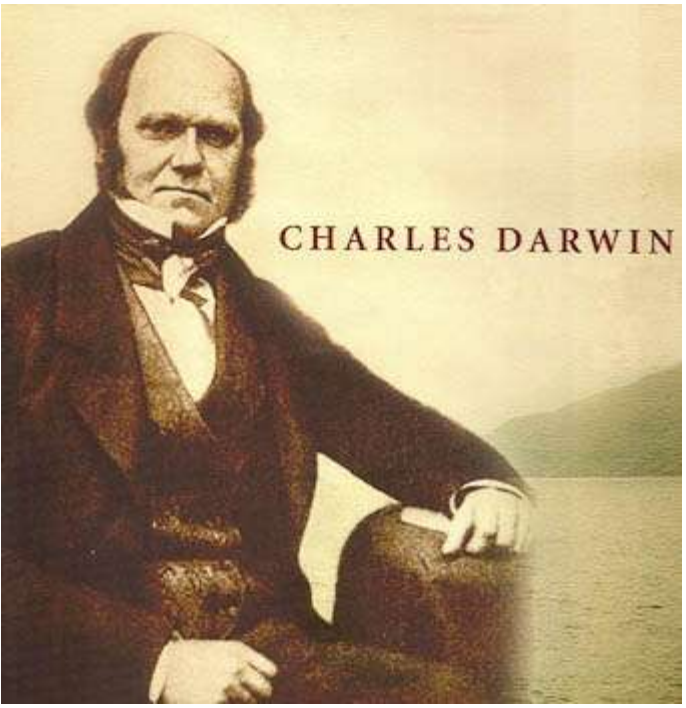


Early 1800s

Natural History very active – John Ray, Linnaeus, Buffon, Lamarck

Geology is an established field, strata mapped out

Age of Earth estimated to be millions of years by Hutton

Fossils accepted as extinct animals

Similarities between anatomy and embryology were noted

Mechanisms of evolution proposed - Lamarck

<u>Still, the questions were:</u>

What natural mechanism could explain evolution?

What hereditary mechanism could explain variation and enable organisms to change?

Darwin answered part of this. It took until the 1920s to fully work out.

Charles Darwin (1809 –1882)

Charles Robert Darwin was born and grew up in Shrewsbury, England

Son of a wealthy doctor, interested in botany. Mother was the daughter of Josiah Wedgwood, the pottery manufacturer, died when he was 8.

Grandfather was Erasmus Darwin, physician, wrote poems about evolutionary change.

Studied to become a doctor at Edinburgh University, but didn't like it (he was nauseated by the sight of blood).

Attended Cambridge to study theology. and become a Clergyman, but didn't like that either.

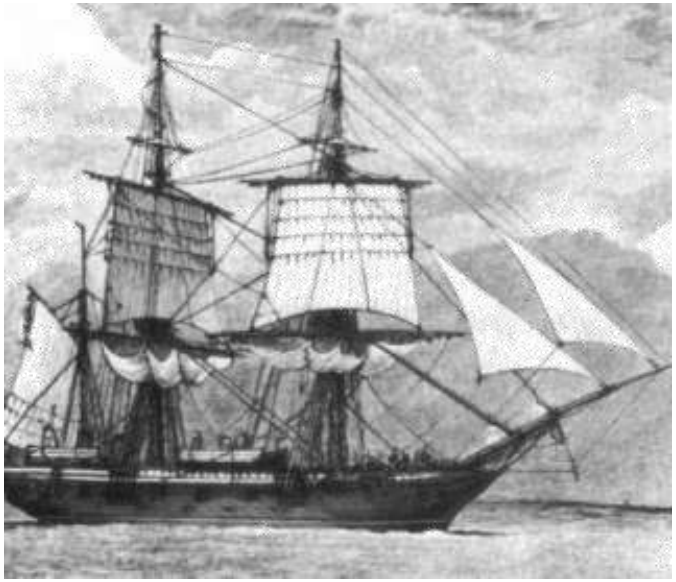
Overall, just a mediocre student in school.

In his *Autobiography* he wrote:

‘Nothing could have been worse for the development of my mind… the school as a means of education to me was simply a blank’

From an early age, Darwin had a passion for nature – both collecting it (and shooting it).
Spent his time bird-watching and collecting beetles.

Voyage of the Beagle 1831-1836



Robert FitzRoy, the captain of the *Beagle*,

While Darwin was at Christ's College, botany professor John Henslow became his mentor.

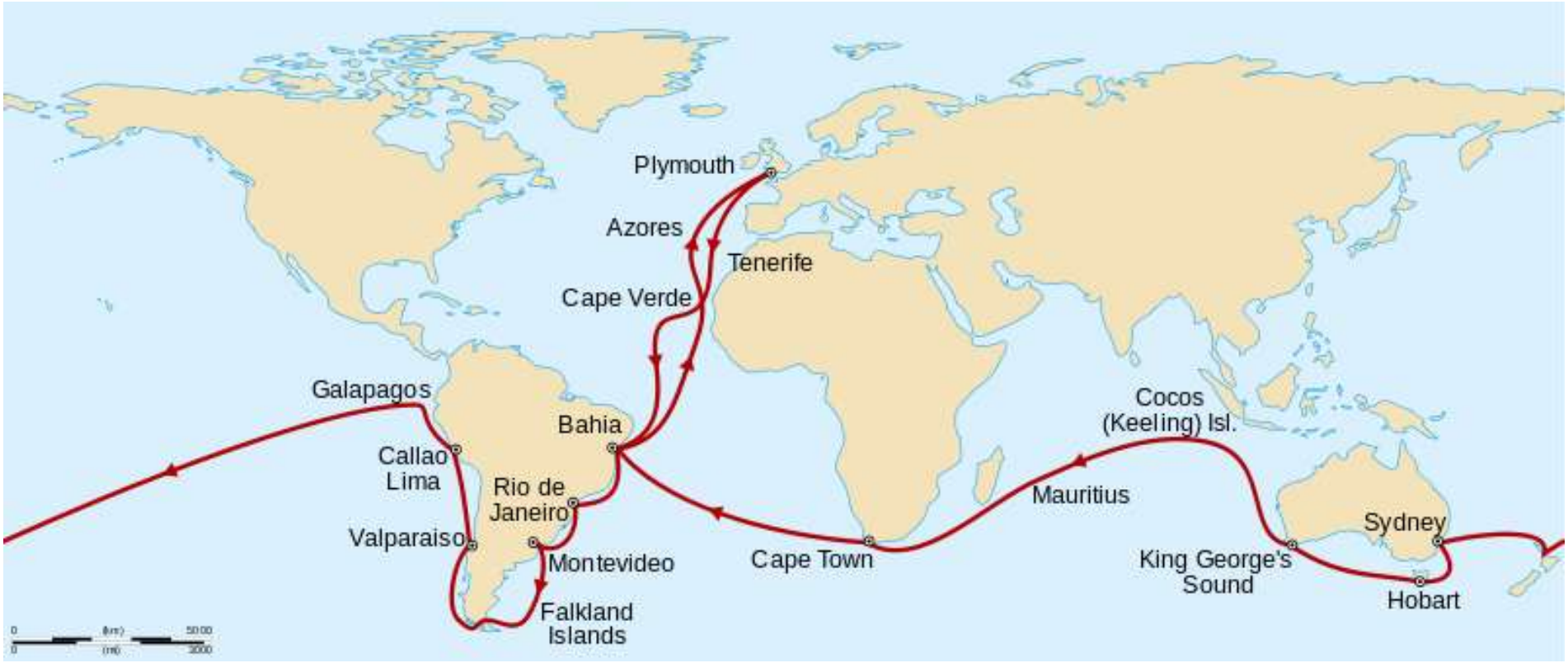
Darwin graduated Christ's College with a bachelor of arts degree in 1831, Henslow recommended him for a naturalist's position aboard the HMS Beagle.

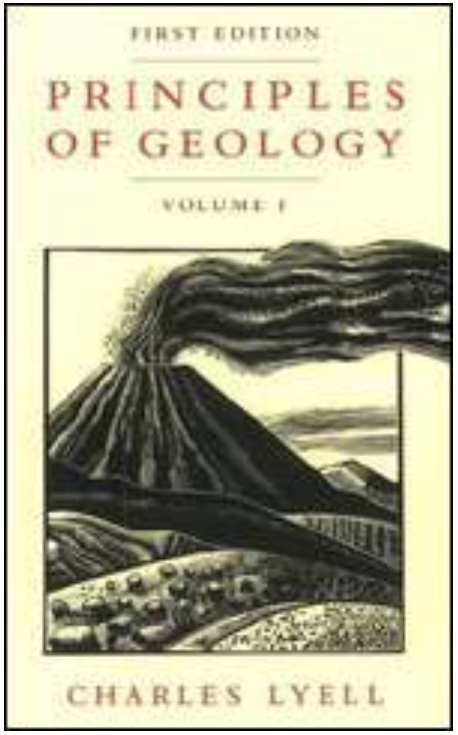
The ship, commanded by Captain Robert FitzRoy, was to take a five-year survey trip around the world. The voyage would prove the opportunity of a lifetime for the budding young naturalist.

