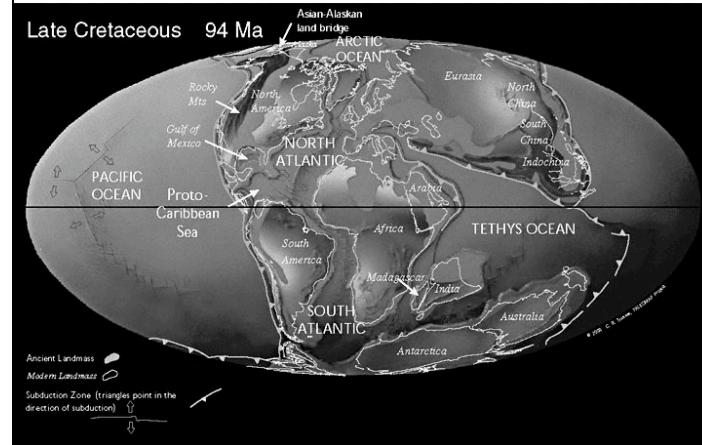


Plate TECTONICS

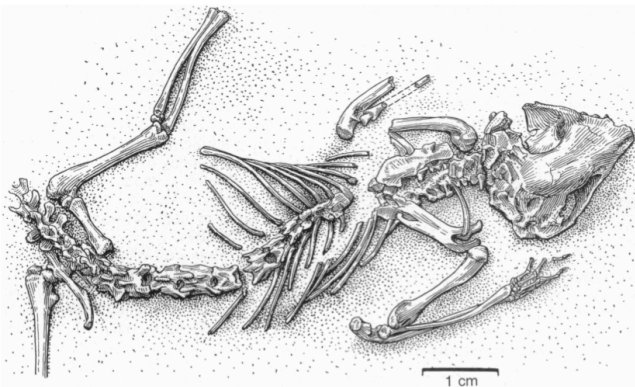
or

"I feel the Earth move under my feet. . ."

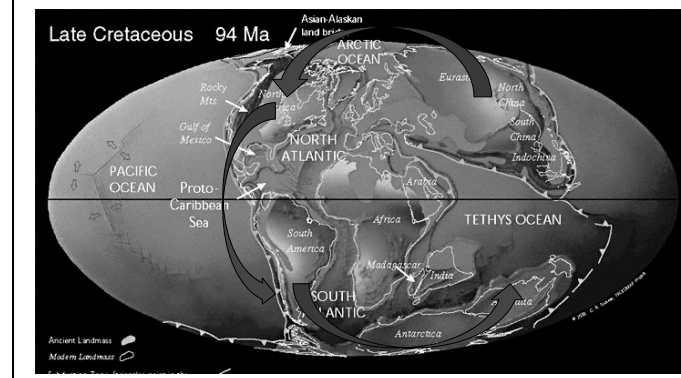
At 94 million years ago, Gondwana has started rifting apart, with Africa and India the first to break away. . . .



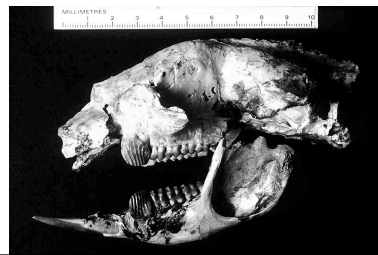
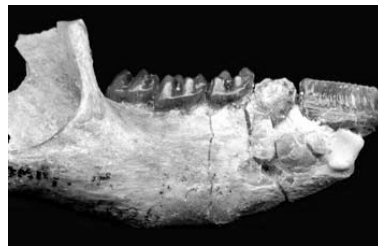
This is the time frame in which mammal lineages are diversifying—*Asiatherium*, for example, is a Late Cretaceous *marsupial* from Mongolia.









Marsupials appeared in Asia, but they managed to disperse all the way to Australia, via island chains and land bridges.

