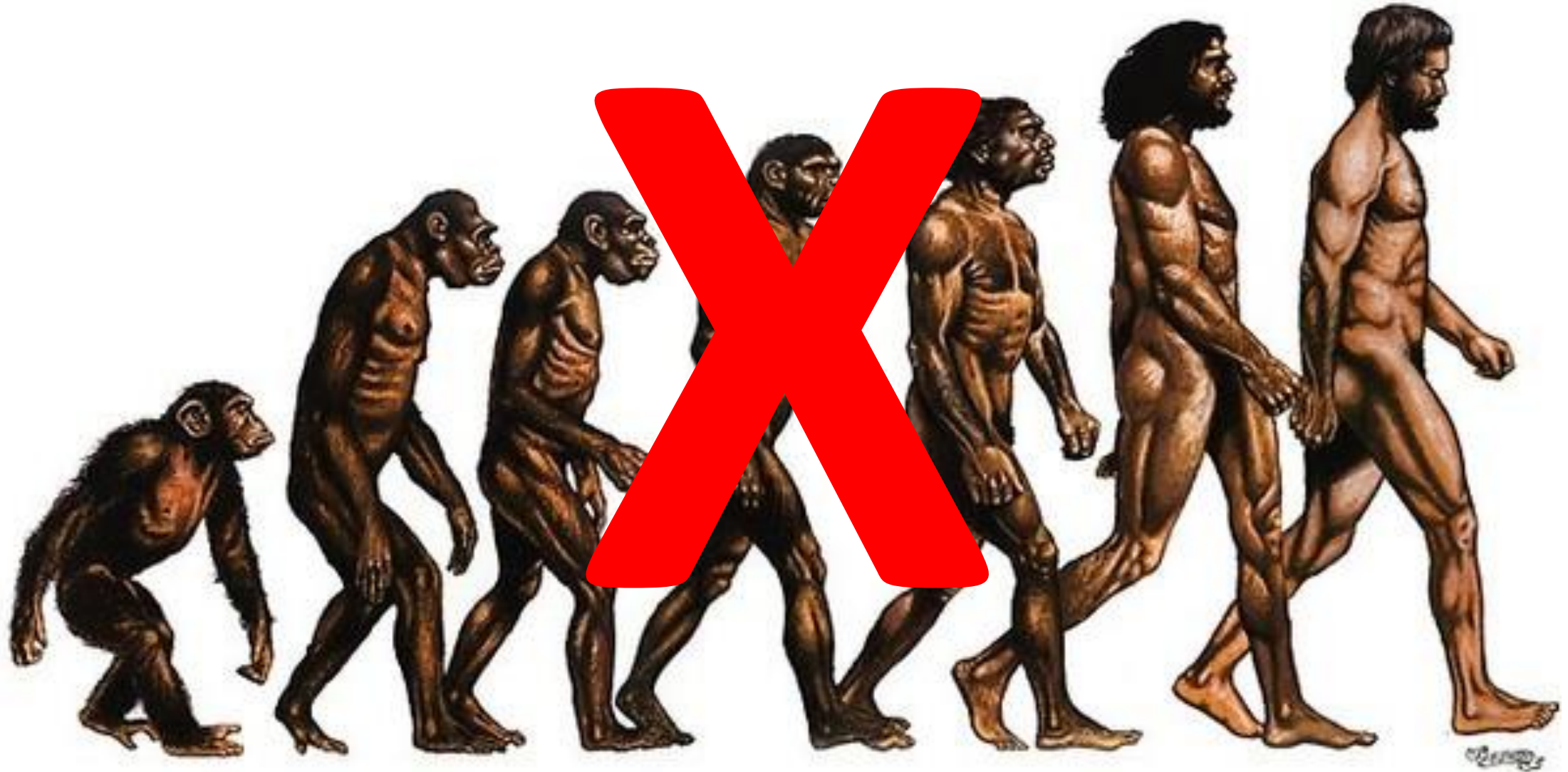
What is biological ideas are illustrated in this comic?



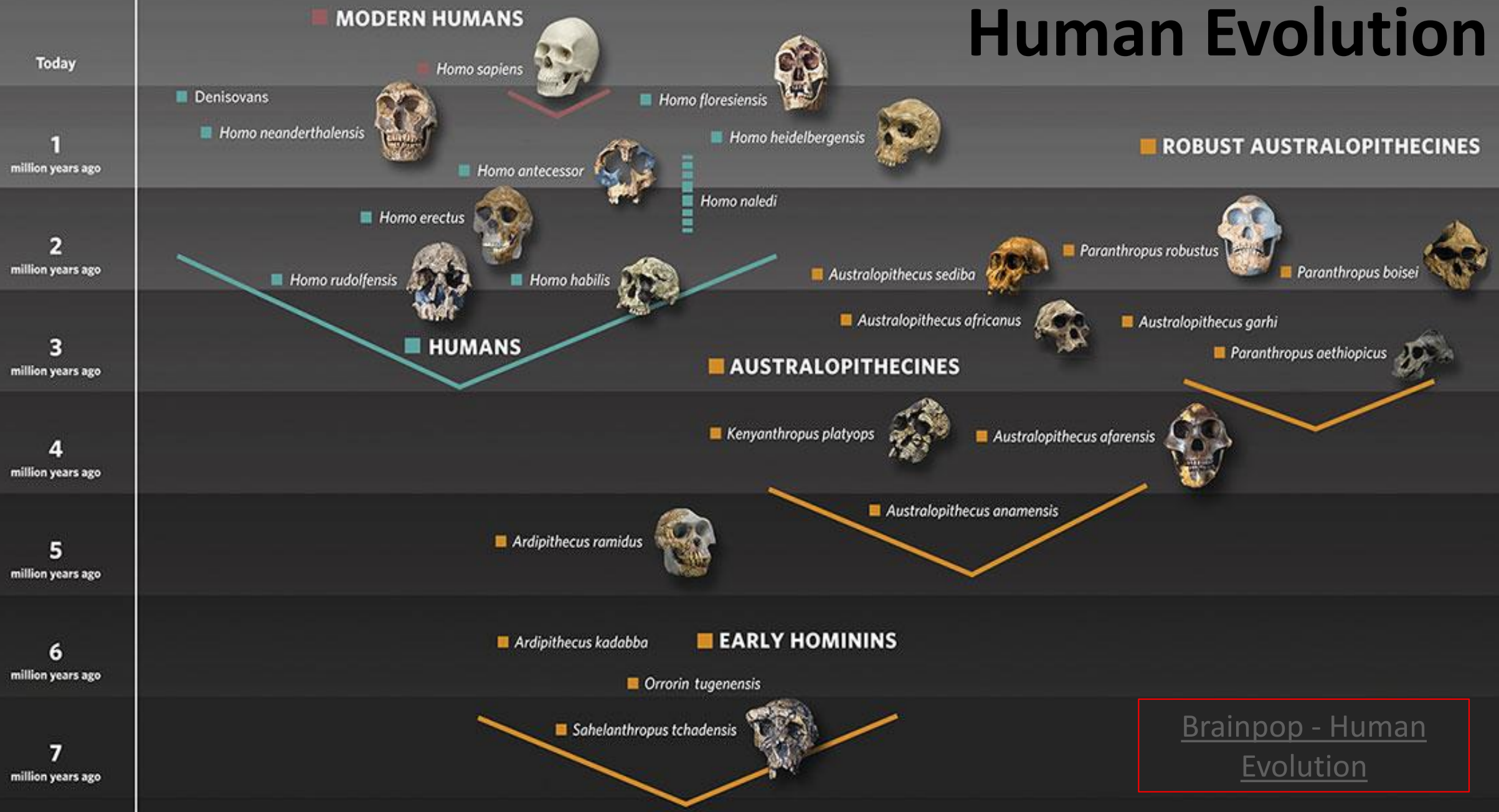
Evolution - the process of change over time



Human Evolution? Not exactly



Human Evolution

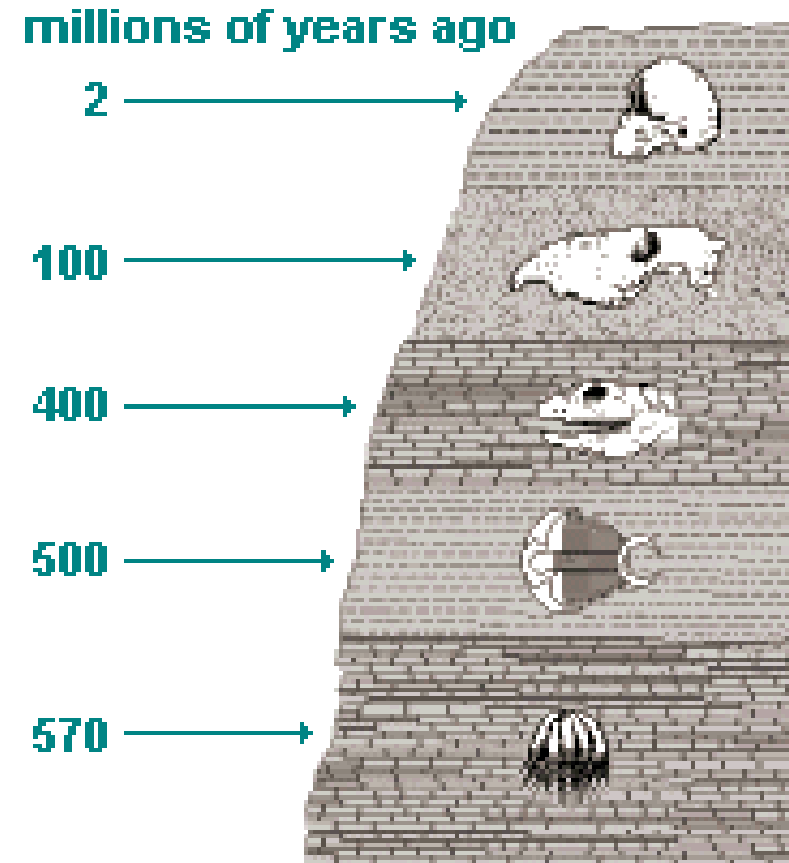


Brainpop - Human Evolution

Evidence supporting Evolution

The Theory of Evolution is supported by evidence from:

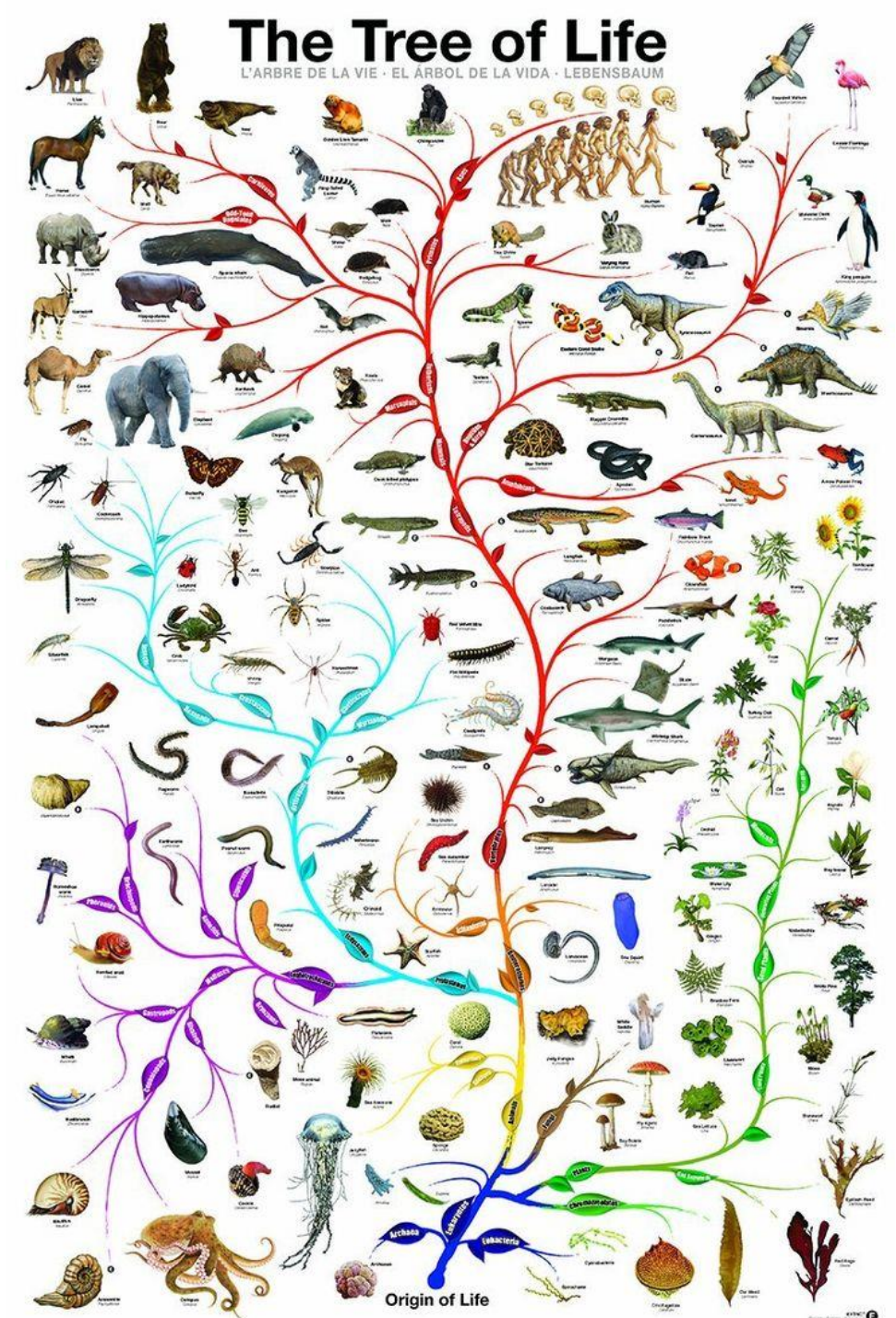
- Geologic records
- Fossils
- Comparative Anatomy
- Comparative Cytology
- Comparative Embryology
- Comparative Biochemistry



The Theory of Evolution

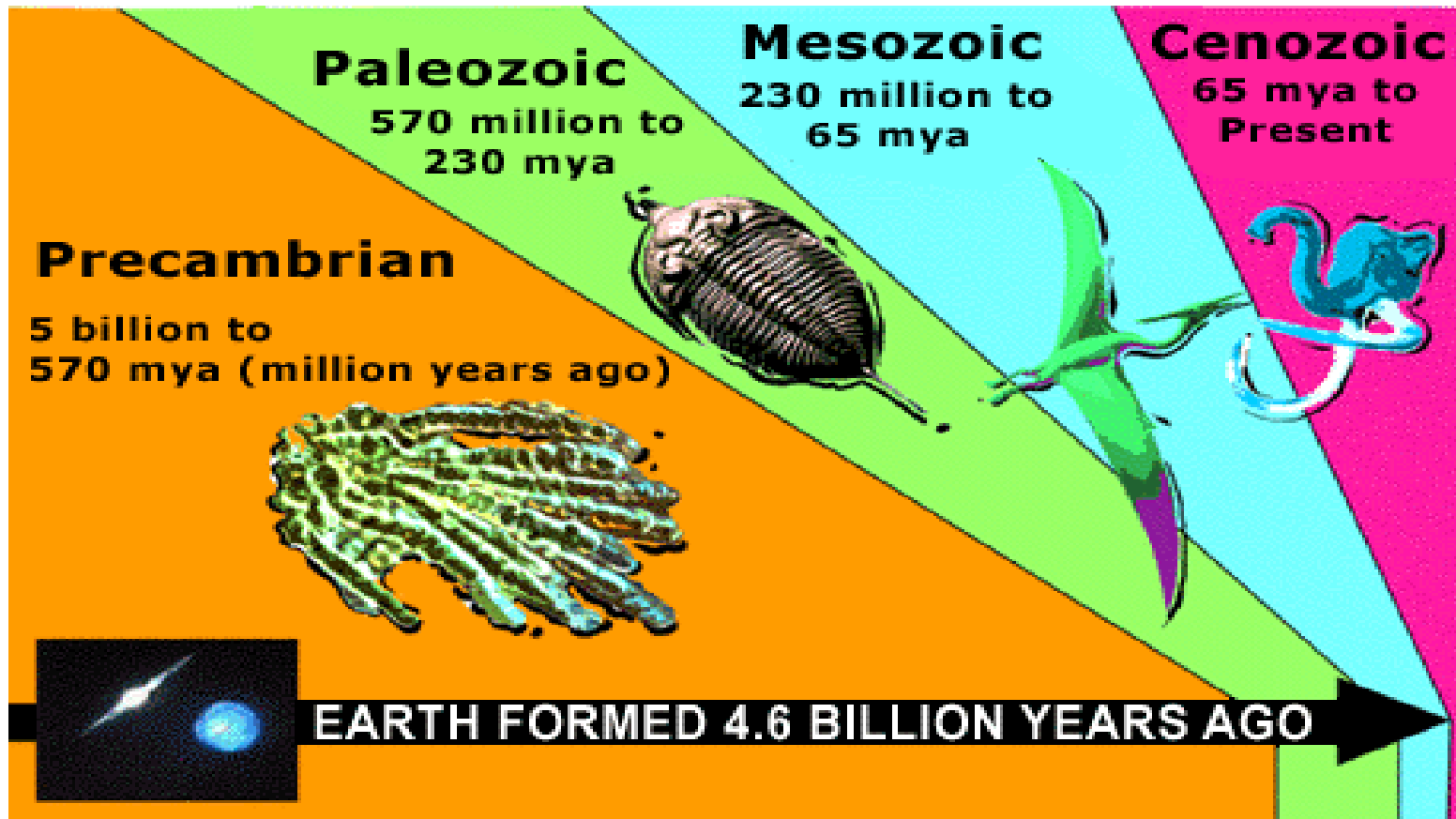
The Theory of Evolution states that:

- Existing life forms evolved from earlier life forms
- Simple organisms evolve before complex organisms