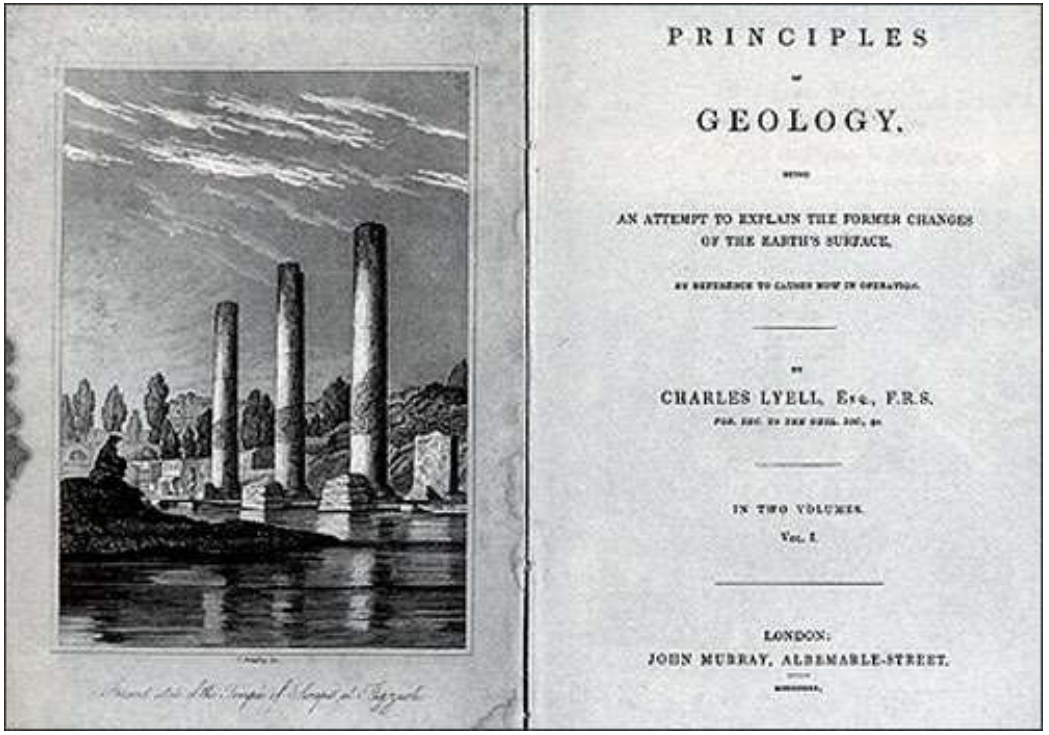
He joined the voyage of the Beagle as an unpaid "Science Officer" (age 22) and they set sail on 27 December 1831.

For five years was able to collect on a grand scale, and also learn something about the distribution of animals and plants, about geology, and about fossil remains

Voyage Route of the Beagle

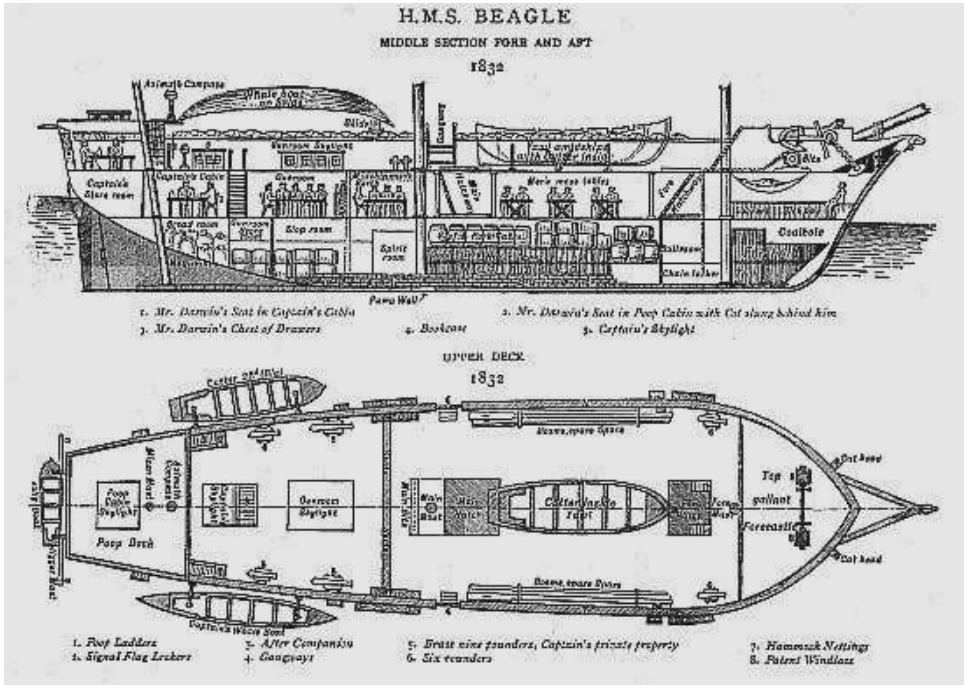






In June of 1830, Lyell published the first volume of his three-volume work, *Principles of Geology*. In this book he wrote a history of geology and a description of the inorganic physical processes at work in the modern world.

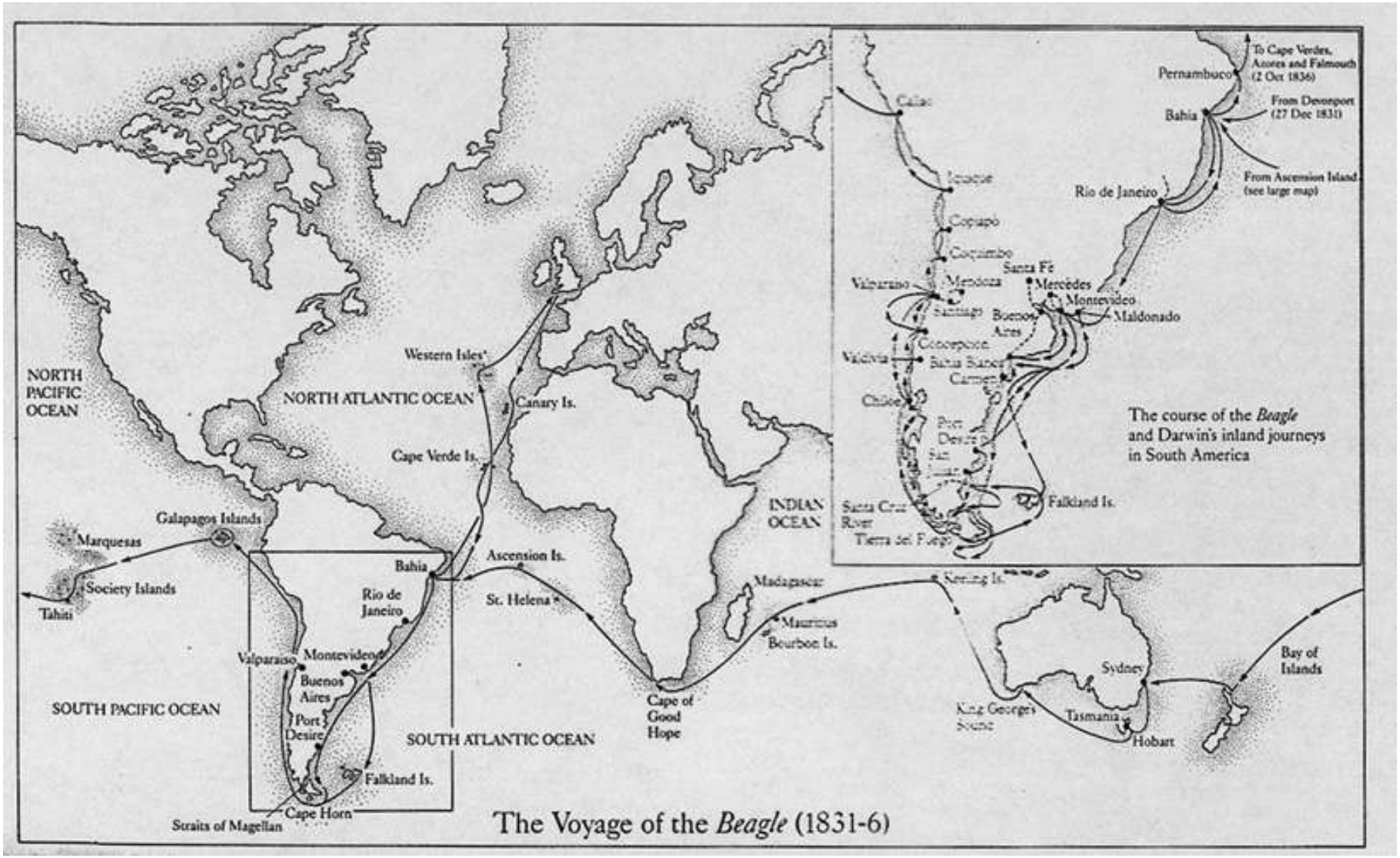
Darwin took a copy of this volume with him when the Beagle set sail in late December 1831.



Darwin's time on the *Beagle* was mixed; when they were at sea he was horribly sea sick and couldn't do anything except lie in his hammock nibbling biscuits and reading books.

