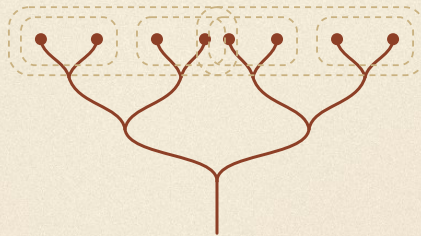


MY OWN READING OF DARWIN · IN EIGHT PARTS

ON THE ORIGIN OF SPECIES

By Means of Natural Selection

Charles Darwin, 1859 — first edition



PART EIGHT OF EIGHT · THE LAST ONE

The Evidence in the Body, and the Last Word

*Chapters XIII & XIV: Mutual Affinities, Morphology, Embryology,
Rudimentary Organs · Recapitulation and Conclusion*

*“Light will be thrown on the origin
of man and his history.”*

Darwin’s one sentence about us, Chapter XIV

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

Everything, collected

Seven parts of arguing. Now the two chapters where Darwin stops defending himself and starts gathering — and the evidence almost nobody quotes turns out to be the evidence that finishes the job.

There is a shape to this book that only becomes visible near the end.

Chapters 1 to 5 built the machine. Chapters 6 to 12 were Darwin under attack — his own attack, mostly, since he raises nearly every objection himself before anyone else can. Difficulties. Instinct. Hybrids. The wreck of the fossil record. The map.

Chapter 13 is different in temperature. The defending is over. Darwin turns round and says, in effect: now let me show you the things my theory explains that nobody even thought needed explaining.

WHAT THESE TWO CHAPTERS DO

Chapter 13 takes four completely separate branches of biology — how naturalists file living things, how bodies are built, how embryos develop, and the useless bits of anatomy everyone had shrugged at — and shows that all four are puzzles under the old view and obvious under his.

Chapter 14 is Darwin summing up: the case restated, the objections answered one last time, a forecast of what biology will look like when this is accepted, and then the most famous closing paragraph in the history of science.

I'll be honest about my own reading here. Chapter 13 is the chapter I nearly skimmed. It has a boring title — *Mutual Affinities of Organic Beings* — and it sounds like housekeeping. It is the strongest chapter in the book.

Why this is the chapter that actually wins

Everything before this point is Darwin arguing that his mechanism *could* have produced the living world. Variation could accumulate. Selection could sculpt. The gaps in the rocks could hide the intermediates. Could, could, could. He is defending a possibility.

Chapter 13 flips the direction. It asks a different question, and it asks it about facts that were already sitting in every museum and every textbook in Europe:

Why is life shaped like this, rather than any of the other ways it could have been shaped?

WHY THAT MATTERS — A theory that explains why things are the way they are is doing ordinary work. A theory that explains why they aren't some other, equally workable way is doing something much harder, and much more convincing.

Nobody in 1859 thought the filing system of biology needed explaining. Nobody thought it was strange that a bat's wing has the same bones as your hand. Nobody thought a whale carrying a hip bone that holds up nothing was a fact in need of a cause. These were just how things were.

Darwin's move is to notice that "just how things are" is four separate coincidences, and that one very ordinary idea removes all four at once.

MY TAKE — THE SHAPE OF THE FINISH

Chapter 6 was "*here is everything that could kill me.*" Chapter 13 is "*here is everything that only makes sense if I'm right.*"

The first kind of chapter keeps a theory alive. The second kind is what actually converts people. And the historical record backs that up — when you read what Darwin's contemporaries changed their minds about first, it is almost never natural selection. It's common descent, and it's the evidence in this chapter that did it.

So: four kinds of evidence, then the summing up. Let's go.

SECTION TWO · CHAPTER XIII OF THE BOOK

II

Why life comes in boxes inside boxes

Every naturalist in Europe filed living things the same way, in groups within groups within groups. None of them could say why the filing cabinet had that shape. Darwin can, and the answer is embarrassingly plain.

The filing system nobody designed

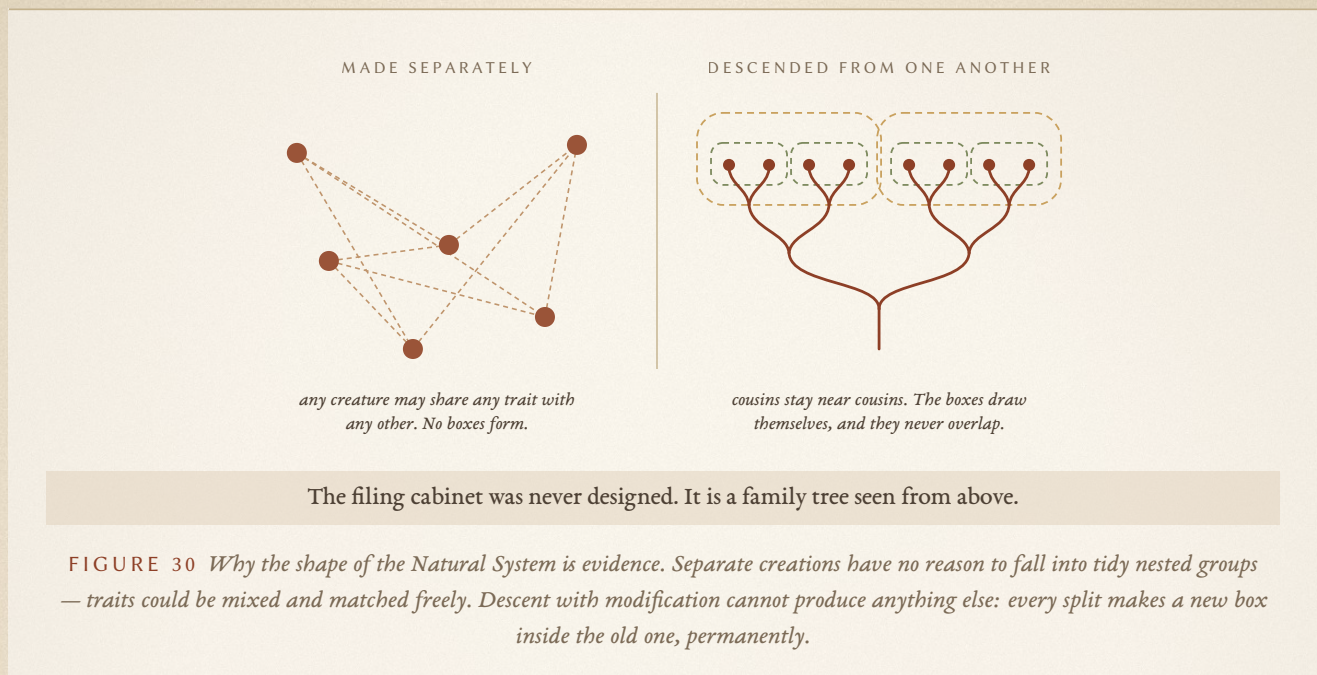
Start with something so familiar it's invisible. Living things come in nested groups.