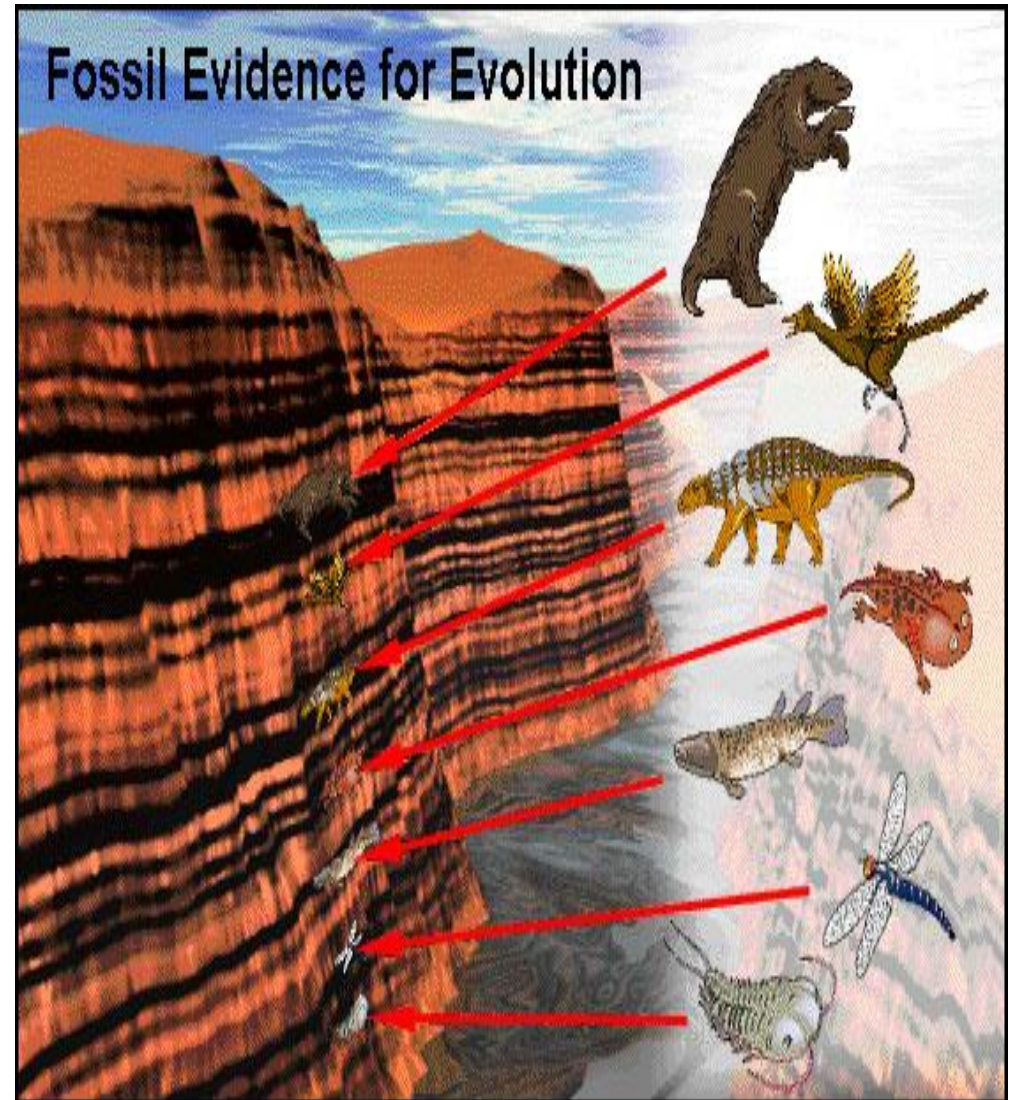
Geologic Record

- Earth's timeline
- Earth is about **4.5 billion** years old



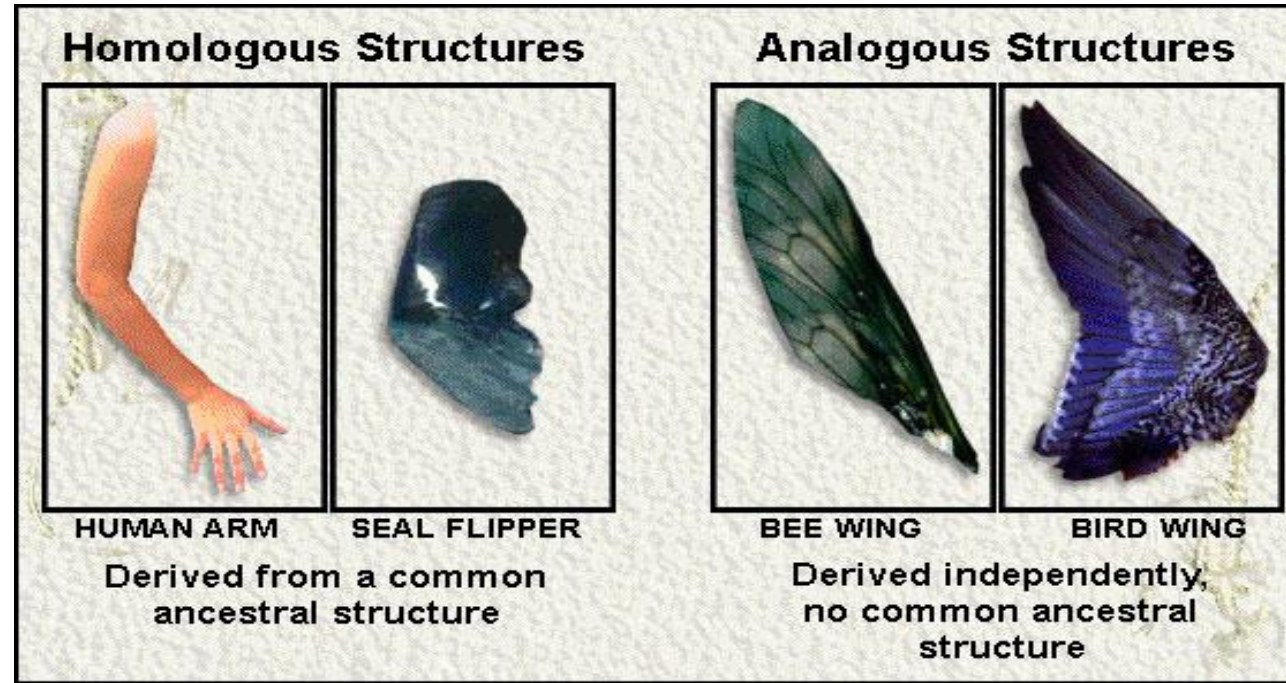
Fossil Record

- Fossils:
 - direct or indirect remains of organisms preserved in rocks, amber, ice or tar
 - can indicate how long ago an organism existed
- **Age** of a fossil:
 - determined by **carbon dating** or by location of rock layer



Comparative Anatomy

- comparing body structures



- **Homologous** – similar anatomical structure, but have a different function

- **Analogous** – different anatomical structure, but have a similar function

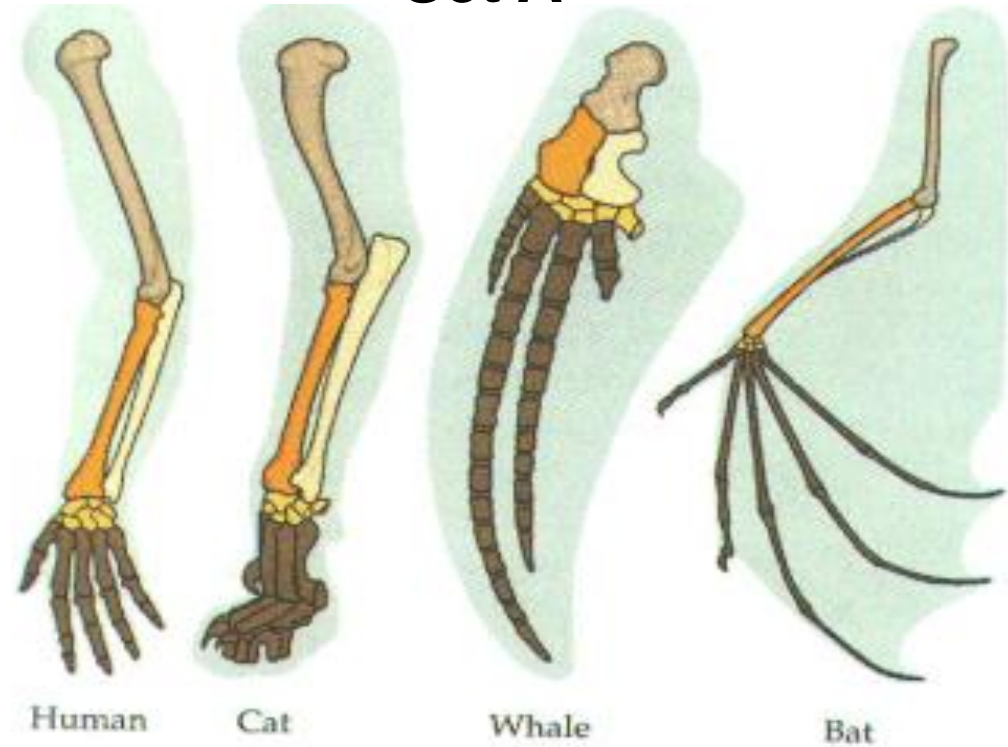
Q: Which set of pictures represents homologous structures?

–Ans: Set A

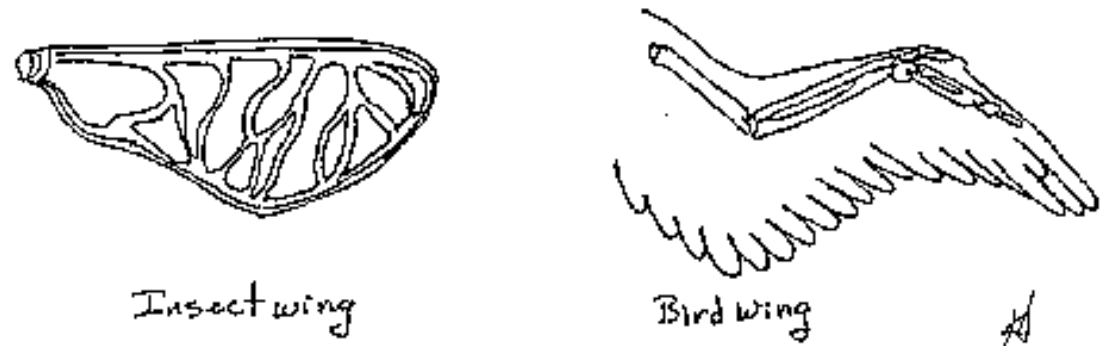
Q: Which set of pictures represents analogous structures?

–Ans: Set B

Set A



Set B



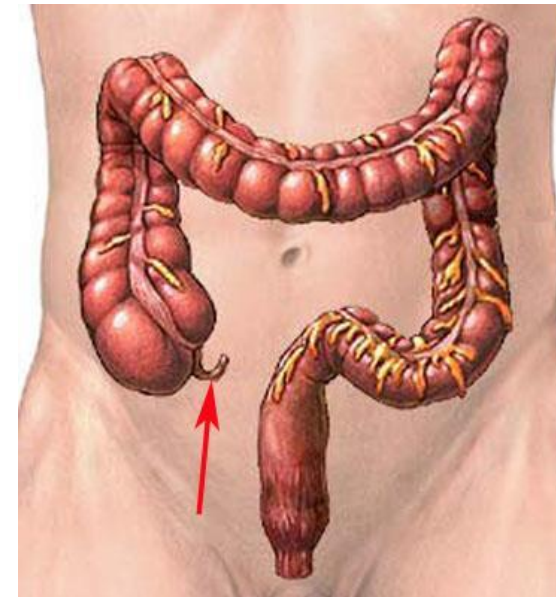
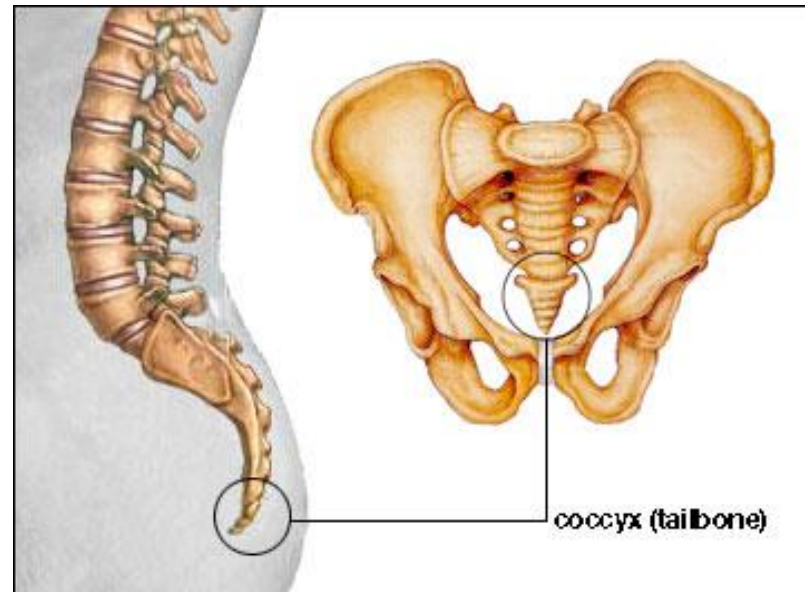
Vestigial Structures

- structures that have lost their original function
- shows common ancestry with those that still use them

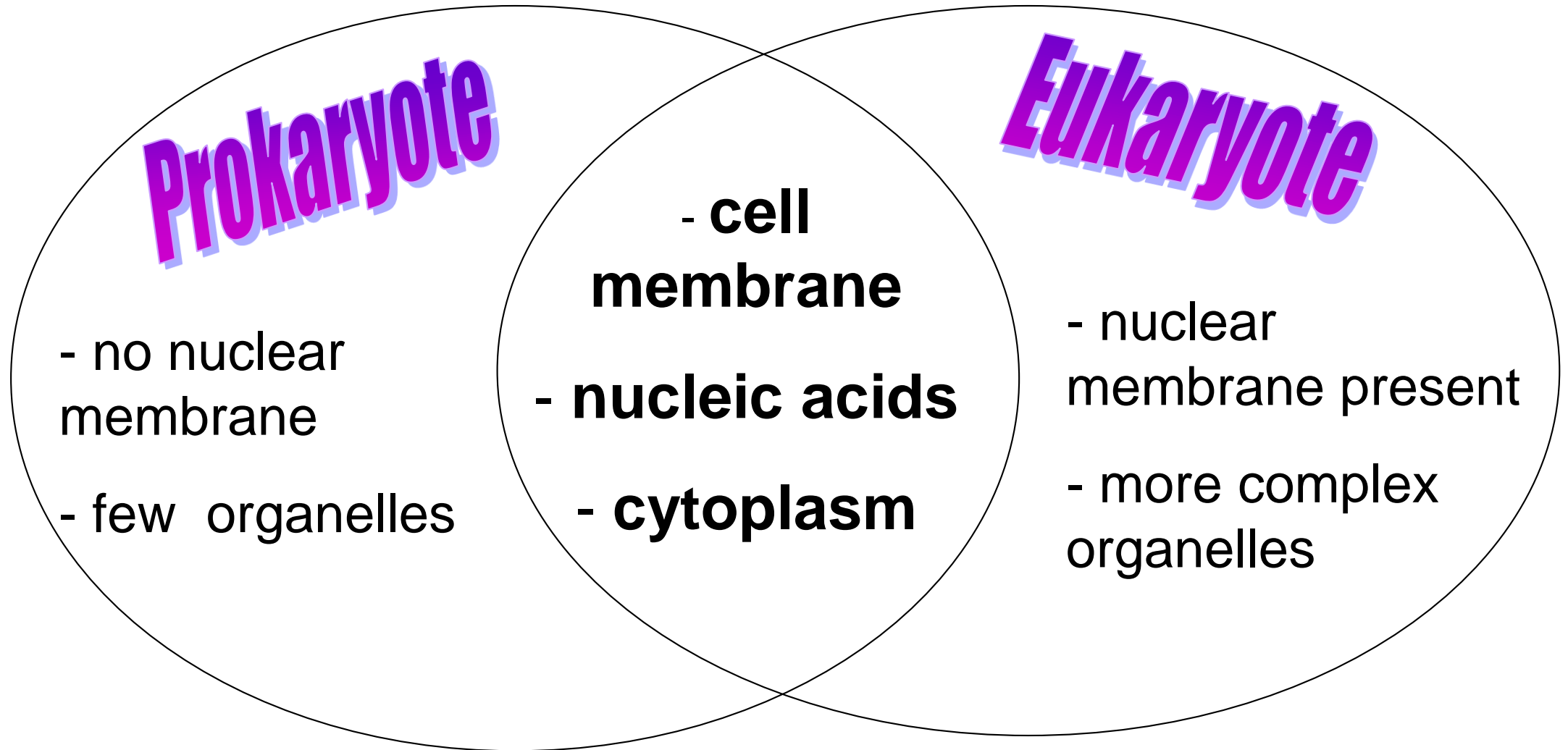
Ex. pelvic bones in a whale



Ex. tailbone, appendix in humans

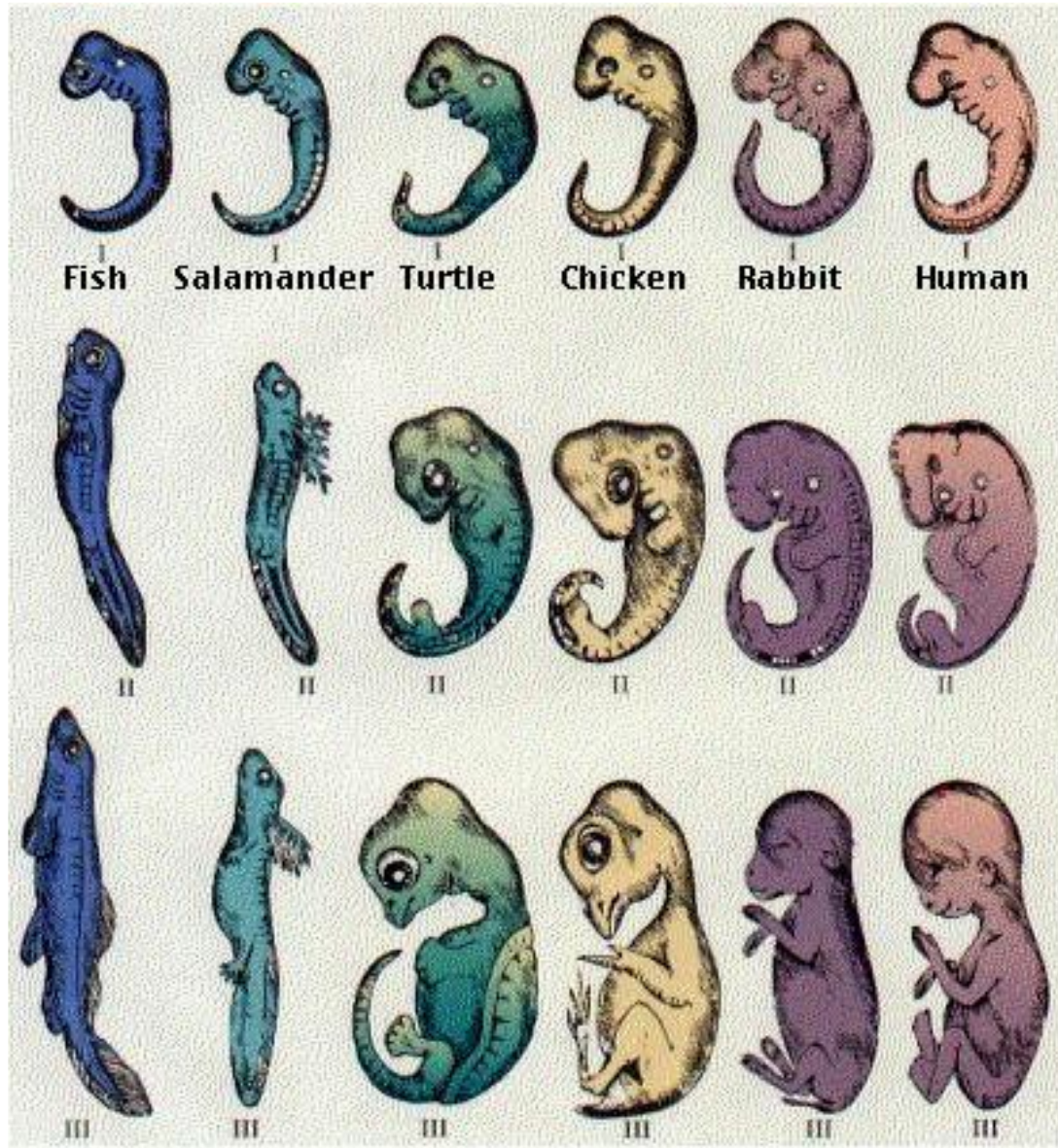


Comparative Cytology



Q: What do prokaryotic cells and eukaryotic cells have in common?