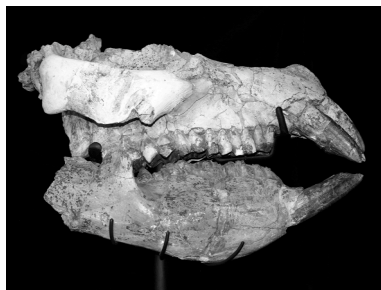



Placental mammals are as old as marsupials, but the few placental lineages that dispersed by land to Australia, while that was still possible, died out there. Marsupials, however, radiated into forms like the 25 million-year-old *Ngamaroo*, kin to kangaroos (top) and the 10-20-million year-old *Ekaltadeta*, a galloping, predatory “killer kangaroo” (bottom)



 European mole	 Australian marsupial mole	Australia still has no native placental mammals (except for bats, marine mammals, and species introduced by humans), and the marsupials have radiated into a remarkable diversity of forms, many of which are convergent on placental mammals.
 African flying squirrel	 Australian sugar glider	
 South American anteater	 Australian numbat	

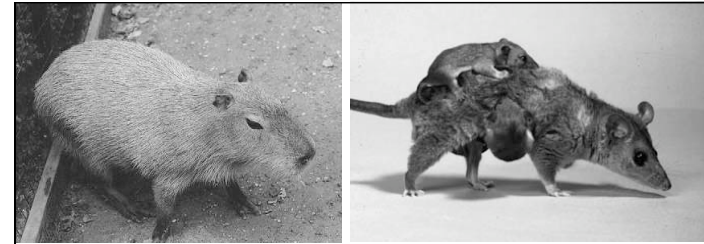
Both marsupials and placental mammals reached South America, but not all modern orders of mammals made it. Other orders of mammals evolved in isolation from the rest of the world, including the vaguely elephant-like *pyrotheres* (top), and the *notoungulates*, which ranged from rhino-like beasts to the rabbit-like *Propachyrukhos* (bottom).



	Marsupials unique to South America included <i>Thylacosmilus</i> , convergent on the more famous “saber-toothed cats” but not related—this is a marsupial, not a placental mammal! In fact, the “saber-tooth” form evolved convergently at least four times in mammal evolution.
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The mammal lineages that reached South America also radiated into unique forms that are still with us. (*This is ultimately why Darwin observed that strange similarity between South American fossil and living mammals!*)

- Marsupials
 - several species of “possum”
- Rodents
 - Unique South American rodents include: nutria, capybara (world’s largest rodent!), chinchillas, New World porcupines
- Primates
 - South American monkeys, including marmosets, tamarins, and others, form a separate clade from African and Asian monkeys
- Xenarthrans
 - Sloths, armadillos, and true anteaters
- Perissodactyls (“odd-toed” hoofed mammals)
 - Tapirs



A capybara—a pig-sized rodent

Brazilian short-tailed possum

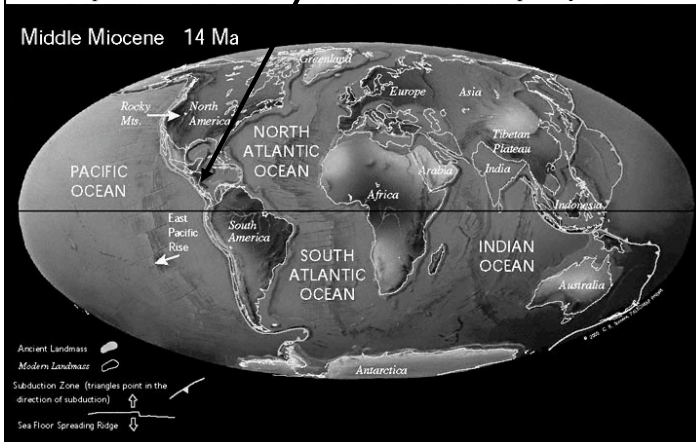


A tamandua, or tree anteater

A mara— a rabbit-like beast

Some South American beasts. . .