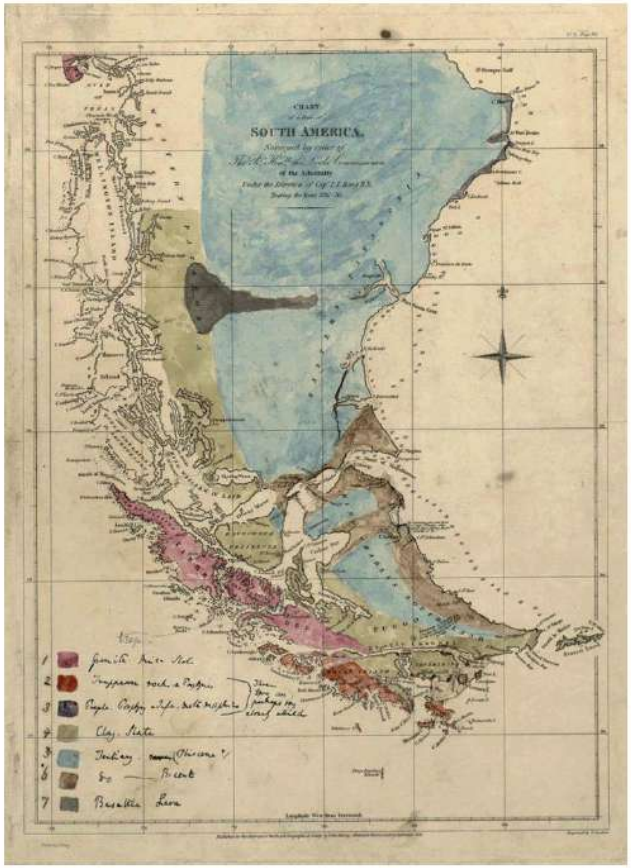
Captain FitzRoy was a firm creationist.

Read book by Charles Lyell, who had decided that the earth was very old, millions of years old, and that over time it had changed very slowly. He also said that we can see this happening today



The mission of the *Beagle* was to mainly study and map the coast of South America.

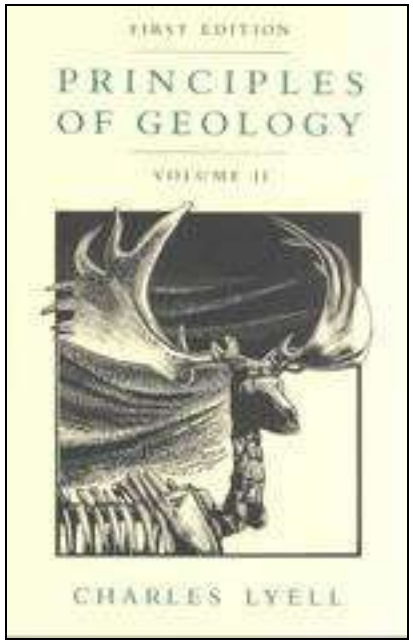
Itinerary of HMS Beagle and landings and journeys of Charles Darwin in the interior of South America.



Darwin studied and drew geological maps of South America made by the surveyors aboard previous expeditions 1826-1830.

He interpreted his findings in light of Lyell's thinking about geology

The Second Volume of Lyell's work reached Darwin in South America…



In the second volume Lyell dealt with processes such as the type of climatic change which might cause species to appear and disappear. He was very interested in why some species seemed to replace others in the fossil record and that there were very rarely entire replacements – more often, some forms persisted, and others dropped out.

(Lyell) reasoned:
"…***in the universal struggle for existence, the right of the strongest eventually prevails***"

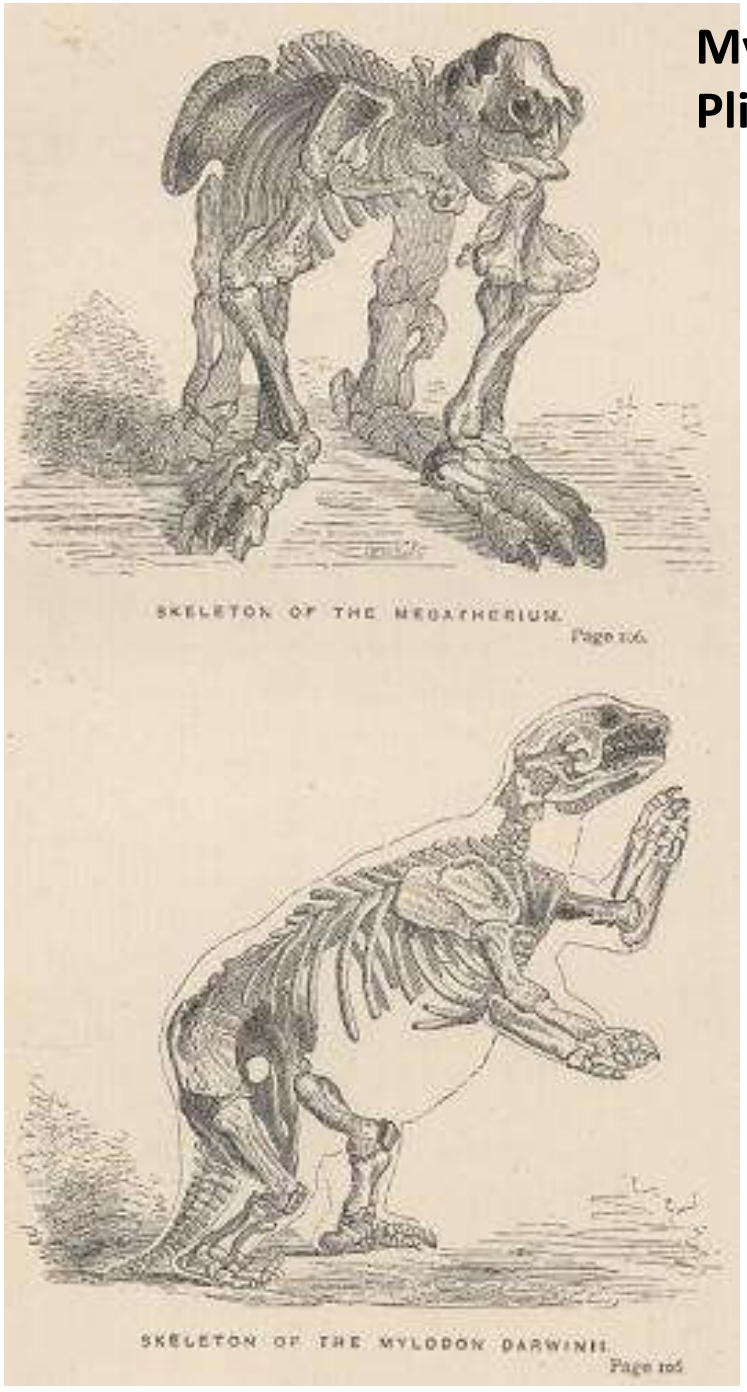
Darwin's fossil collections in South America

- elephants, *Mastodons*,
- giant ground sloths, *Megatheria*
- giant armadillo, *Glyptodon*
- giant guinea pig, *Toxodon*
- fossils camelids.

Fossils were packed up carefully and posted back to England where Henslow cared for them.

Darwin made detailed notes about his finds, the type of sediment they were found in and what other fossils were found in that layer., clues as to what environment these huge animals lived in.

