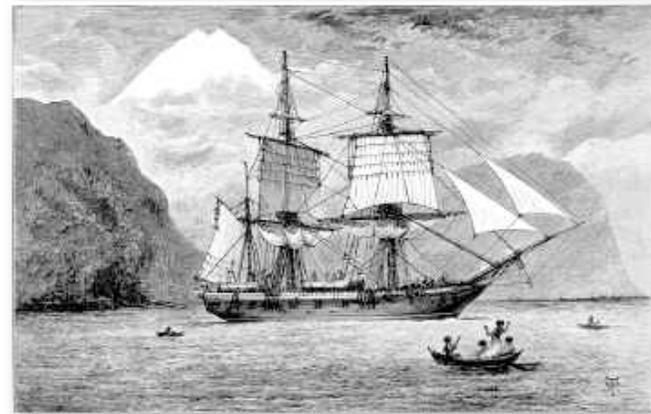


Voyage on the HMS Beagle

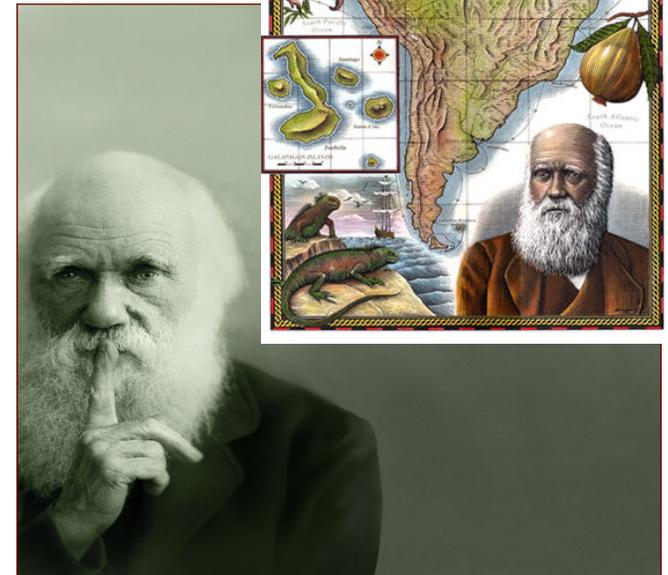
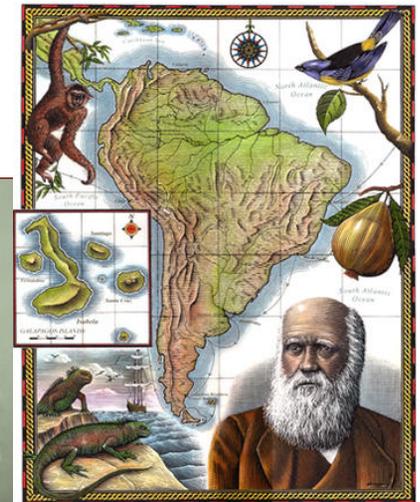
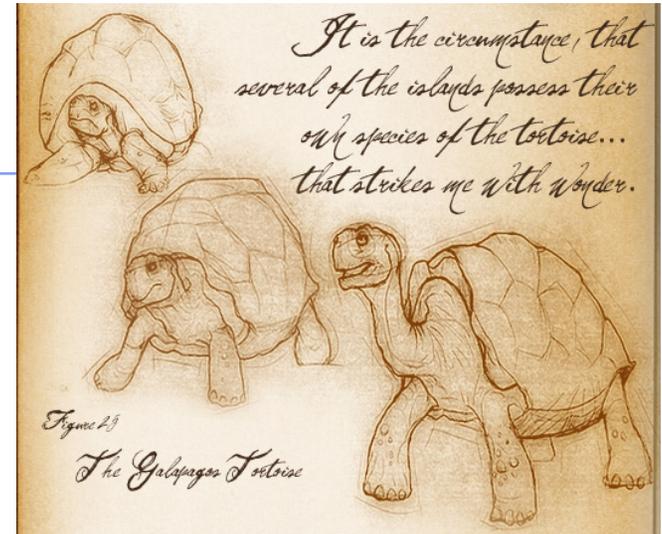
- Invited to travel around the world
 - ◆ From 1831-1836 (22 years old!)
 - Captain FitzRoy chose Darwin because of his education, his similar social class, and his similar age to the captain.
 - ◆ main mission of the *Beagle* was to chart South American coastline
 - During this voyage, Darwin makes many observations of nature and collects many specimen to study.

Robert Fitzroy



Some details stood out to Darwin during his travels:

- ◆ **Organisms had characteristics that suited their environment.**
- ◆ **South American fossils more closely resembled modern living species from that continent than those from Europe.**
 - **Organisms from temperate regions of South America were more similar to those from the tropics of South America than to those from temperate regions of Europe.**
- ◆ **Most organisms of the Galapagos lived nowhere else, but resembled species living on the South American mainland.**
 - **It seemed that the islands had been colonized by plants and animals from the mainland that had then diversified on the different islands**

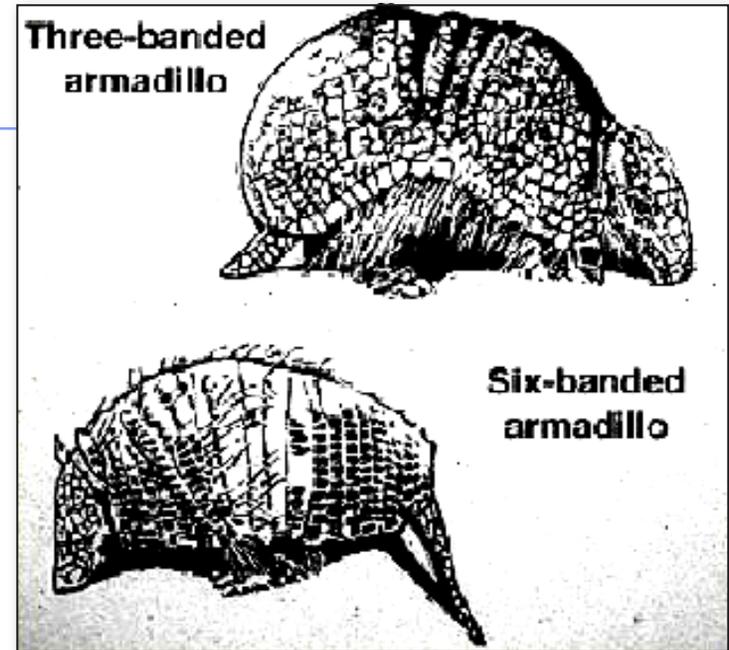


Succession of types

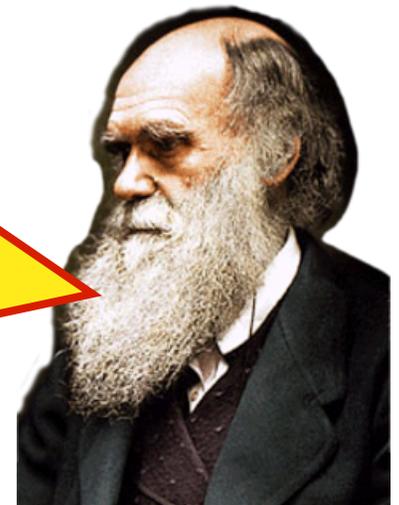
Armadillos are native to the Americas, with most species found in South America.

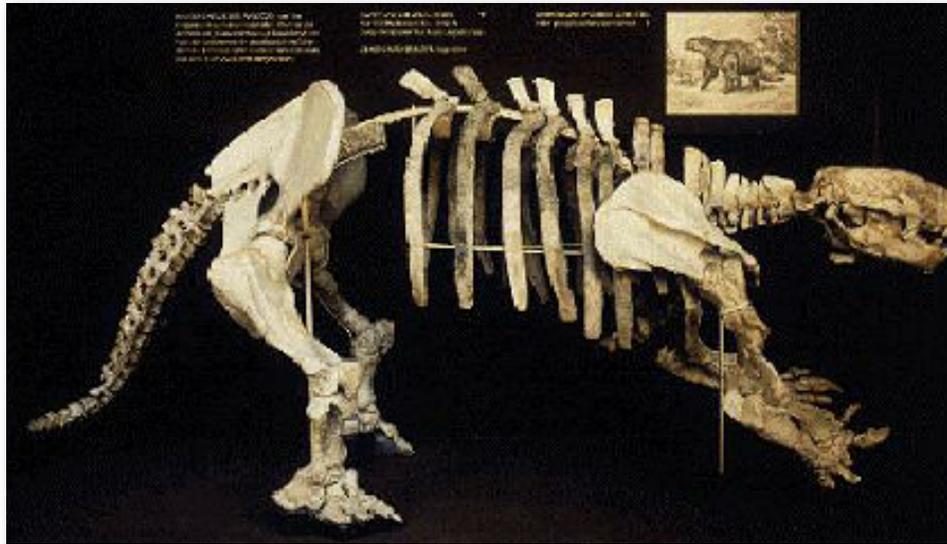


Glyptodont fossils are also unique to South America.



Why should extinct armadillo-like species & living armadillos be found on the same continent?

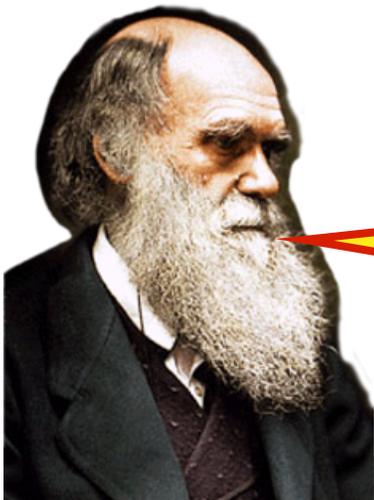




Mylodon (left) Giant ground sloth (extinct)



Modern sloth (right)