At 14 million years ago, here’s the subduction zone that would produce the Isthmus of Panama (still not complete yet)



But when the isthmus formed. . .

. . . what do you suppose that did to the marine species of southern North America and northern South America?

(HINT: It starts with a **V** and rhymes with “vicariance”)

There are many species of marine invertebrate on the Pacific side of the isthmus with an uncanny similarity to Caribbean species. . .

Strombus pugilis



Strombus gracilior

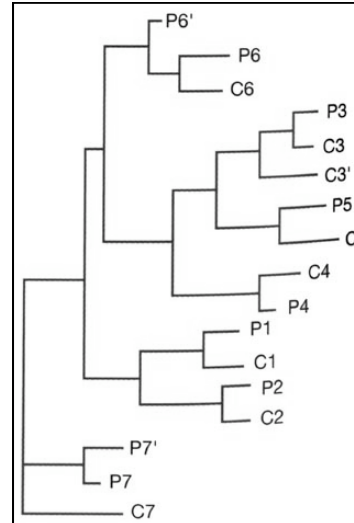
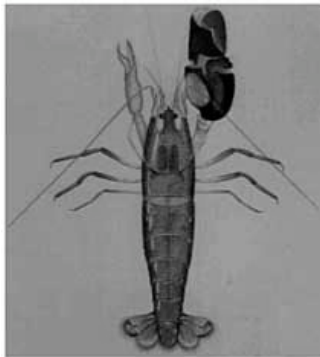
. . . because both species descend from a common ancestor, which was divided into separate populations when the isthmus formed.

Purpura patula



Purpura pansa

To get a little deeper into why this is so, consider a recent study on *Alpheus* (snapping shrimp, or pistol shrimp). . .



Cladistic analysis of fourteen species of *Alpheus*, on both sides of the isthmus, shows that the closest relative of each Pacific species (P) is a Caribbean species (C)—a pattern explained by vicariance caused by the formation of the Isthmus of Panama!

For the land animals and plants, things were different. . .

- Formation of the Isthmus allowed *dispersal* in both directions
- From south to north: armadillos, opossums, sloths, porcupines
- From north to south: oaks, bears, cats, raccoons, rabbits, skunks, camels

This is known as the *Great American Interchange*.

Opossums came north. . .



Bears went south. . .

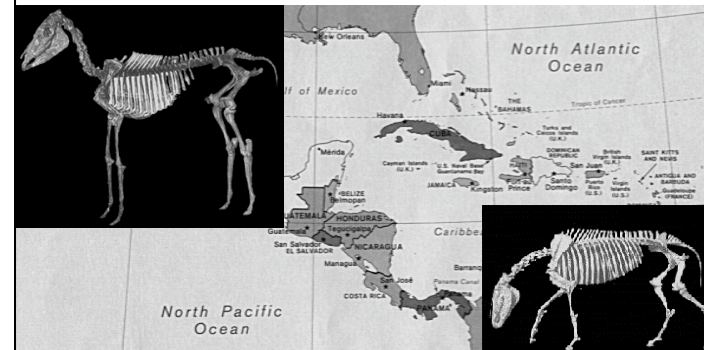
This is known as the *Great American Interchange*.

Porcupines came north. . .

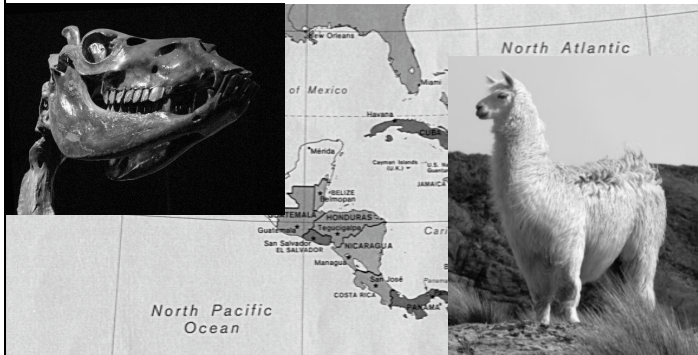


Cats went south. . .

