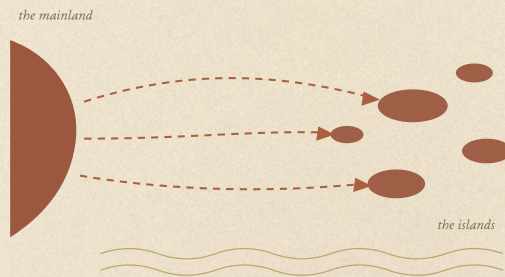


MY OWN READING OF DARWIN · IN EIGHT PARTS

ON THE ORIGIN OF SPECIES

By Means of Natural Selection

Charles Darwin, 1859 — first edition



PART SEVEN OF EIGHT

Why Things Live Where They Live

Chapters XI & XII: Geographical Distribution

*“The naturalist, looking at the inhabitants of these volcanic
islands in the Pacific... feels that he is standing
on American land.”*

Darwin on the Galápagos, Chapter XII

READ AND EXPLAINED BY LOVEPREET SINGH

I read the whole book myself. This is what I understood,
written the way I'd explain it to a friend.

I

A question nobody thought to ask

Part Six looked down into the rock. These two chapters look out across the map, and start from something so ordinary that nobody had noticed it was strange.

Why does anything live where it lives?

It sounds like a non-question. Kangaroos live in Australia. Sloths live in South America. Polar bears live in the Arctic. That's just where they are.

But there was an answer on offer in 1859, and it was perfectly reasonable: each creature was placed where it suits. Camels where it's dry, seals where it's cold, monkeys where the fruit is. The fit between an animal and its home is obvious, so the fit is the explanation.

The lovely thing about that answer is that it makes checkable predictions. Similar places should hold similar creatures. Different places should hold different ones. If you find two spots on earth with the same temperature, the same rainfall and the same ground, the things living there should match.

Darwin spent five years sailing around the world looking at exactly this. And what he found is that the prediction fails, everywhere, in a pattern.

WHAT THESE TWO CHAPTERS DO

Chapter 11 establishes three facts about how life is spread over the earth, none of which fit the “placed where it suits” account. Then it tackles the obvious objection to Darwin's alternative — if everything spread from one place, *how did it get across the sea?* — and answers it with experiments he ran in his own house.

Chapter 12 goes to the islands, and that is where the argument stops being suggestive and becomes very hard to answer.

These are the most enjoyable chapters in the book. This is Darwin's home ground, he is writing about things he saw with his own eyes, and you can feel him enjoying himself.

II

Geographical Distribution

Three facts that break the obvious explanation, and then a man in Kent filling jars with salt water to prove that seeds can cross an ocean.

Fact one: climate is not doing the work

Darwin starts by taking the “placed where it suits” idea seriously and testing it properly.

He picks out regions that match each other closely in everything physical — temperature, rainfall, soil, terrain — and looks at who lives there. The great grassy plains of South America. The dry open country of Australia. The equivalent stretches of southern Africa.

By the placement theory, these should be stocked with much the same sorts of creatures, because the conditions are much the same. They are not even slightly.



FIGURE 25 *Darwin's first fact. If creatures were placed where conditions suited them, these three should hold much the same sorts of animals. Instead each holds an entirely separate cast, and the only thing that distinguishes the three regions is that they cannot reach one another.*

And the reverse also fails. Travel across a single continent, from a hot lowland up into a cold highland, and the conditions change completely — while the inhabitants stay obviously related. Cousins, adjusted.

So similarity of climate does not produce similarity of inhabitants, and difference of climate does not produce difference of inhabitants. Whatever is organising life across the map, it isn't the weather.

Fact two: barriers are doing the work

What *does* line up with the differences is obstacles.

Run a line down the Andes and the animals on the eastern side differ from those on the western side, at the same latitude, in the same climate. Look at the narrow neck of land at Panama: the sea creatures on one side and the other are almost entirely different species, separated by a strip of land a few miles wide.

Wherever you find a serious obstacle to movement — a mountain chain, a desert, a stretch of open ocean — you find different inhabitants on either side of it. Wherever there is no obstacle, the inhabitants blend.

IN DARWIN'S OWN WORDS

“Barriers of any kind, or obstacles to free migration, are related in a close and important manner to the differences between the productions of various regions.”

WHAT HE MEANS — Anything that stops living things moving around is closely tied to how different the inhabitants of two places are. *Productions* is his word for whatever lives and grows in a place.