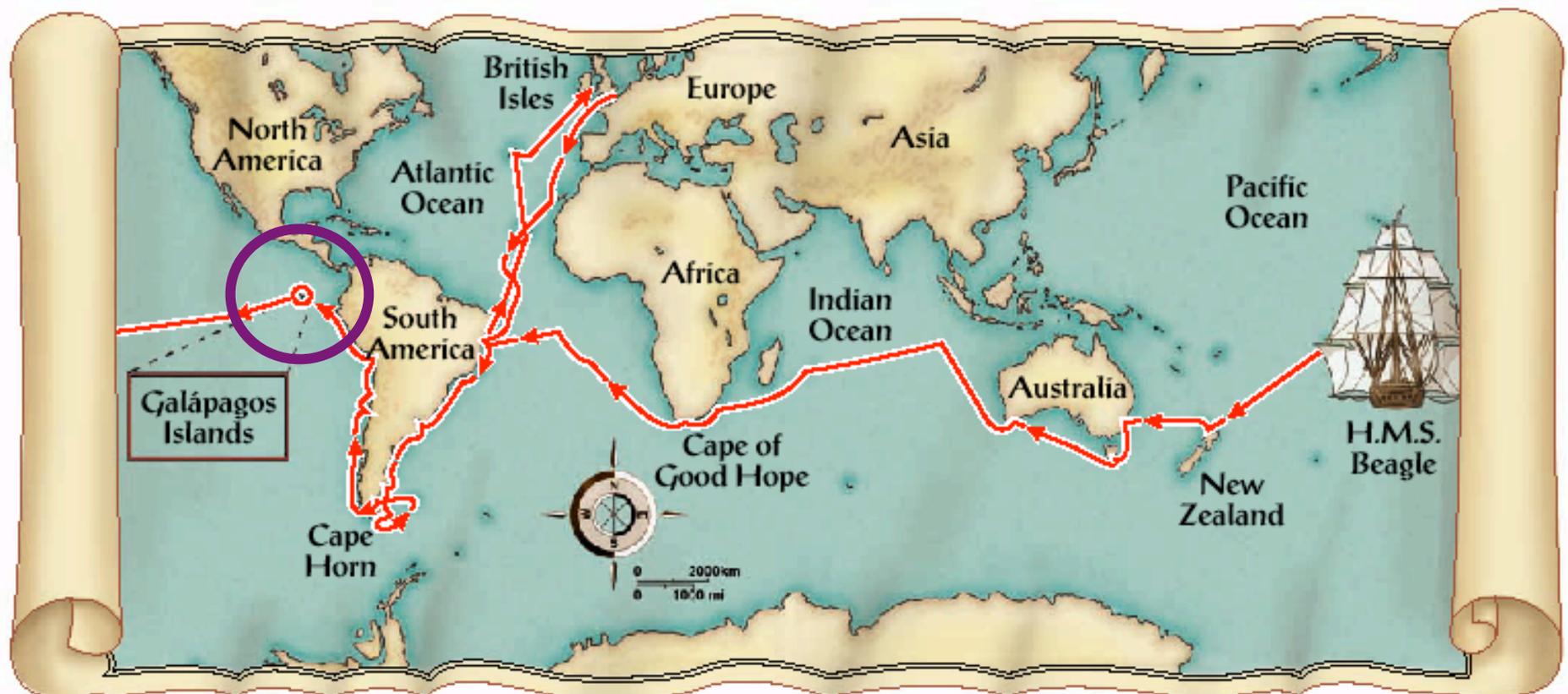


"This wonderful relationship in the same continent between the dead and the living will...throw more light on the appearance of organic beings on our earth, and their disappearance from it, than any other class of facts."

Voyage of the HMS Beagle

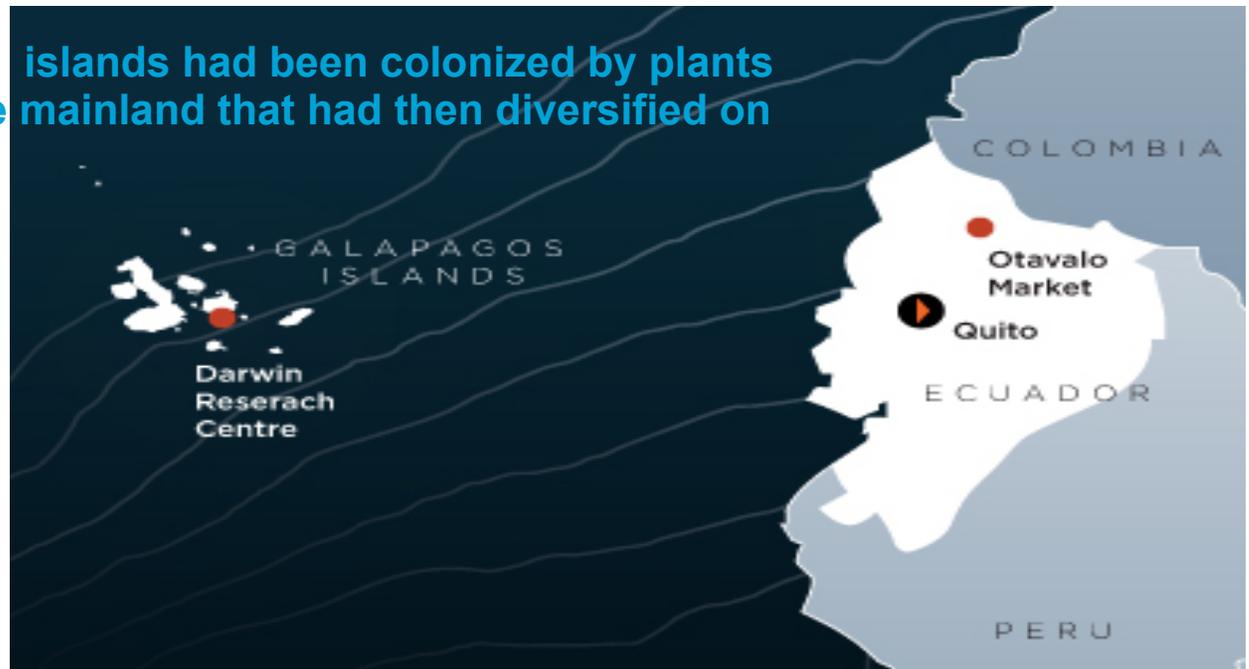
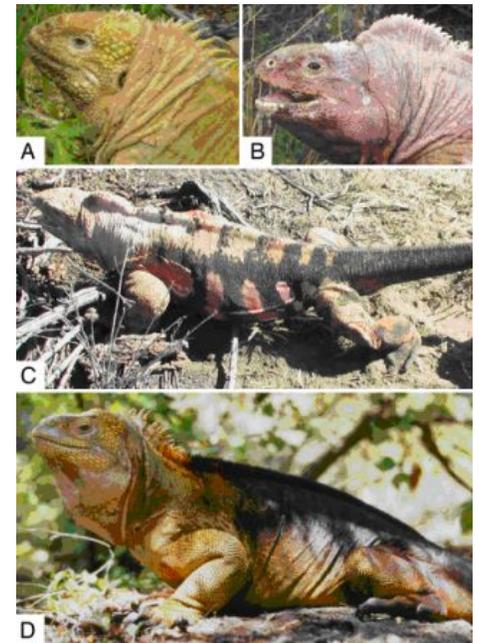


- Darwin noted that the plants and animals of South America were very distinct from those of Europe
 - ◆ Stopped in the Galapagos Island (500 miles off coast of Ecuador)

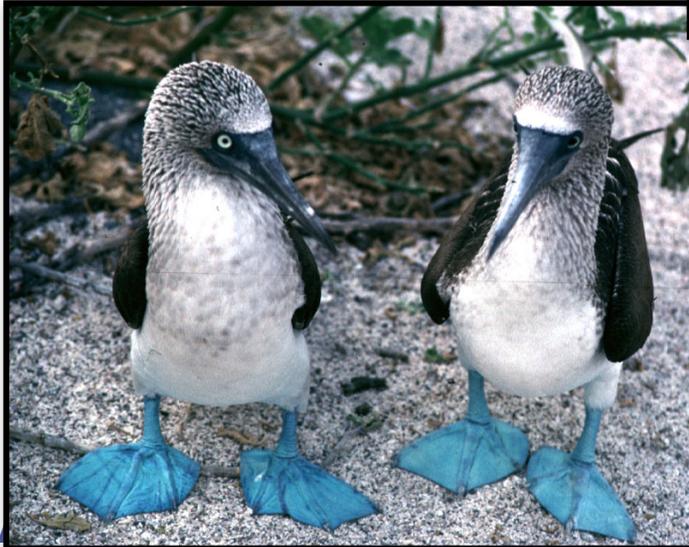


Voyage of the HMS Beagle

- The origin of the fauna (*animal life*) of the Galapagos, 900 km west of the South American coast, especially puzzled Darwin.
- ◆ On further study after his voyage, Darwin noted that while most of the animal species on the Galapagos lived nowhere else, they resembled species living on the South American mainland.
 - It seemed that these islands had been colonized by plants and animals from the mainland that had then diversified on the different islands



In each island of the Galapagos, he found many unique species



In the Galapagos Darwin found... birds

Collected many different birds on the Galapagos Islands.

Initially, thought he found very different kinds...



Finch?



Sparrow?



Woodpecker?



Warbler?

The Birds...

- **Galápagos birds**
 - 22 of the 29 species of birds on the Galapagos are **endemic**
 - found only on these islands
 - collected specimens of all
- **One particular group...**
 - at first, he paid little attention to a series of small birds
 - some were woodpecker-like, some warbler-like, & some finch-like



But Darwin found... a lot of finches

Darwin was amazed to find out:

- ALL 14 species of birds were related and were finches...

But there was only one species of finch on the mainland!!!



Large Ground Finch



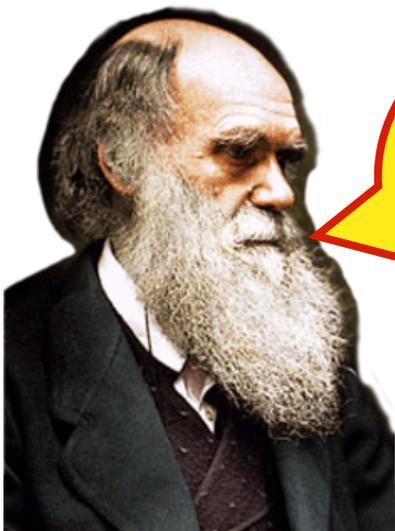
Small Ground Finch



Warbler Finch



Veg. Tree Finch



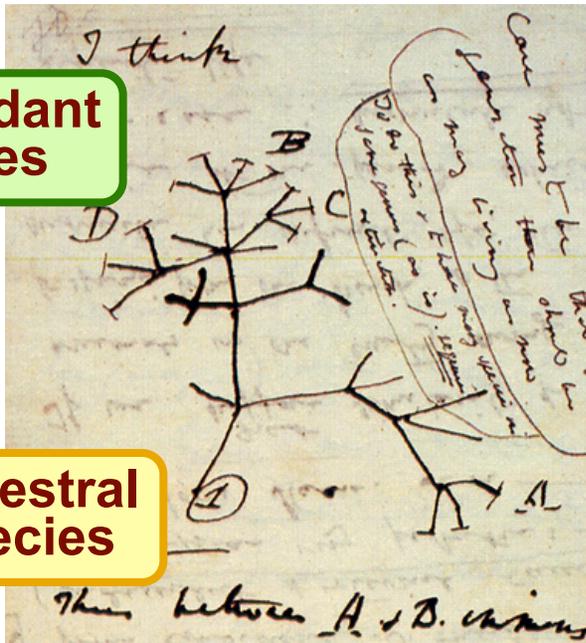
How did one species of finches become so many different species now?

Tree Thinking -

“Did all species of finch originated from an ancestral mainland finch?”