Comparative Embryology



- Comparing embryonic development
- Q: What evidence suggests that all these organisms have a common ancestor?
- All look similar in early stages of development (ex. tail, gill slits, shape)

Comparative Biochemistry

- Comparing the chemistry of living things (proteins and DNA)

Human DNA

A-G-G-C-A-T-A-A-A-C-C-A-A-C-C-G-A-T-T-A

Chimpanzee DNA

A-G-G-C-C-C-C-T-T-C-C-A-A-C-C-G-A-T-T-A

Gorilla DNA

A-G-G-C-C-C-C-T-T-C-C-A-A-C-C-A-G-G-T-A

Q – Which 2 organisms have the greatest similarity?

Chimp & gorilla

Q – Is the human more similar to the chimp or the gorilla? Why?

Chimp – fewer differences

Q - Which method of comparison is most effective at determining evolutionary relationships?

Why?

- comparative biochemistry (DNA & proteins)
- organisms may have similar physical characteristics but may still have hidden / unseen genetic differences

Lesson 2

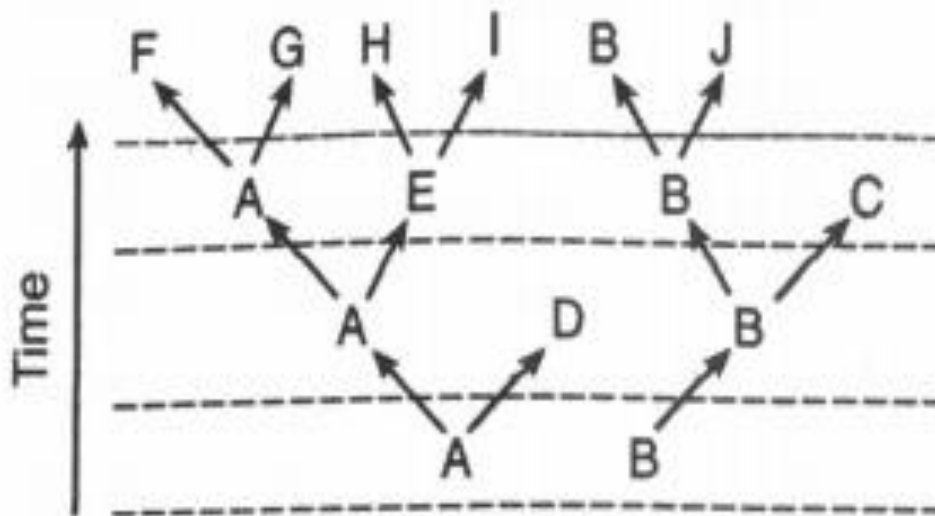
Theories of Evolution

-Lamarck

-Weissman

-Darwin

Base your answers to questions 1 and 2 on the diagram below and on your knowledge of biology. Letters *A* through *J* represent different species of organisms. The vertical distances between the dotted lines represent long periods of time in which major environmental changes occurred.



2

1. Which species appears to have been most successful in surviving changes in the environment over time?

(1) *A*

(2) *B*

(3) *C*

(4) *H*

4

2. Which species was the first to become extinct?

(1) *E*

(2) *J*

(3) *C*

(4) *D*

What evolutionary misconception is illustrated in this comic?

Evolution does NOT occur in one individual organism in its lifetime.

Evolution occurs in a SPECIES over LONG periods of time.



How do we get our characteristics?

- Inherited Characteristics (genetic)
- Acquired Characteristics (learned, developed with practice)

What are some of YOUR own inherited and acquired characteristics?

Ex.

- **Brown eyes**
- **Light skin**
- **Short stature**

Ex.

- **Neat handwriting**
- **Organized**
- **Hula hooping champion**

Jean Lamarck's Theory of Evolution

Theory of Use and Disuse states:

1) the size of an organ is determined by how much it is used

- Ex. Ballet dancers have large/strong leg muscles because they use them a lot (get smaller when no longer in use)

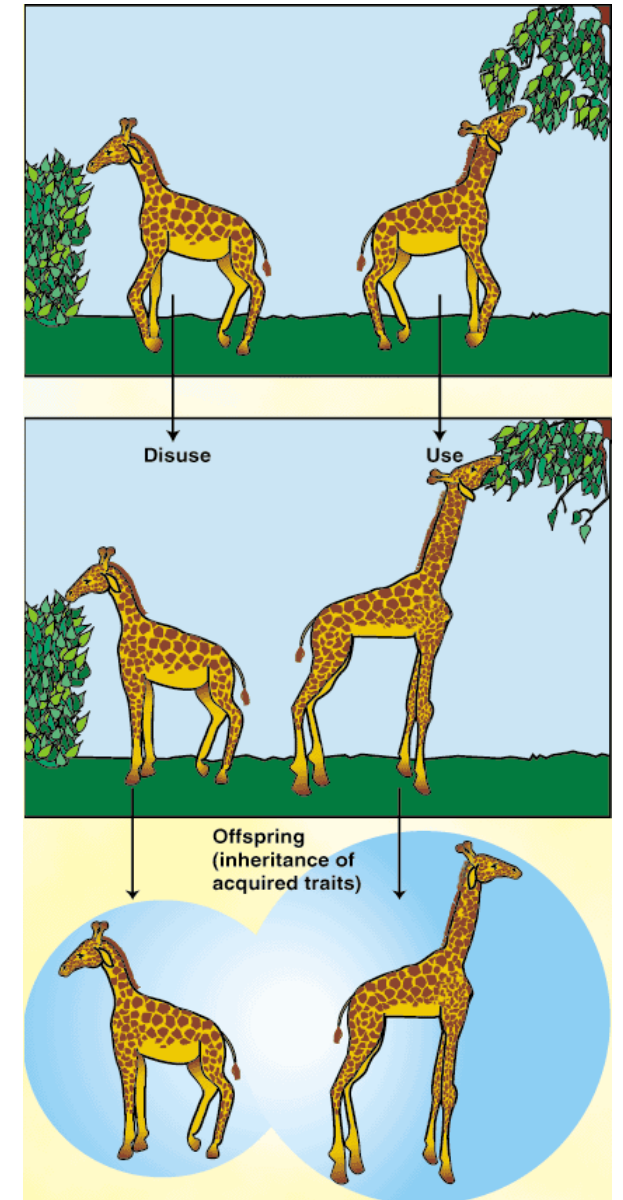


Jean Lamarck's Theory of Evolution (cont.)

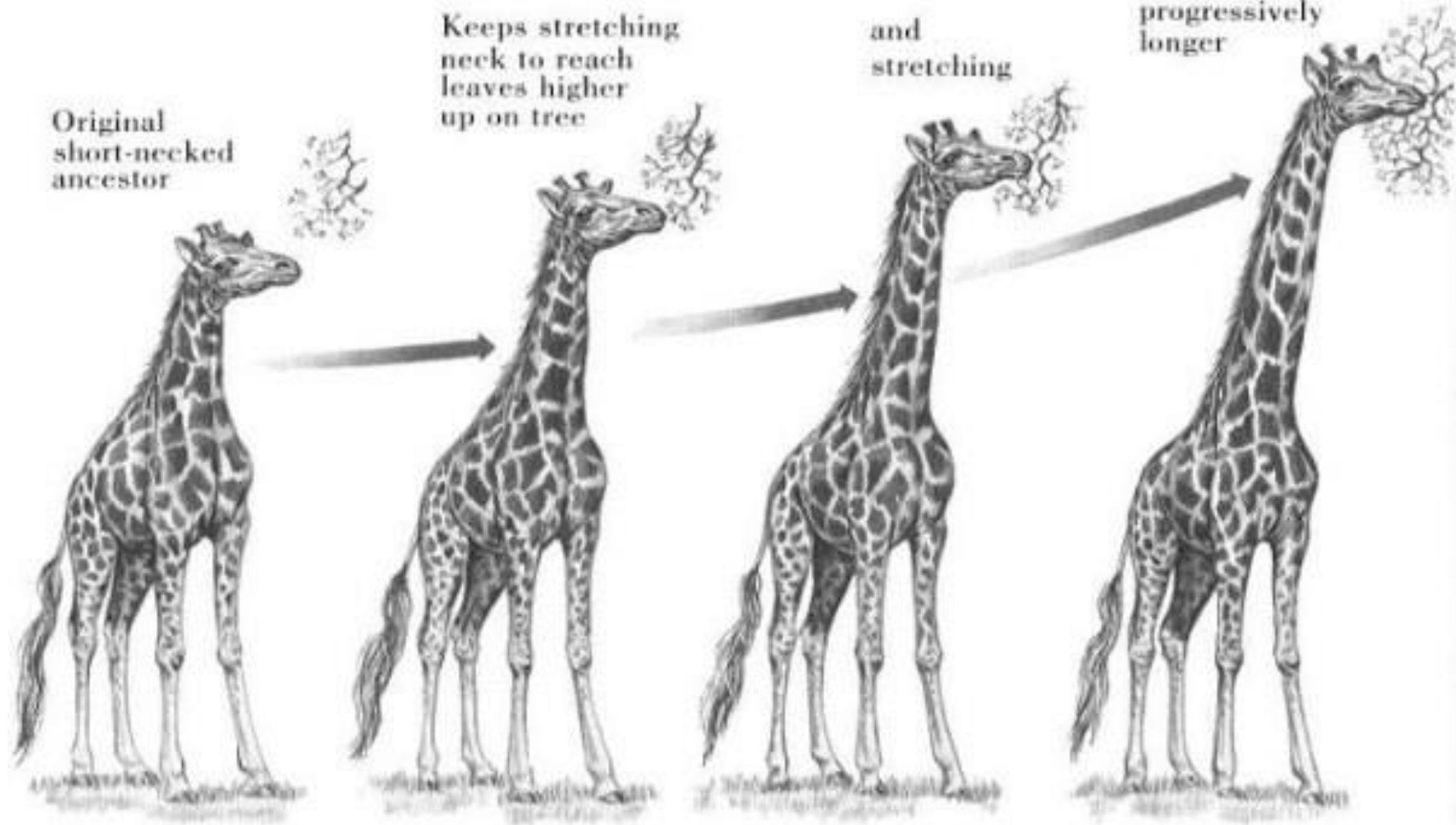
2) Says that individual organisms develop new structures because they NEED them

–Ex. Giraffes stretched and grew longer necks because they NEEDED to reach the leaves of a tree

WRONG!



LAMARCK'S GIRAFFE



Original short-necked ancestor

Keeps stretching neck to reach leaves higher up on tree

and stretching

and stretching until neck becomes progressively longer

Driven by inner "need"

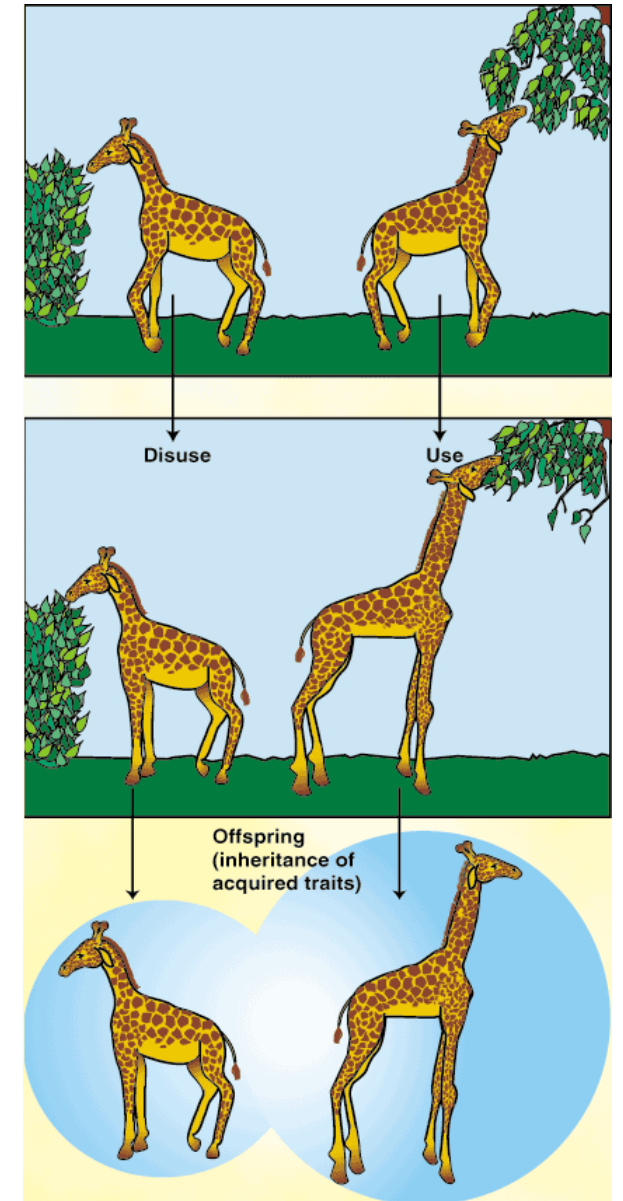
Jean Lamarck's Theory of Evolution (cont.)

3) Said offspring will inherit acquired characteristics

–Ex. Baby giraffes are born with long necks because parents stretched them and passed it on

WRONG!

Or is it???



Epigenetics

- The study of potentially heritable changes in gene expression
- does NOT involve changes to the DNA sequence
- a change in phenotype without a change in genotype
- affects how cells read the genes

[Video - Epigenetics \(brief animated explanation\)](#)

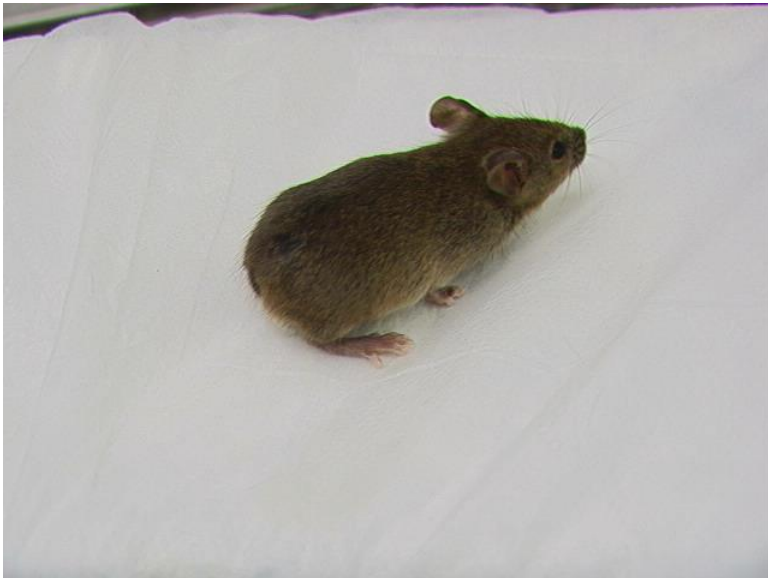
[Video - Epigenetics Ted Talk](#)

[Video - Epigenetics \(Bozeman Science\)](#)



August Weismann (disproved Lamarck)

- By performing an experiment:



He cut off tails from mice



Then mated the tail-less mice



But offspring were born WITH tails!

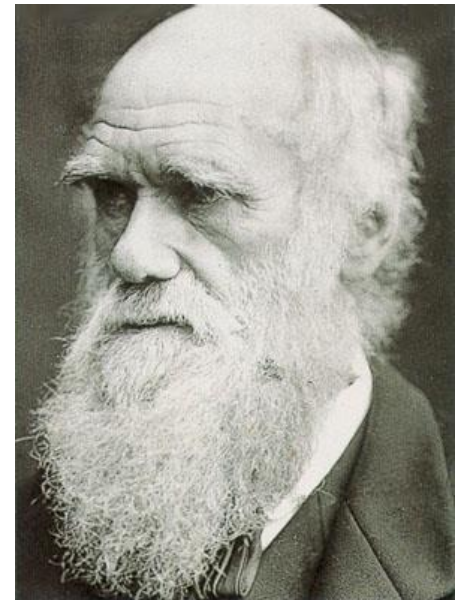
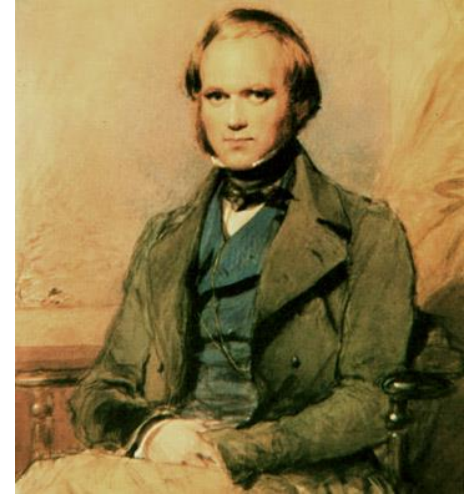
Q: What would Lamarck's theory have expected?