MY TAKE — THIS IS THE WHOLE CHAPTER IN ONE LINE

Climate predicts nothing. Barriers predict everything.

That is a very strange result if creatures were put where they fit. It is the *only* result you could get if creatures had to travel to where they are — because then the thing that decides who lives where isn't suitability, it's reachability.

Which means the map of life is not a map of good fits. It is a map of where things managed to get to.

Fact three: within one region, relatives replace each other

The third fact is the one from Part One — the thing that nagged at Darwin on the *Beagle*. As you travel across a continent, one species is quietly swapped for a closely related species, then another, then another. Not random replacements. Cousins, all the way down the coast.

Three facts, then: climate doesn't explain it, barriers do, and a region's inhabitants are all related to one another. Every one of those follows immediately if life spreads outward from where it arose, and stops where it can't go further.

Which leaves one enormous objection

If every species began in one place and spread from there, then every plant and animal on every island had to *get there*. Across open sea. Without a boat.

The fashionable answer at the time was to invent land. Whenever a distribution looked awkward, naturalists proposed a sunken continent or a vanished land bridge to explain it. Darwin thought this was lazy and said so — you cannot conjure a continent every time a plant turns up somewhere inconvenient.

So he did something else. He went home and started testing whether ordinary things could cross oceans.



He did not argue that things can cross oceans. He went and measured it.

FIGURE 26 A selection of Darwin's own results. He soaked 87 kinds of seed in salt water; 64 of them still germinated after a month. He kept pond mud in his study for six months and counted every plant that came up. This is a man with jars in every room.

And that's only part of it. He fed seeds to birds and recovered them from droppings and owl pellets, still able to grow. He looked at what floats in the crop of a dead bird washed out to sea. He worked out how much earth clings to a bird's foot, and how many seeds are hiding in it. He considered icebergs carrying soil and stones, and driftwood carrying seeds embedded in it.

None of these is dramatic. Every one of them is *occasional*. But an occasional event, given a few million years, becomes a certainty.

The ice age — a natural experiment

Then Darwin plays what I think is his best card in this chapter, and it works because it uses an event that had already been established by other people, for other reasons.

Geologists had recently accepted that a great cold period had gripped the northern hemisphere and then retreated. Darwin asks: *if that happened, what should the map look like now?*

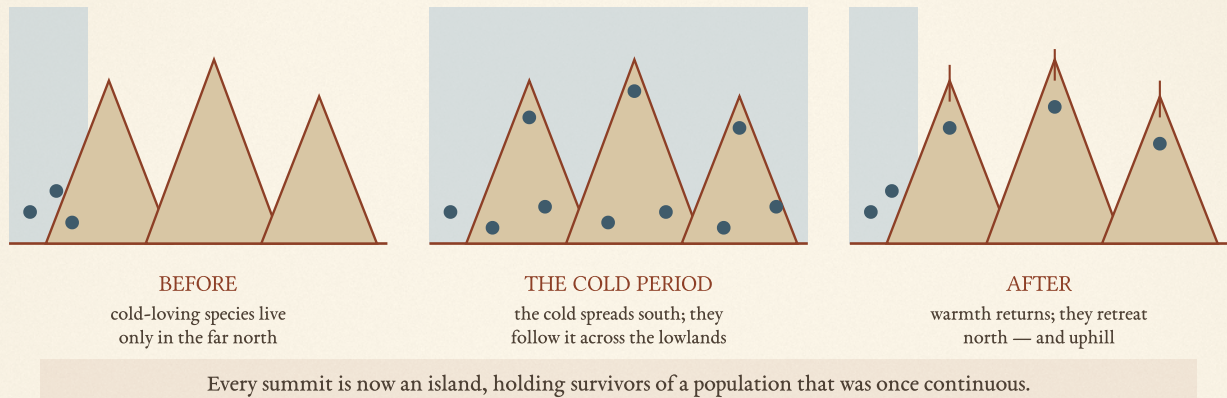


FIGURE 27 Darwin's cleanest argument. A known past event predicts a specific present-day pattern — the same cold-adapted species stranded on the tops of mountain ranges hundreds of miles apart, with nothing like them in the warm country between. That is exactly what botanists find.