Descendant species

Ancestral species



Large Ground Finch



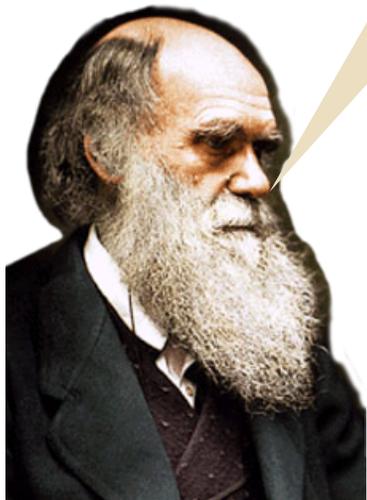
Small Ground Finch



Warbler Finch



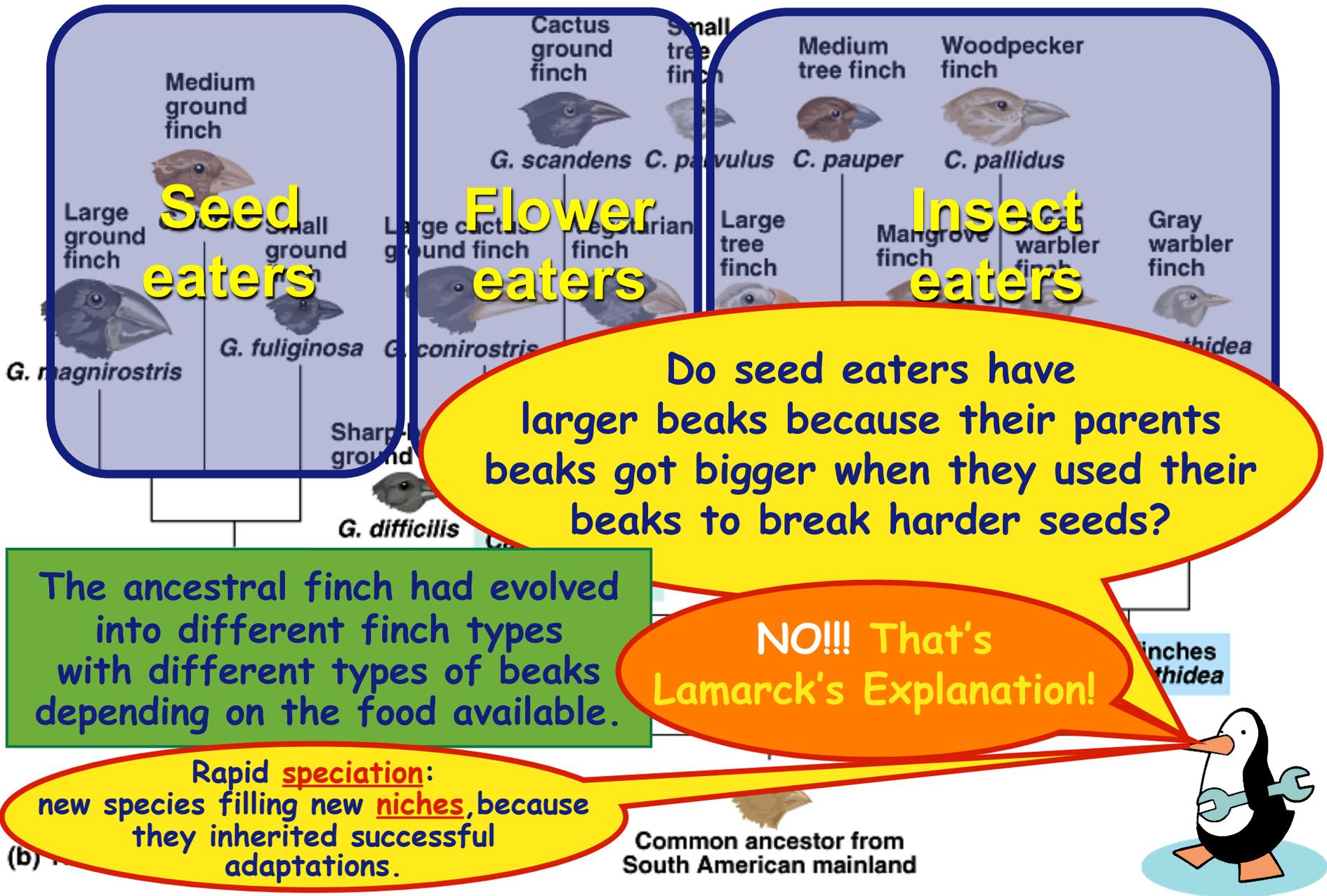
Veg. Tree Finch



He realized he was observing examples of **ADAPTATIONS:**

Inherited traits of organisms that enhance their survival and reproduction in a specific environment

He noted a correlation between the species and food source



One of Darwin's Conclusion

- ◆ Originally, South American finches landed on islands

- Each island had slightly different microenvironments & food sources



- ◆ Since there exists natural variations in beak size, some individuals could gather food more easily than others when hard seeds were the primary food option

- Individuals with slightly bigger beaks could crack open large seeds easier and had a survival advantage in areas with large seeds as food source.

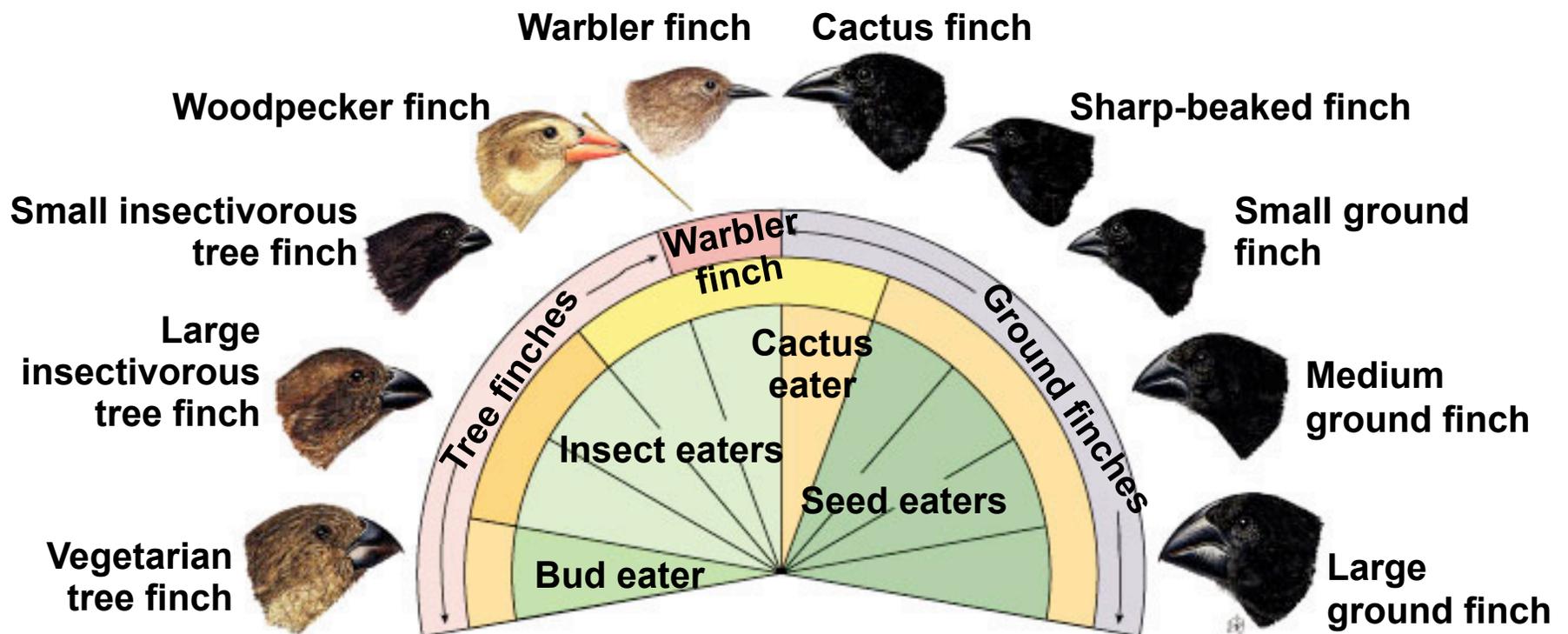


- Variation is inherited from parents and...

- Genes (alleles for genes) for bigger beaks were passed down to the next generation in greater numbers
- Over time, this population became dominated by larger beaked birds.

Darwin's Conclusion

- ◆ Over many generations, the populations of finches changed depending on environment because of **DIFFERENTIAL REPRODUCTION NOT ACQUIRED TRAITS!!! NEW SPECIES EMERGED!**
 - ◆ There was an accumulation of advantageous traits in the different populations

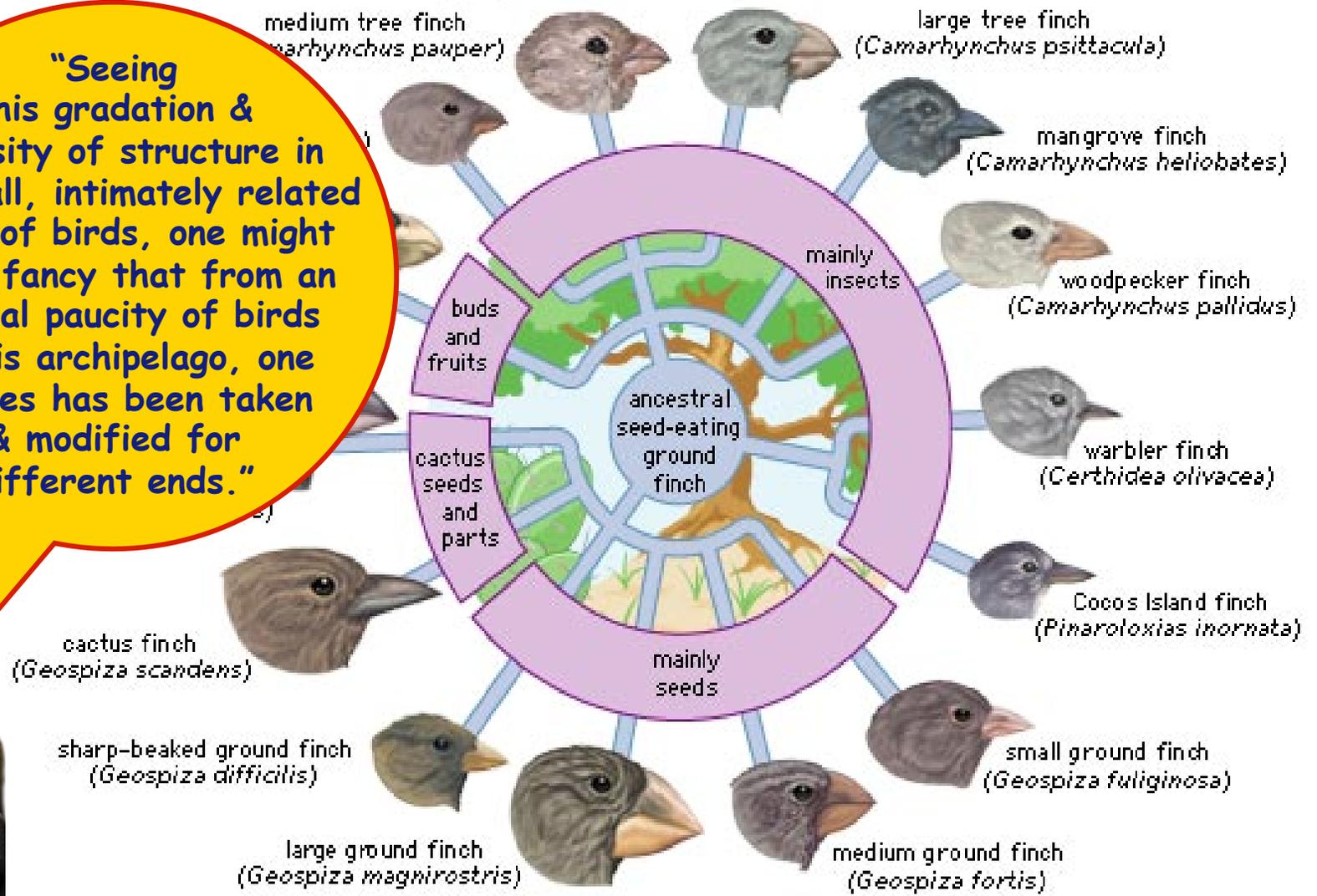
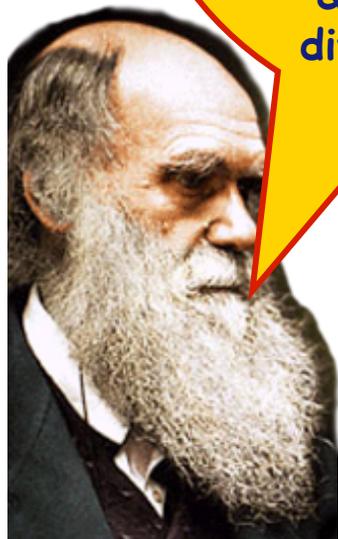