A: Tail-less babies (did not happen)

- **Conclusion**: acquired traits are **NOT** inherited by the offspring, thereby proving Lamarck **WRONG**

Theory of Natural Selection (Charles Darwin)

- Said that the environment determines traits
- Survival of the “fittest”
 - “fit” = best suited for that environment to survive to reproduce, NOT necessarily the strongest/fastest etc.
 - Organisms with favorable adaptations (characteristics or traits) for their environment will survive to reproduce more successfully than those with unfavorable adaptations

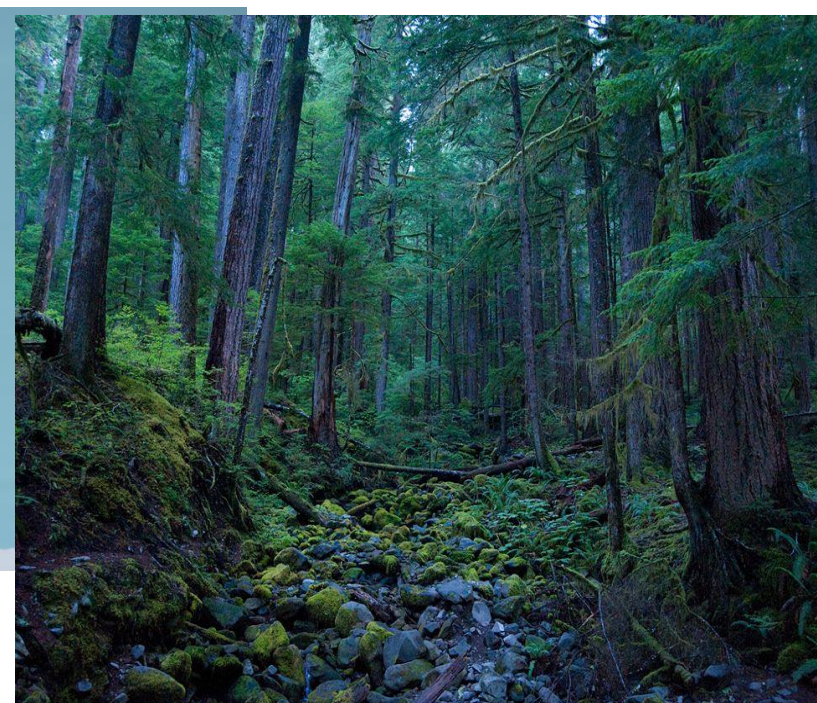


Which environment is the polar bear best “fit” for?

- cold snowy climate

Why?

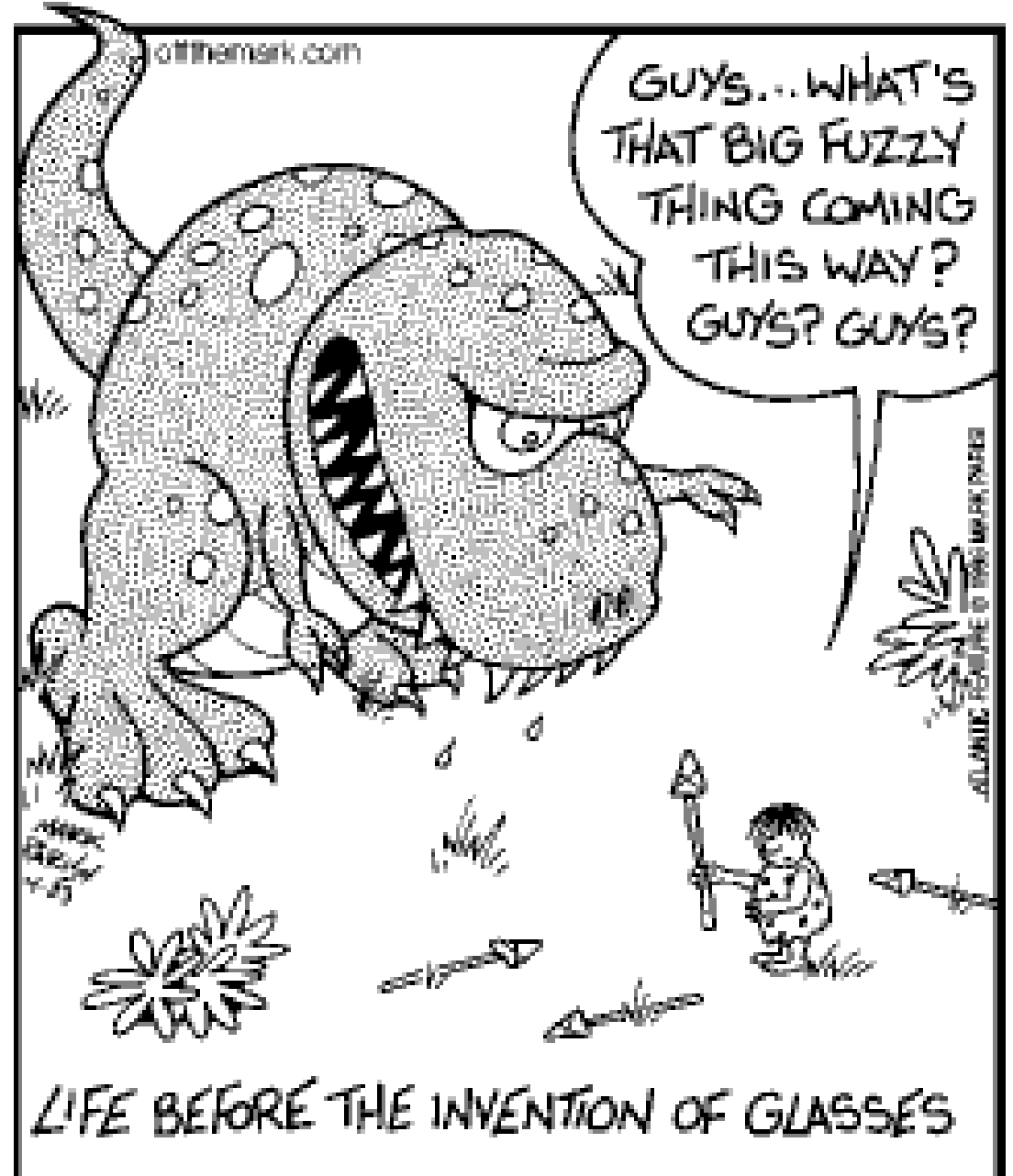
- It has adaptations (traits) suited for that environment
 - fur to keep warm in cold temperatures
 - white color to blend with surroundings to hunt effectively



What evolutionary concept is illustrated in this comic?

Darwin's Survival of the Fittest

Bad eyesight is not best "fit" for that environment so he will not survive



What evolutionary concept is illustrated in this comic?

Lamarck's Theory,
evolution due to
need

WRONG!



What is illustrated in this comic?

Lamarck's Theory,
evolution due to
need

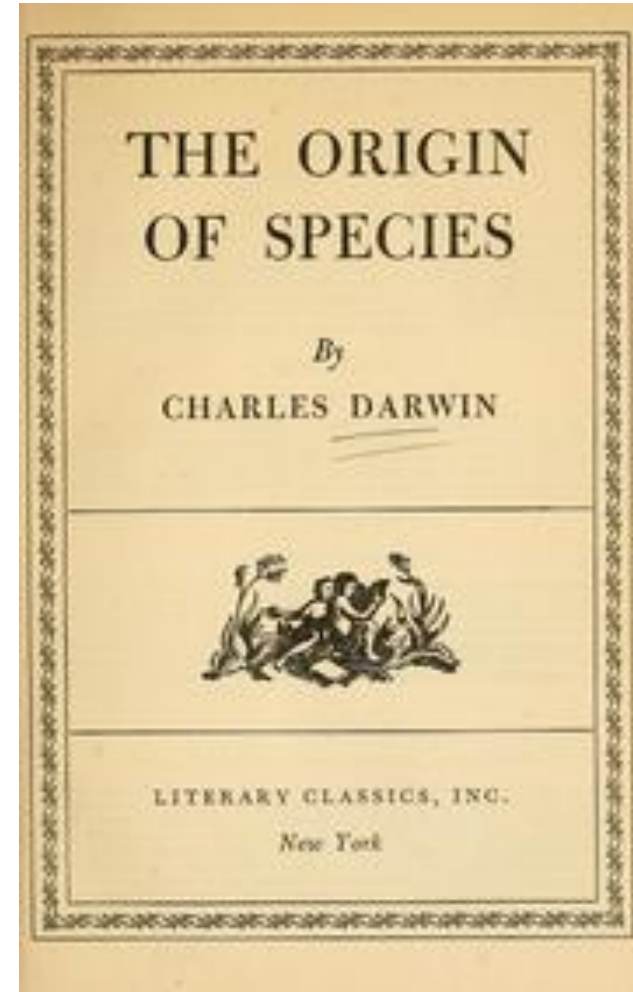
WRONG!

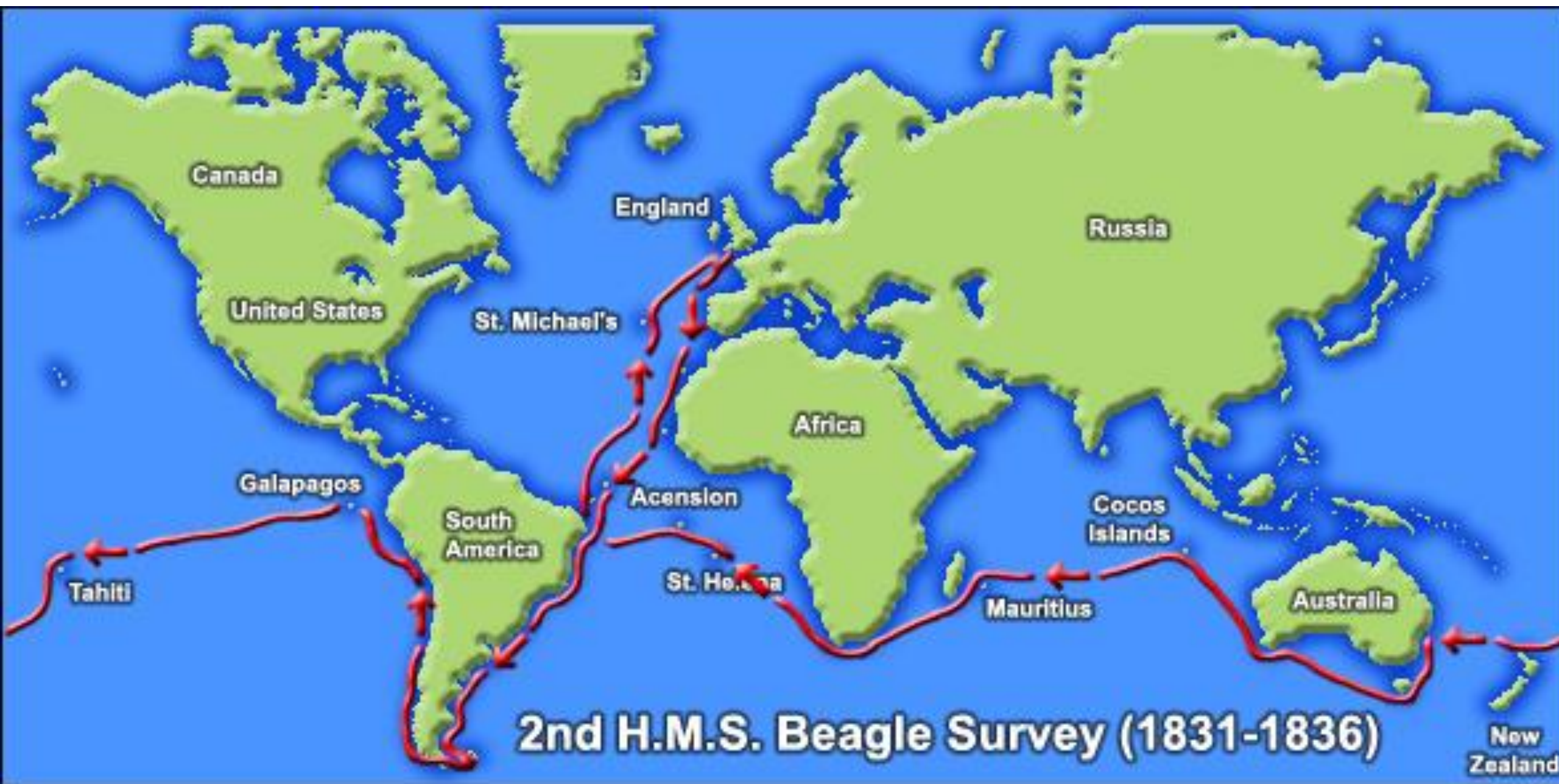


Lesson 3

Darwin's Theory of Natural Selection

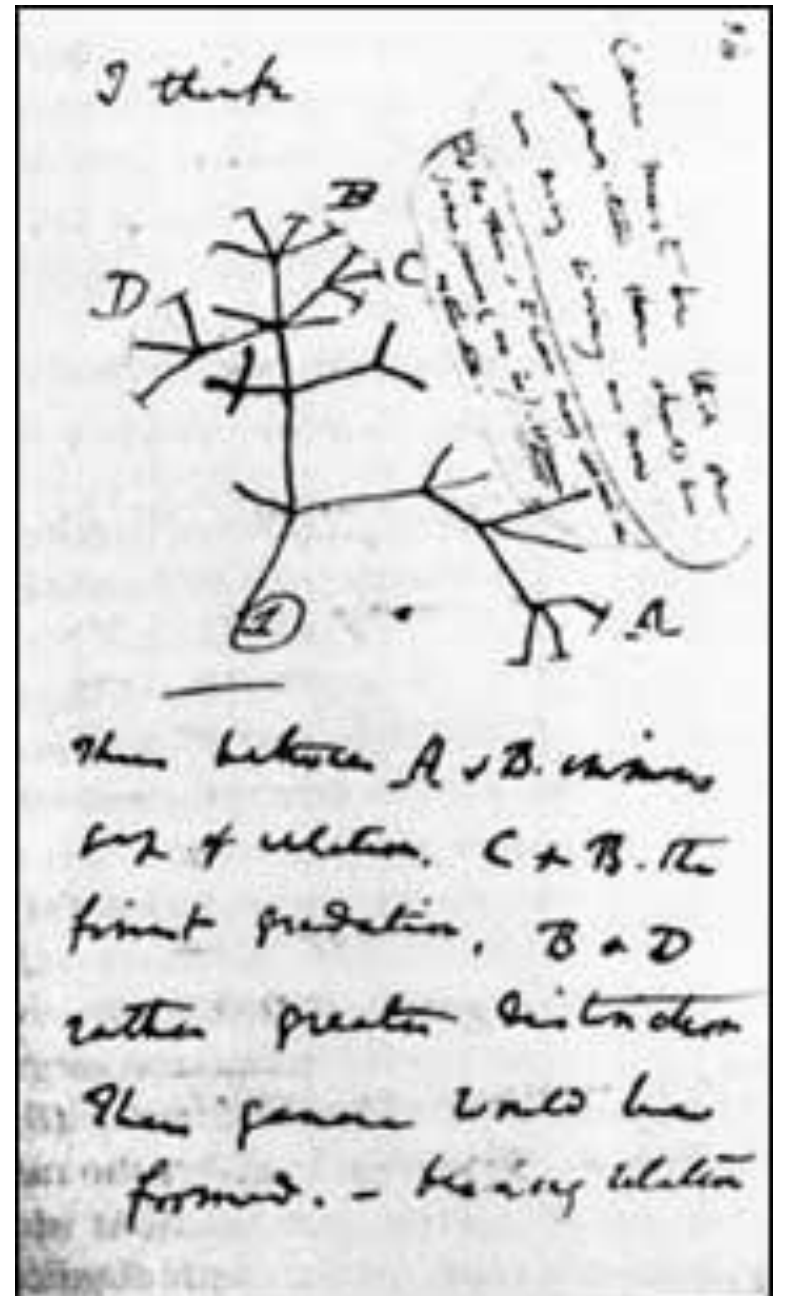
How did Darwin come up with his theory of Natural Selection?





Galapagos Archipelago

H.M.S. Beagle Survey
Sept 15 to Oct 20 1835



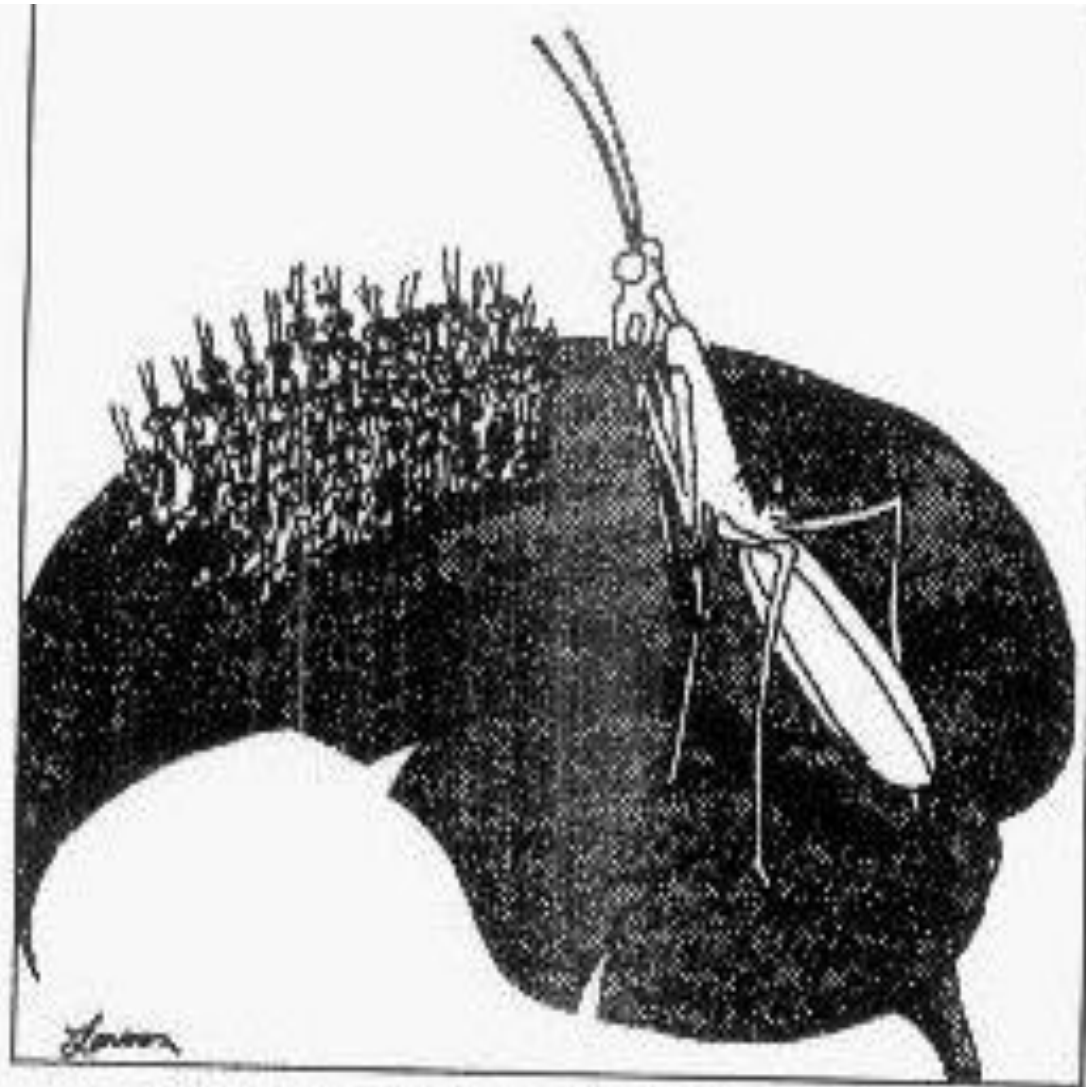


What are the main ideas of Darwin's theory of Natural Selection?

