



# Evolution

THE EVER-CHANGING LIVING WORLD

# EVOLUTION OVERVIEW

**History of Evolutionary Theory**

**Evidence for Evolutionary Theory**

Microevolutionary Principles

- Mutation, Genetic Drift, Migration, Natural Selection

Macroevolution

- Speciation, Extinction
- Adaptive Radiation, Coevolution, Convergent Evolution

Phylogenetic Trees

Biological Classification / Taxonomy

# History of Evolutionary Theory

13-1: EVOLUTION AND LIFE'S DIVERSITY

# TEXTBOOK READING

Read section 13-1. Answer these questions:

1. How does your textbook define evolution? (/1)
2. Write a short paragraph about fitness and adaptation. In your paragraph, define these words ***in your own words and with examples.*** Explain how the two concepts are related. (/3)



# Evidence for Evolutionary Theory

13-2: THE AGE OF THE EARTH

13-3: THE FOSSIL RECORD

13-4: EVIDENCE FROM LIVING ORGANISMS

# HISTORICAL PERSPECTIVES (NOT TESTABLE)

*An animal depends upon the natural conditions around it. If the buffalo were here today, I think they would be very different from the buffalo of the old days because all the natural conditions have changed. They would not find the same food, nor the same surroundings.*

*- Okute (Shooter), Teton Lakota, 1911*

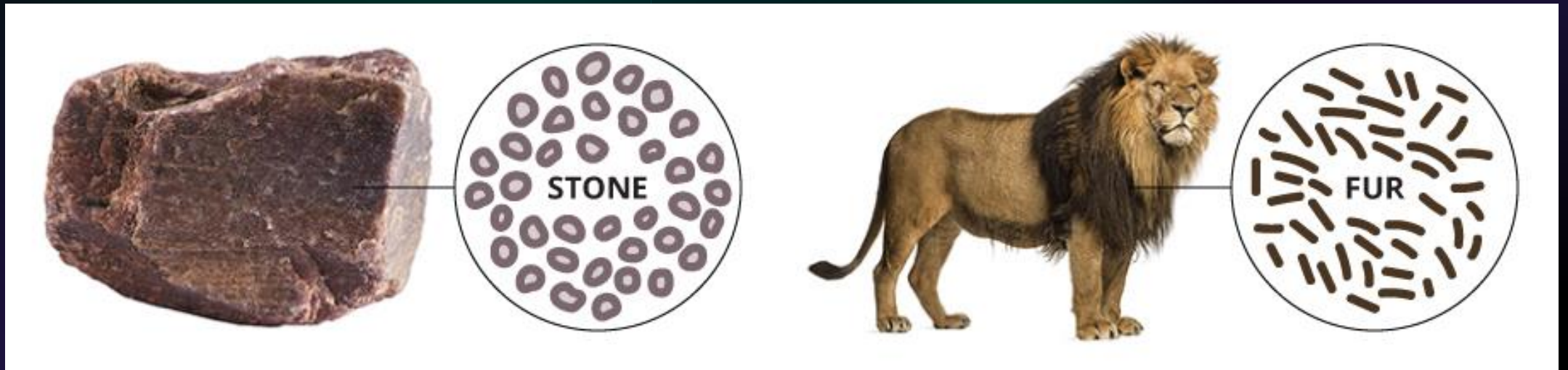




# HISTORICAL PERSPECTIVES (NOT TESTABLE)

Living things are the result of chance combinations of atoms

*The Greek Atomists around 500 BCE (including Democritus) described atoms as the smallest component of all matter and living things*



# HISTORICAL PERSPECTIVES (NOT TESTABLE)

The Earth is only a few thousand years old. It was created by an intelligent higher power, along with all living things.

*After the Greek Atomists (especially around 200 CE), this became the prevailing school of thought. The reasoning was that living things were too anatomically complex to have occurred by chance. Multiple religious influences (Judaism, Christianity, Islam) helped promote this idea.*





# HISTORICAL PERSPECTIVES (NOT TESTABLE)

Species were created at once, but emerged sequentially, instead of all at the same time.

*Augustine of Hippo (354-430)*

“... from mineral to plant, from plant to animal, and from animal to man”

*Othman Amr al-Jahiz (?-869) and Abu-l-Hasan 'Ali al-Masudi (?-956)*







# HUTTON AND LYELL (EARTH IS OLD!)

## James Hutton (1788):

- Earth is constantly changing through natural processes (volcanic activity, erosion, sedimentation)
- Geological changes occur slowly over time
- Earth is very old, much older than thousands of years

## Charles Lyell (1830):

- Geographical features can be built up or torn down, through countless small changes over vast periods of time



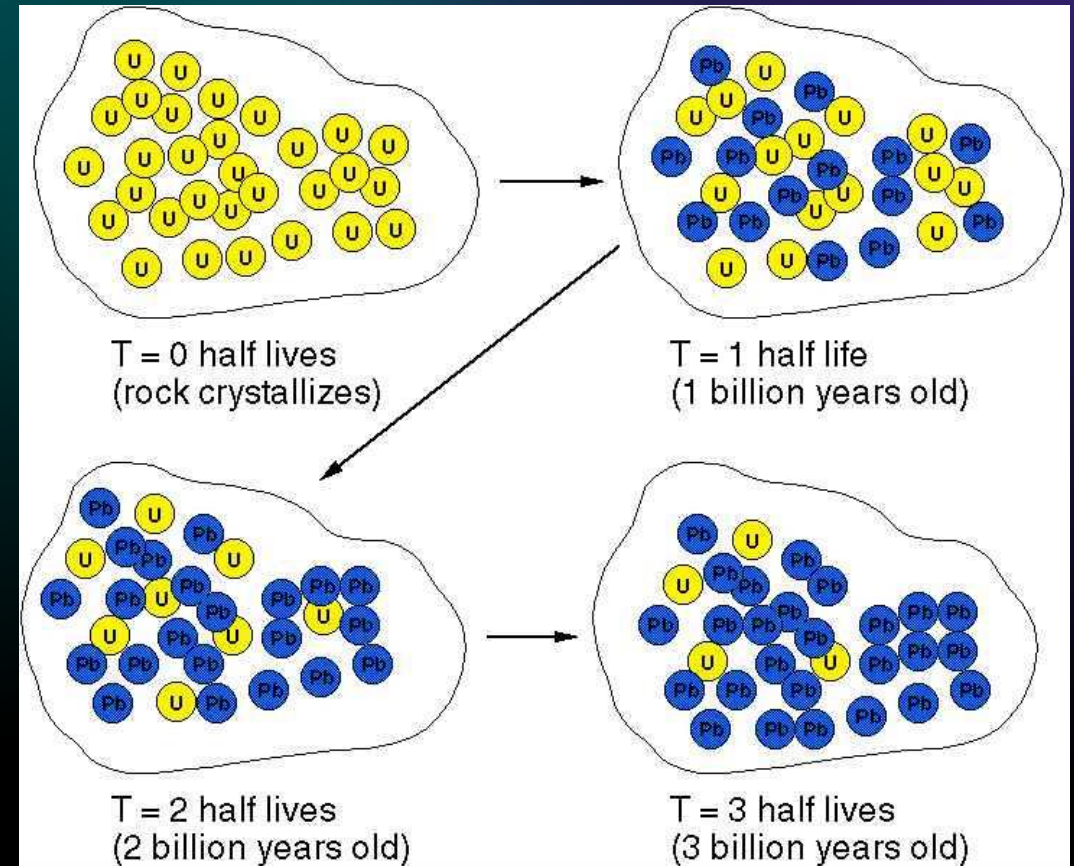
# LIFE IS OLD...?

- Geologists began discovering **fossils** (remains of ancient organisms, preserved in rock)
- Some fossils resembled living organisms, but not all



# RADIOACTIVE DATING

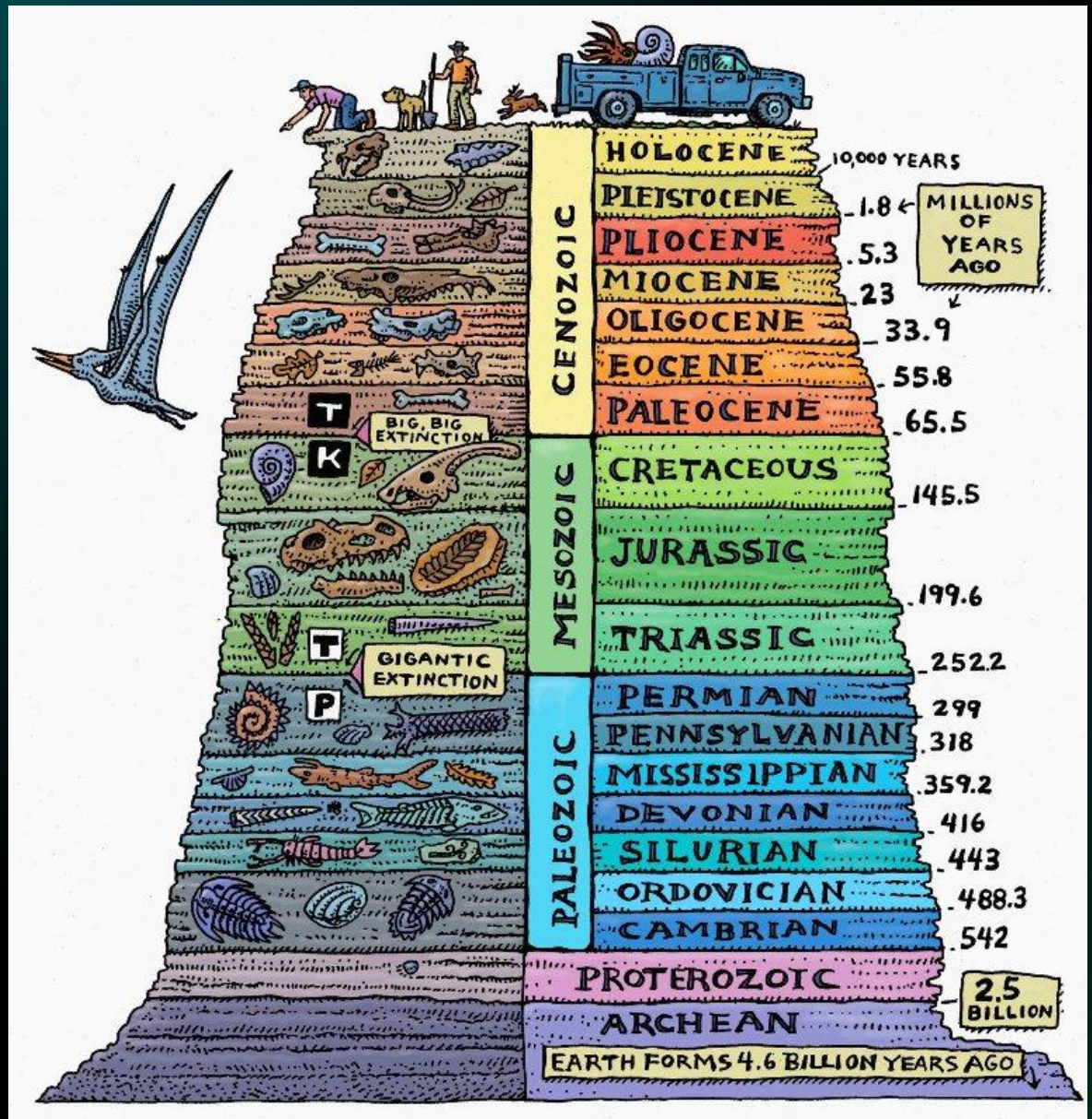
- When rock is formed, radioactive isotopes begin decaying at known rates
- **Radioactive dating:** determining the age of a rock or fossil by measuring the radioactive elements in it