The Galapagos Finches were an example of **ADAPTIVE RADIATION** =

Fast evolutionary differentiation because of increase in the morphological and ecological diversity of a single, rapidly diversifying lineage. Phenotypes adapt in response to the environment, with new and useful traits arising.

Adaptive radiation in Galapagos finches

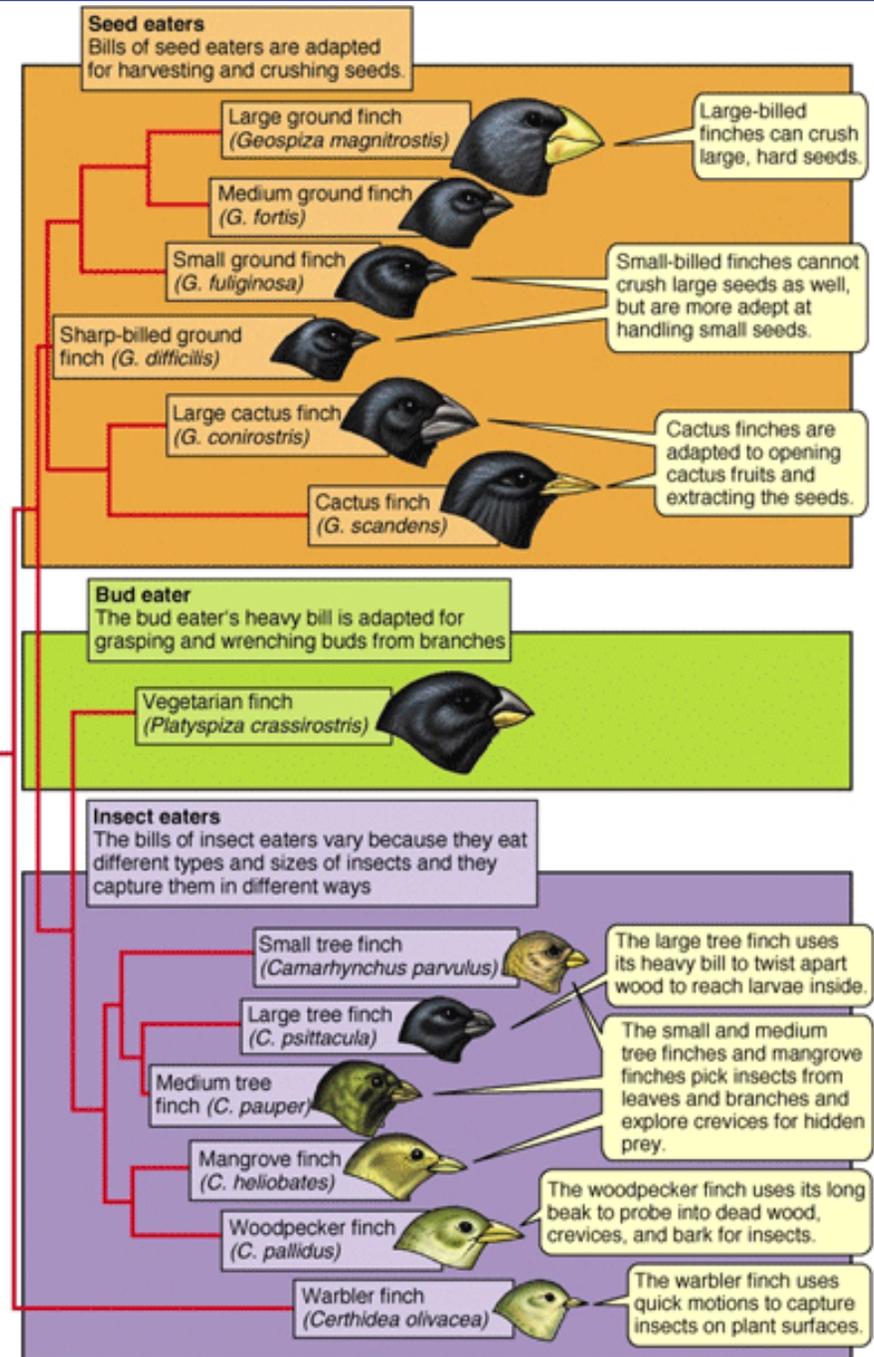
"Seeing this gradation & diversity of structure in one small, intimately related group of birds, one might really fancy that from an original paucity of birds in this archipelago, one species has been taken & modified for different ends."



Darwin's finches

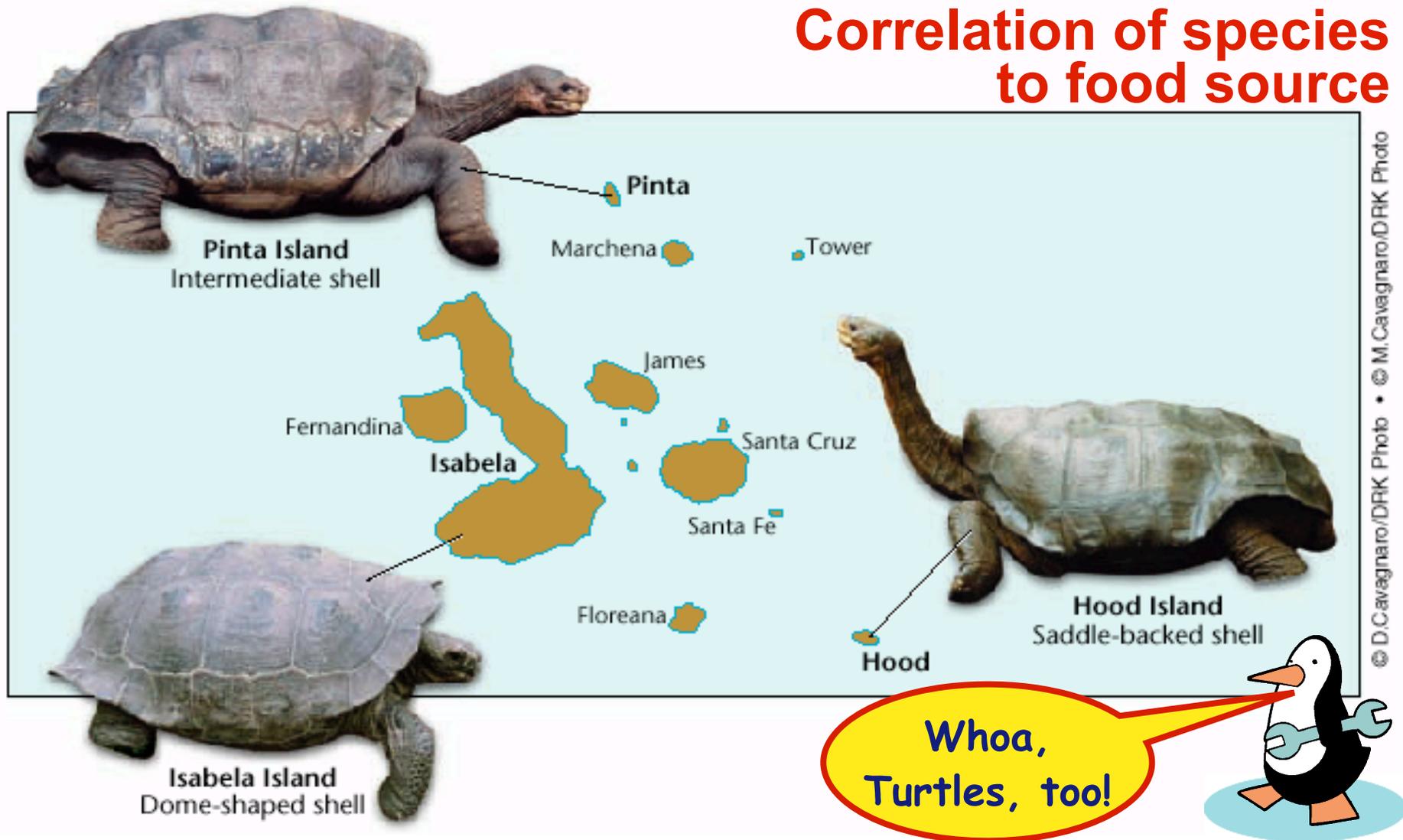
- Differences/variations in beak size & shape allowed some finches to...