“Paine Lake at Dusk, Paine Lake, Alberta, Canada
Special Mention
© Darwin Wiggett, Water Valley, Alberta, Canada

1. Overproduction

Within a population, more offspring are born than can possibly survive



"Of course, long before you mature, most of you will be eaten."

2. Competition



- Organisms compete for space, food, water, mates, and other limited resources in their struggle for existence

3. Variations

◆ Differences among individuals of a species



4. Survival of the Fittest

- **Organisms with favorable adaptations survive to reproduce**
- **Organisms with unfavorable traits die**

This polar bear's white fur, which helps conceal it from its prey in the Arctic, has been selected for over thousands of years.



Lichen growth
on a tree

Lichen = light
color

Tree bark = dark
color



Ex. English Peppered Moth

- Before Industrial Revolution: lichen covered trees were light color
- After Industrial Revolution:
Environment changed:
Pollution killed the lichens revealing darker colored bark

How did this affect the moth population?



Ex. English Peppered Moth

Which moth is best "fit" to survive in the original environment (light color trees)? Why?



light colored moths blend in better to avoid predators

Which moth is best "fit" to survive in the changed environment (dark trees)? Why?



Dark colored moths blend in better to avoid predators

5. Reproduction

- **Individuals that survive pass on their favorable traits to their offspring**



6. Speciation

- Over time, different variations can cause populations to diverge and become their own separate species

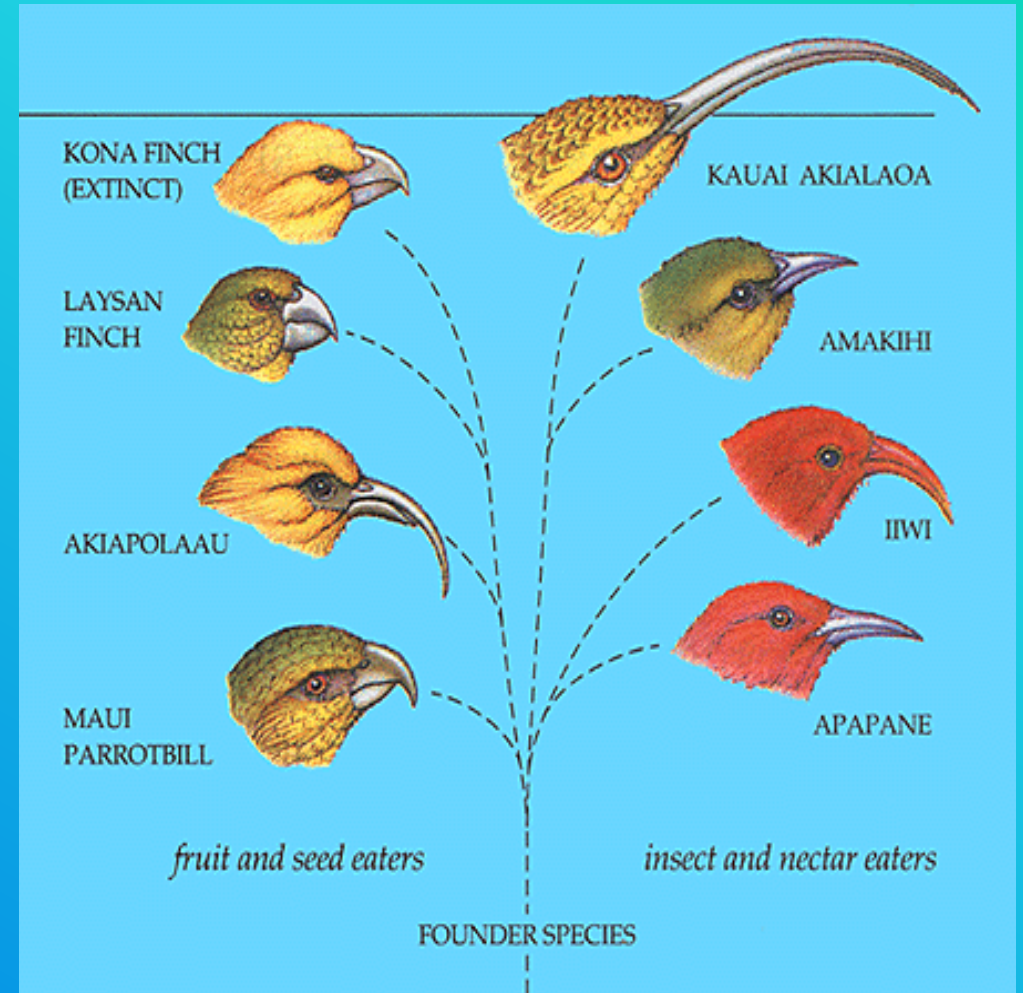


Figure 19.13 A few Hawaiian honeycreepers, an example of how a new arrival in species-poor habitats on an isolated archipelago can be the start of a flurry of allopatric speciation.

Natural Selection Example:

- Giraffes had many offspring (overproduction)
- Offspring had different length necks (variations)
- Offspring competed for limited resources (competition)
- Long necks = many survive
Short necks = fewer survive (survival of the fittest)
- Long-necked trait was passed on to future generations (reproduction)



Which of Darwin's ideas in his Theory of Natural Selection are related to this cartoon?

Overproduction



Lesson 4

Modern Theory of Evolution (1) **- Mutations**

Modern Evolutionary Theory

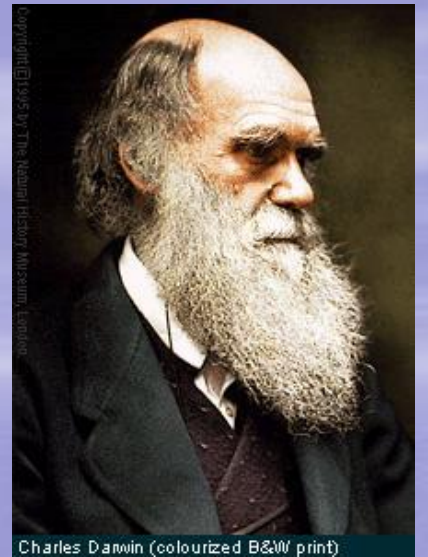
(natural selection and genetics)



**Notice
anything
interesting?**

Weaknesses in Darwin's Theory

- Did not explain the genetic reasons for variations (mutations)
- Did not explain the origin of life itself



“There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and wonderful have been, and are being, evolved.”

- This passage from Chapter XIV concludes *The Origin of Species*. Significantly, Darwin leaves room for a creator in the formation of species. The image of someone “breathing life” into the original species is a direct allusion to biblical notions of creation.

Origin of Life?

- **Heterotroph Hypothesis**

- Primitive Earth conditions
- Heterotrophs evolved before autotrophs (no CO₂)
- Anaerobes before aerobes (no O₂)

- **Hydrothermal vents**

- Living organisms that do not depend on sunlight for energy may have been first

[Video - 100 Greatest Discoveries 5of9 Evolution \(Bill Nye\)](#)

Play from 11:40 to 20:00 (origin of life)

Mutations

- **Occur randomly and spontaneously**
- **Cause variations**
- **Favorable traits are passed on & increase in frequency within a population**
- **Unfavorable traits decrease over time**
- **If the environment changes, traits with low survival value may become favorable and increase in number**

Species that are...

- More likely to evolve:

- reproduce sexually
- genetically varied
- have more mutations



- Less likely to evolve:

- reproduce asexually
- little genetic variation
- have fewer mutations



Geographic Isolation

@AmoebaSisters

If you **REALLY** loved me, you'd swim across.

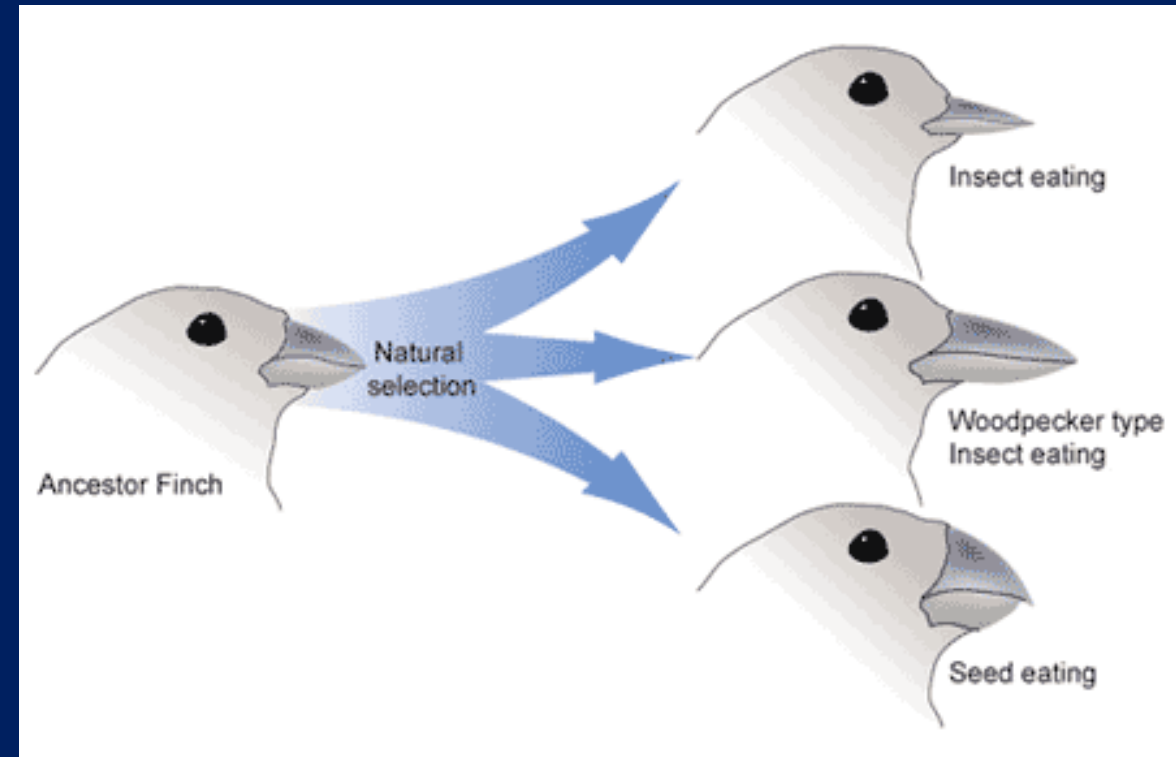


- physical separation into smaller populations by geographic barriers (mountains, oceans, rivers, deserts etc.)

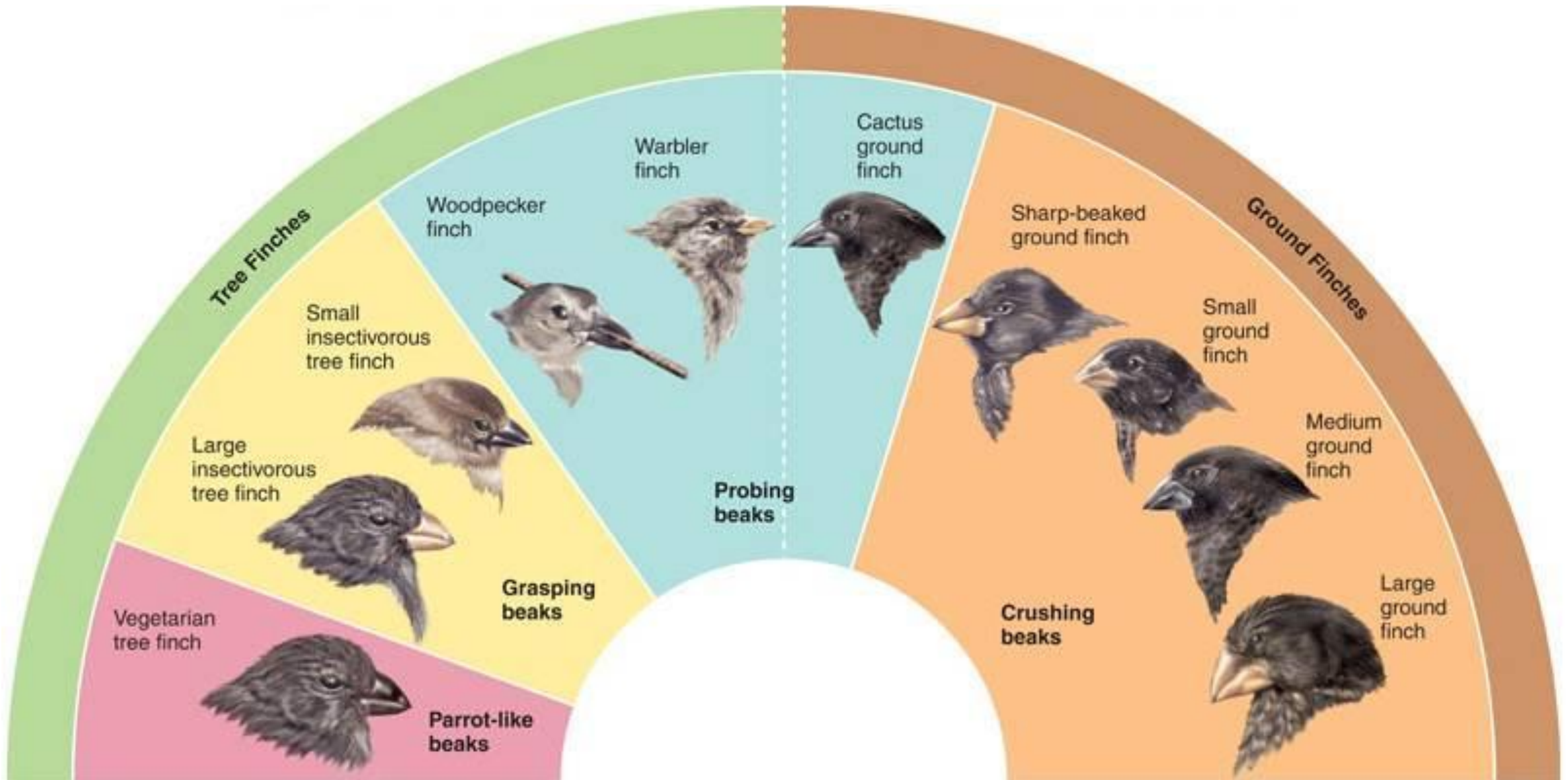


Geographic Isolation (cont.)

- May lead to:
 1. Reproductive isolation: isolated populations become so genetically different, they cannot interbreed
 2. Speciation: production of a new species



Speciation in Galapagos Finches



Time Frames for Evolution

- Evolution does **NOT** progress in any set direction!

Gradualism:

- slow, continuous change over time

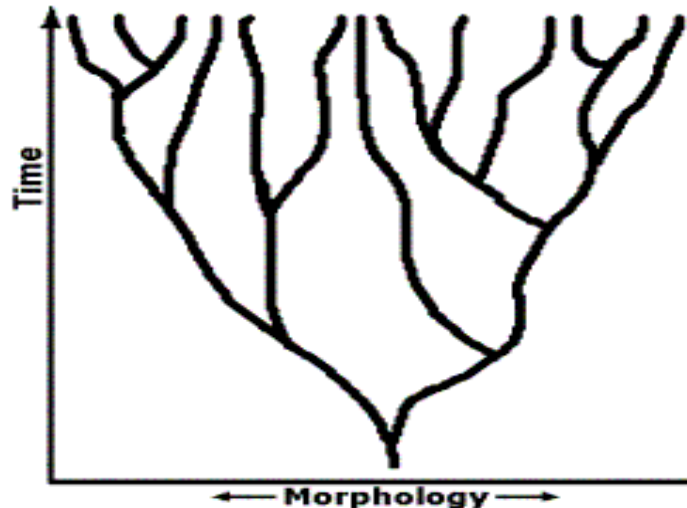
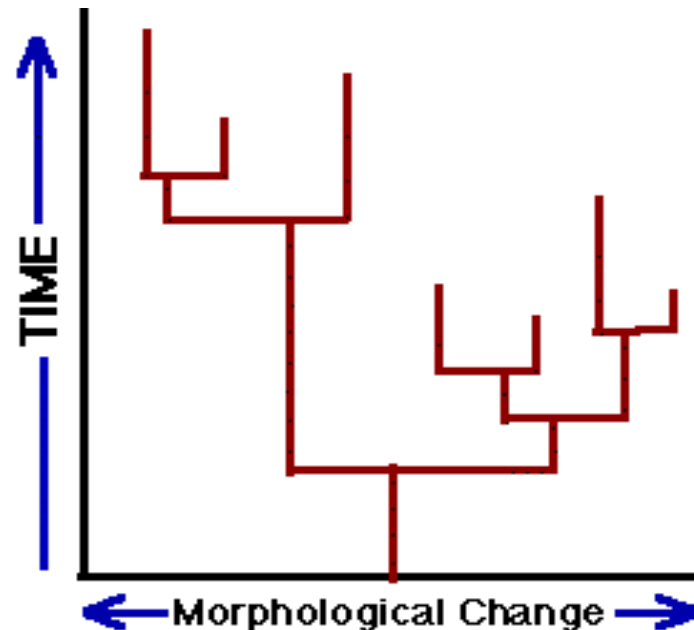
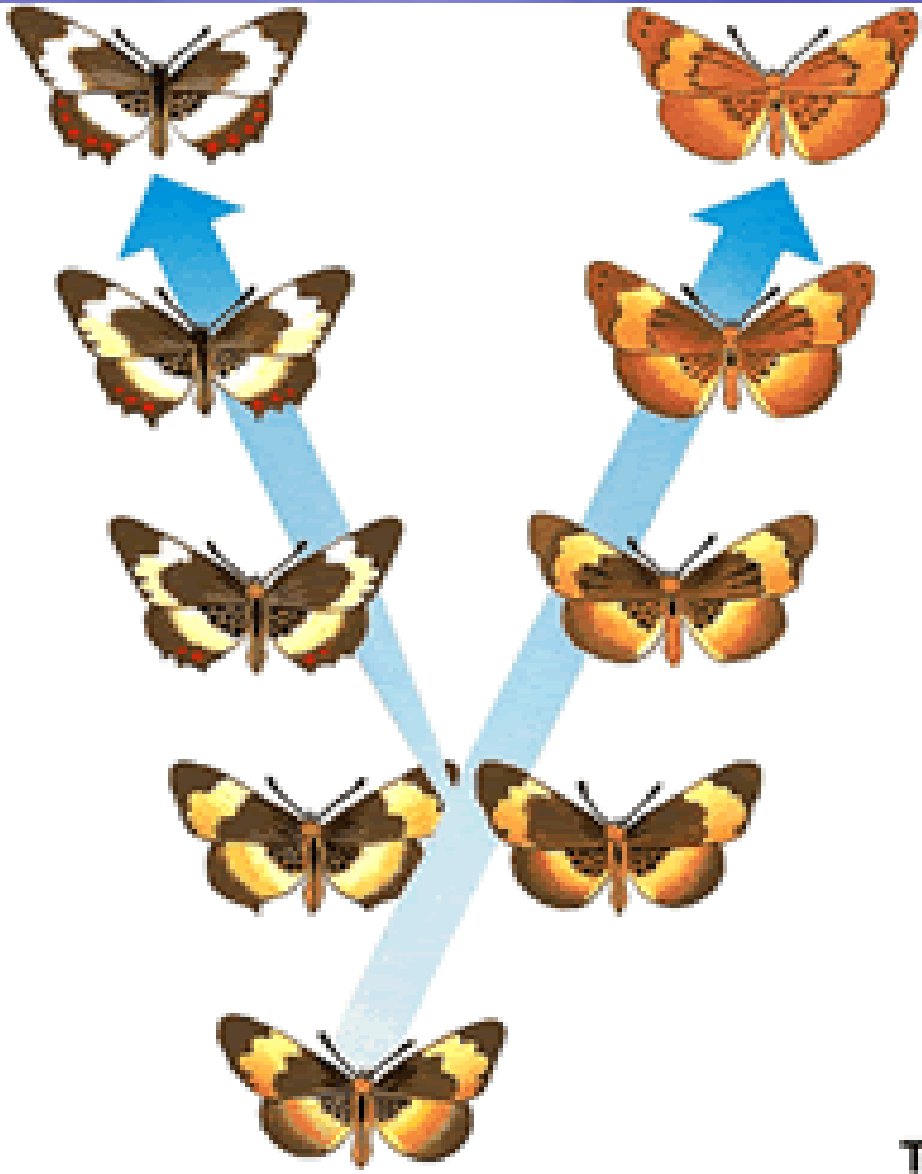