North American native horses dispersed south, but later died out on both continents, and did not reappear until 16th-century European explorers introduced domestic horses, a different species.



And camels, native to North America, dispersed south—but later died out in North America—leaving the llama lineage all alone.



Wallace's Line

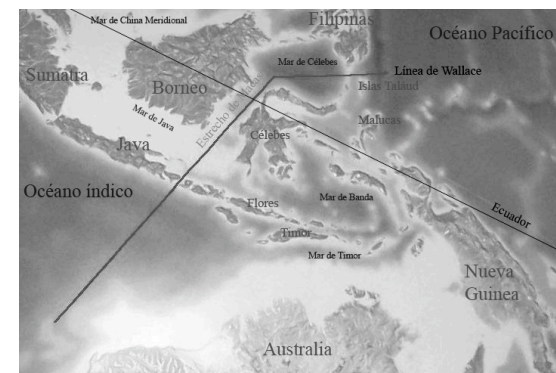
- Documented by Alfred Russel Wallace during his studies in Indonesia and Malaysia, 1857-1862
- Asian birds, mammals, fish, plants are all found west of the Line
 - Tigers, rhinos, pheasants, squirrels, monkeys, orangutans. . .
- Australian birds, mammals, fish, plants are found east of the Line
 - Parrots, cockatoos, megapodes, cuscus, birds of paradise. . .

Alfred Russel Wallace described the situation thus:



The Islands of Baly and Lombok, for instance, though of nearly the same size, of the same soil, aspect, elevation and climate, and within sight of each other, yet differ considerably in their productions, and, in fact, belong to two quite distinct zoological provinces, of which they form the extreme limits.
—Letter to *The Zoologist*, 1857

Wallace's Line. In Indonesia, the line separates the islands of Bali (to the west) and Lombok (to the east), which are only 20 miles apart.



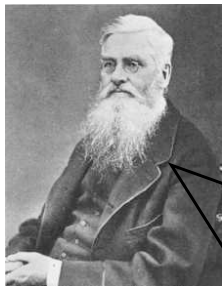
To the west: trogons, squirrels, tigers—plus rhinos, monkeys, deer, civets. . .



To the east: cuscus, cockatoos, megapodes (“bush turkeys”), tree kangaroos—plus many parrots, birds of paradise. . .

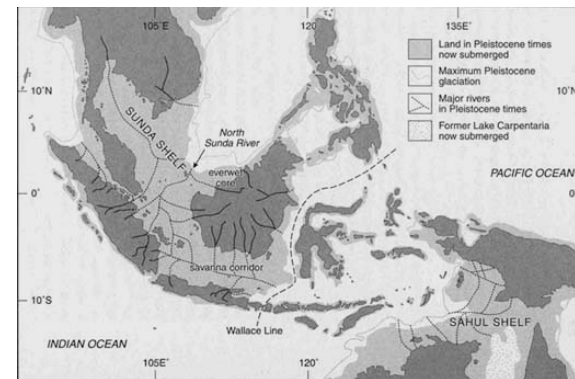


Alfred Russel Wallace explained this:



The inference that we must draw from these facts is undoubtedly, that the whole of the islands eastwards beyond Java and Borneo. . . do essentially form a part of a former Australian or Pacific continent. . . It is interesting to observe among the islands themselves, how a shallow sea always intimates a recent land-connexion.
—*The Malay Archipelago*, 1869

When the sea level was lower, many now-separate regions were connected. . . but Bali and Lombok never were (they're separated by a trench). Subduction-related volcanoes also tend to block dispersal through Indonesia.



This demonstrates one of the borders between the eight major global *biogeographic realms* (sometimes called *ecozones*, although that word can also mean a smaller biogeographic division).