- ◆ Successfully compete
- ◆ successfully feed
- ◆ successfully reproduce
 - these finches pass successful traits onto their offspring

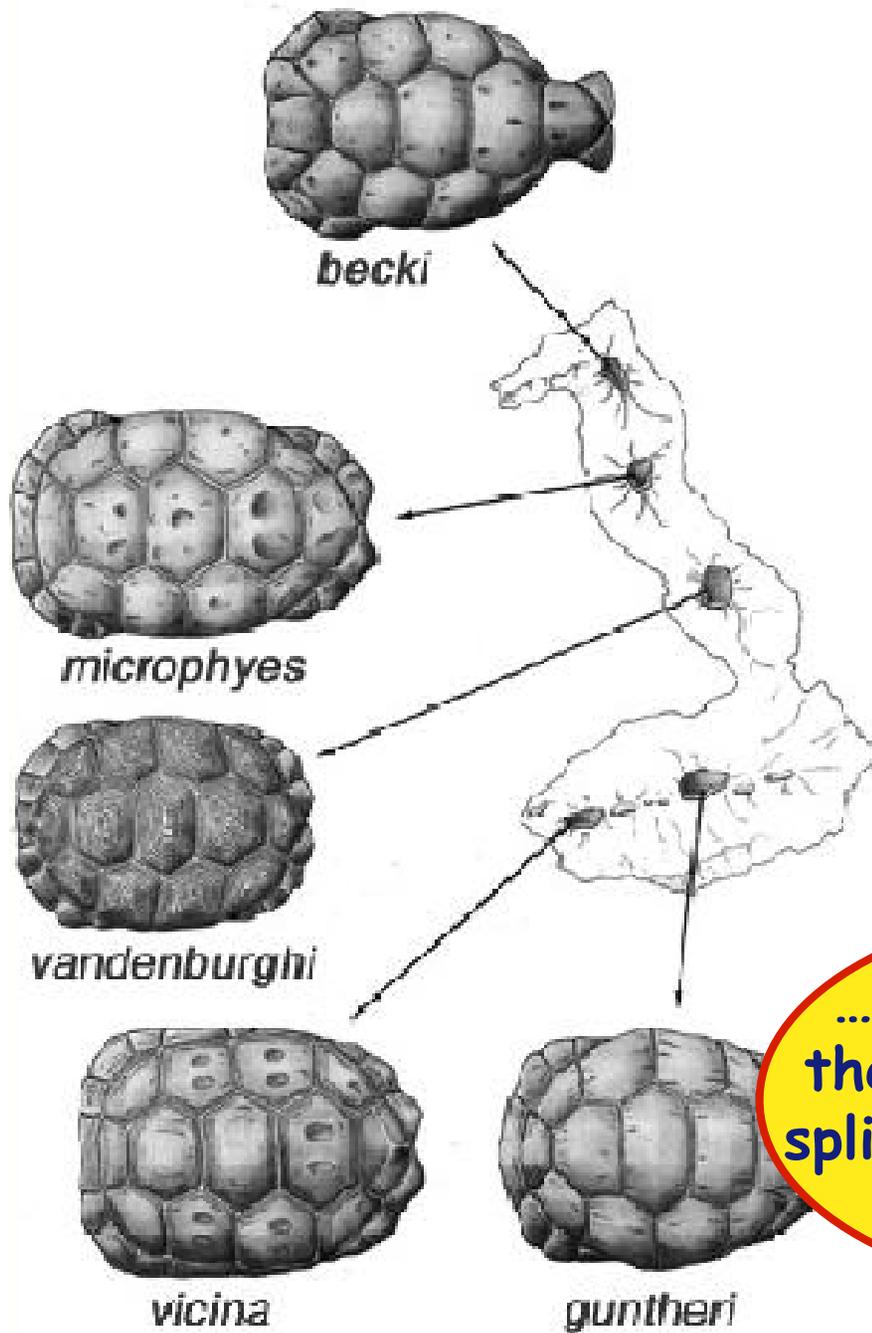


More observations...

Correlation of species to food source

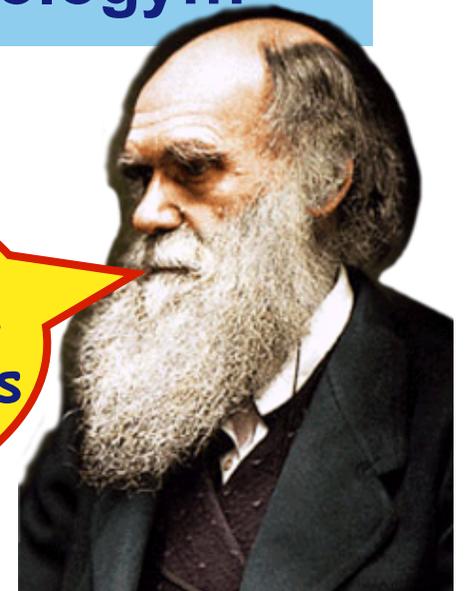


Variation Among Tortoises 🌴 Darwin observed that the characteristics of many animals and plants varied noticeably among the different Galápagos Islands. Among the tortoises, the shape of the shell corresponds to different habitats. The Hood Island tortoise (right) has a long neck and a shell that is curved and open around the neck and legs, allowing the tortoise to reach the sparse vegetation on Hood Island. The tortoise from Isabela Island (lower left) has a dome-shaped shell and a shorter neck. Vegetation on this island is more abundant and closer to the ground. The tortoise from Pinta Island has a shell that is intermediate between these two forms.

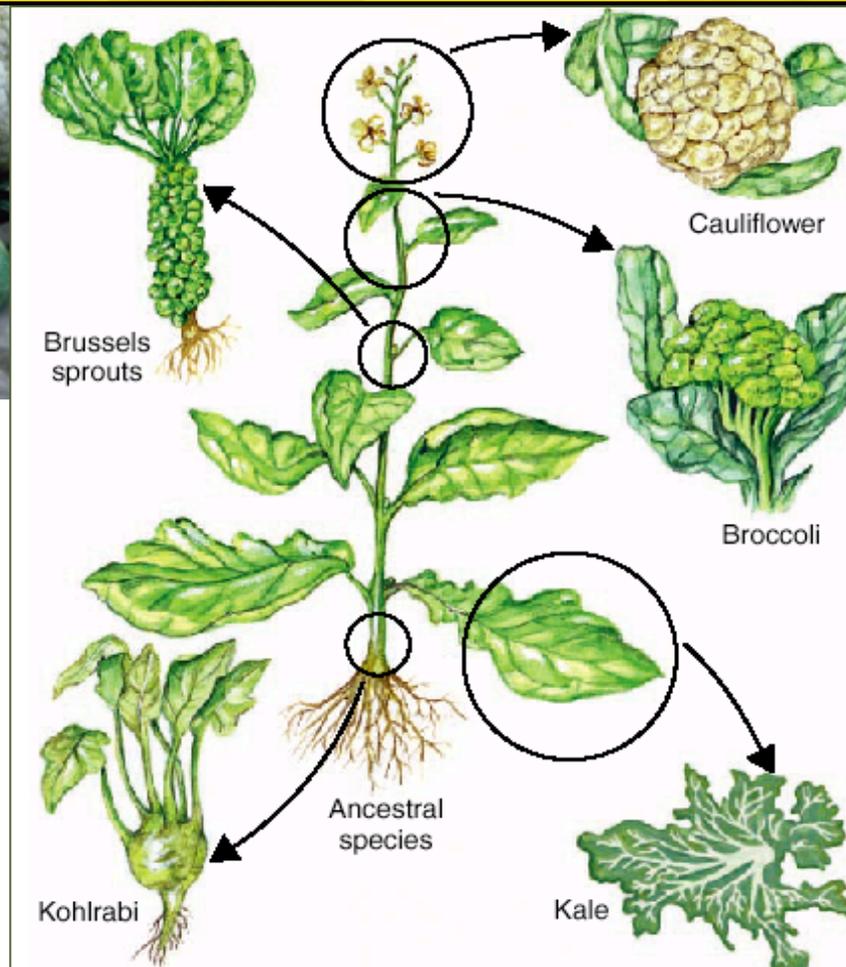
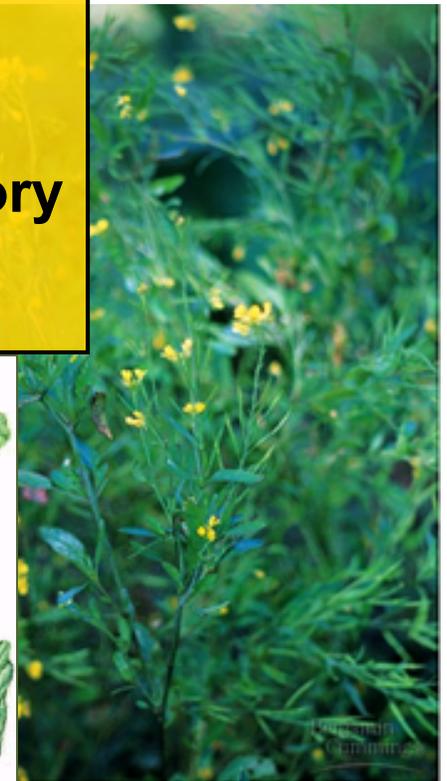


Many islands also show distinct local variations in tortoise morphology...

...perhaps these are the first steps in the splitting of one species into several?



Darwin used the practice of **Artificial selection** to persuade skeptics of his theory of Natural Selection



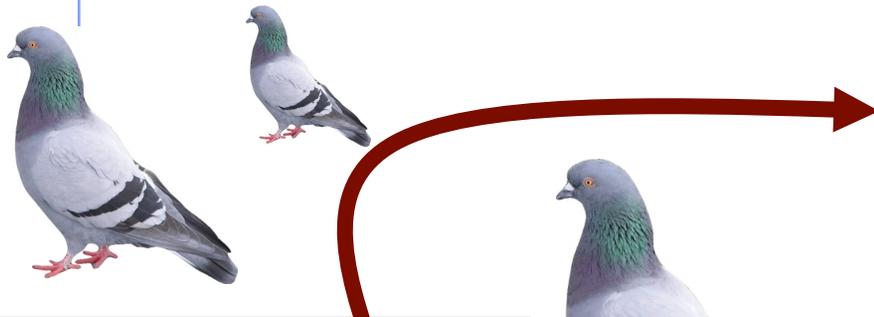
Modifying species over generations by selecting and breeding individuals that possess desired traits

This is not just a process of the past...

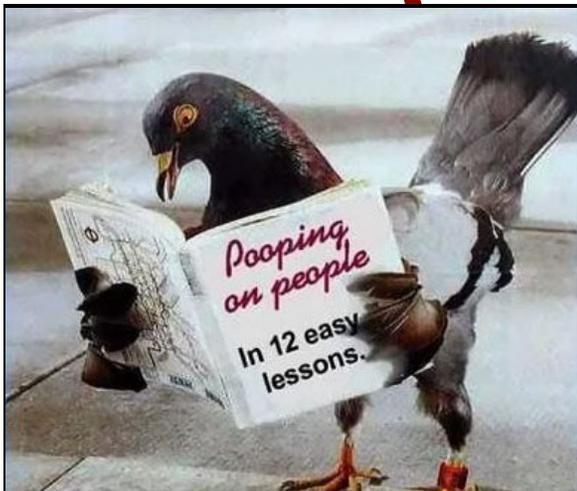
It is all around us today

Selective breeding

The raw genetic material (variation) is hidden in the common pigeon.



By breeding only those pigeons that exhibit more of the trait we want, we can create a new pigeon that looks very different from the ancestor pigeon.



Selective breeding

Hidden variation can be exposed through selection!