# A NEW TIMELINE

Earth is indeed very old:  
4.5 billion years old!





# INTERPRETING THE FOSSIL RECORD

The fossil record is difficult to interpret.

- Fossils form by chance.
- Hard parts (shells, bones) fossilize better than soft parts.
- Many fossils incomplete or poorly preserved.
- Radioactive dating gives estimates, not exact ages.

# INTERPRETING THE FOSSIL RECORD

## Conclusions from Fossils:

- Earth's geography and atmosphere have changed over time.
- Life has changed over time. New species have emerged. Many species have gone extinct.
- Many species resemble other species...



# TEXTBOOK READING

Read textbook section 13-2 “The Age of the Earth” and 13-3 “The Fossil Record”, focusing on main ideas.

3. How old did people used to think the Earth was? How old is the Earth, actually? (/1)
4. Summarize the contributions of James Hutton and Charles Lyell. What were their key findings? (/1)
5. What is a fossil? How are fossils formed? (/2)
6. Why don't all living things leave behind fossils? Give two reasons. (/1)



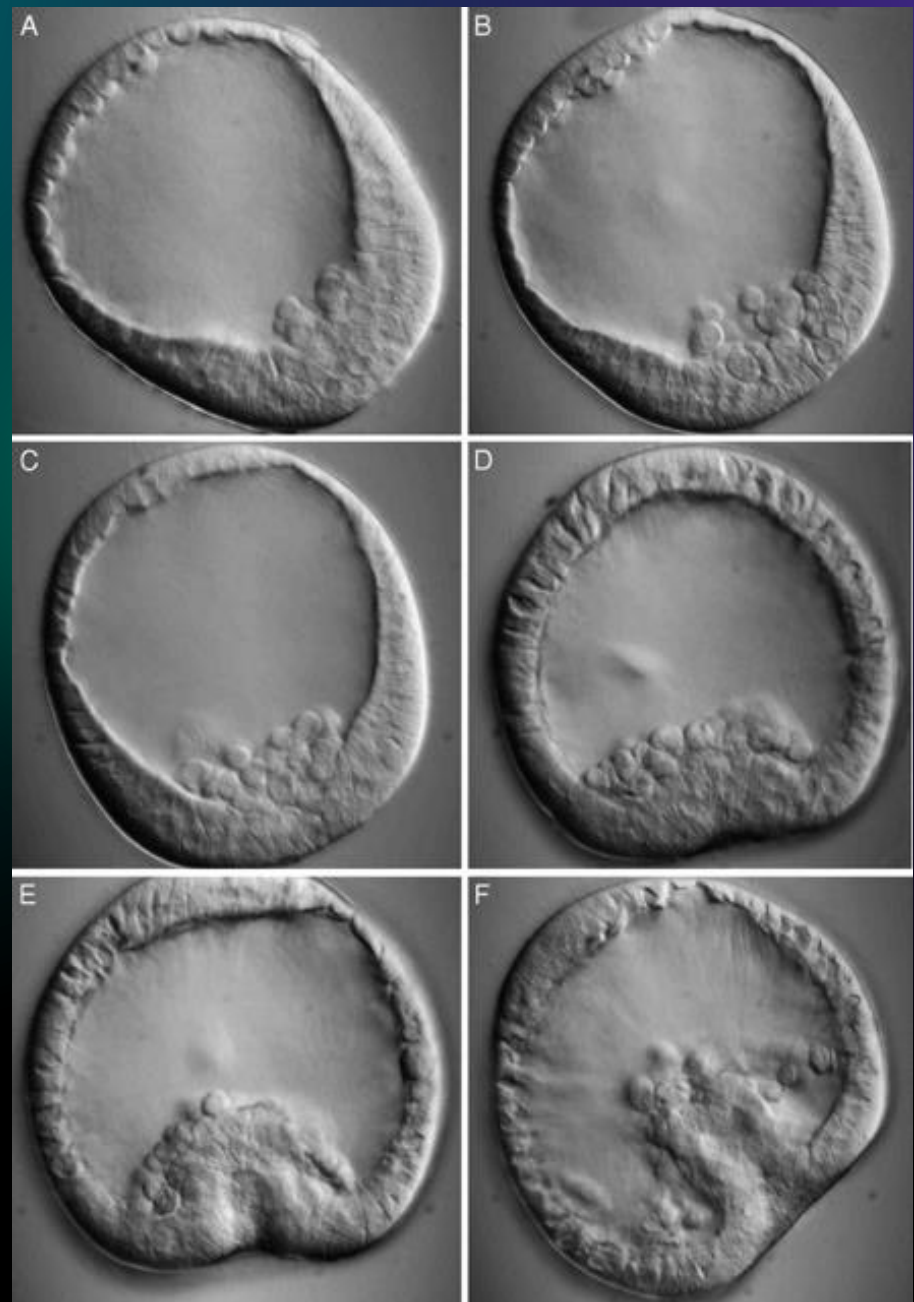
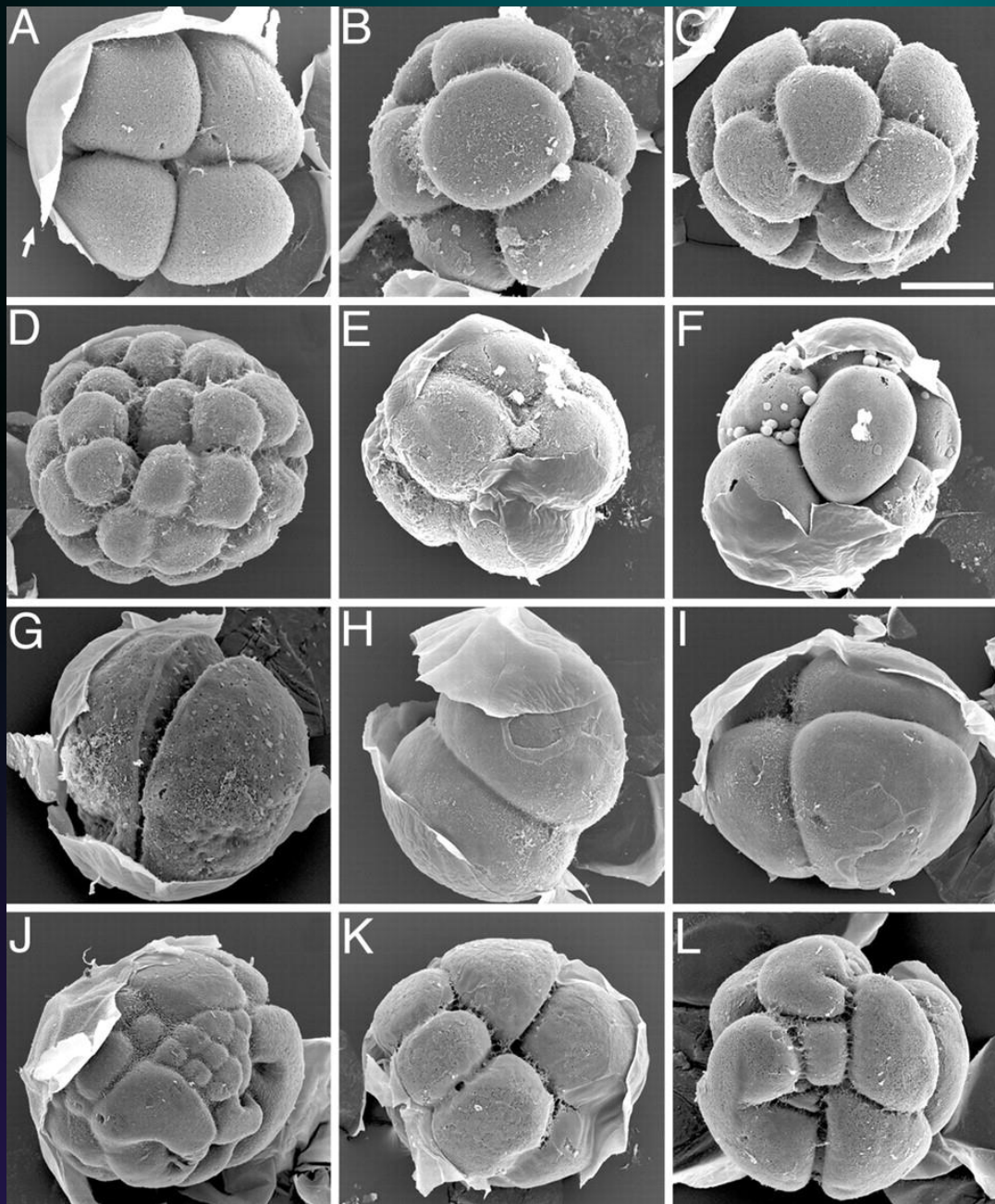
# EVIDENCE FROM COMPARATIVE ANATOMY