Mylodon – Giant Sloth
Pliocene, S. America



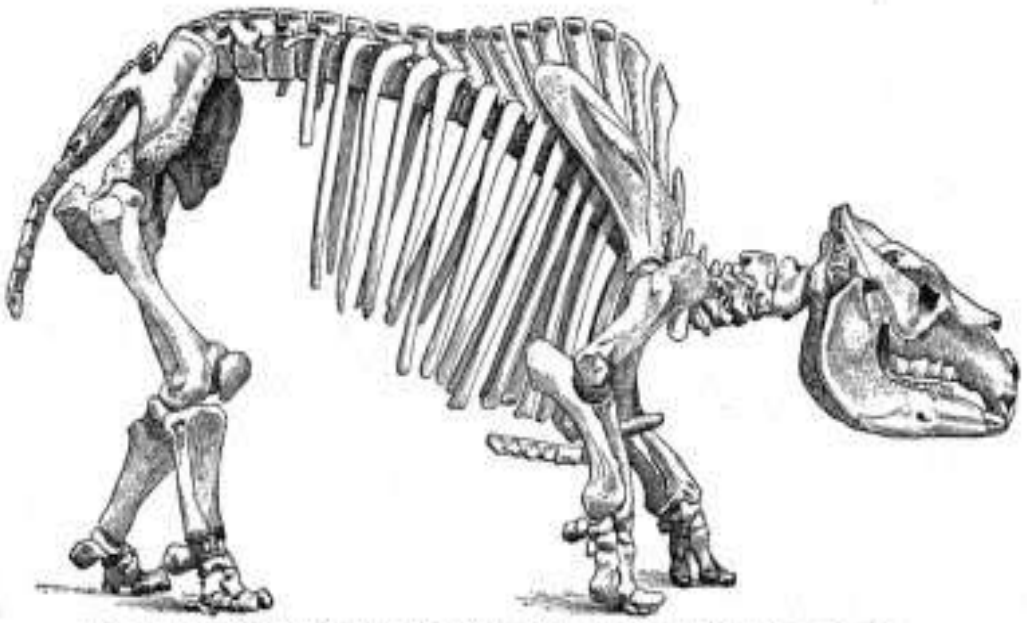
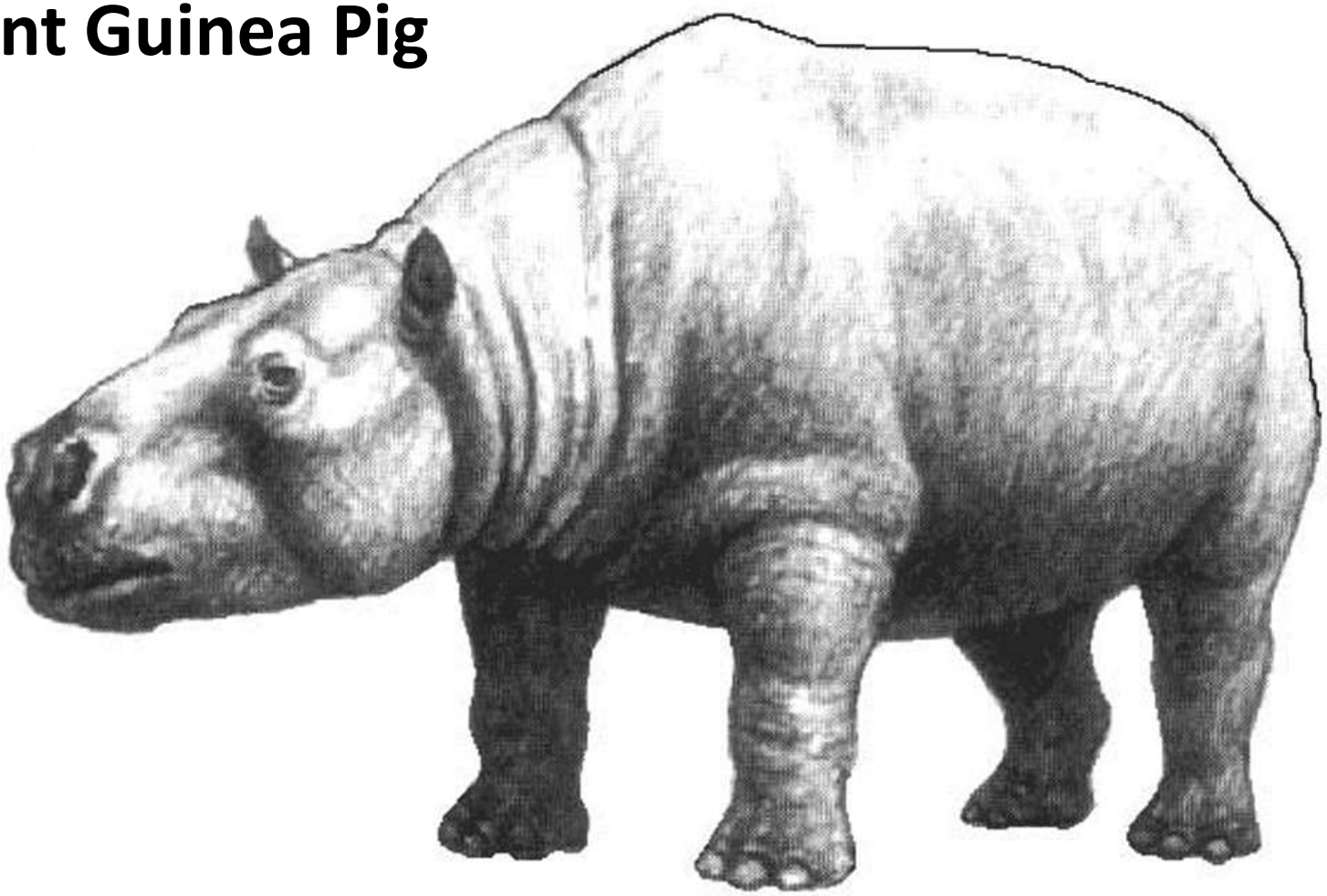


FIG. 4.—The skeleton of a gigantic extinct rat-like animal—the Toxodon—from the Argentine, South America. Length from the snout to the tail, nine feet. (This figure is lent by the Trustees of the British Museum).

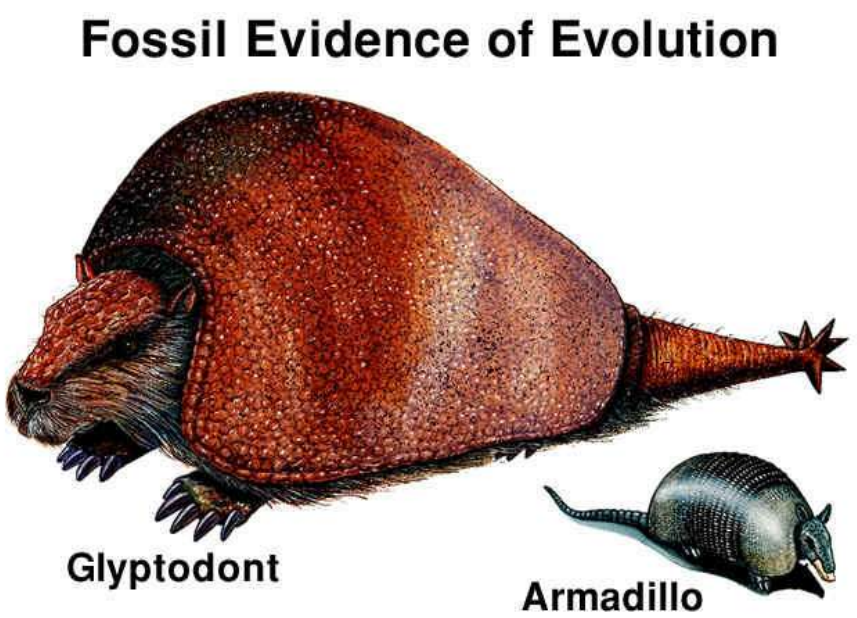
"I had no idea at the time, to what kind of animal these remains belonged".

C. Darwin 1839

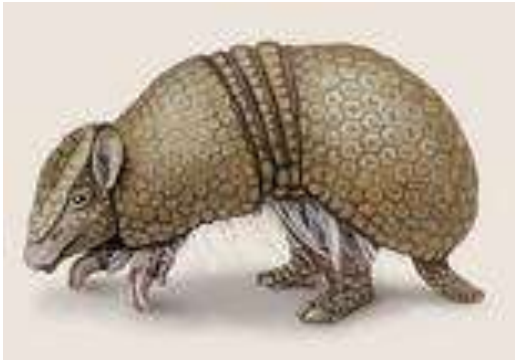
Toxodon
giant Guinea Pig



The extinct giant armadillo, *Glyptodon*



"The most important result of this discovery, is the confirmation of the law that existing animals have a close relation in form with extinct species." Darwin (1839).



Surely a further clue for Darwin that species are not isolated and immutable in time

Extinct armadillos

Extinct llama-like animals in genus Hemiauchenia

guanaco

vicuna

The Lesser Rhea or Darwin's Rhea

Evidence for Adaptation

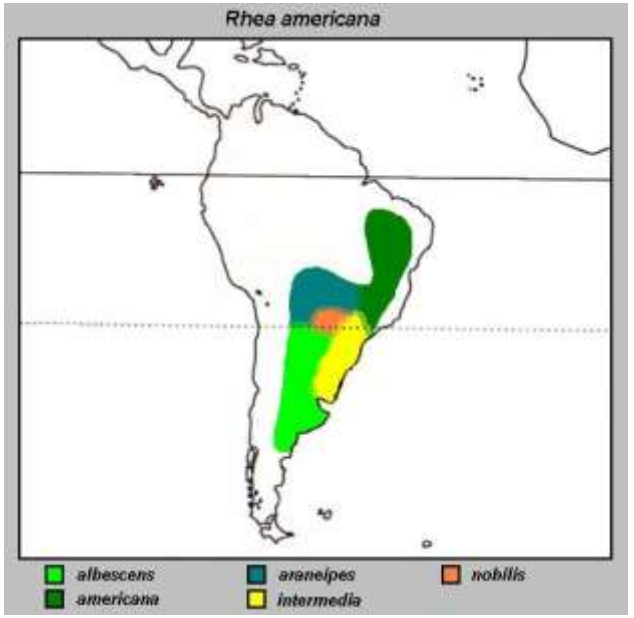
Rhea Distribution

in Argentina

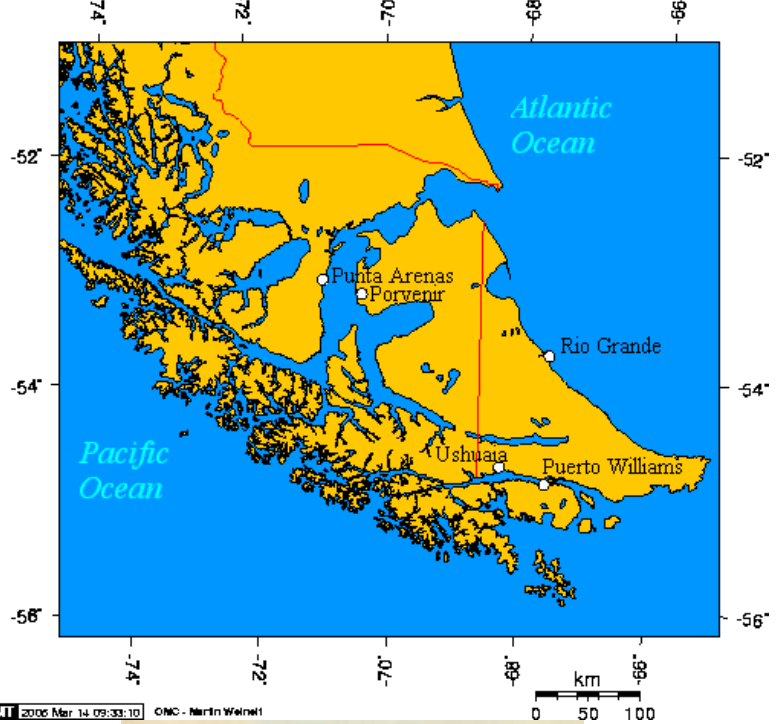
Lyell had also written that changes in flora and fauna might be **explained by their isolation in different ecological circumstances**.