Read what that does. It explains, in one stroke, why the summits of the Alps, the Pyrenees, the Scottish highlands and the far Arctic share species — and why the warm land in between shares none of them. Nobody created an identical little flora on each separate mountaintop. The mountaintops are the last high ground of a retreating army.

And it isn't a story Darwin invented to fit the facts. The ice age was established independently. He takes somebody else's event, derives a prediction from his own theory, and checks it.

SECTION THREE · CHAPTER XII OF THE BOOK

III

Geographical Distribution, continued

The islands. This is where the argument stops being persuasive and becomes, as far as I can tell, unanswerable.

An oceanic island is one that rose out of deep sea — usually volcanic — and has never been joined to a continent. The Galápagos, the Azores, Madeira, Cape Verde, St Helena.

Darwin opens with fresh water, and it's a nice warm-up. Ponds and lakes are islands too — isolated bodies of water separated by miles of dry land. You'd expect each one to have its own private set of

creatures. Instead the same freshwater plants, snails and fish turn up in ponds all over a country, and often across continents.

How? Floods join things temporarily. Ducks fly between ponds with mud and weed on their feet — and Darwin, being Darwin, hung a duck's foot in an aquarium and watched freshly-hatched water snails crawl onto it and hang on. He then worked out how far a duck could fly with a snail attached.

Then he goes out to sea.

What is on an oceanic island, and what is not

Darwin lays out the facts, and they are peculiar enough that it's worth reading them slowly.

- Oceanic islands hold far fewer species than an equal area of mainland.
- A large share of what they do hold is found nowhere else on earth.
- They are rich in birds, insects and plants.
- They have no native land mammals — Darwin searched the old voyage accounts and could not find one clear case on an island more than three hundred miles from a continent.
- Except bats, which are everywhere.
- They have no frogs, toads or newts. Not one, on any island in any of the great oceans.



The two questions that finish the argument

Darwin now asks two things, and once they're asked the placement theory has nowhere to stand.

FIRST: WHY BATS?

THE SHARPEST QUESTION IN THE CHAPTER

“Why, it may be asked, has the supposed creative force produced bats and no other mammals on remote islands? On my view this question can easily be answered; for no terrestrial mammal can be transported across a wide space of sea, but bats can fly across.”

WHAT HE MEANS — If islands were stocked deliberately, why put bats there and no other mammals? On my account it’s obvious: a bat can fly over the water and a mouse cannot.

There is no reason at all, on the placement view, for bats to be the one mammal on remote islands. Bats are not especially island-suited. Islands are perfectly good habitat for rodents — rats brought by ships prove it within a few decades of arriving.

The one and only thing that separates bats from every other mammal is that they can cross the water. That is the entire explanation, and it explains nothing else about them.

SECOND: WHY NO FROGS?

The frog case is even better, because Darwin can point at what happens when the barrier is removed.

Oceanic islands have no native frogs, toads or newts anywhere in the world. Yet frogs introduced by humans to Madeira, the Azores and Mauritius did not merely survive — they multiplied until they became a nuisance.

So the islands suit frogs perfectly. Frogs simply couldn’t get there, because their eggs die in salt water and an adult frog cannot survive a long crossing.

MY TAKE — THIS IS THE CLEANEST TEST IN THE WHOLE BOOK

Chapter 12 sets up something close to a controlled experiment, and nature had already run it.

Hypothesis A: creatures live where conditions suit them. Prediction: islands should hold whatever suits islands.

Hypothesis B: creatures live where they could get to. Prediction: islands should hold whatever can cross water — and be missing whatever cannot, *even if the island would suit it perfectly*.

The result: no frogs, and imported frogs become a plague. No land mammals, and imported rats overrun the place. Bats, which fly, everywhere.