Species that are evolutionarily related are similar:

- Developmental Biology
  - Embryo Development
  - Hox Genes
- Homologous structures
- Vestigial structures
- Biochemistry

CUTENESS ALERT!  
YOUR BABY  
PHOTOS AHEAD



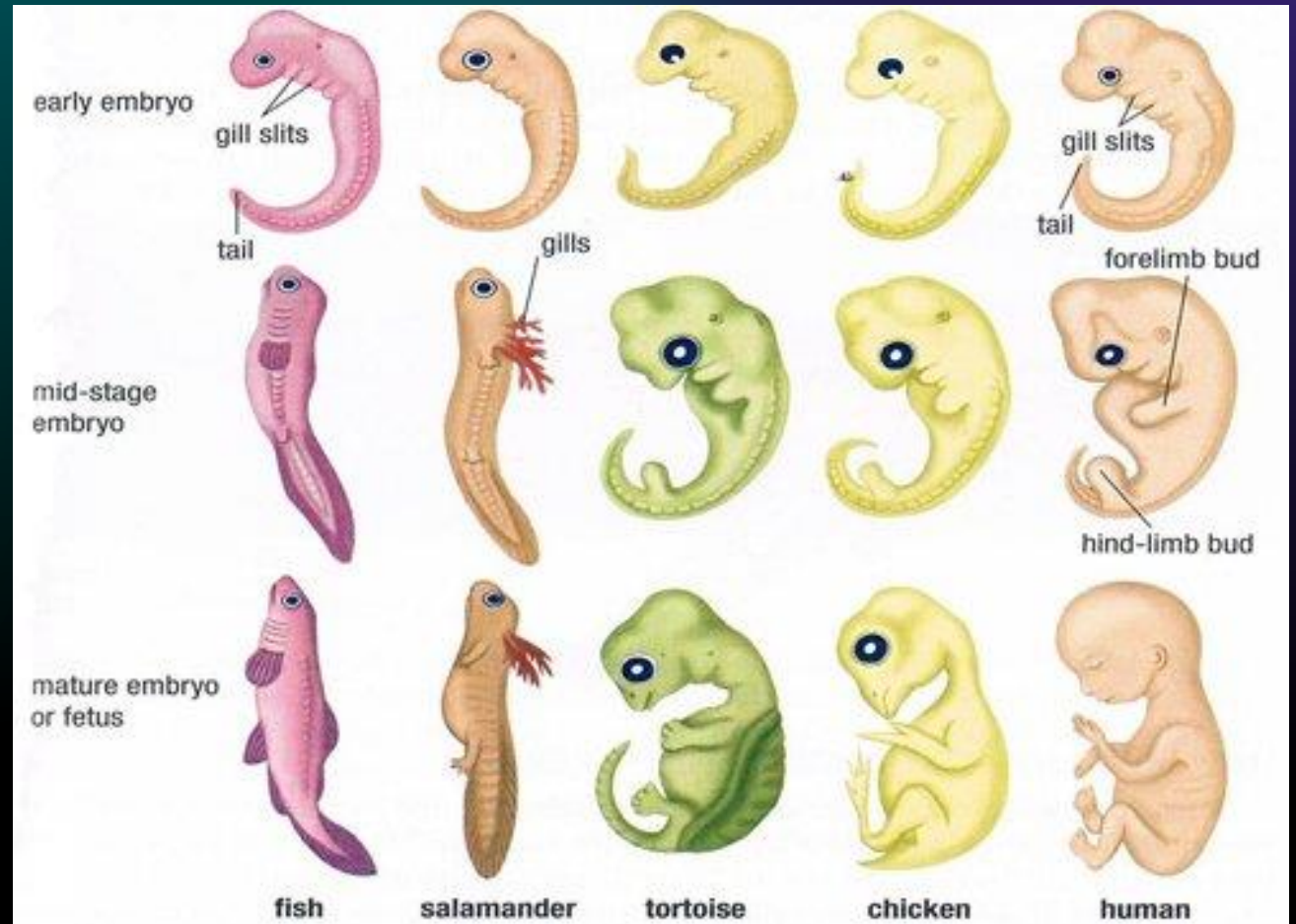


Just kidding: these are sea urchin baby photos. But you looked exactly the same a few hours after you were conceived!



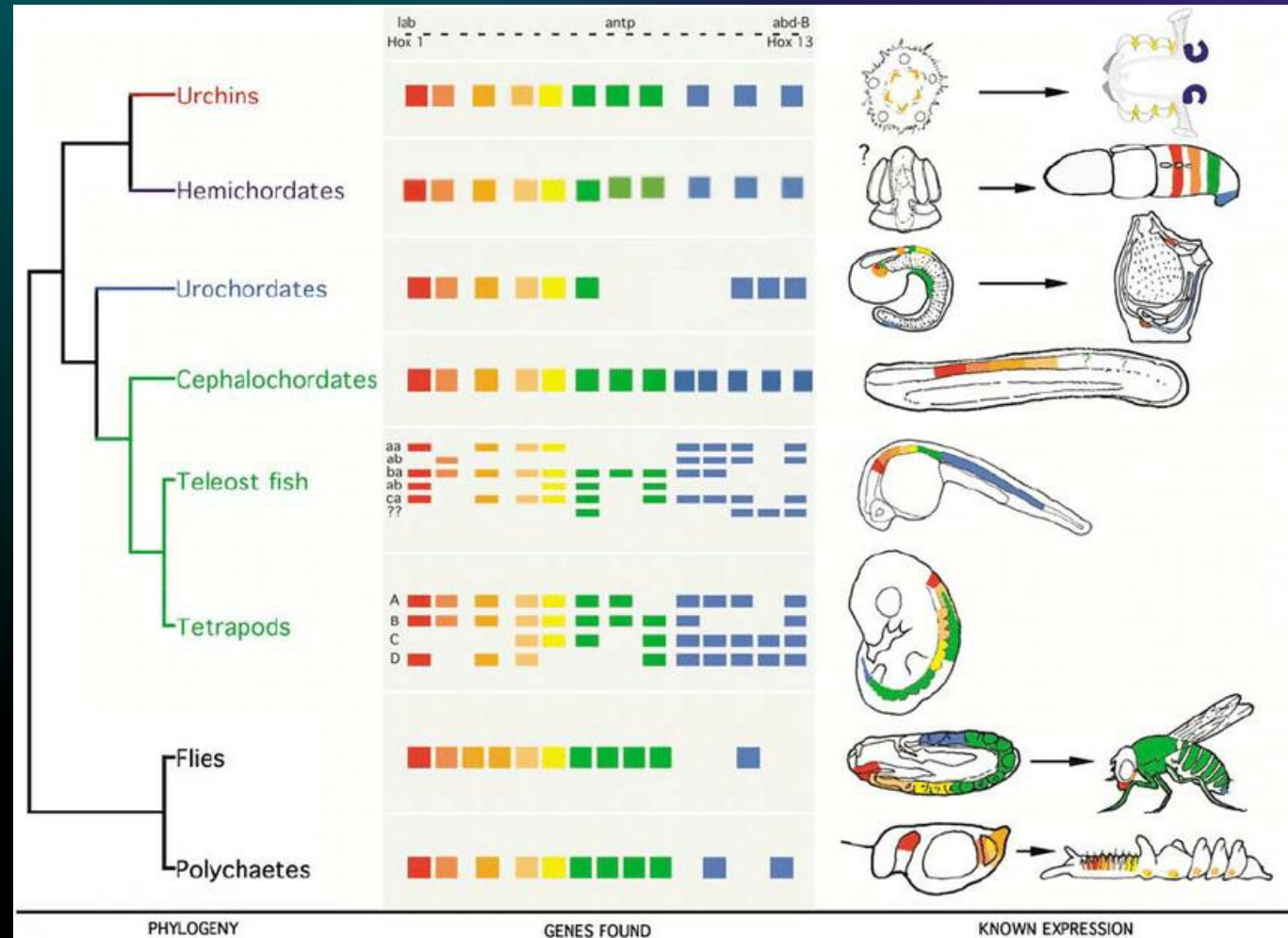
# EMBRYO DEVELOPMENT

- **Embryo:** organism at an early stage of development
- Many important similarities between embryos of related organisms (E.g. all chordate embryos have gill slits, tails, and webbed fingers/toes)



# HOX GENES

- Animal body plans (head→tail patterning) are controlled by the same set of **Hox genes**
- Mutations in the number or type of Hox genes leads to bizarre, often lethal phenotypes