Figure 1. This represents the "tree of life" under Darwin's gradual theory of evolution where one species turns into another species through slow, smooth, gradual changes over long periods of geological time.

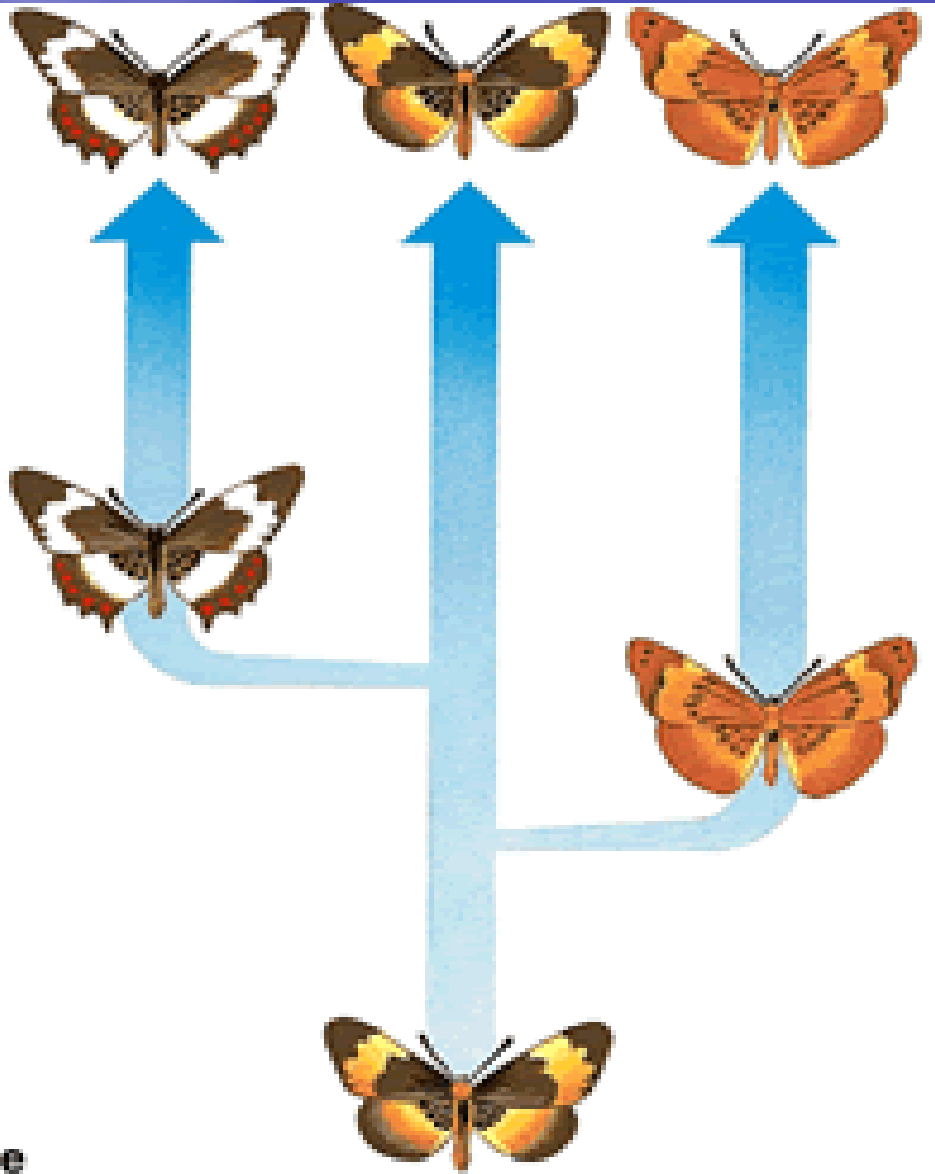
Punctuated Equilibrium:

- periods of stability with brief periods of change





(a) Gradualism model



(b) Punctuated equilibrium model

Lesson 5

Modern Theory of Evolution (2)

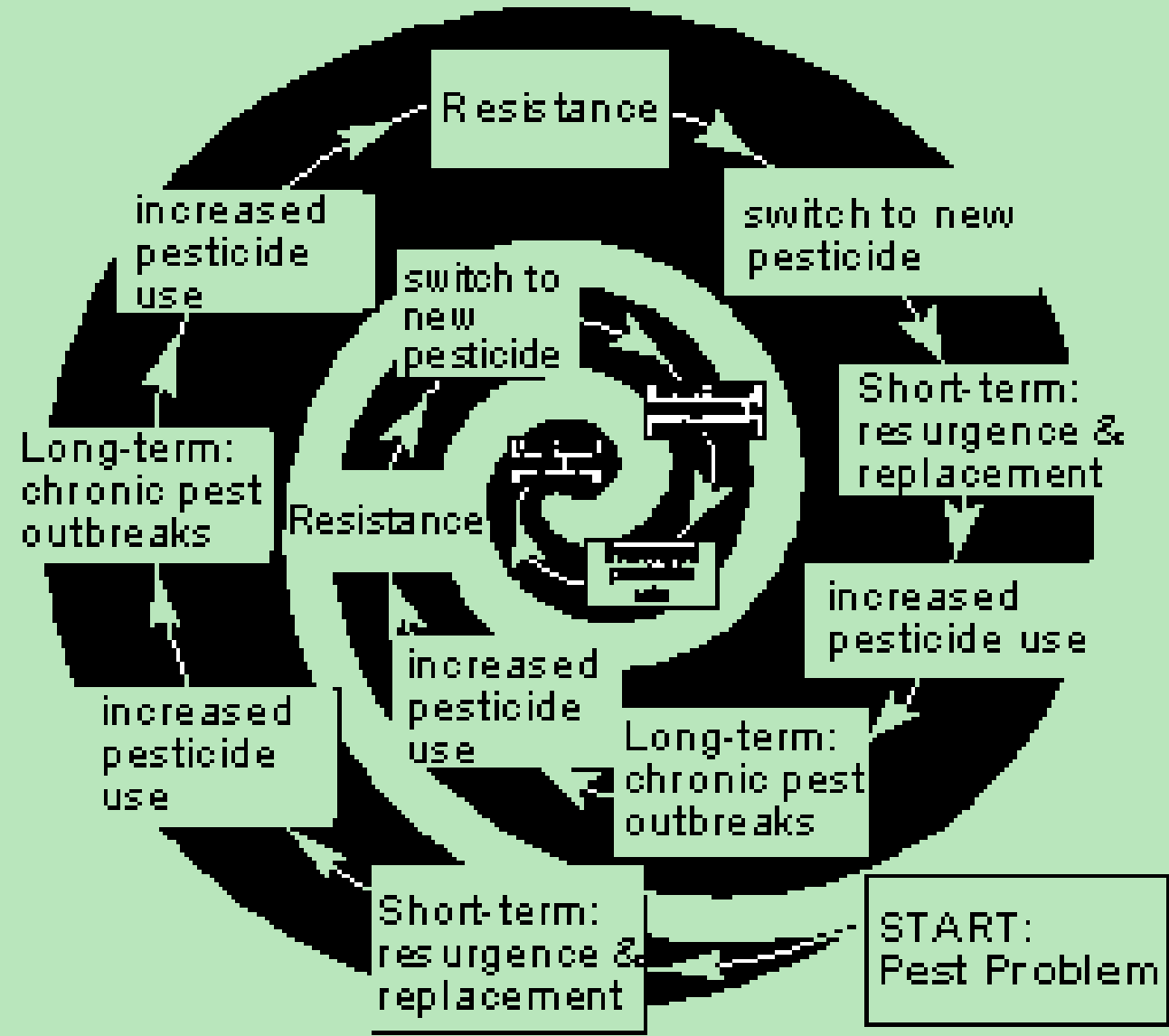
Impacts on Natural Selection

- Antibiotic & pesticide resistance

[Video - Evolution of Bacteria on a mega-plate petri dish](#)



The Resistance Treadmill



Human Impact on Natural Selection

- Pesticide Resistance

some insects have mutations making them naturally resistant to pesticides so they survive & reproduce

Result:

↑ insect population
resistant to pesticide

- Antibiotic Resistance

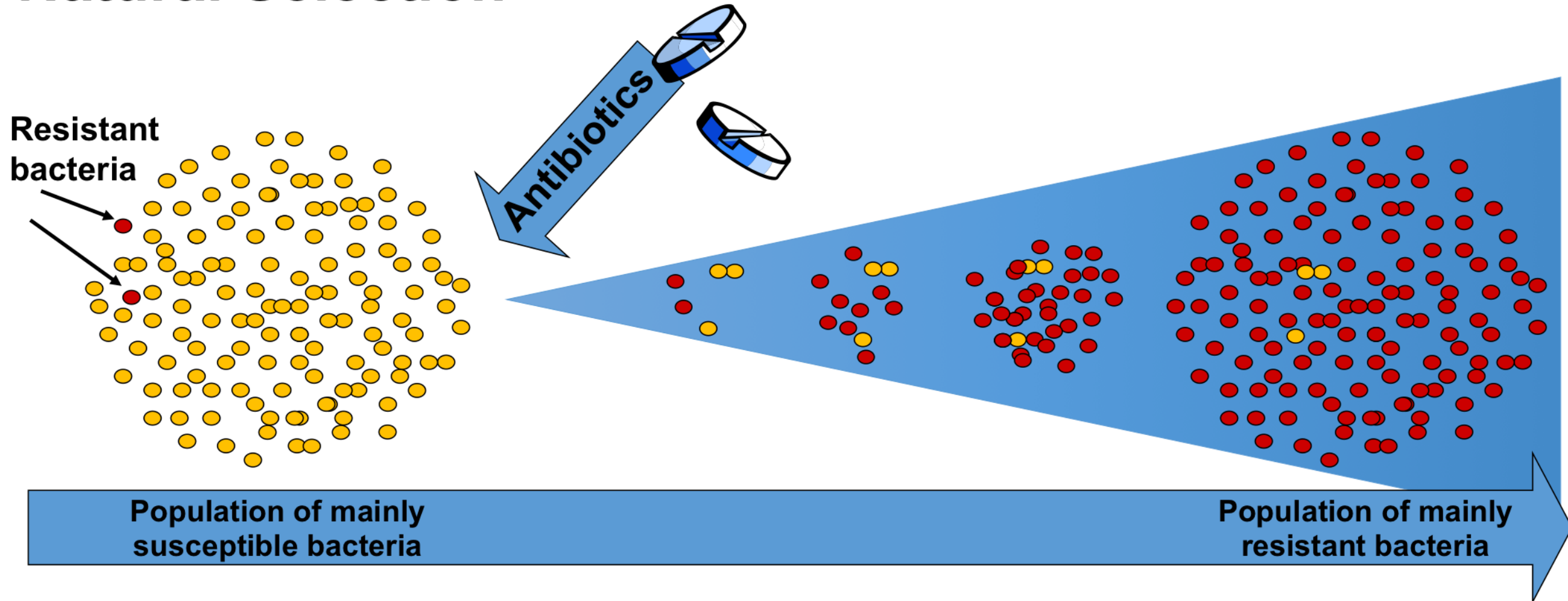
some bacteria have mutations making them naturally resistant to antibiotics so they survive & reproduce

Result:

↑ bacteria population
resistant to antibiotics

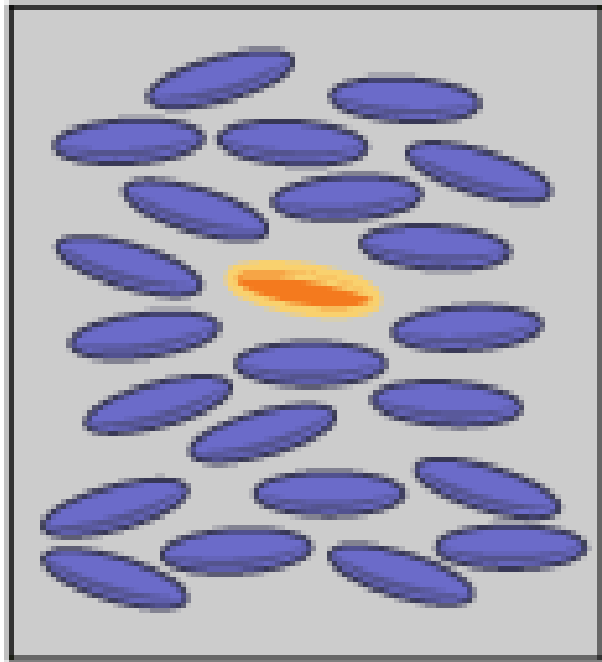
- **Overuse of these substances can result in unintentional consequences!**

Natural Selection

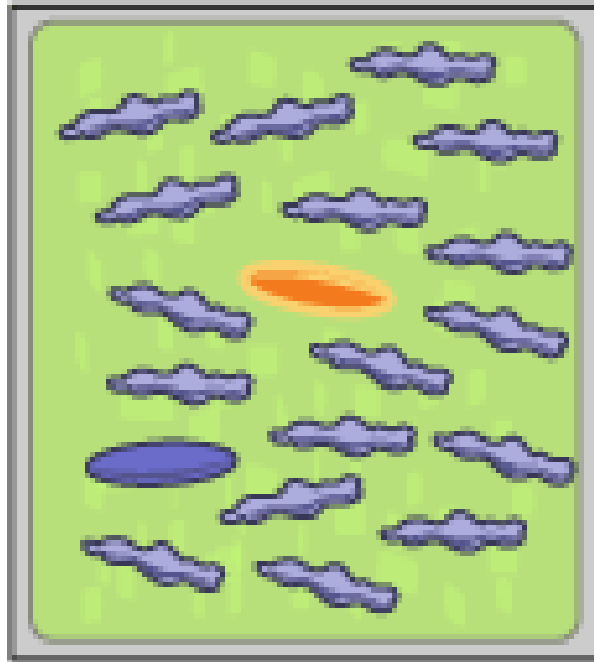


- Resistant bacteria have little/no competition
- Easily survive and reproduce = MORE resistant bacteria!

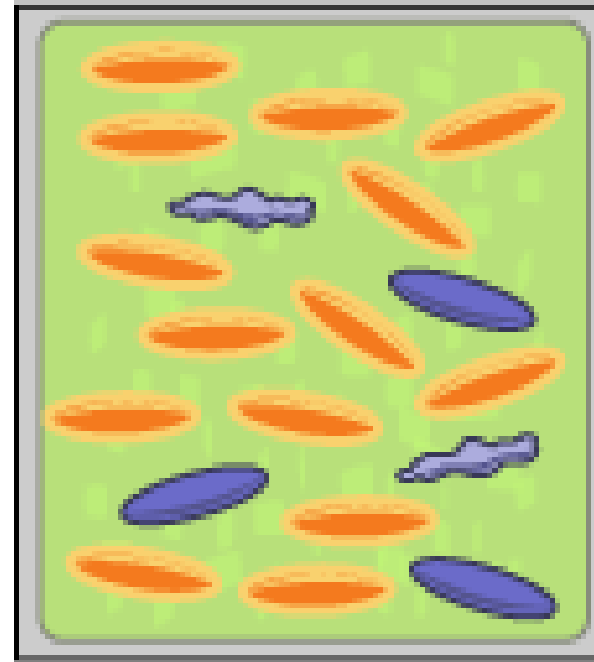
1
A bunch of bacteria,
including a resistant
variety...