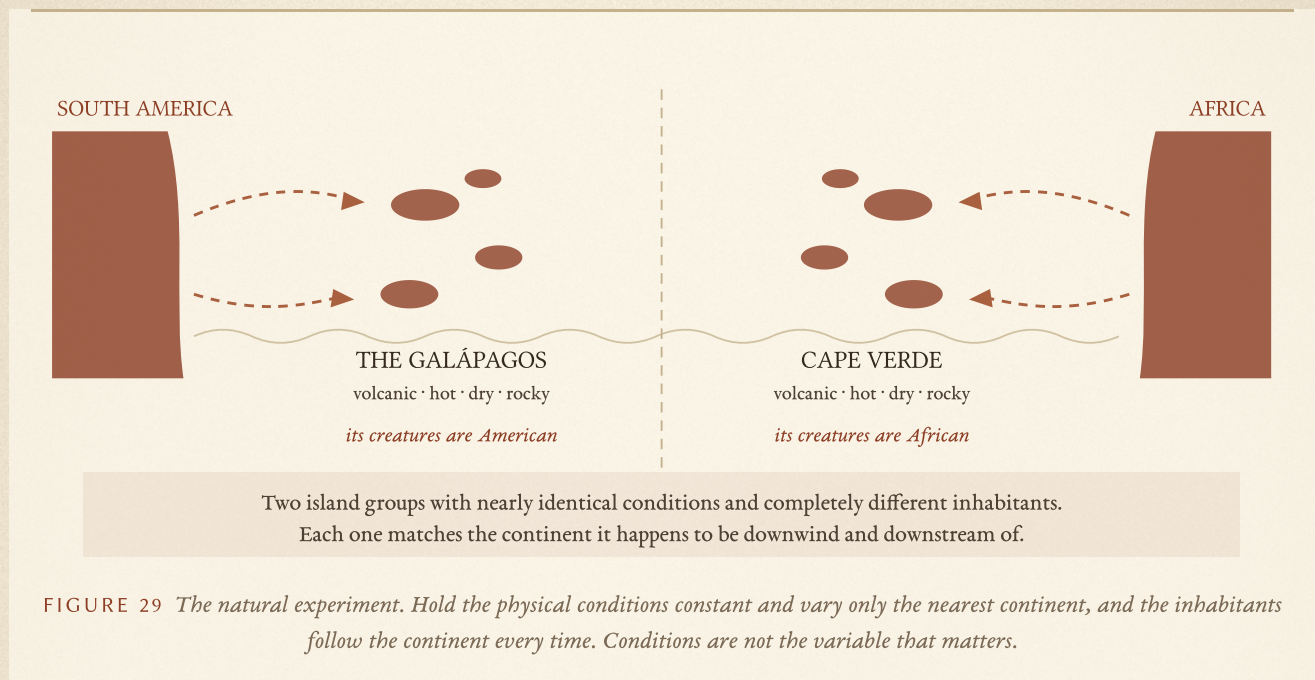
Hypothesis A doesn’t just fail. It fails in the exact direction B predicted.

And then the two archipelagos

The last piece is the one that made me put the book down for a minute.

Take the Galápagos: a group of volcanic islands in the Pacific, hot, dry, rocky, about six hundred miles off the coast of South America. Its plants and animals are strange, many found nowhere else — and they are unmistakably *American* in character. Their nearest relatives are on that continent.

Now take the Cape Verde islands: volcanic, hot, dry, rocky, a few hundred miles off the coast of West Africa. Physically, remarkably similar to the Galápagos. And its inhabitants are unmistakably *African*.



And the pattern repeats *inside* the Galápagos. Islands within sight of one another, formed of the same rock in the same sea, carry their own distinct but closely related species. A short stretch of water is enough of a barrier.

THE LINE ON THE COVER OF THIS PART

“The naturalist, looking at the inhabitants of these volcanic islands in the Pacific... feels that he is standing on American land.”

WHAT HE MEANS — You are six hundred miles out in the ocean, on black volcanic rock that looks nothing like the mainland, and everything around you still feels like South America.

Which it should, if these islands rose empty from the sea and were then colonised, over a very long time, by whatever happened to blow, float or fly across from the nearest land — and then changed, in isolation, into something new.

A MYTH WORTH CORRECTING

Everyone has heard that Darwin worked out evolution by studying the finches of the Galápagos, and that the different beaks were his moment of revelation.

It is very nearly all wrong. He barely noticed the finches at the time, didn't label which island most of them came from, and had to reconstruct it afterwards from other people's notes. The finches are not mentioned anywhere in this book. The birds that did strike him on the islands were the mockingbirds, which differed clearly from island to island.

The famous finch story came much later, mostly from a 1947 book by the ornithologist David Lack, who gave them the name "Darwin's finches." They are a superb example of what Darwin described. They just weren't how he found it.

SECTION FOUR

IV

The one thing Darwin was missing

He explained the map with movement alone, because in his world the map itself could not move. It can.

Everything in these two chapters rests on one silent assumption: the continents have always been where they are now. Land could rise and sink, in Darwin's picture, but it could not travel.