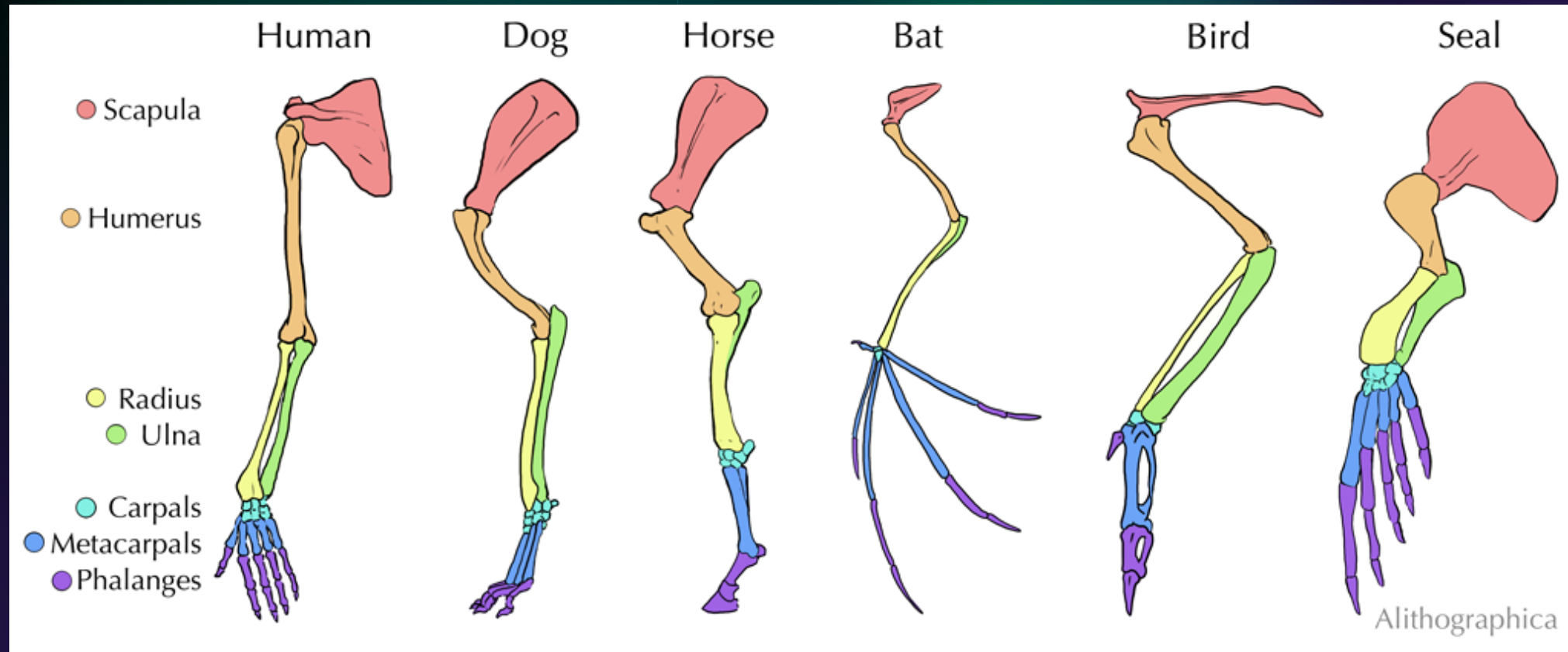


# HOX GENE MUTATIONS

Warning: you may find these images disturbing

# HOMOLOGOUS STRUCTURES

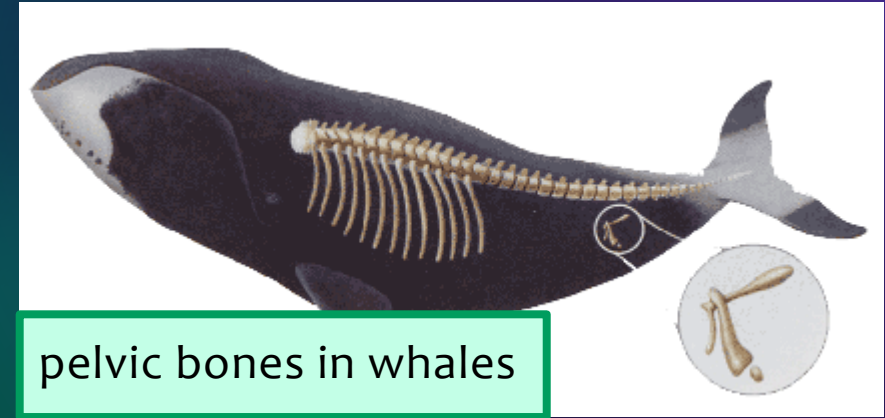
**Homologous structures:** body structures (e.g. bones, organs) inherited from a common ancestor





# VESTIGIAL STRUCTURES

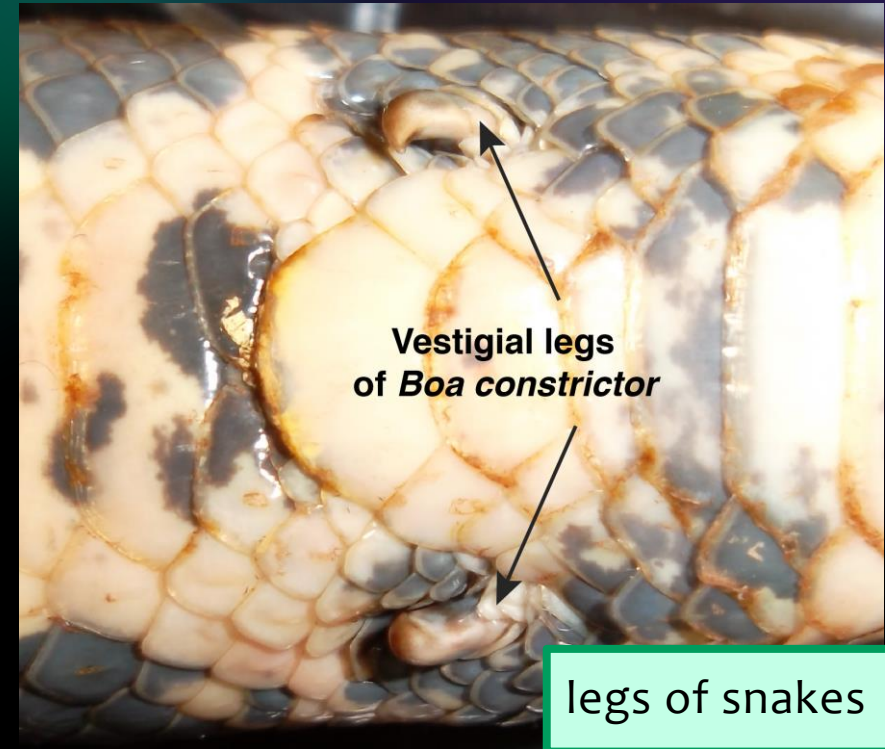
**Vestigial structures** are homologous structures that have no function. They are usually reduced in size.



pelvic bones in whales



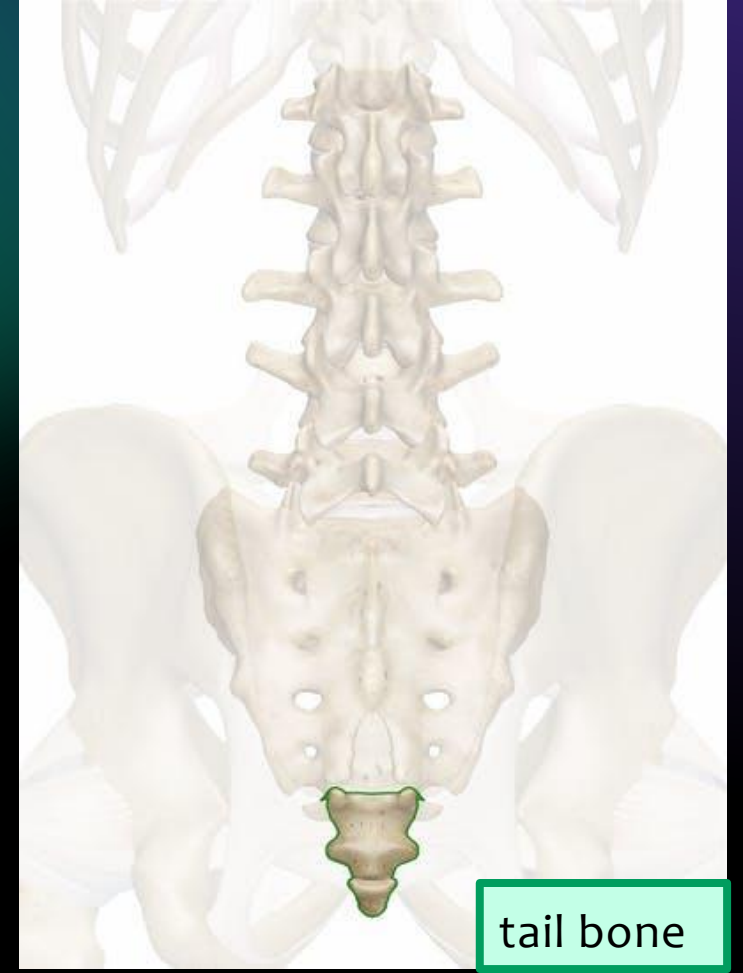
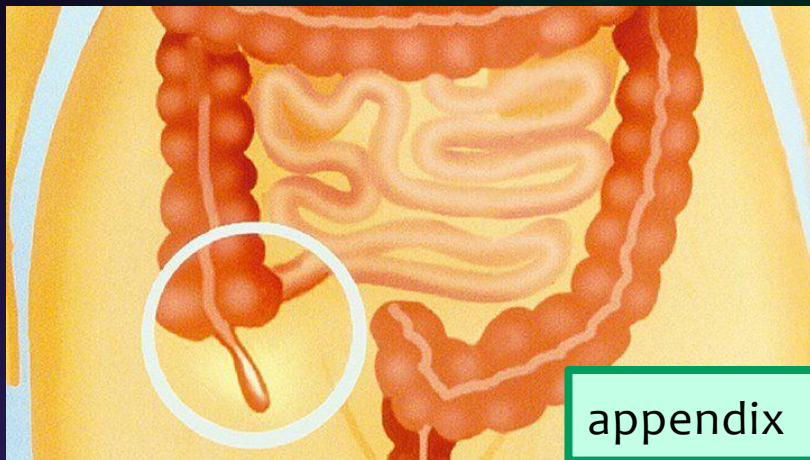
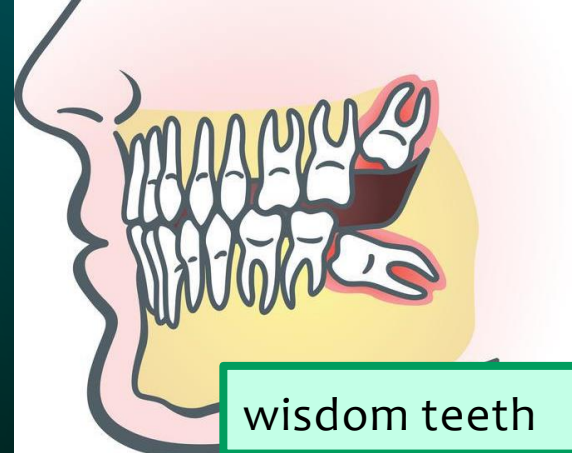
eyes in star-nosed mole rat: [video](#)