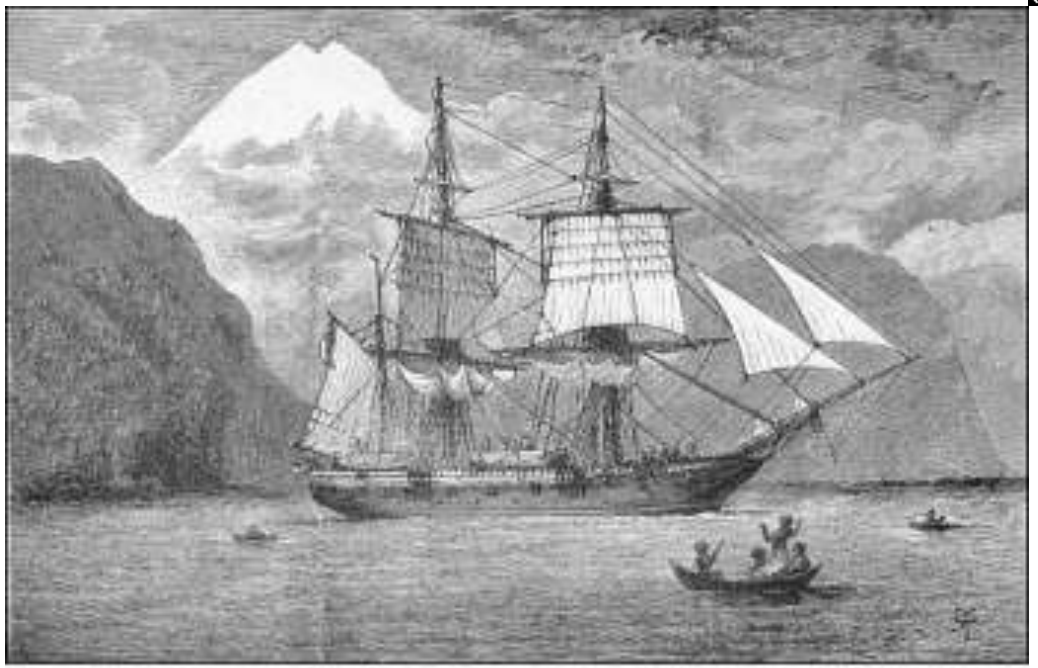
Darwin thought that this might account for the rheas being very different in separate parts of South America.

The Greater Rhea



Tierra del Fuego, at the tip of South America. Rounding this point remains one of the world's greatest sailing challenges.





H.M.S. *Beagle* in Straits of Magellan. Mt. Sarmiento in the distance.

Darwin in Chile

While Darwin was in the town of Valdivia a massive earthquake hit around at around 11:30 on the morning of the 20th. It lasted three minutes and the devastation was horrible - nearly every building in the area was destroyed.


GALÁPAGOS ISLANDS

Darwin in Galapagos Islands

5 weeks there in 1835
600 miles from mainland Ecuador
5 large islands, several smaller
Right on the Equator
Volcanic origin
~5 million years old

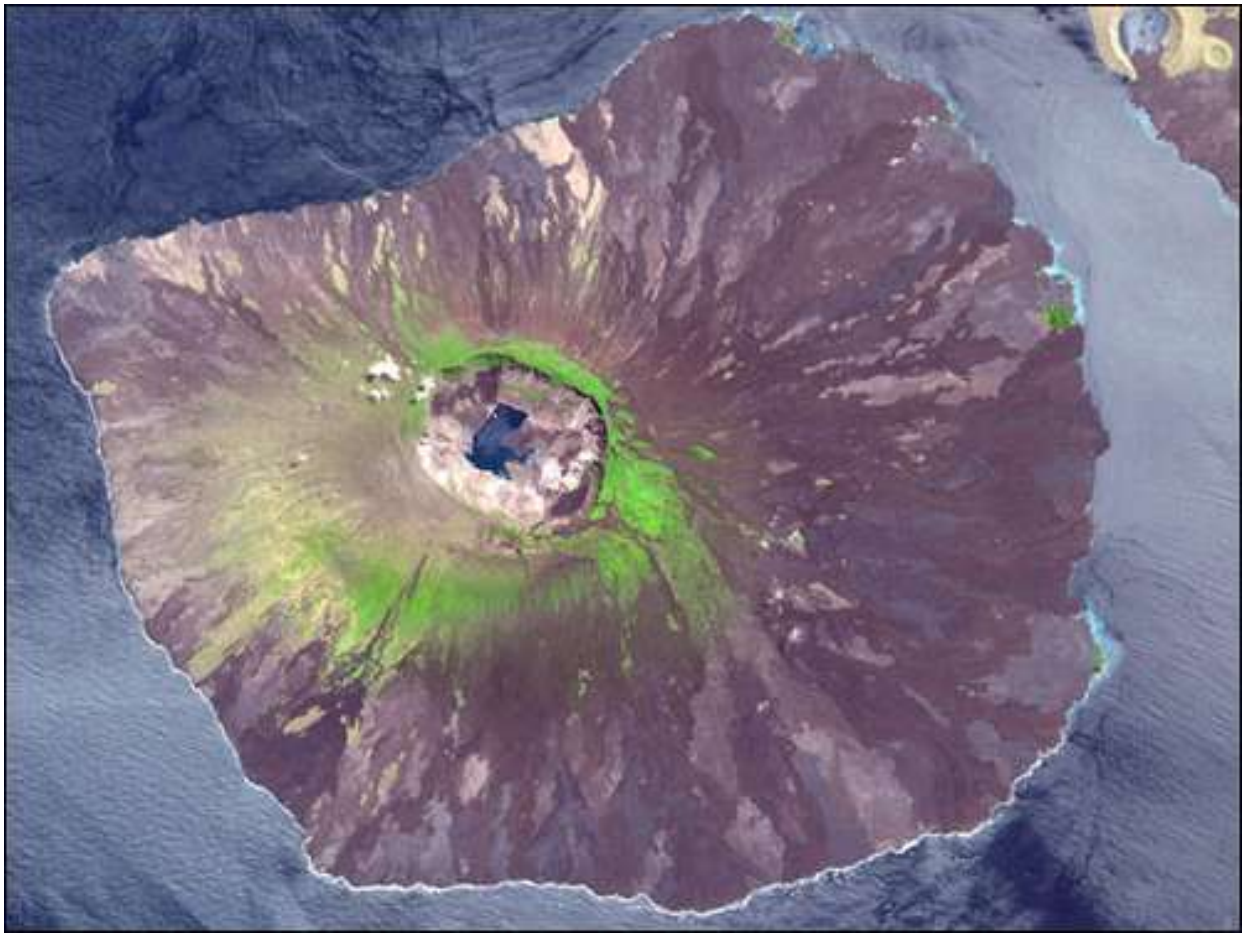
Fauna – giant tortoises, large land and marine iquanas, unusual insects
No mammals except mice.
Animals distinctive, resemble South American species.
Tortoises – different on each island
Mockingbirds – different varieties, related to mainland forms

Flora - scrubby, xerophytic, shrubs and cacti.mostly

Peaks of submarine volcanoes that have never had a land connection with South America or any other continent.

All of the Galapagos fauna and flora got there by over-water (distance) colonization.

Galapagos – volcanic islands



A fringe of brilliant green vegetation encircles the crater of the volcano in the center of Isla Fernandina, one of the Galapagos Islands, in this Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) image. In this image, streamers of hardened lava in various shades of purple spread downward from the summit across the island toward the ocean. The different colors may represent lava flows of different ages and compositions. Credit: NASA/GSFC/MITI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.

"… vividly reminded me of those parts of Staffordshire where the great iron foundries are most numerous."

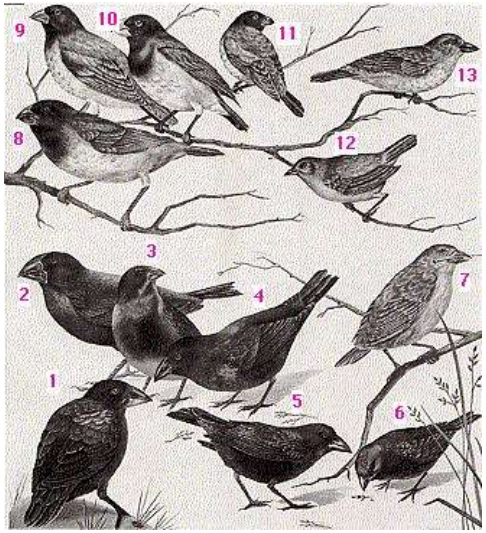
"The black rocks heated by the rays of the vertical sun like a stove, give to the air a close & sultry feeling. The plants also smell unpleasantly. The country was compared to what we might imagine the cultivated parts of the Infernal regions to be."

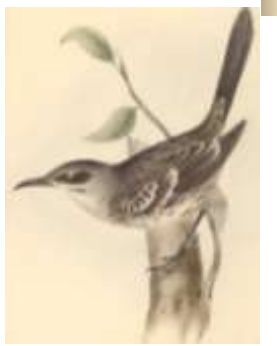
"Nothing could be less inviting than the first appearance. A field of black basaltic lava is everywhere covered by a stunted brushwood which shows little signs of life..."