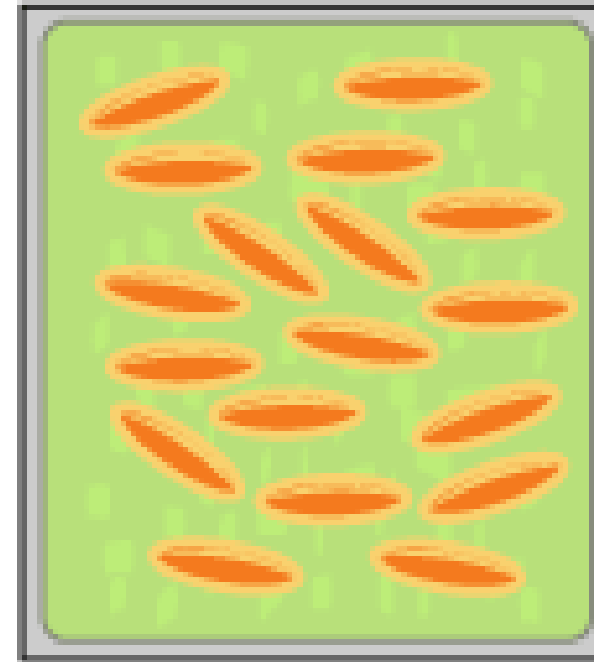
2
...get bathed in
antibiotics. Most
of the normal
bacteria die.



3
The resistant
bacteria multiply
and become more
common.



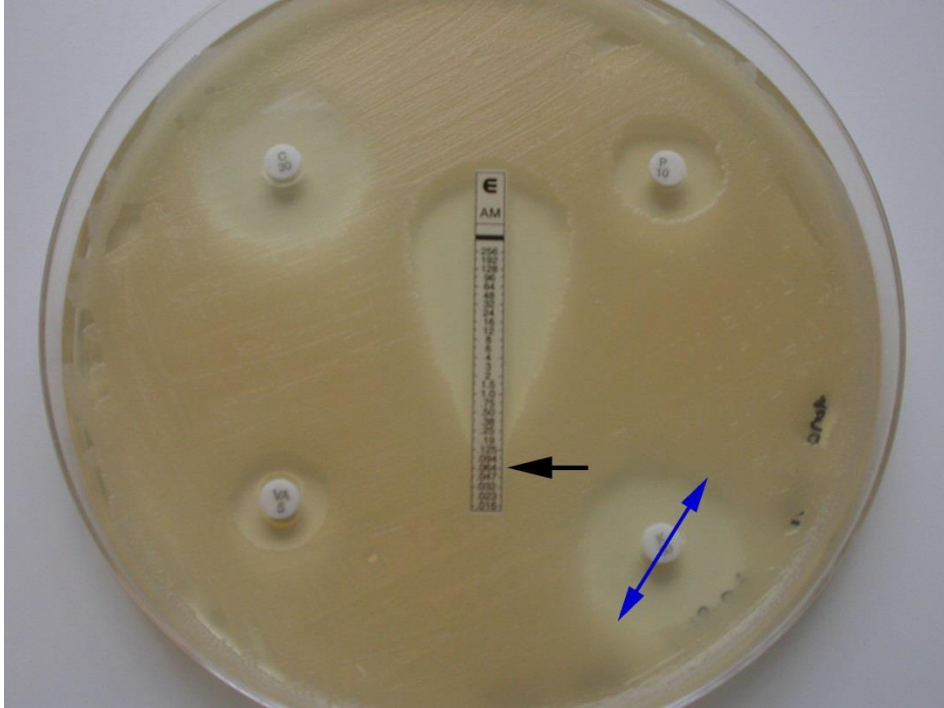
4
Eventually, the
entire infection
evolves into a
resistant strain.



 normal bacterium

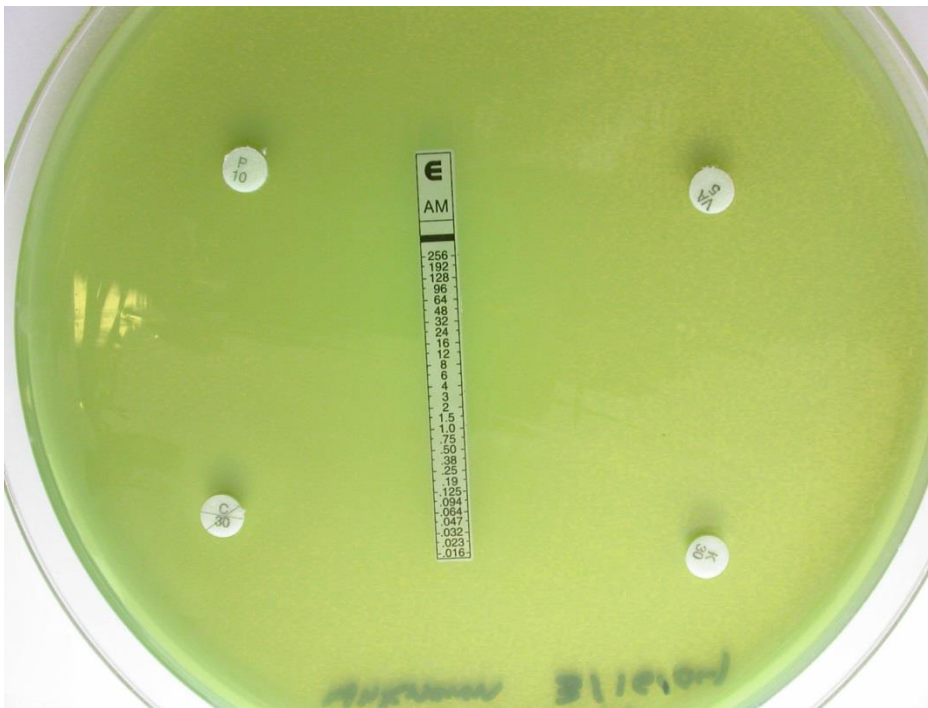
 dead bacterium

 resistant bacterium



Bacteria growth on an agar plate:

- white discs are antibiotics
- clear regions surrounding discs are bacteria free



Q: Why doesn't this plate have any clear regions around its antibiotic discs?

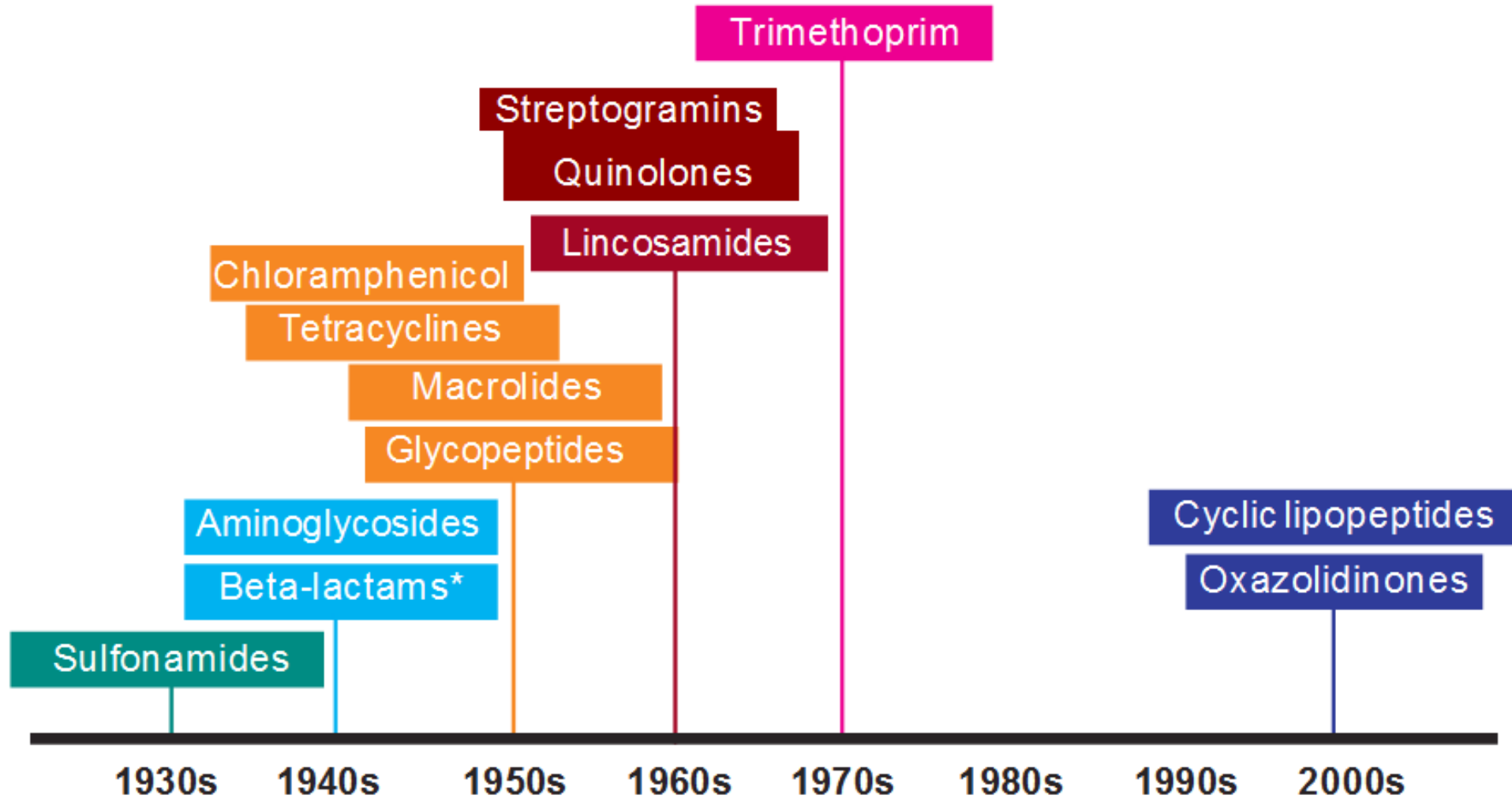
A: These bacteria are resistant to all the antibiotics!



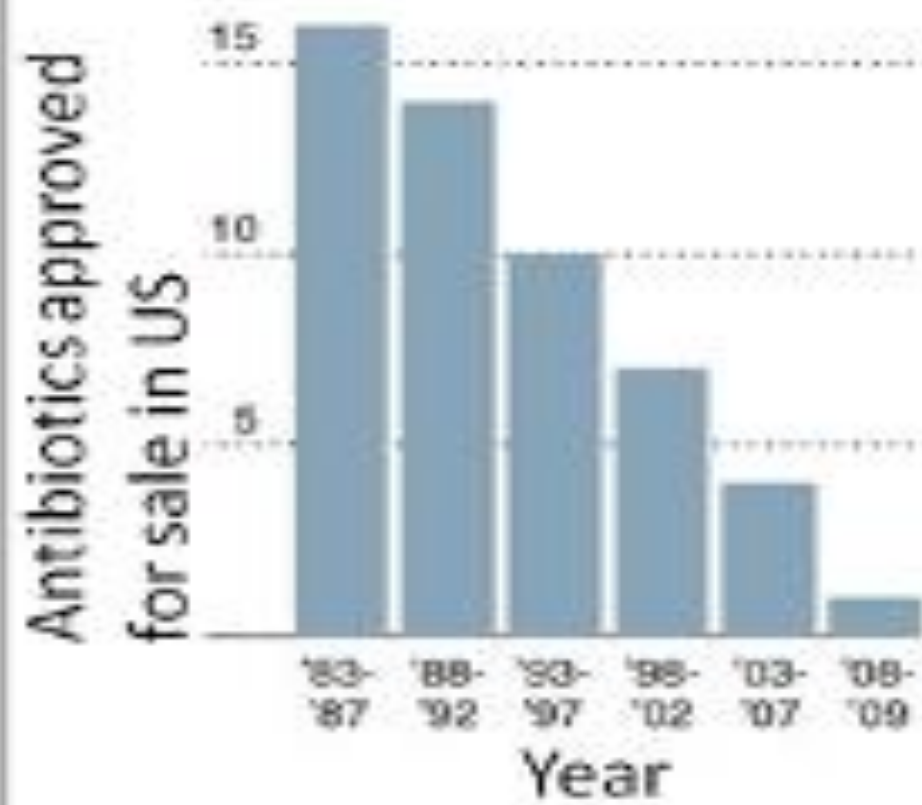
Why are the bacteria free zones on this plate different sizes?

- the bacteria have mutations making them resistant to some of the antibiotics

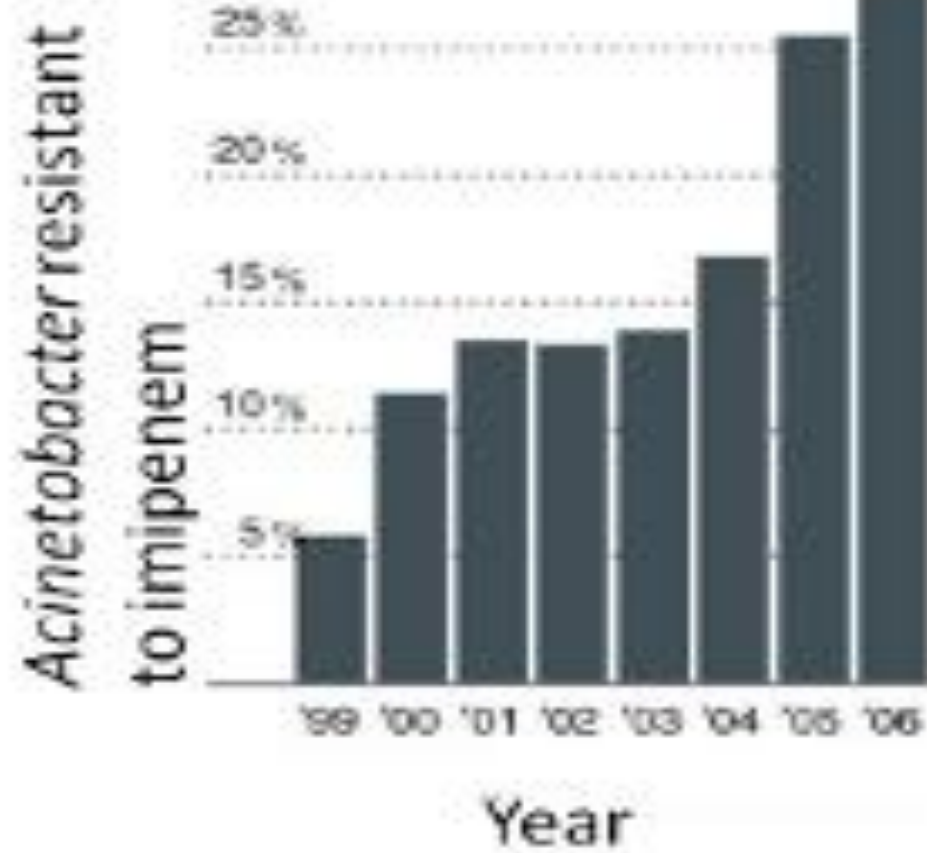
Antibiotics Discovery Timeline (long gap)



Decline in new antibiotics:



Rise in antibiotic resistance:



Source: Infectious Diseases Society of America



2 Million

Antibiotic-resistant
germs cause more than
2 million illnesses and
at least **23,000 deaths**
each year in the US.



Vital^{CDC}signs™

www.cdc.gov/vitalsigns/stop-spread

Ways you can help reduce/slow antibiotic resistance:

- Don't take antibiotics too often (practice good hygiene & strengthen your natural immunity), healthy immune systems can fight some infections
- Only take antibiotics as directed by a doctor (NOT for viral infections, only bacterial)
- Finish full prescription of antibiotics even if you feel better
- Wash with regular soap & hot water to remove germs instead of anti-bacterial soaps or hand sanitizers
- Buy food that was not produced from animals given antibiotics

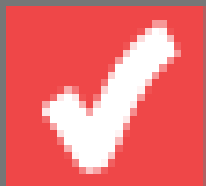
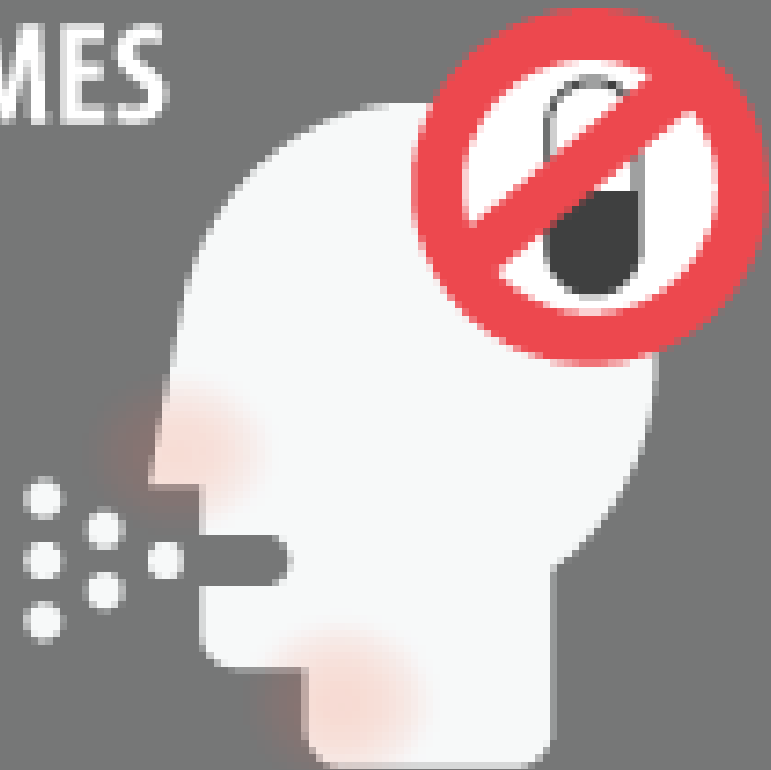
A new report grades the 25 largest US fast food and "fast casual" restaurant chains on their antibiotics policies and practices:



SOURCE: CHAIN REACTION II SURVEY AND SCORECARD

9 OUT OF 10 TIMES

a sore throat is
caused by a virus



Use antibiotics only when prescribed by a doctor, and ensure your family does so.