Vestigial legs of *Boa constrictor*  
legs of snakes



# VESTIGIAL STRUCTURES OF HUMANS

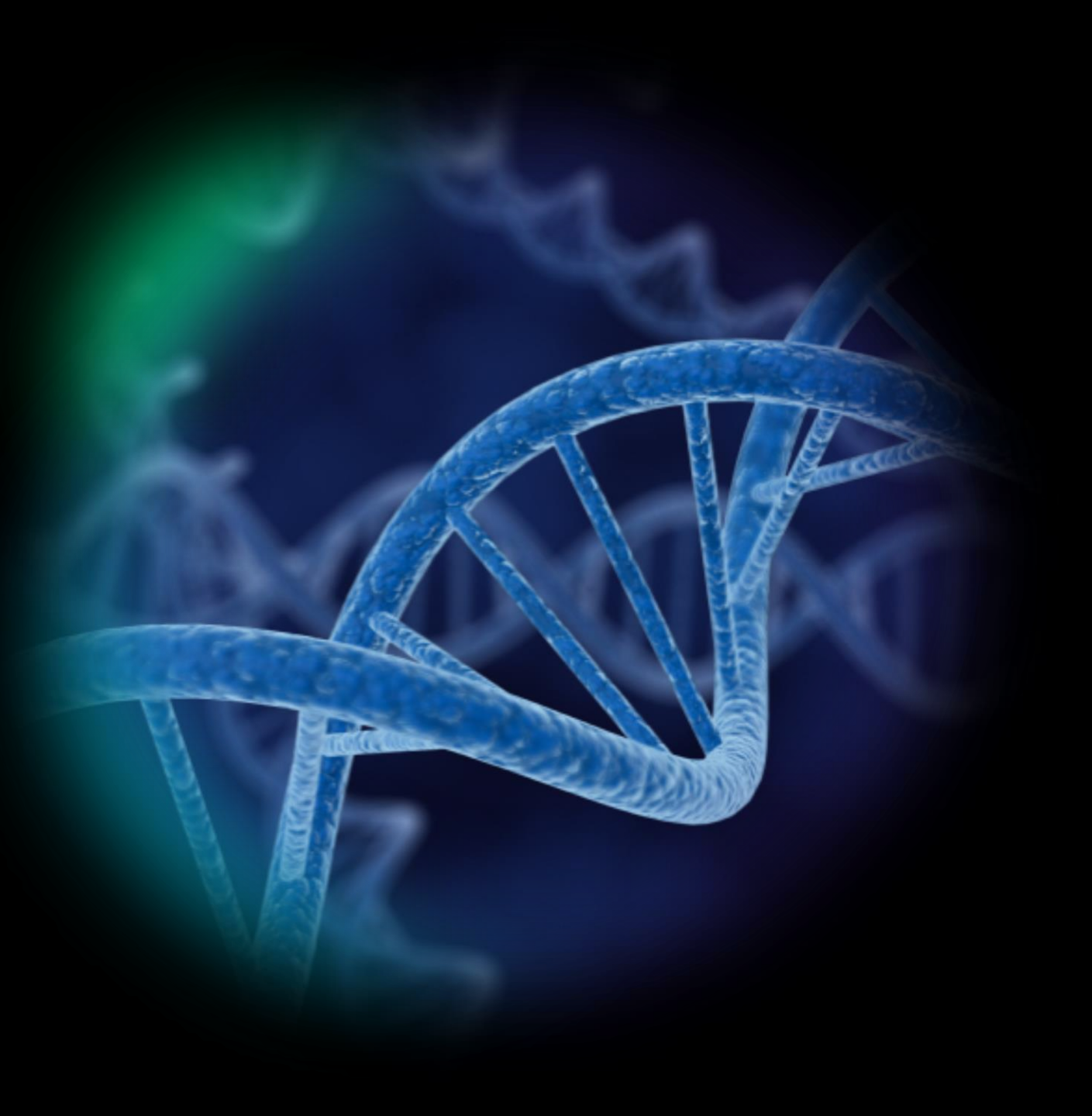




# BIOCHEMICAL SIMILARITIES

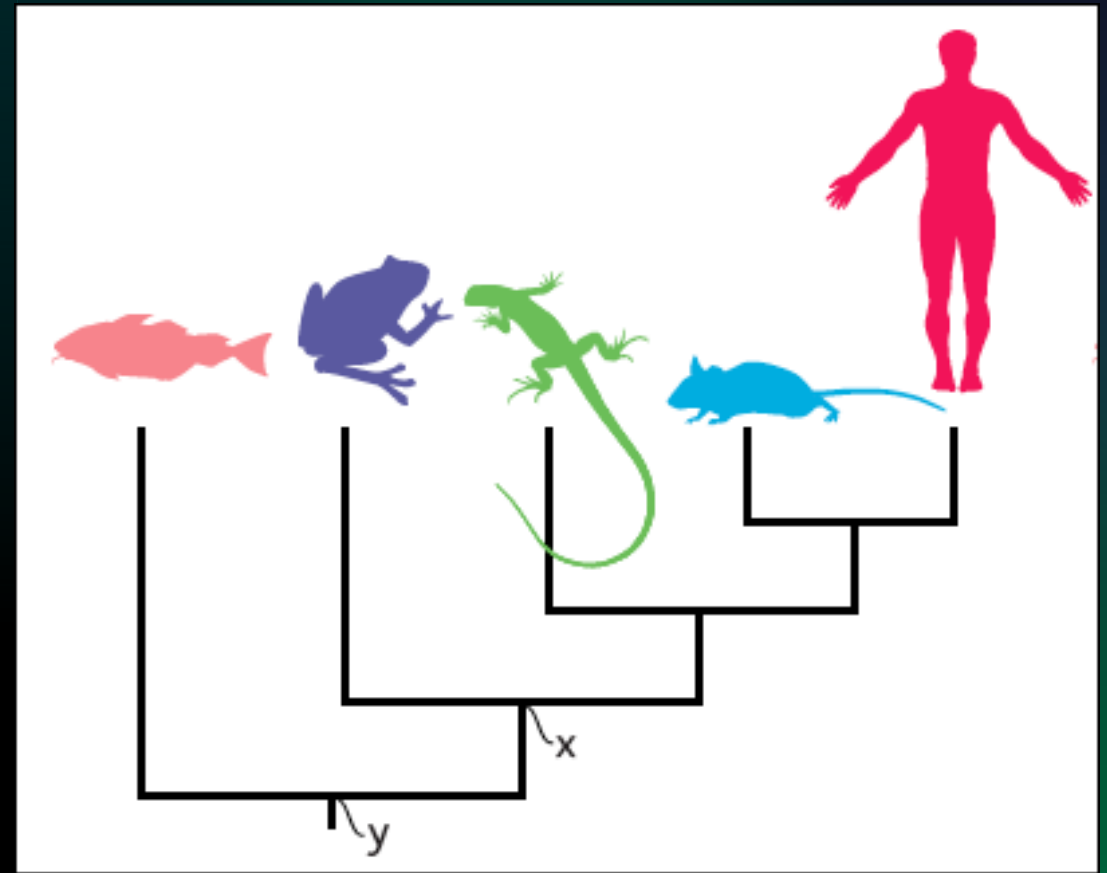
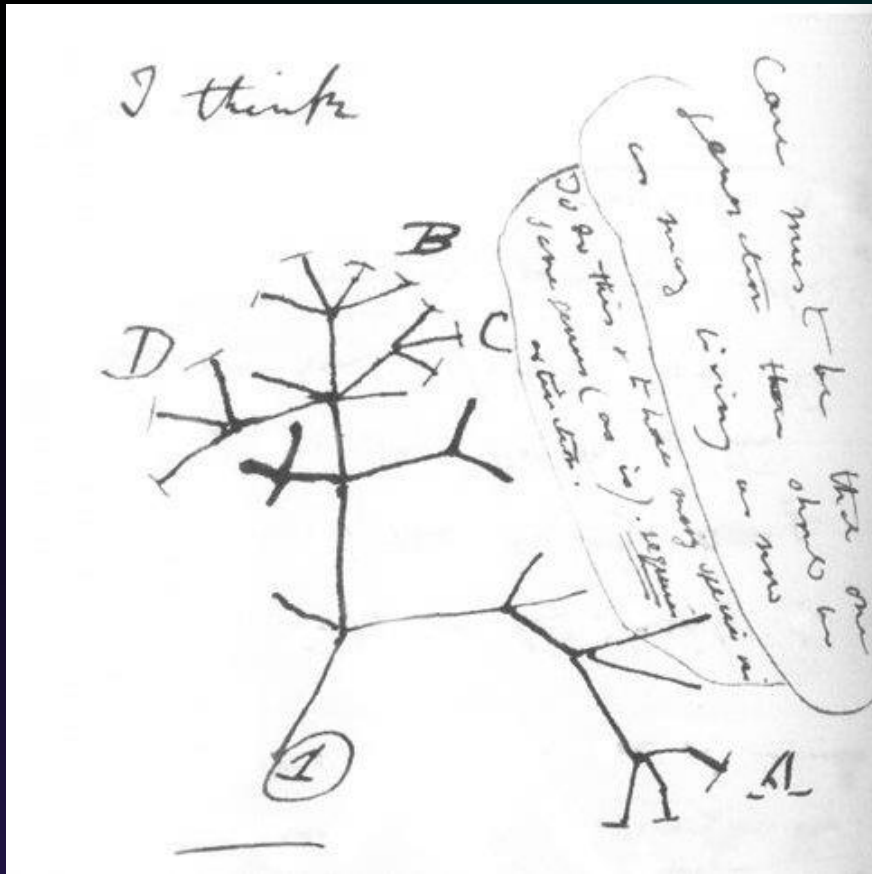
Many similar molecules shared  
by all living organisms:

- DNA or RNA as genetic material
- ATP is the energy-carrying molecule
- ...and others