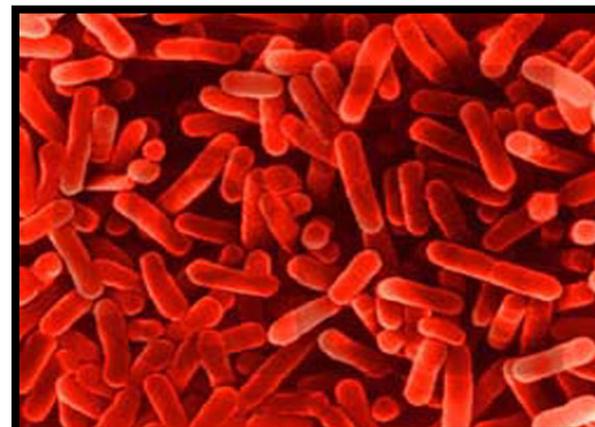


Allowing some to breed and others not to breed....



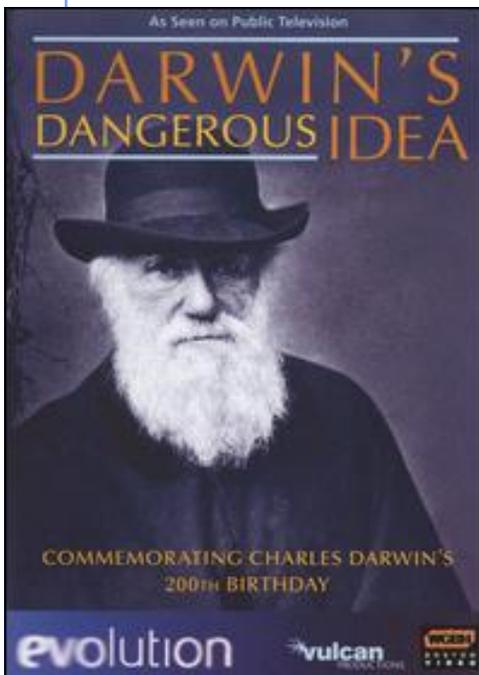
Darwin's four observations of Nature:

1. Members of a population often vary in their traits.
2. Traits are inherited from parents to offspring.
3. All species are capable of producing more offspring than the environment can support.
4. Because of the lack of food or other resources, many offspring do not survive.



Darwin's Two Inferences:

1. Individuals whose inherited traits give them a higher probability of surviving and reproducing in an environment, tend to leave more offspring than others.
2. The unequal ability of individuals to survive and reproduce will lead to the accumulation of favorable traits in the population over generations.



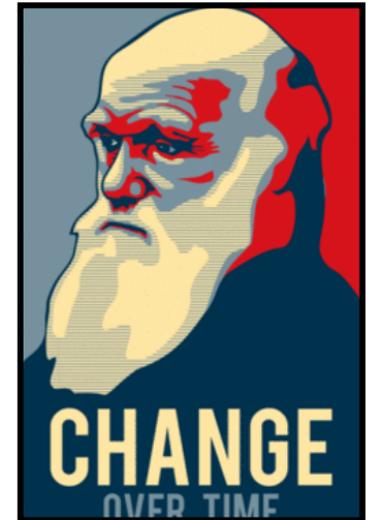
DESCENT WITH MODIFICATION

Today "EVOLUTION" =
Change in the genetic makeup of a
population over time.

Mechanism of Evolution =
NATURAL SELECTION

Factors such as predators, lack of food, or adverse physical conditions increases the proportion of favorable traits in a population.

DARWIN'S RATIONALE BEHIND THE THEORY OF EVOLUTION:



- Individuals who **inherit** advantageous traits have a higher probability of **surviving** and **reproducing**.
 - Many generations later, the proportion of traits (alleles for genes) in a population changes
 - Many more individuals will have the advantageous traits (will have inherited the alleles for the beneficial phenotypes)



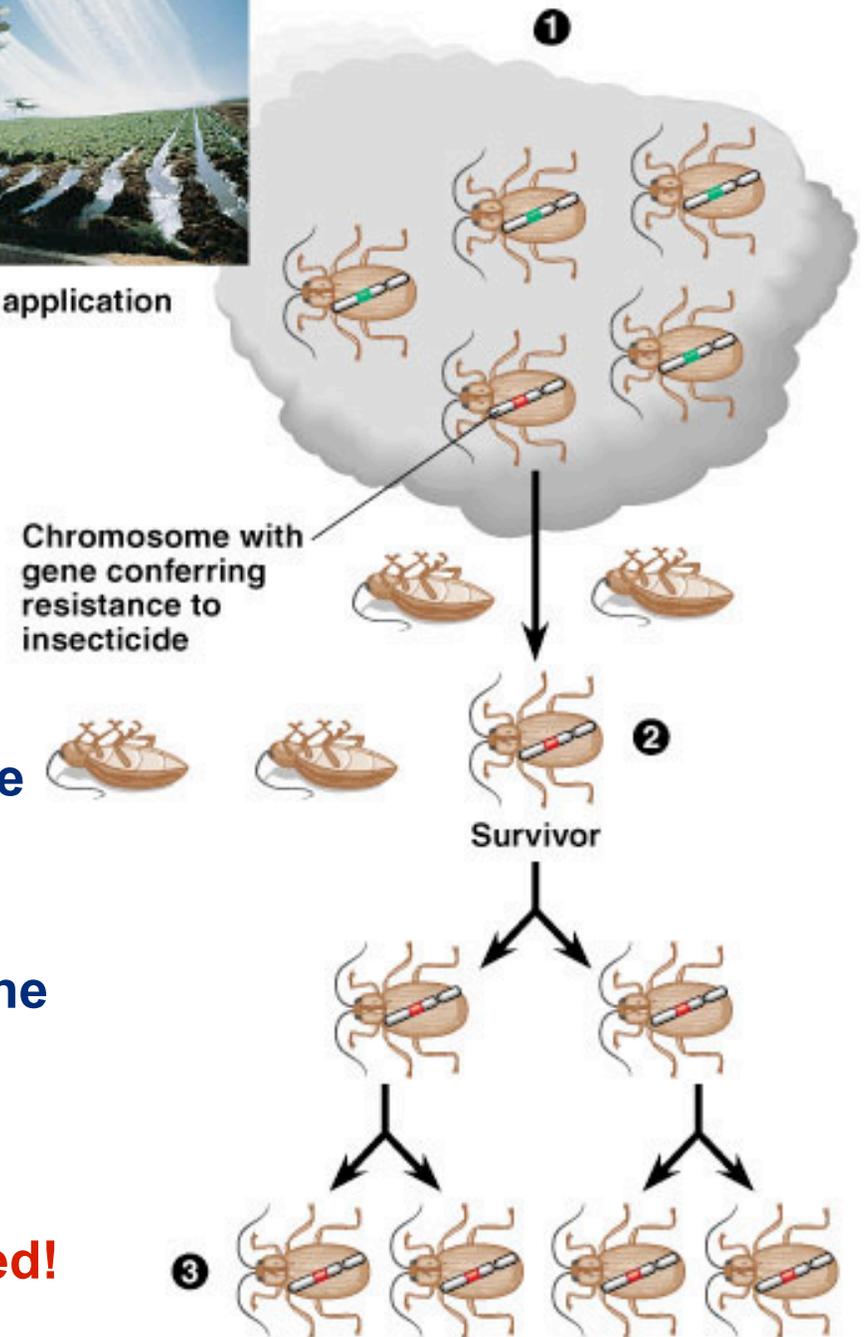
Nature “selects” who reproduces successfully

Evidence of Natural selection in action

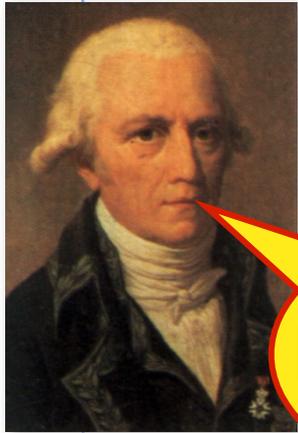
- **Over time insecticides stop working... Why?**
 - ◆ Genetic variation exists within a population of insects and some may be able to resist the poison
 - ◆ **Insecticide doesn't kill all individuals**
 - Resistant survivors reproduce
 - Resistance is inherited
 - The gene for insecticide resistance spreads through the population
 - ◆ **The population is drug resistance**
 - **The population evolved!**



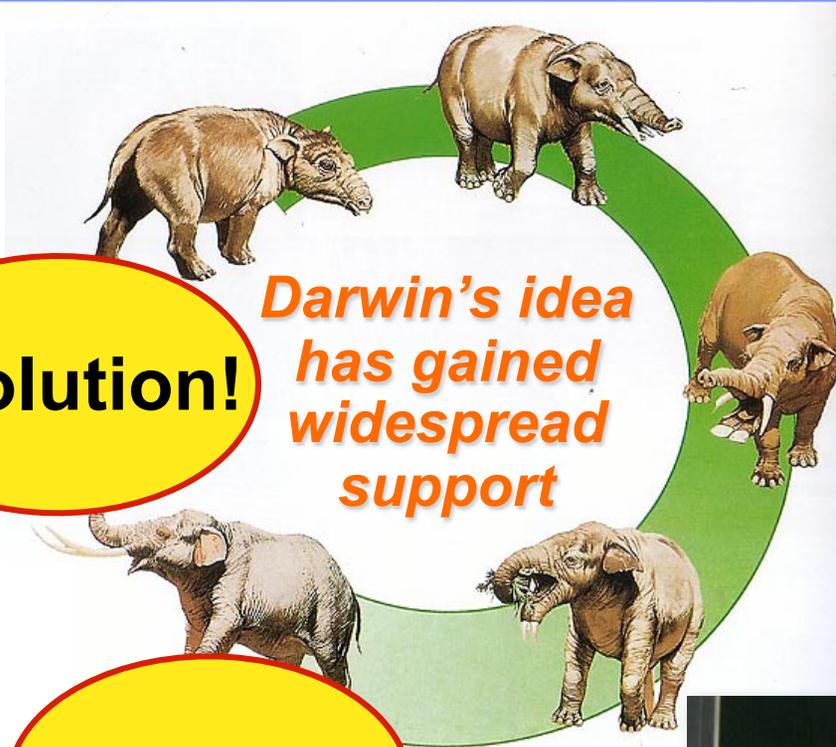
Insecticide application



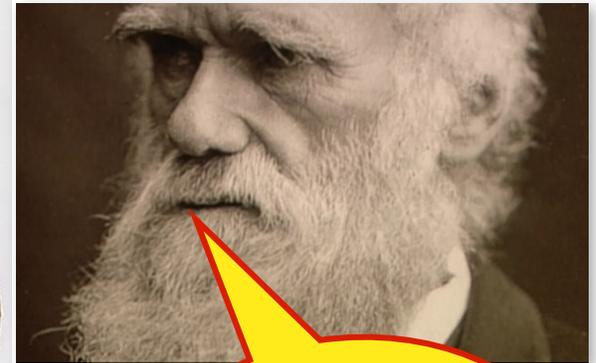
Evolution as Change Over Time



Evolution!



*Darwin's idea
has gained
widespread
support*



Evolution!