“hideous-looking creatures, of a dirty black colour, stupid and sluggish in their movements”

Galapagos Tortoise

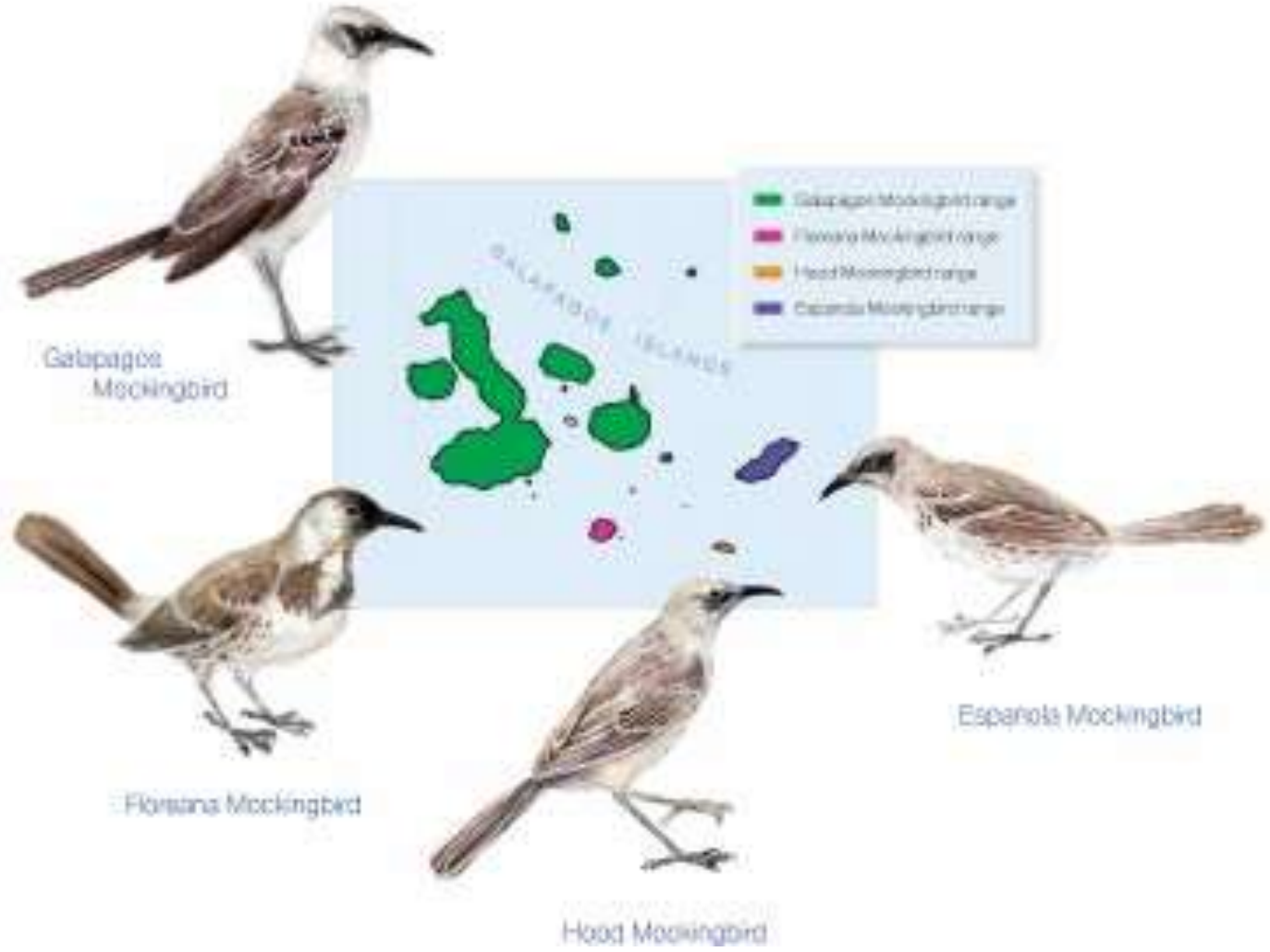
"*Here almost every product of the land and water bears the unmistakable stamp of the South American continent.* ***There are 26 land birds – the close affinity of most of these birds to South American species*** *in every character, in their habits, gestures, tones of voices, was manifest*."



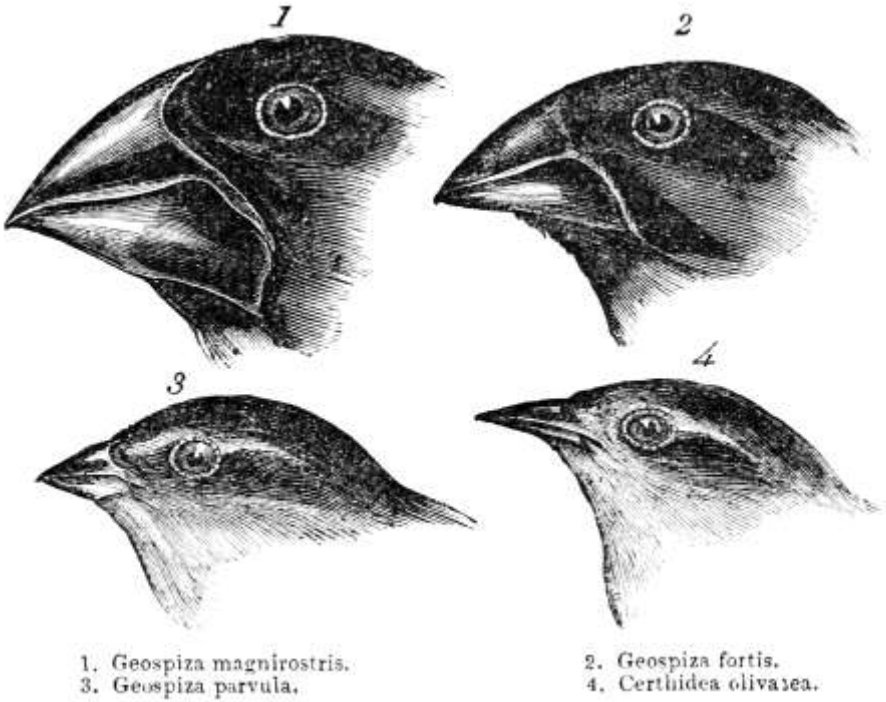


"I pushed off a branch with the end of my gun, a large hawk"