# DARWIN'S CONCLUSION

Living organisms evolved through gradual modification of earlier forms – **descent with modification from a common ancestor.**





# DARWIN'S INFLUENCES: OUTLINE

1. Hutton and Lyell: Earth is old and changes slowly over time
2. Lamarck's Theory of Evolution
3. Malthus's "Struggle for Existence"
4. Artificial Selection by Farmers
5. Voyage of the Beagle







# HUTTON AND LYELL (EARTH IS OLD!)

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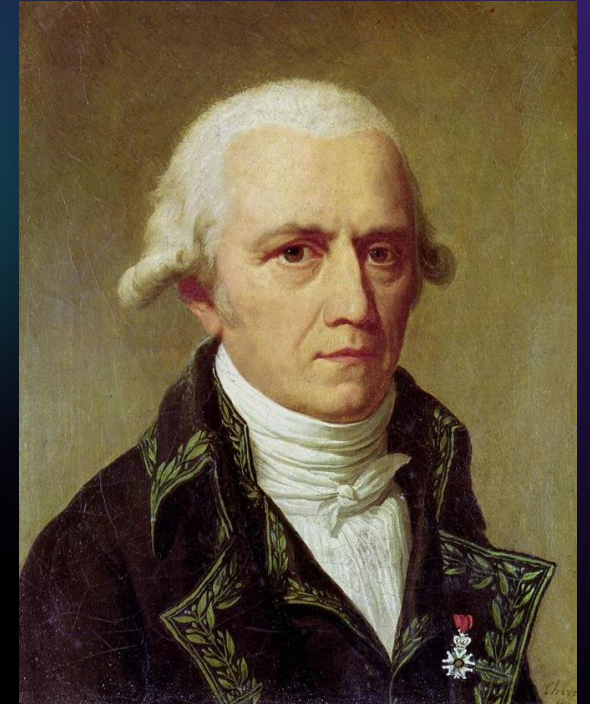
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## Charles Lyell (1830):

- Geographical features can be built up or torn down, through countless small changes over vast periods of time

# LAMARCK'S THEORY OF EVOLUTION

- Jean Baptiste de Lamarck was a French naturalist (1744-1829)
- Lamarck's theory of evolution:
  - Organisms change during their lifetimes to adapt to the environment (**desire to change, use and disuse**)
  - Changes are inherited by offspring







# DESIRE TO CHANGE (LAMARCK)

- Organisms change because they *want to improve and adapt* to their environments
- (Interpretation: if you and your descendants try hard enough to fly, you will grow wings because you need them.)



# USE AND DISUSE (LAMARCK)

- Body parts used most often will become more developed and specialized for environment
- Body parts that are not used will become underdeveloped or disappear



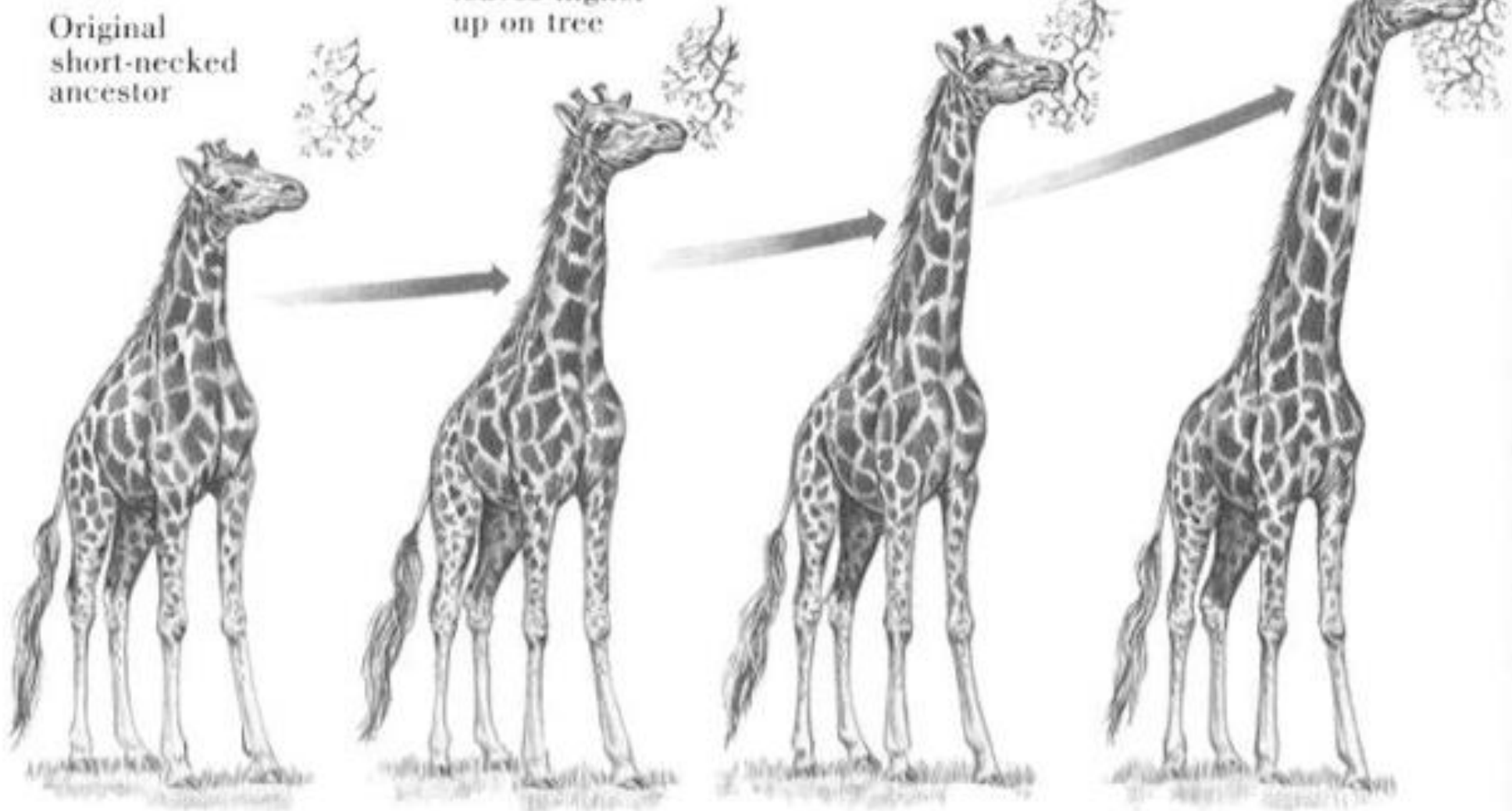
# LAMARCK'S GIRAFFE

Original  
short-necked  
ancestor

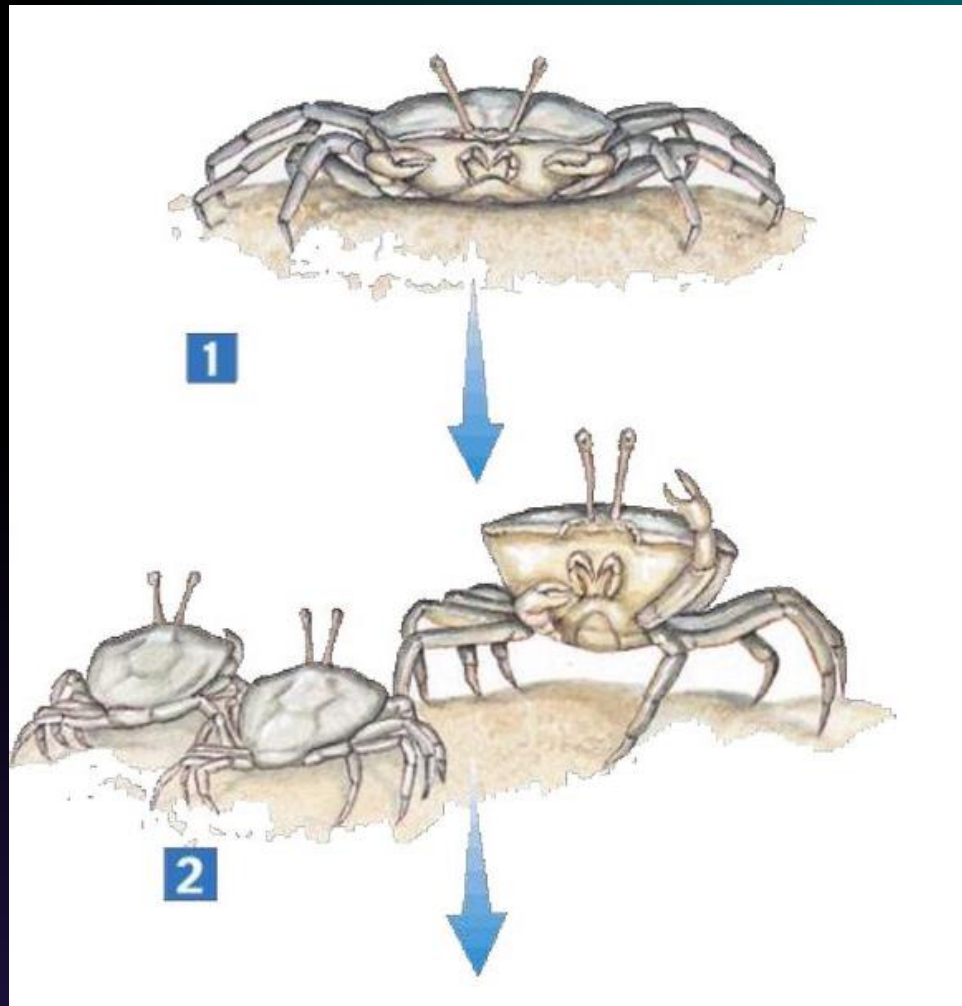
Keeps stretching  
neck to reach  
leaves higher  
up on tree