So when he met a distribution that dispersal couldn't explain, he had two options — invent a land bridge, which he refused to do, or work harder at showing ordinary transport could manage it. He chose the second, and the jars of seawater are the result.

He was more right than anyone expected. Dispersal really does far more than his contemporaries believed. But he was also, on some cases, straining — because a third option existed that nobody would take seriously until half a century after his death.

CONTINENTAL DRIFT

In 1912 Alfred Wegener proposed that the continents move. He was ridiculed for fifty years, largely because he could not say what force would push a continent around. In the 1960s the mechanism was found on the sea floor, and plate tectonics became the foundation of modern geology.

Which means some distributions Darwin struggled with weren't crossings at all. Southern beech trees in South America, Australia and New Zealand; flightless birds scattered across the southern continents. Those groups never crossed any ocean. They were on one continent, and the continent broke up underneath them.

It's worth being precise about what this changes. It doesn't touch the argument. Darwin's claim is that distribution is explained by *descent plus movement plus barriers*, not by suitability. Plate tectonics adds a second kind of movement he didn't know about — and it makes the barriers themselves historical objects with dates. The islands chapter is untouched, because oceanic islands really did rise empty from deep water and really did have to be colonised.

THE REST OF THE SCORECARD

- The dispersal experiments held up. Seeds do cross oceans. Birds do carry mud, seeds and snails. Island colonisation by rare accident is now a measured field with numbers attached.
- Island biogeography became a discipline. There are now equations relating an island's size and remoteness to how many species it holds — the pattern Darwin noticed by eye.
- Invasive species prove the point daily. Every time a creature is carried past a barrier it could never cross alone and then thrives, it confirms that the barrier — not the climate — was what kept it out. Rabbits in Australia. Rats on every island they reached. Frogs in Madeira, exactly as Darwin recorded.
- The ice-age argument was right, and there have been many glacial cycles rather than one. The stranded mountaintop populations are still there, and now they are being squeezed off the tops of their mountains by a warming climate — the same mechanism running one step further.

THE SENTENCE I'D KEEP FROM THIS PART

The map of life is not a map of where things fit best.

It is a map of where things managed to get to, and what happened to them once they were stuck there.

Every hard word in this part

Same rule as always — explained the way I'd explain it to a ten-year-old.

Geographical Distribution

Which living things are found where, on the map. Darwin's claim: it is decided by history and barriers, not by which conditions suit whom.

Productions

Darwin's catch-all for everything that lives and grows in a place — the animals and plants of a region taken together.

Barrier

Anything that stops living things moving: a mountain chain, a desert, a strip of land, and above all open sea. The single best predictor of whether two regions have different inhabitants.

Oceanic Island

An island that rose from deep sea — usually volcanic — and was never joined to a continent. It started empty, so everything on it had to arrive. Galápagos, Azores, Cape Verde, St Helena.

Continental Island

The other kind — a piece of continent cut off by rising sea, like Britain. It came with its inhabitants already aboard, which is why Britain has foxes and frogs and the Azores don't.

Endemic

Found in one place and nowhere else. Islands are full of endemics, because arrivals get isolated and then change.

Batrachians

Darwin's word for frogs, toads and newts. Absent from every oceanic island in the world — and a plague on several of them once humans carried them over.

Single Centre of Creation

Darwin's principle that each species arose once, in one place, and spread from there — rather than appearing independently in several regions at once.

Means of Dispersal

All the ways a living thing crosses ground it cannot walk over: floating, blowing, riding in mud on a bird's foot, surviving a journey through a bird's gut, drifting on timber or ice.

Glacial Period

The cold era that pushed cold-loving species south across the lowlands and then, on retreating, stranded them on mountain summits hundreds of miles apart.

Naturalised

A species carried to a new region by humans that establishes itself and spreads. Every successful one is an accidental experiment showing the barrier was the obstacle, not the climate.

Plate Tectonics

The twentieth-century discovery that continents move. Darwin's biggest missing piece — some groups he thought must have crossed water were simply riding continents that split apart.

REFERENCE

Lines worth remembering

If you forget everything else from Part Seven, keep these eight.