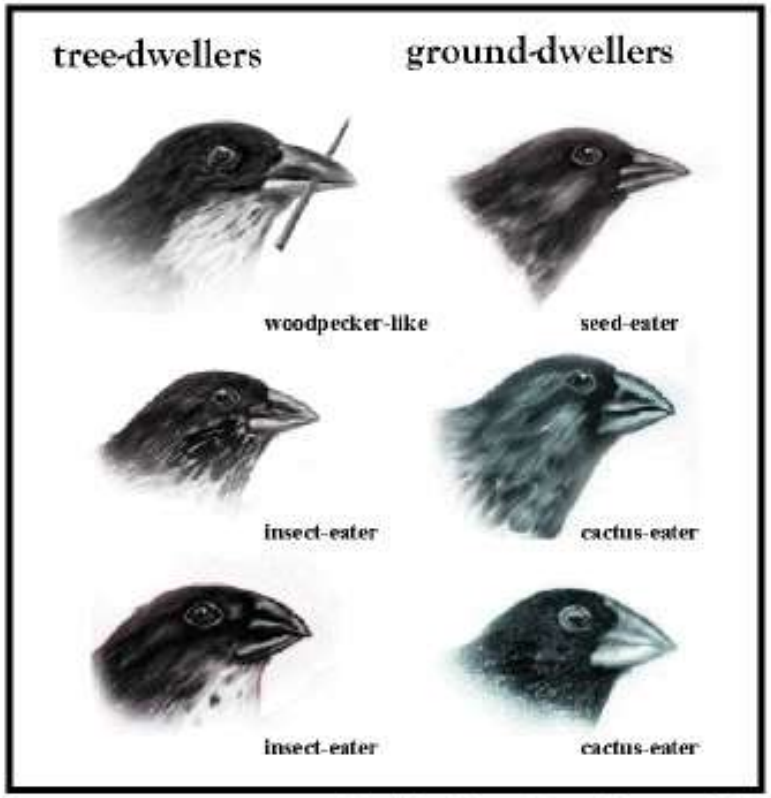
Galapagos Mockingbirds



Galapagos Finches

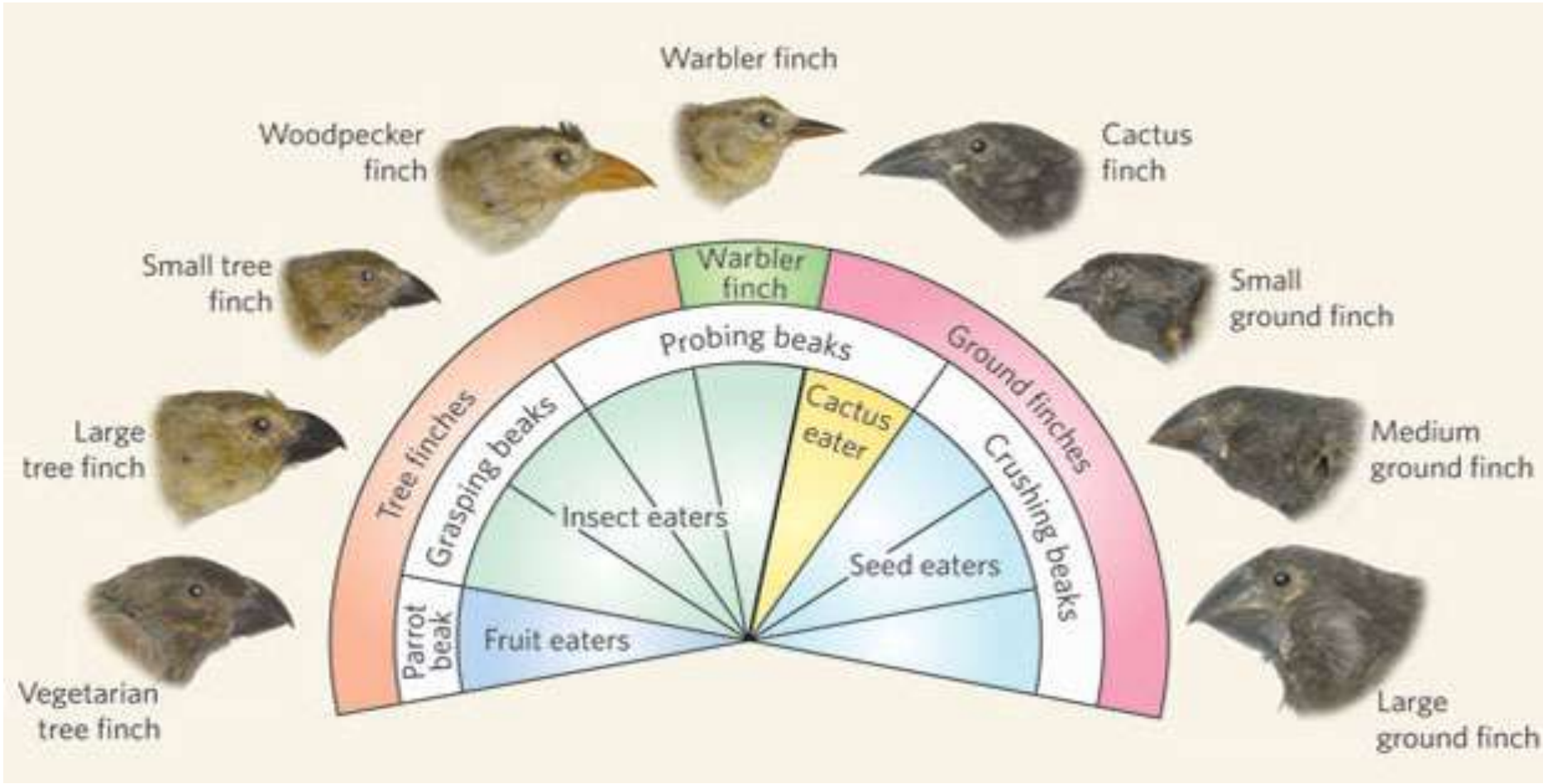


Darwin's Illustrations of finches

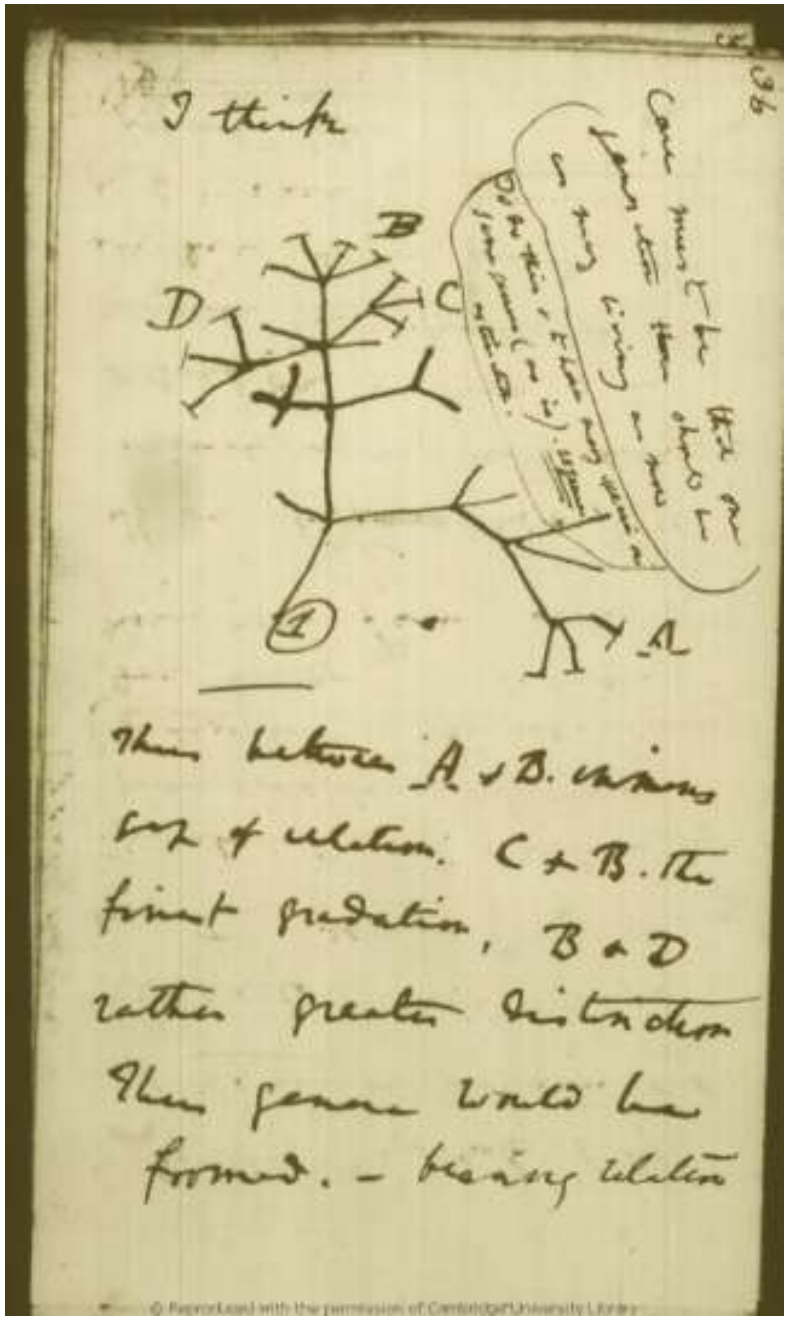


variation in beak form of some Galapagos finches

In the Galapagos, Darwin observed 13 previously unclassified species of finches. These birds differed from each other in such features as the size and shape of their beaks. The finches that eat seeds have strong, stubby beaks for cracking and crushing. Those that eat insects have beaks that vary in size, depending on their favorite insect. Darwin hypothesized that "one species had been taken and modified for different ends". How, he thought, could such adaptive change occur? Lamarck's explanation was not satisfying for the practical Darwin.



13 varieties of finch on different islands, some that ate insects, others that ate seeds. Darwin suspected they were descendants of a single ancestor species that dispersed across the islands then adapted to the different foods available on each.