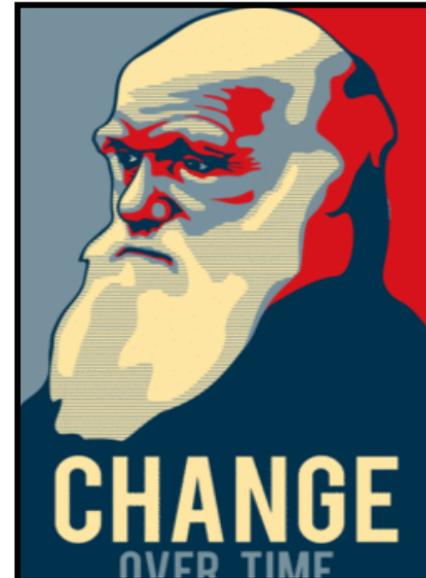
Evolution!

Evolution!



AVOID MISCONCEPTIONS - Keep These Points In Mind

1. POPULATIONS NOT INDIVIDUALS EVOLVE!!!
2. NATURAL SELECTION CAN AMPLIFY OR DIMINISH ONLY HERITABLE TRAITS
 - ✓ TRAITS ARE FAVORED DEPENDING ON THE ENVIRONMENTAL CONTEXT AND NOT BECAUSE A TRAIT IS INHERENTLY BETTER THAN ANOTHER



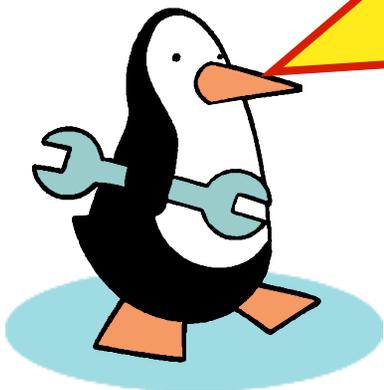
AVOID MISCONCEPTIONS!

Individual organisms
do NOT evolve!!!



Organisms
don't adapt (not in an
evolutionary sense);
Organisms HAVE
adaptations.

The Theory of Evolution by means of Natural Selection states that the POPULATIONS, not individuals, EVOLVE by acquiring adaptations over time that make it easier for them to survive and reproduce in their environment.



AVOID MISCONCEPTIONS!

Evolution is **NOT**
GOAL-DIRECTED!

No population chooses
to evolve one way
versus another.



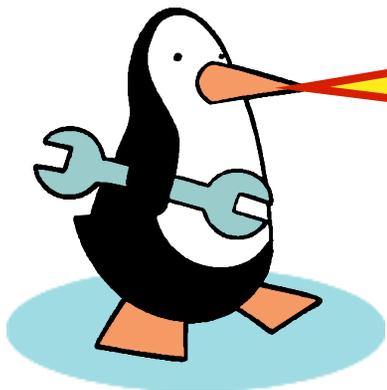
wrong



right

The species
that is able to survive long
enough to reproduce the most will
contribute more to the gene pool of the
next generation compared to one that
produces fewer or no offspring.

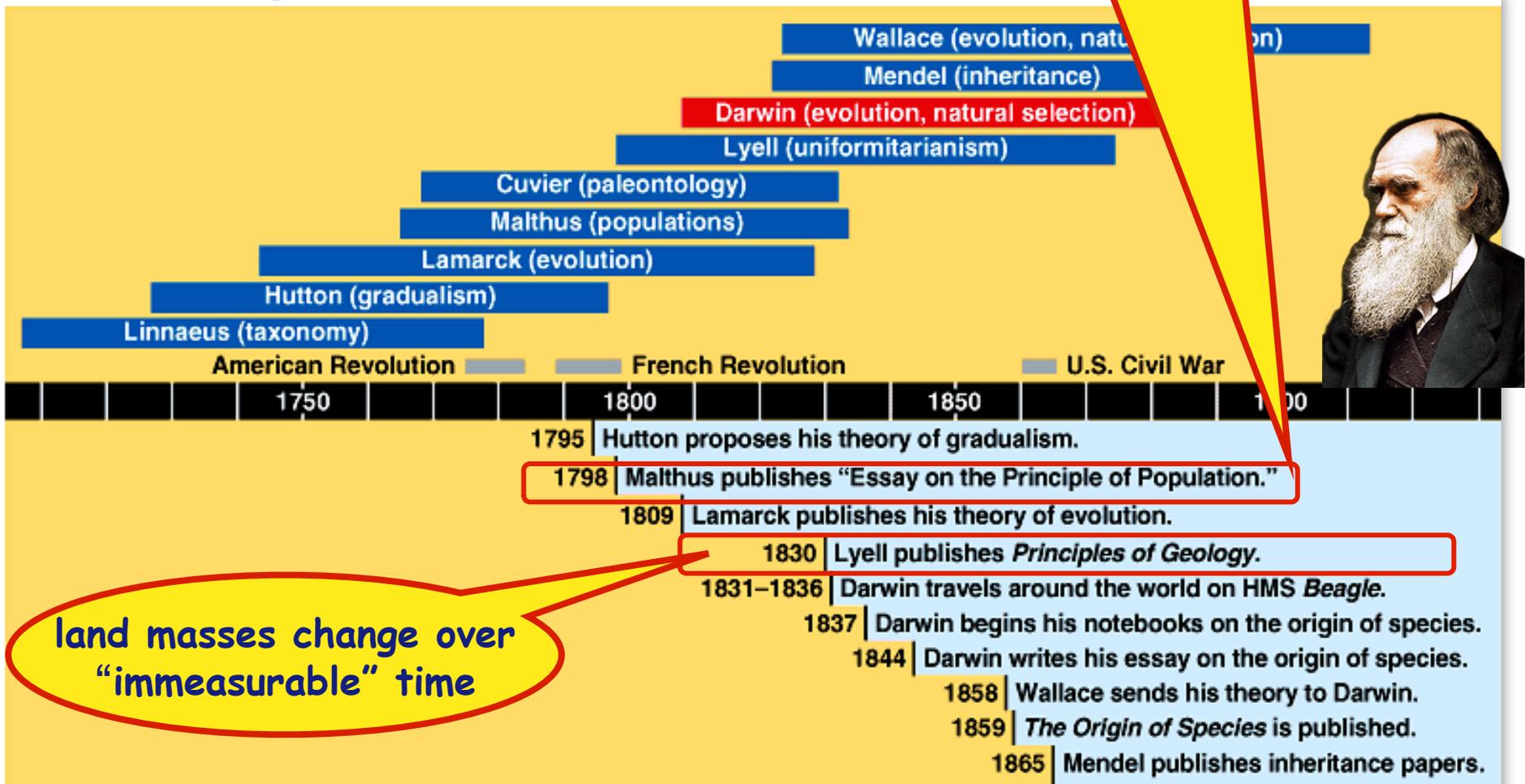
That's all...



In historical context

- Other people's ideas paved the path for Darwin's thinking

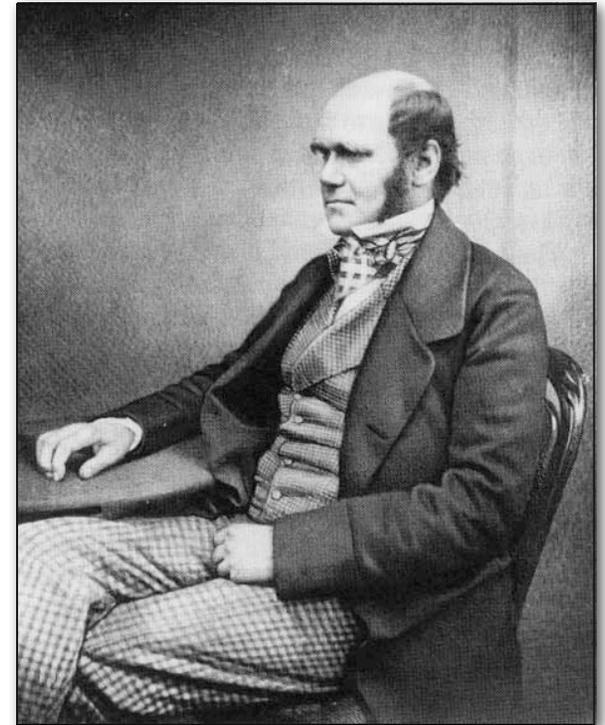
Human suffering (disease, famine, war) are due to competition: resulting in a struggle for survival - population growth exceeds food/resources supply



land masses change over "immeasurable" time

But Darwin was a Reluctant **Revolutionary**

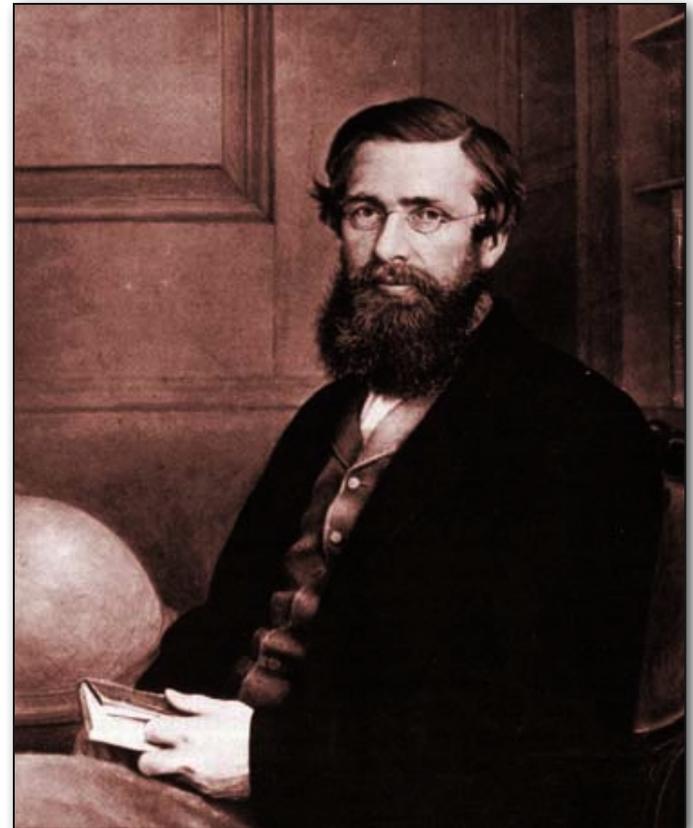
- **Returned to England in 1836**
 - ◆ **wrote papers describing his collections & observations**
 - ◆ **long treatise on barnacles**
 - ◆ **draft of his theory of species formation in 1844**
 - **instructed his wife to publish this essay upon his death**
 - **reluctant to publish but didn't want ideas to die with him**



And then came the letter....

Then, in 1858, Darwin received a letter that changed everything...

Alfred Russel Wallace
a young naturalist working in the East Indies, had written a short paper with a new idea. *He asked Darwin to evaluate his ideas and pass it along for publication.*



The time was ripe for the idea!