- 1 Three regions with the same climate hold three unrelated casts of creatures. Similar conditions do not produce similar inhabitants.
- 2 Barriers, on the other hand, predict everything. Wherever movement is blocked, the inhabitants differ — even at the same latitude in the same weather.
- 3 So the map of life is not a map of good fits. It is a map of where things managed to get to.
- 4 Darwin didn't argue that seeds can cross oceans — he filled his house with jars and measured it. 137 days afloat and still able to grow.
- 5 The ice age is his cleanest argument: a known past event predicts stranded arctic species on separated mountain summits today. Which is what botanists find.
- 6 Oceanic islands have no land mammals except bats, and no frogs at all. That list is exactly the list of things that cannot cross open water.
- 7 Introduced frogs thrive on those same islands to the point of nuisance. The islands suited them all along. They just couldn't get there.
- 8 Galápagos creatures are American; Cape Verde creatures are African. Same conditions, different continents — and the inhabitants follow the continent.

Part Seven on one page

Tear this out. It's the whole thing in ninety seconds.

THE QUESTION, AND THE ANSWER BEING TESTED

Why does anything live where it lives? The 1859 answer: each creature was placed where conditions suit it. That makes a checkable prediction — similar places should hold similar creatures — and it fails everywhere.

CHAPTER 11 — THE THREE FACTS

1. Climate explains nothing. The plains of South America, Australia and southern Africa share sun, rain and grass, and not one animal family.
2. Barriers explain everything. Mountains, deserts and open sea line up exactly with where the inhabitants change — the Andes, the neck of land at Panama splitting one sea into two faunas.
3. Within a region, relatives replace each other from place to place. Cousins all the way down the coast.

All three follow immediately if life spreads outward from where it arose and stops where it cannot go on.

SO HOW DOES ANYTHING CROSS AN OCEAN?

Darwin refused the fashionable answer of inventing sunken land bridges, and measured instead. Seeds afloat in salt water for 137 days and still able to grow — far enough for roughly 924 miles of current. 537 plants raised from three spoonfuls of pond mud. 22 grains of dried mud on one partridge's foot. Seeds recovered alive from bird droppings and owl pellets. Every route is *occasional* — and occasional, over millions of years, is certain.

THE ICE AGE — HIS CLEANEST ARGUMENT

A cold period already established by geologists pushed arctic species south across the lowlands. When warmth returned they retreated north *and uphill*, leaving isolated survivors on mountain summits hundreds of miles apart, with nothing like them in the warm land between. Exactly what is found.

CHAPTER 12 — THE ISLANDS, AND THE DECISIVE TEST

Oceanic islands hold birds, bats, insects and plants — and no land mammals and no frogs whatsoever. That list of absences is precisely the list of creatures that cannot cross water. Darwin's question: why would a creative force put bats on remote islands and no other mammal? And when humans carried frogs to Madeira and the Azores, the frogs became a nuisance — so the islands suited them all along.

THE NATURAL EXPERIMENT

The Galápagos and Cape Verde are both volcanic, hot, dry and remote — nearly identical conditions. Galápagos creatures are American. Cape Verde creatures are African. Hold conditions constant, vary the nearest continent, and the inhabitants follow the continent.

WHAT HE WAS MISSING

Continental drift. Some distributions weren't crossings at all — those groups stayed put while the continent split underneath them. It adds a second kind of movement without touching the argument.

Part Eight — the last one

Chapter 13: Mutual Affinities, Morphology, Embryology, Rudimentary Organs · Chapter 14: Recapitulation and Conclusion

Everything is now in place, and Darwin spends the last two chapters collecting.

Chapter 13 is, for my money, the most quietly devastating chapter in the book, and it works by asking one question over and over: *why is life shaped like this rather than some other way?*

Why do biologists file living things in nested boxes — groups inside groups inside groups — when nothing forces that shape? Why does the same handful of bones appear, rearranged, in a bat's wing, a whale's flipper, a horse's leg and your hand? Why do the embryos of a fish, a bird and a human look so alike at the start and so different at the end? And why are we all carrying around parts that do nothing — the stubs of hind legs buried inside a whale, eyes under the skin of a blind mole, an appendix?

Every one of those is a puzzle if each creature was designed for its job. Every one of them is unremarkable if creatures are modified copies of their ancestors, working with the parts they inherited.

Chapter 14 is Darwin summing up, answering his critics in advance, and finally — on the very last page — letting himself write one beautiful paragraph about a tangled bank. It contains the most famous closing sentence in the history of science, and one carefully placed sentence about ourselves.



End of Part Seven of Eight · *Why Things Live Where They Live*

My own reading of Darwin — Lovepreet Singh