and  
stretching

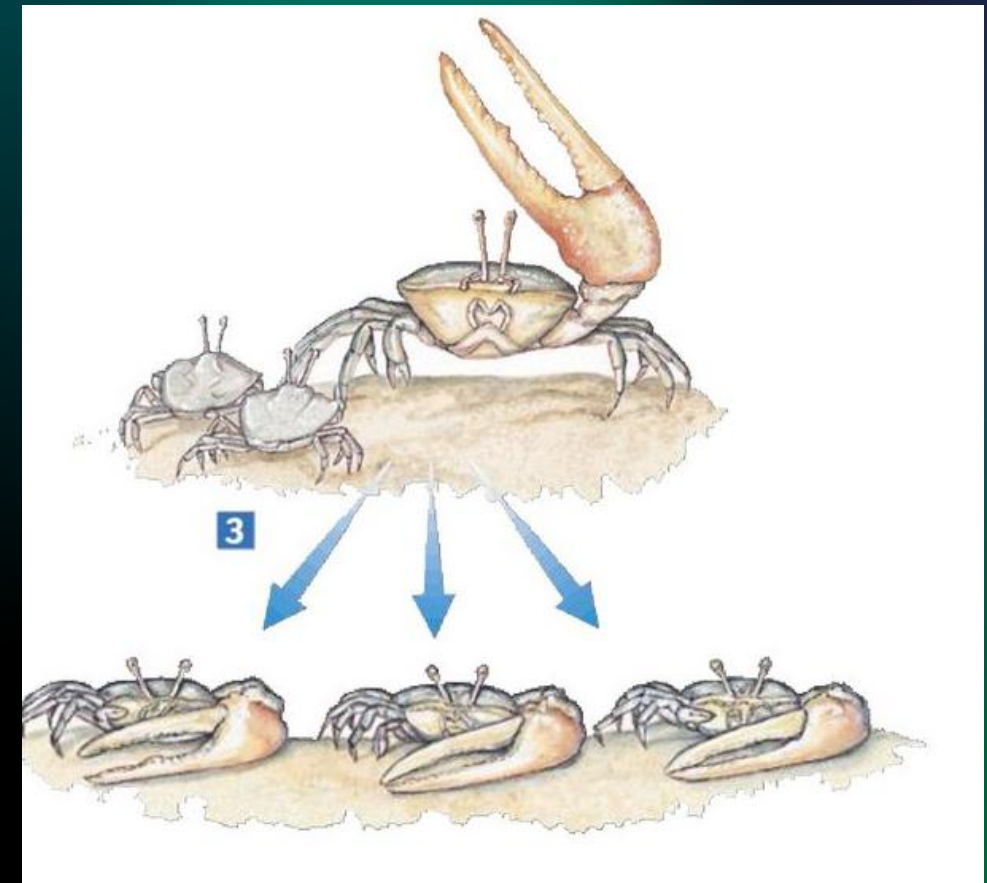
and stretching  
until neck  
becomes  
progressively  
longer



Because the front claw is used repeatedly, it becomes larger. This characteristic (large claw) is passed on to its offspring.



Male fiddler crab uses its front claw to ward off predators and to attract mates.





# PASSING ON ACQUIRED TRAITS (LAMARCK)

- Newly acquired traits are passed on to offspring
- Structures that have become smaller from disuse will eventually disappear over generations

Lamarck's theory of evolution be like:





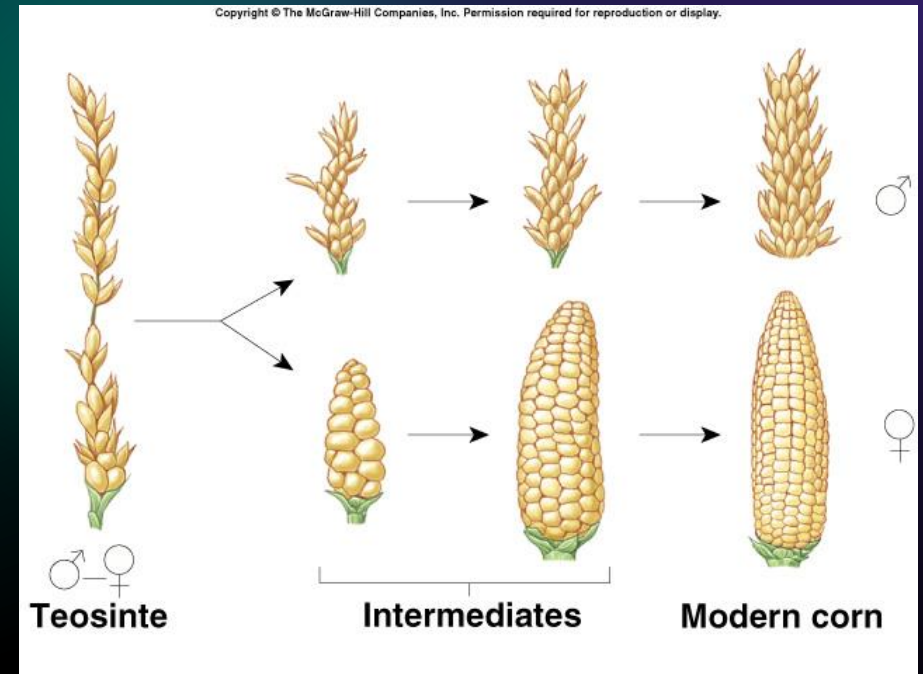
# MALTHUS' CONTRIBUTIONS

- Thomas Malthus was an English economist in the 19<sup>th</sup> century
- Observation: when human population increases, competition for resources (food, space) occurs
- **Struggle for Existence:**
  - Human population is limited by famine, war, and disease
  - Not all individuals survive and reproduce



# ARTIFICIAL SELECTION BY FARMERS

1. Natural, heritable variation exists in the population
2. Farmers select and breed organisms with desirable trait(s)
3. Over generations, the desired trait(s) becomes more common in the population



# PRACTICE

- Read textbook section 13-1 (p. 269-271).
- Read textbook section 14-1 (p. 291-295).
- On pg 295, complete questions #1-4. (Stuck on #4? Refresh your memory of Darwin's theory by reading section 13-1.)