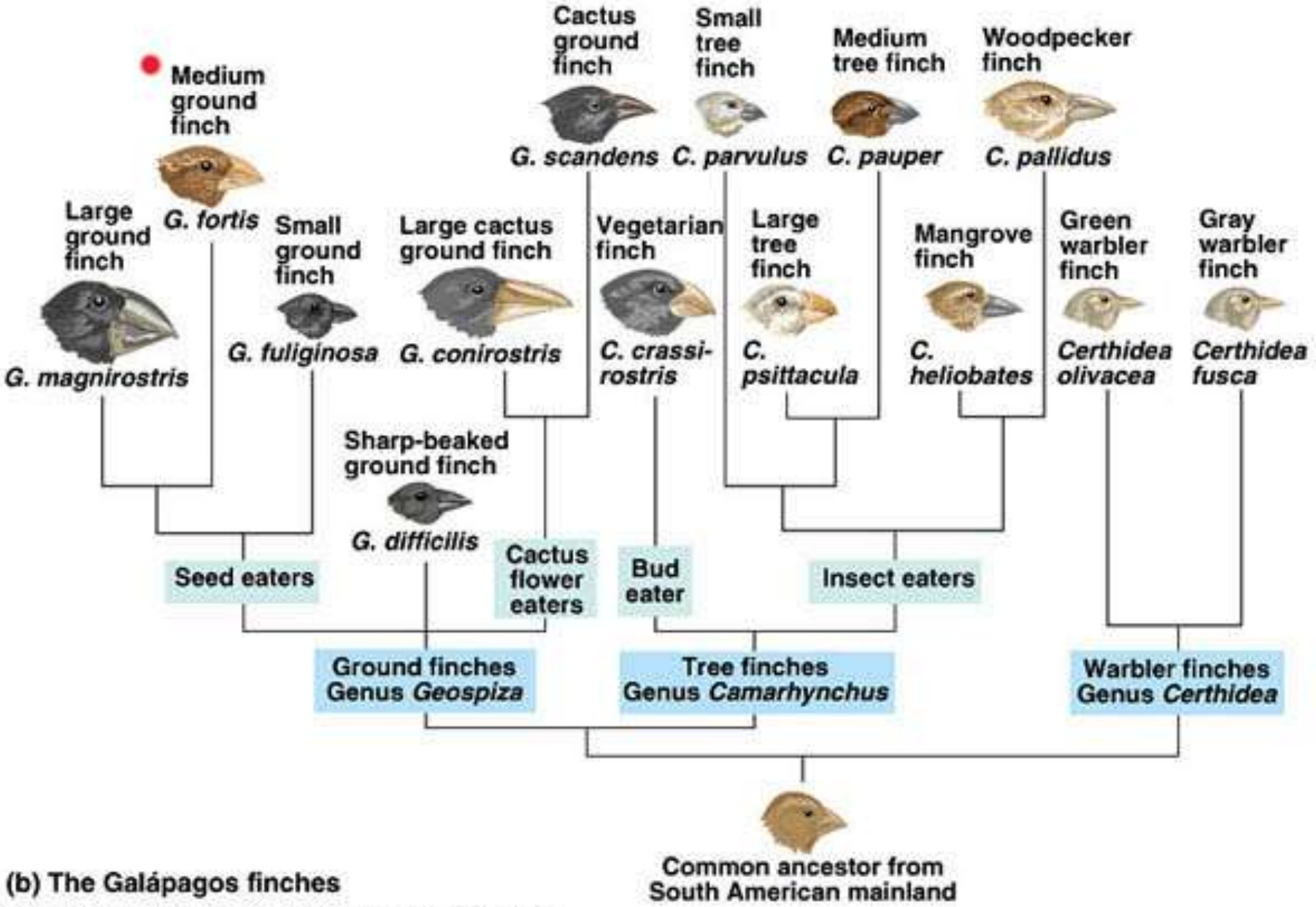


Charles Darwin's 1837 sketch of an evolutionary tree, from his First Notebook on Transmutation of Species (1837) .

Interpretation of handwriting:

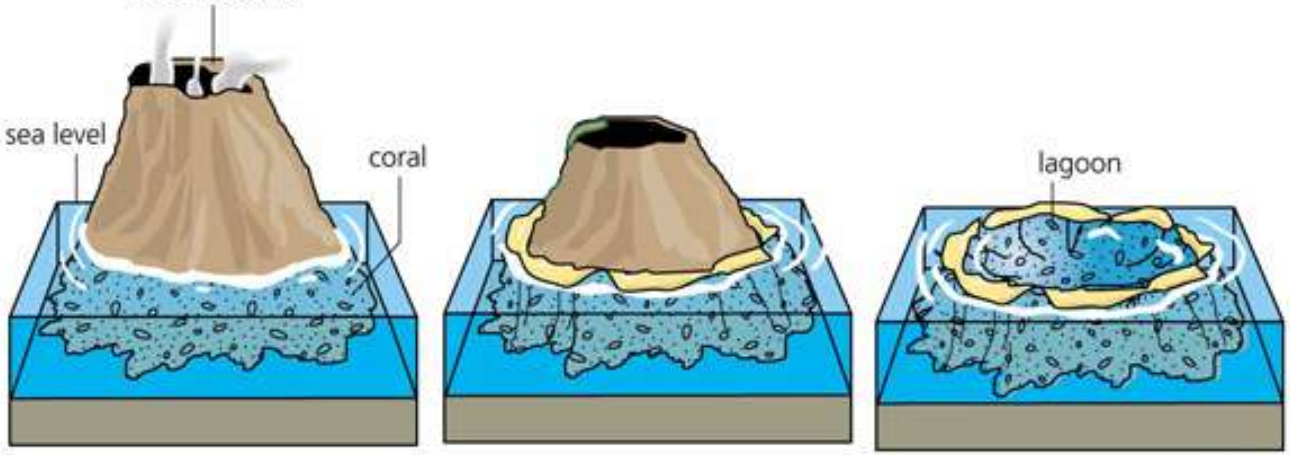
"I think case must be that one generation should have as many living as now. To do this and to have as many species in same genus (as is) requires extinction . Thus between A + B the immense gap of relation. C + B the finest gradation. B+D rather greater distinction. Thus genera would be formed. Bearing relation" (next page begins) "to ancient types with several extinct forms"

The Modern Phylogenetic View of Finch Relationships



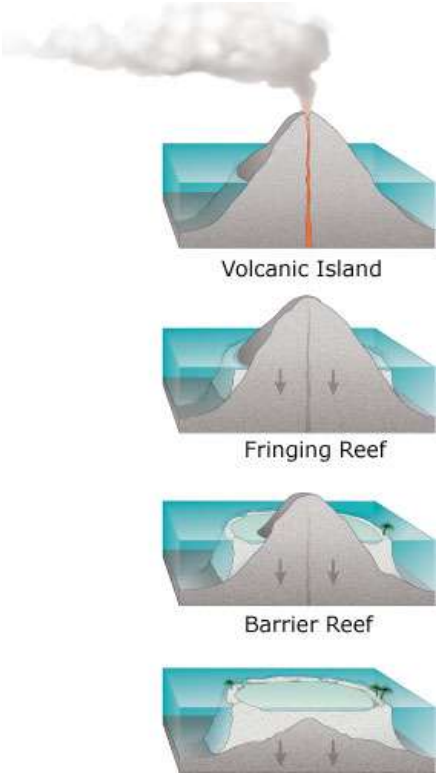
(b) The Galápagos finches

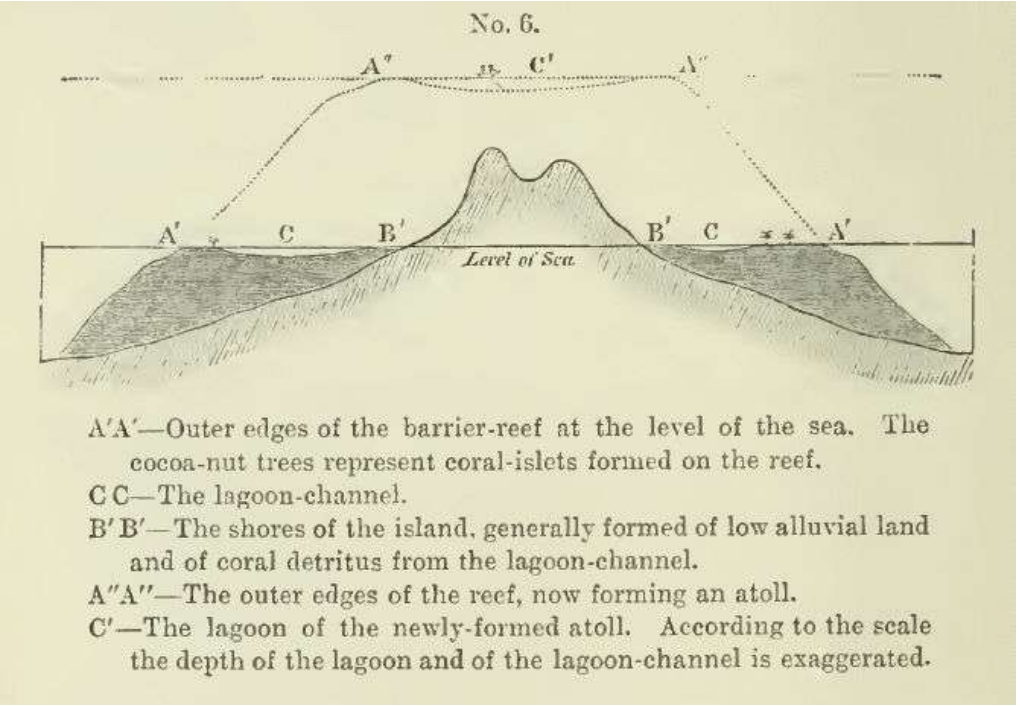
On the way back, a stop in Tahiti…..



Atoll formation and reef growth

Darwin (1842) proposed that volcanic islands with fringing reefs, islands with barrier reefs and atolls (i.e. ring-shaped reefs without a volcanic island) are different stages of one process, controlled by time, subsidence of the volcanic core and reef growth.





A′A′—Outer edges of the barrier-reef at the level of the sea. The cocoa-nut trees represent coral-islets formed on the reef.
C C—The lagoon-channel.
B′B′—The shores of the island, generally formed of low alluvial land and of coral detritus from the lagoon-channel.
A″A″—The outer edges of the reef, now forming an atoll.
C′—The lagoon of the newly-formed atoll. According to the scale the depth of the lagoon and of the lagoon-channel is exaggerated.

The Structure and Distribution of Coral Reefs*, Being the first part of the geology of the voyage of the Beagle, under the command of Capt. Fitzroy, R.N. during the years 1832 to 1836*, was published in 1842 as Charles Darwin's first monograph

Return to England

Married Emma Wedgewood, heiress to a large fortune from the pottery business, and essentially retired.

Wrote up his notes, books, and gathered information for his theory of origin of species.

FUEGIAN

NARRATIVE

OF THE

SURVEYING VOYAGES

OF HIS MAJESTY'S SHIPS

ADVENTURE AND BEAGLE,

BETWEEN

THE YEARS 1826 AND 1836,

DESCRIBING THEIR

EXAMINATION OF THE SOUTHERN SHORES

OF

SOUTH AMERICA,

AND

THE BEAGLE'S CIRCUMNAVIGATION OF THE GLOBE.

IN THREE VOLUMES.
VOL. II.

LONDON:
HENRY COLBURN, GREAT MARLBOROUGH STREET.

1839.

After returning to England, Darwin spent 20 years collecting and systematizing his evidence, although it was his experiences on the voyage of the H.M.S. Beagle that had the greatest impact on him.

He had almost all the pieces of the puzzle of evolution. He believed that individuals vary and that these differences could be inherited.

What he did not have was a mechanism that could explain <u>how</u> this variation was inherited.

End