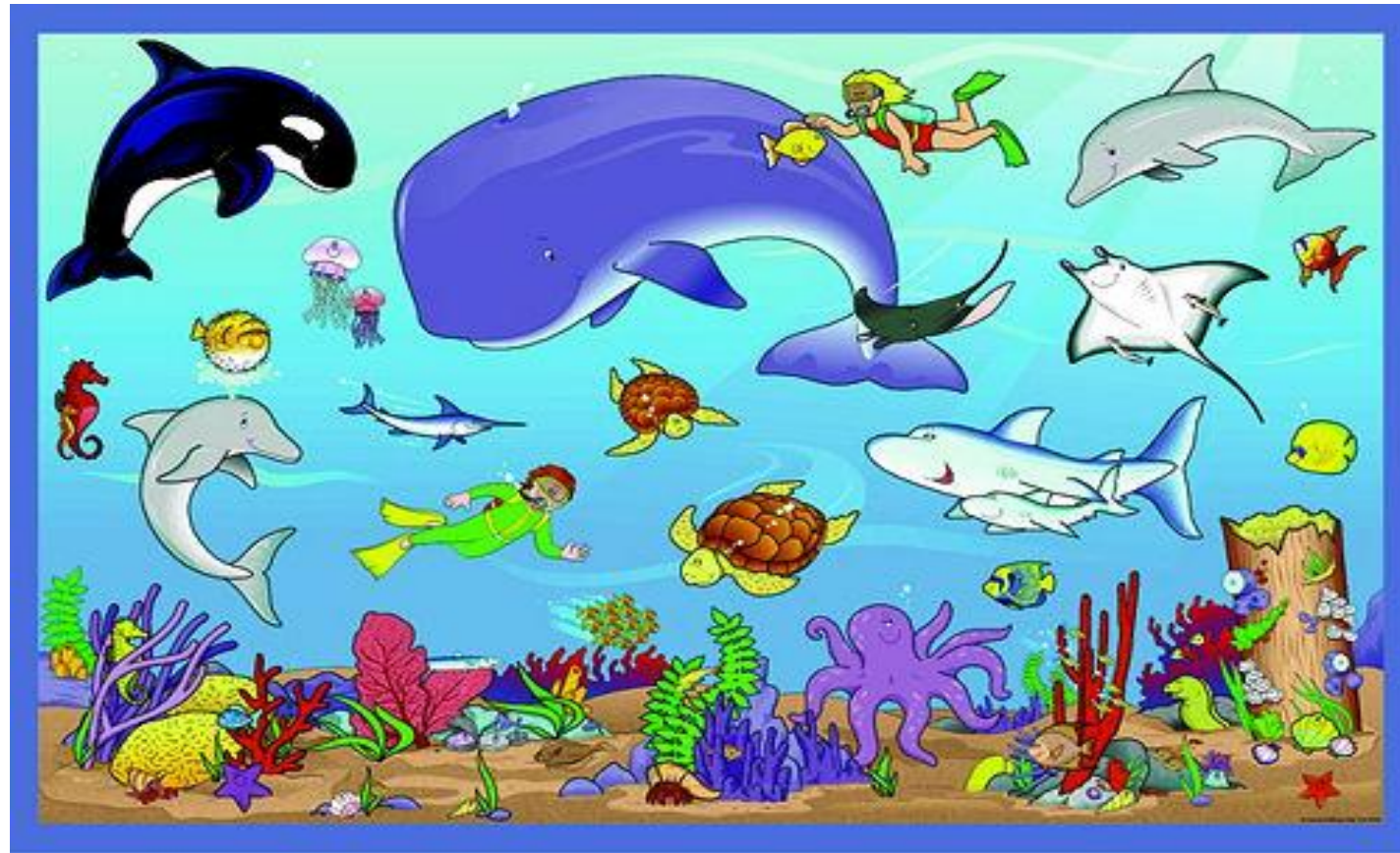
Lesson 6

Phylogenetics & Taxonomy

Dichotomous Keys

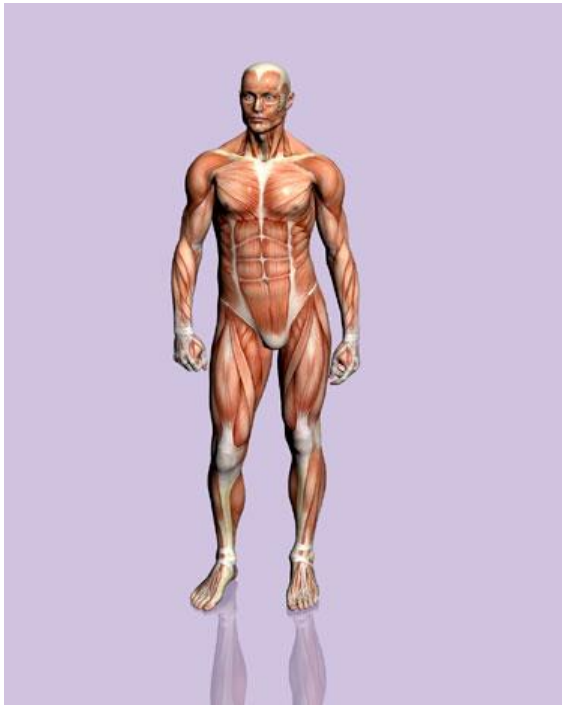
Phylogenetics & Taxonomy

Classifying organisms into groups



Phylogenetics

- the study of evolutionary relationships
- based on how closely related species are to each other
- ex. The beluga whale is more closely related to humans than sharks, they have a more recent common ancestor



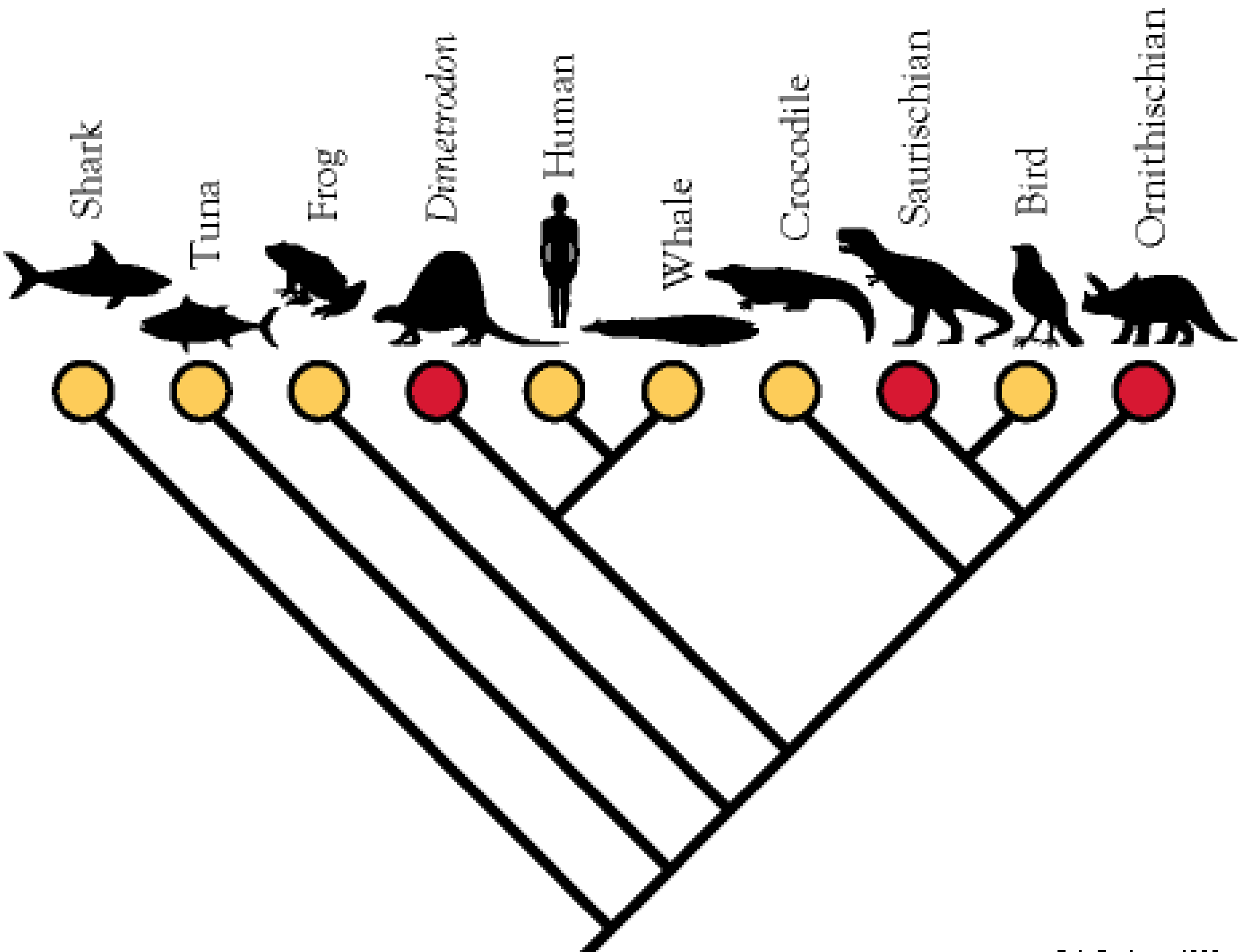
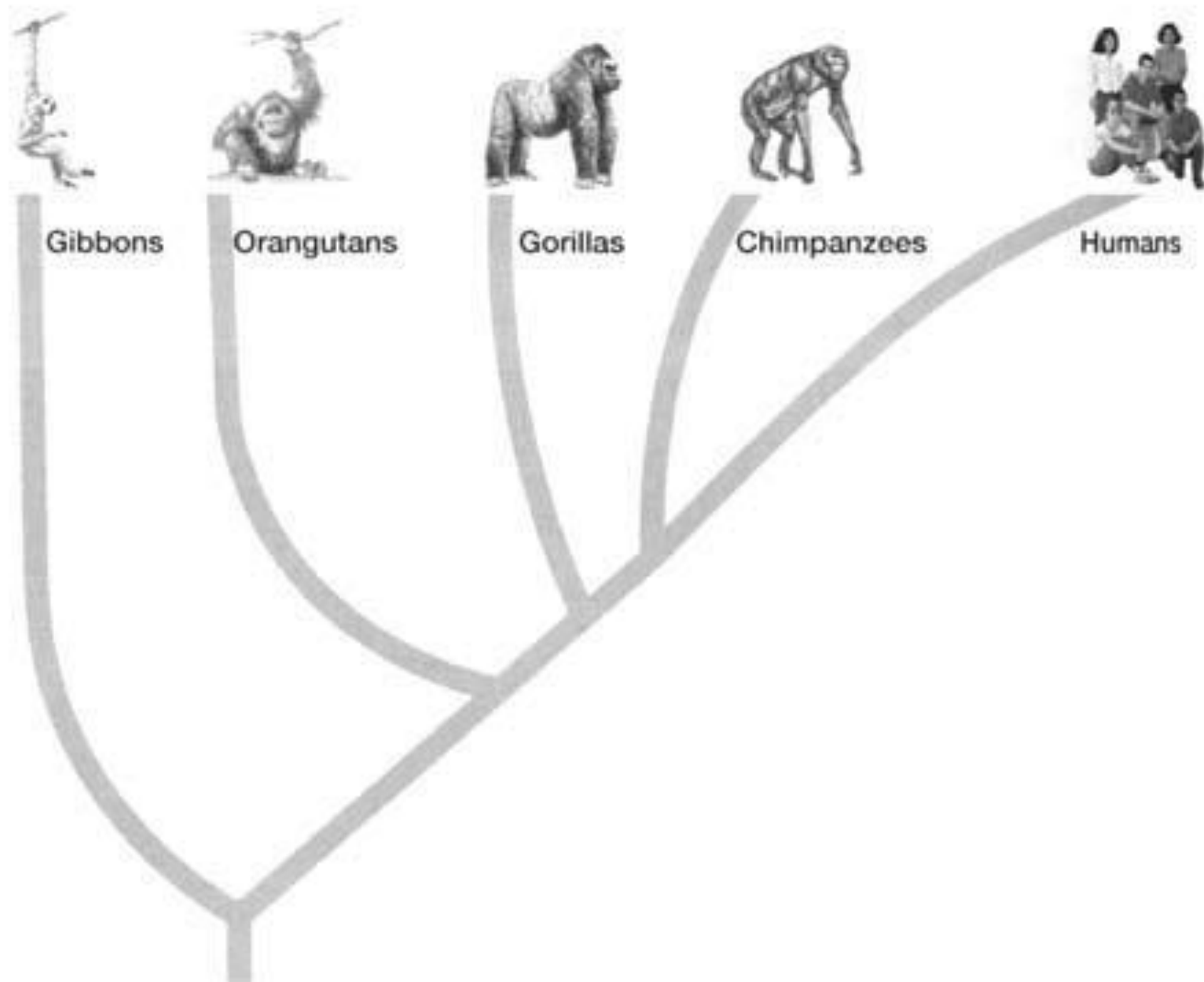


Figure 24 Phylogenetic tree of apes and humans.

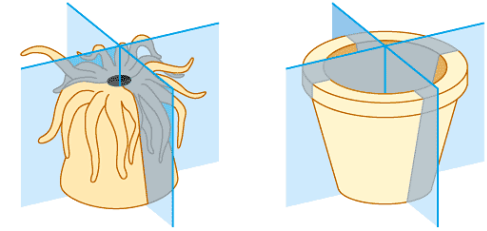
The evolutionary group that led to modern gibbons diverged earlier than other primate groups.



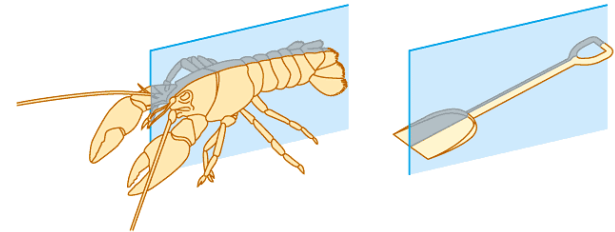
How can you tell if species are closely related?

Compare their:

- Physical structure
- Reproduction method
- Embryological development
- DNA/RNA sequences
- Behavior (mating, feeding, etc.)
- Type of Symmetry
- Cell structure

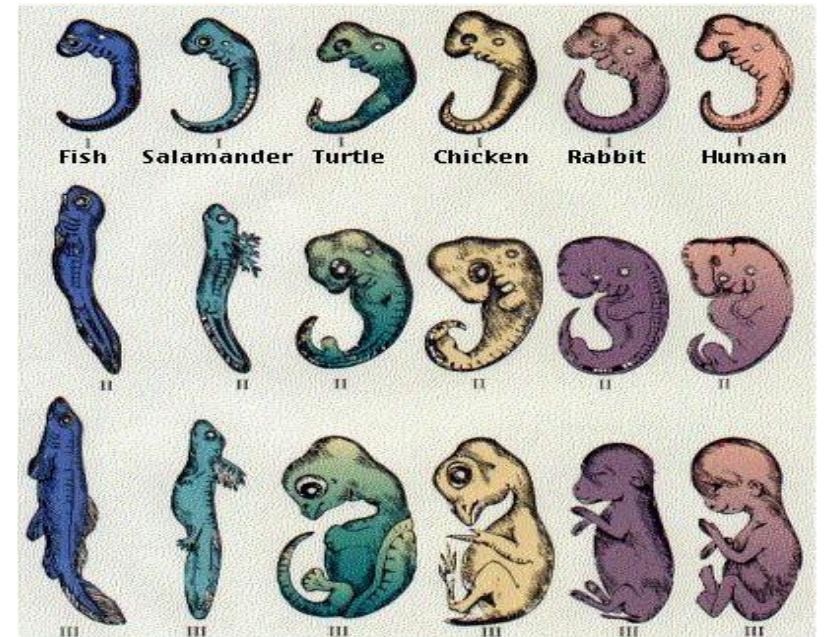


(a) Radial symmetry



(b) Bilateral symmetry

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Taxonomy

- Groups (taxa) are arranged in a hierarchy that extends from the most general classification to the most specific.

Dear

King

Philip

Came

Over

From

Great

Spain

- Domain.....Eukarya
- Kingdom.....Animalia
- Phylum.....Chordata
- Class.....Mammalia
- Order.....Primates
- Family.....Hominidae
- Genus.....*Homo*
- Species.....*sapiens*
= Humans

Dumb

Kids

Playing





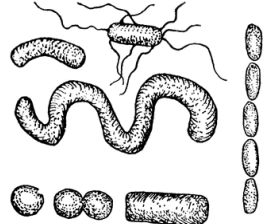

Carelessly

On

Freeways

Get

Squished

<p>Animalia</p>	<ul style="list-style-type: none"> • Eukaryotic & <u>Multicellular!</u> • Ingestion (eating) • Sexual 	 <p>Mammals, amphibians, sponges, insects, worms, fishes, etc</p>
<p>Plantae</p>	<ul style="list-style-type: none"> • Eukaryotic • Photosynthesis (using sunlight to make energy) • Asexual or sexual 	 <p>Mosses, flowering plants</p>
<p>Fungi</p>	<ul style="list-style-type: none"> • Eukaryotic • Absorption of decomposing materials • Mostly asexual but meiosis occurs in some species 	 <p>Mushrooms, yeast, molds</p>
<p>Protista</p>	<ul style="list-style-type: none"> • Eukaryotic • Nutrition may be by absorption, photosynthesis, or ingestion • Asexual or sexual 	 <p>Amoebae, green algae, brown algae, diatoms, euglena</p>
<p>Archaea (archaebacteria)</p>	<ul style="list-style-type: none"> • Prokaryotic • may be by absorption or <u>chemosynthesis</u> • Asexual by binary fission, budding, or fragmentation 	 <p>Methanogens, Thermophiles</p>
<p>Bacteria (eubacteria)</p>	<ul style="list-style-type: none"> • Prokaryotic • intake may be by absorption, photosynthesis, or <u>chemosynthesis</u> • Asexual by binary fission, budding, or fragmentation 	 <p>Cyanobacteria (blue-green algae), Actinobacteria</p>

Binomial Nomenclature

- each species is assigned a two-part scientific name using the Genus and species classifications
- written in *italics*, Genus capitalized, species lower case
 - Ex. *Homo sapiens* (humans)
 - Ex. *Drosophila melanogaster* (fruit fly)
 - Ex. *Tursiops truncatus* (bottlenose dolphin)



Dichotomous Key

- a series of paired phrases used to classify living things

Geospiza



Bird W

Platyspiza



Bird X

Certhidea



Bird Y

Camarhynchus



Bird Z

Dichotomous Key to Representative Birds

1. a. The beak is relatively long and slender.....*Certhidea*
b. The beak is relatively stout and heavy.....go to 2
2. a. The bottom surface of the lower beak is flat and straight*Geospiza*
b. The bottom surface of the lower beak is curvedgo to 3
3. a. The lower edge of the upper beak has a distinct bend*Camarhynchus*
b. The lower edge of the upper beak is mostly flat*Platyspiza*



Species E



Species F



1 A dichotomous key to these six species is shown below. Complete the missing information for sections 5.a. and 5.b. so that the key is complete for all six species. [1]

What statements would best assist in identifying species E and F?

- 5a. **Has white wings**
- 5b. **Has black wings**

Dichotomous Key

1. a. has small wingsgo to 2
b. has large wings.....go to 3
2. a. has a single pair of wingsSpecies A
b. has a double pair of wingsSpecies B
3. a. has a double pair of wingsgo to 4
b. has a single pair of wings.....Species C
4. a. has spotsgo to 5
b. does not have spotsSpecies D
5. a. _____.....Species E
b. _____.....Species F