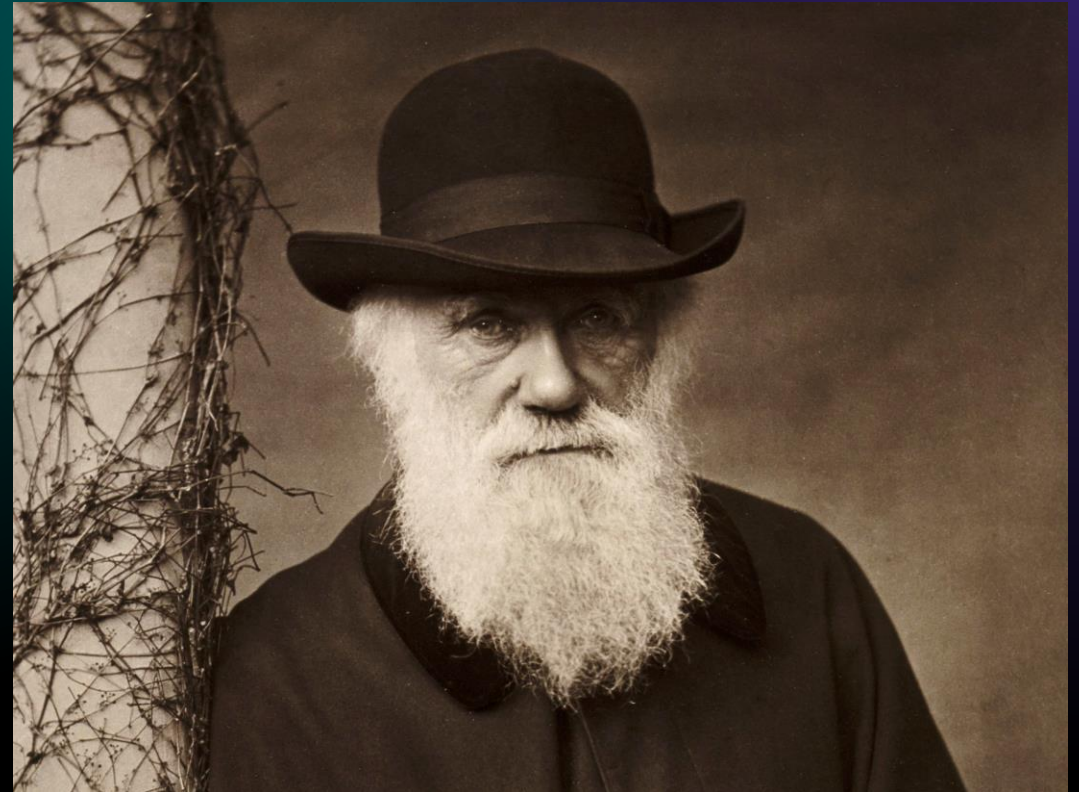
# Charles Darwin's Theory of Evolution

13-1: EVOLUTION AND LIFE'S DIVERSITY

14-2: EVOLUTION BY NATURAL SELECTION

# WHO WAS CHARLES DARWIN?

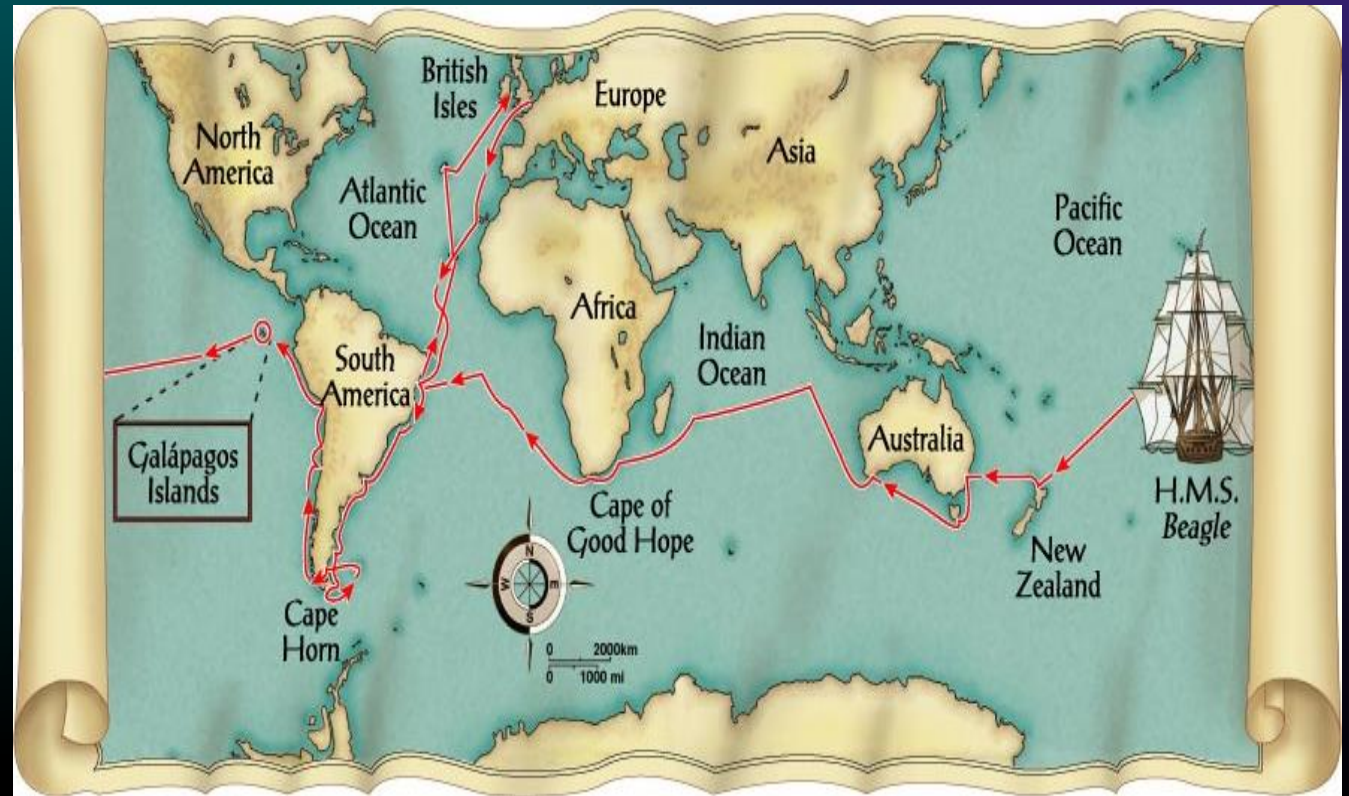
- English naturalist, geologist, and biologist (1809-1882)
- Studying theology (religion) to become a minister
- Saw science as an extension of religion





# VOYAGE OF THE BEAGLE

- 5-year voyage
- Darwin's goal: to find evidence to support the biblical account of creation
- Darwin kept detailed journals and collected many specimens



# DARWIN'S OBSERVATIONS

Darwin discovered fossils. Some looked like living organisms; others did not.



Where did they go? How were they related to living organisms?



# DARWIN'S OBSERVATIONS

Darwin discovered species he had never seen before.



Where did they come from? Why were they in one place but not another?

# DARWIN'S OBSERVATIONS

Darwin discovered familiar ecosystems with unfamiliar animals.

Argentina



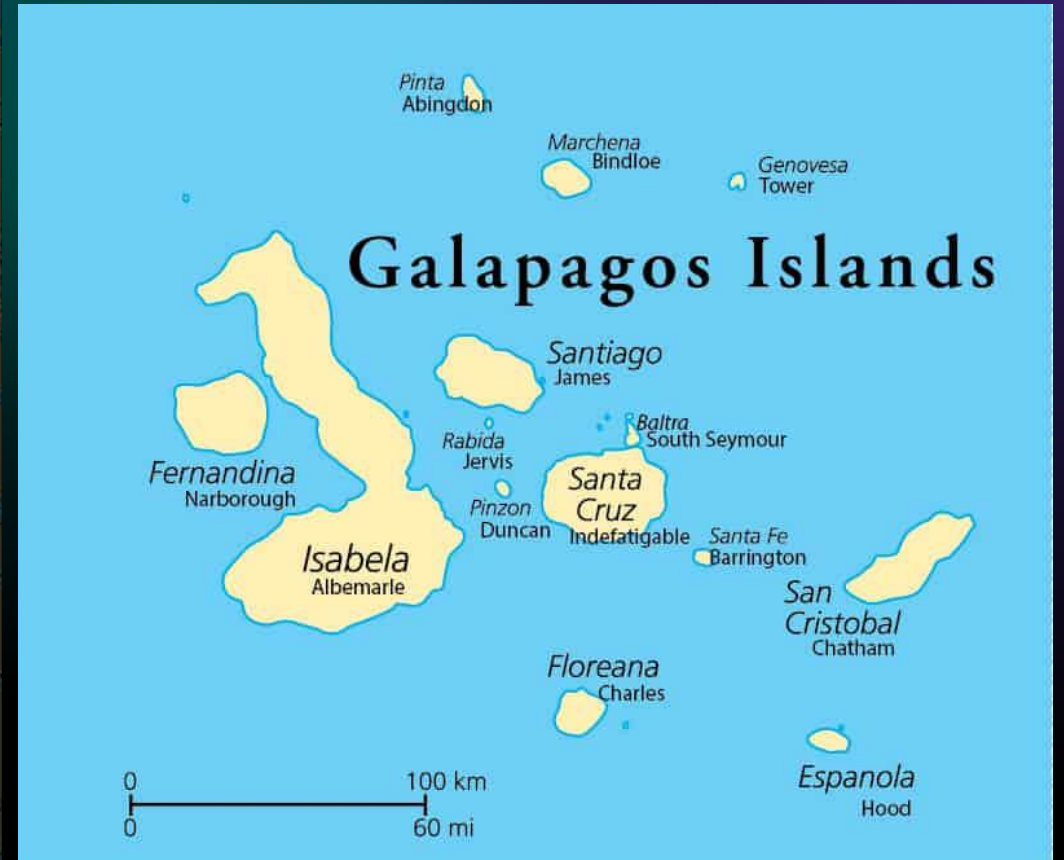
Australia



Where did they come from? Why were they in one place but not another?

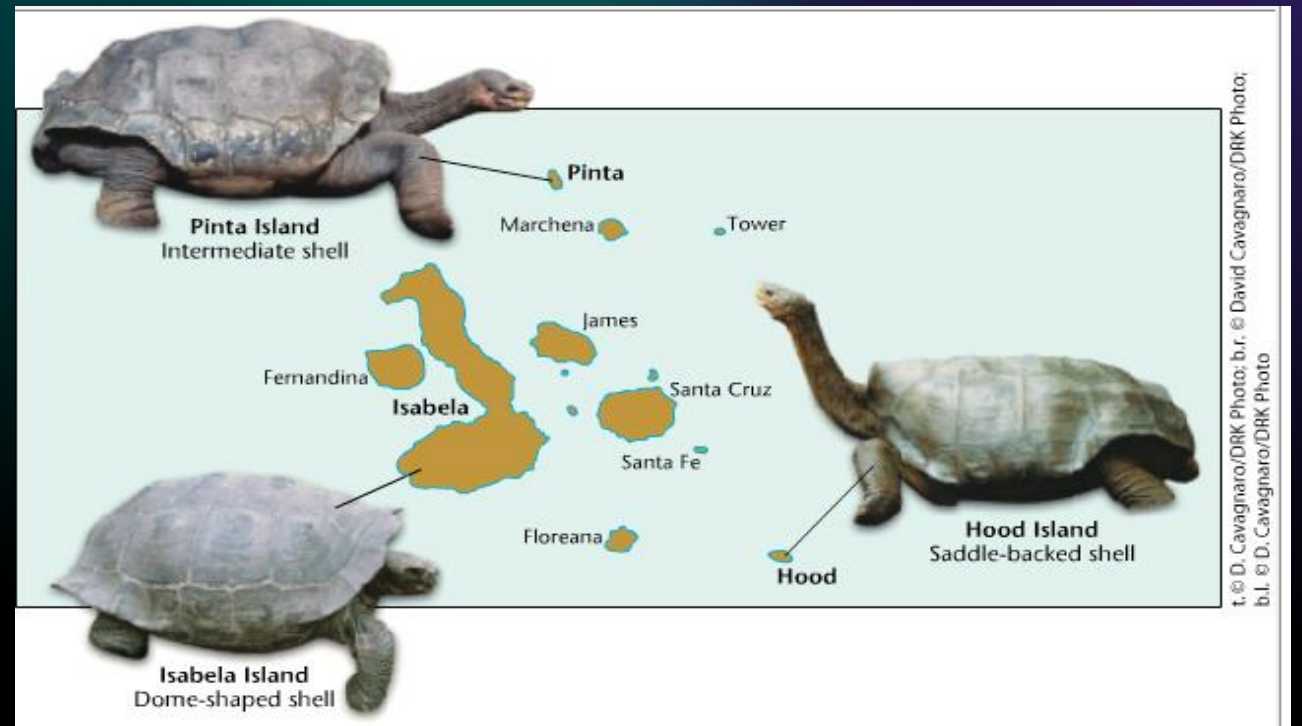


# GALAPAGOS ISLANDS



# GALAPAGOS ISLANDS

- Islands with different environmental conditions had different plants and animals
- Giant tortoises and marine iguanas looked different depending on which island they were from



How does the environment affect the plants and animals that live there?



# GALAPAGOS ISLANDS

- Many different species of finch lived on the island: variation in size, beak shape/size, and food source



Where did they come from? Why could these finches not be found anywhere else?  
Why only finches: why not blackbirds, grosbeaks, wrens, etc?

# DARWIN'S THEORY OF EVOLUTION

- ***Fitness***: the physical traits and behaviours that enable organisms to survive and reproduce in their environments
- Modern organisms were produced by ***evolution***: gradual change in species over time
- ***Common descent***: all species have descended from common ancestors
- ***Adaptation***: inherited characteristic that increases fitness



# DARWIN'S THEORY OF EVOLUTION

Populations evolve through *natural selection*:

1. Natural, heritable variation exists in the population
2. Organisms with adaptive traits, on average, survive and reproduce more (*survival and reproduction of the fittest*)
3. Over generations, adaptations become more common in the population