1858 ON THE TENDENCY OF VARIETIES TO DEPART INDEFINITELY FROM THE ORIGINAL TYPE

by Alfred Russel Wallace written at Ternate, February, 1858
Instability of Varieties supposed to prove the permanent distinctness of Species

ONE of the strongest arguments which have been adduced to prove the original and permanent distinctness of species is, that varieties produced in a state of domesticity are more or less unstable, and often have a tendency, if left to themselves, to return to the normal form of the parent species; and this instability is considered to be a distinctive peculiarity of all varieties, even of those occurring among wild animals in a state of nature, and to constitute a provision for preserving unchanged the originally created distinct species.

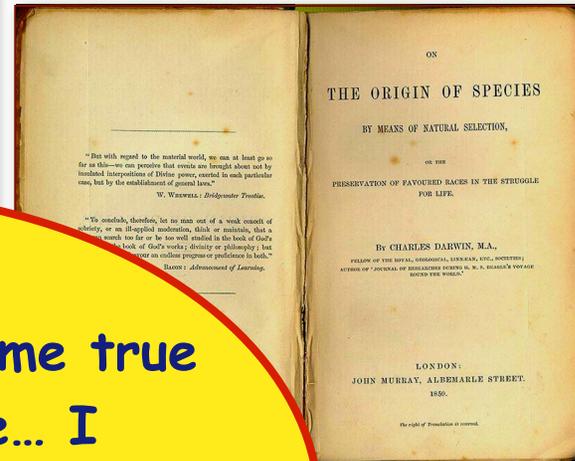
In the absence of scarcity of facts and observations as to varieties occurring among wild animals, this argument has had great weight with naturalists, and has led to a prejudiced belief in the stability of species. Equally general is the belief in "permanent or true varieties," - races of animals which differ so slightly (although constantly) from some other race, that they are considered as varieties of the other. Which is the variety and which the original form is determining, except in those rare cases in which the variety is unlike itself and resembling the other. The "permanent invariability of species," - races which have strict limits, and can never agree with any other, it, which, from the analogy of the varieties of domesticated animals, the tendency of which is certainly proved.

It will be observed that this argument, which is applied to a state of nature are in all respects similar to those which are governed by the same laws as those which are the present paper to show that the tendency of nature which will cause many varieties to depart further and further from the original form of domesticated animals, the tendency of which is certainly proved.

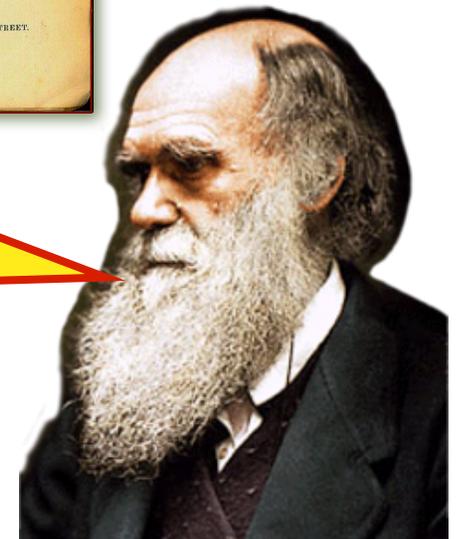
The Struggle for Existence.

Voyage: 1831-1836

November 24, 1859,
Darwin published:



“On the Origin of Species by Means of Natural Selection”

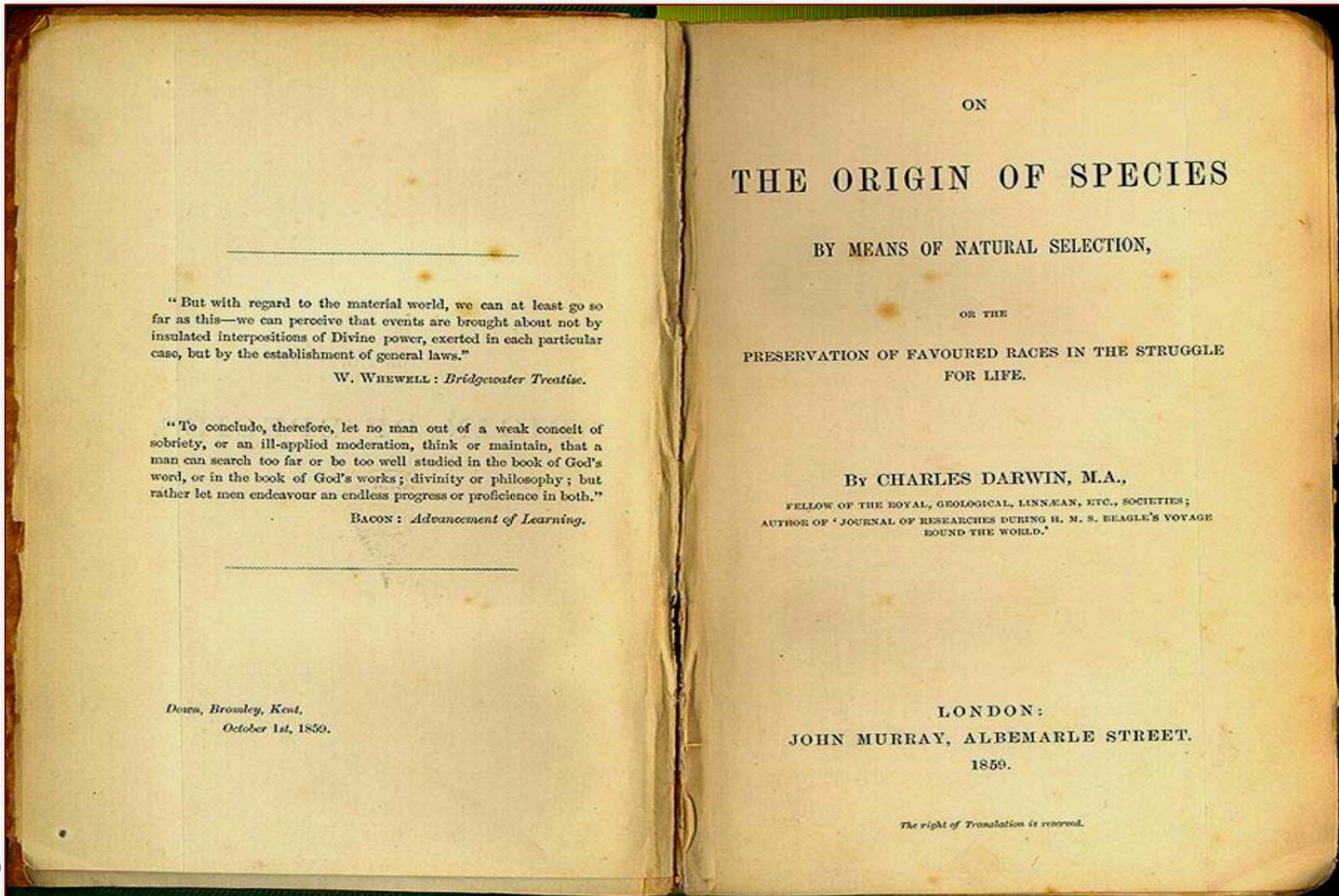


To Lyell—
“Your words have come true with a vengeance... I never saw a more striking coincidence...so all my originality, whatever it may amount to, will be smashed.”

Voyage: 1831-1836

November 24, 1859, Darwin published

“*On the Origin of Species by Means of Natural Selection*”

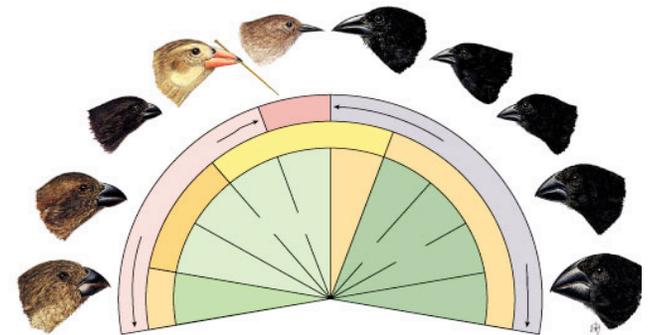


Essence of Darwin's ideas



■ Natural selection

- ◆ variation exists in populations
- ◆ over-production of offspring
 - more offspring are born than the environment can support
- ◆ competition
 - for nutrients, mates, pathogens, nesting sites, escape predators
- ◆ differential survival
 - successful traits = adaptations
- ◆ differential reproduction
 - adaptations become more common in population over time



LaMarckian vs. Darwinian view

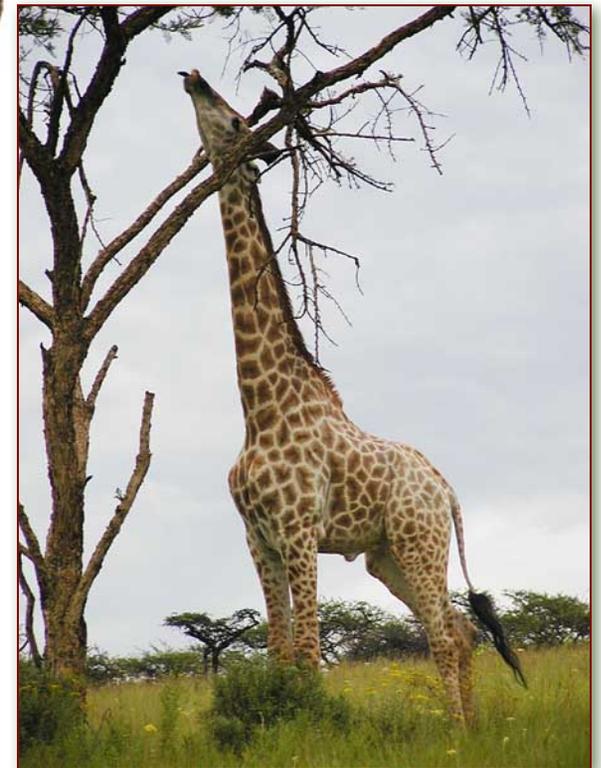
■ LaMarckian

- ◆ in reaching higher for vegetation giraffes stretch their necks & transmit the acquired longer neck to offspring

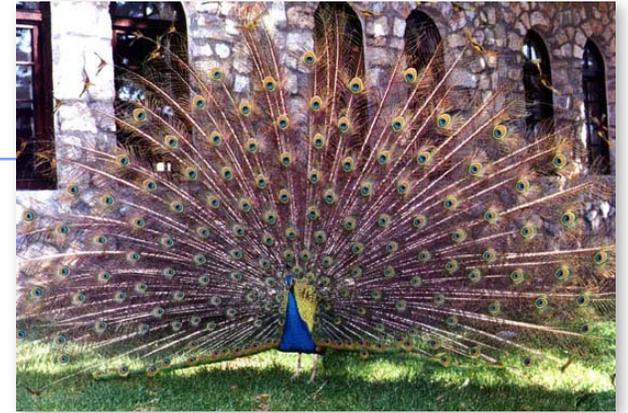


■ Darwinian

- ◆ giraffes born with longer necks survive better & leave more offspring who inherit their long necks



Coherent explanation of observations



**"Nothing in biology
makes sense except in
the light of evolution."**

-- Theodosius Dobzhansky

March 1973

Geneticist, Columbia University

(1900-1975)



**Stick your neck out...
Ask Questions!**