A house cat sits with the other cats. The cats sit inside the carnivores, alongside dogs and bears. The carnivores sit inside the mammals. The mammals sit inside the vertebrates. At every level the box you are in is inside a bigger box, and the bigger box never overlaps a neighbouring box of the same size.

Naturalists called this arrangement the *Natural System*, and the word *natural* is doing a lot of work. They did not think they had invented it. They thought they were discovering it — that there was a real pattern out

there and their job was to find it. Some of them believed they were reading the plan of creation. Others thought they were tracking some abstract “type.” Nobody could say what the pattern actually *was*.

And here is the part that should bother you: nothing forces life to be arranged this way.



If every species had been produced on its own terms, there is no reason its features should sort neatly with any other species. You could have a warm-blooded thing with feathers that suckles its young, a scaly thing with a beak and hair, every combination in the deck. The traits would cross-cut each other and no clean groups would form.

They don’t cross-cut. They nest. Perfectly, and at every scale.

IN DARWIN’S OWN WORDS

“All true classification is genealogical; ... community of descent is the hidden bond which naturalists have been unconsciously seeking.”

WHAT HE MEANS — Every classification that has ever felt *right* to a naturalist is secretly a family tree. Naturalists had been hunting for the principle behind the Natural System for a century. The principle is descent. They were drawing pedigrees without knowing it.

The one other place you find perfect nesting

There is a test you can run on this yourself, and it’s the thing that convinced me.

Think of anything humans have designed and ask whether it nests. Vehicles don’t. A hovercraft has a fan like an aeroplane, a skirt like nothing else and a hull like a boat. Kitchen tools don’t. Buildings don’t. Designers borrow whatever works from wherever it works, which is exactly why designed things form a tangle rather than a tree.

Now think of the things that *do* nest properly. Languages nest — Punjabi, Hindi and Bengali sit inside Indo-Aryan, which sits inside Indo-European, and no language belongs to two families at once. Handwritten manuscripts nest — scribes copy copies, and the errors they inherit sort the surviving books into families. Family names nest. Every single case of clean, deep nesting we can actually watch happening is a case of copying with small changes.

MY TAKE — THE ARGUMENT IN ONE MOVE

Nesting is not what design produces. Nesting is what *copying* produces.

Darwin didn't have to prove that life descends from common ancestors in order to make this stick. He only had to point out that the filing system biologists had already built, for their own reasons, over a hundred years, with no theory of evolution anywhere near it, has the exact signature of copying — and no other known process leaves that signature.

Why the useless features are the trustworthy ones

Then Darwin does something that looks like a technical aside and is actually the sharpest paragraph in the chapter.

He asks: when naturalists classify, which features do they trust? Not the obvious ones. A whale is shaped like a fish, swims like a fish, has fins like a fish — and no naturalist has ever filed it with the fishes. They file it with the mammals, on the strength of things that look trivial: how its jaw hinges, the bones in its ear, the fact that it feeds its young on milk.

Why do they discount the fin and trust the ear bone? Every naturalist did this instinctively, and if you had asked them why, they could not have told you.

Darwin can. The features that are obviously useful to an animal's way of life are exactly the features that different families will converge on independently, because the same problem gets the same solution. Swimming fast in water produces a streamlined body and paddles, whoever you are. So a useful feature tells you about the *job*, not the ancestry. He calls these *analogical* resemblances, and they are traps.

Whereas a detail that does no particular work — the arrangement of small bones in an ear, a fold in a skull, a rudiment that has no function at all — has no reason to appear twice by coincidence. It is only there because it was inherited. So it is a reliable label.

MY TAKE — THIS IS THE BIT I KEEP TELLING PEOPLE ABOUT

The useful features are unreliable evidence of family. The useless ones are the reliable evidence.

That is a genuinely strange rule, and it is the rule working naturalists had already arrived at by feel, without a theory to justify it. Darwin explains their own practice back to them — and it only makes sense on his account, where useless features are inherited leftovers and useful ones are answers to a problem.

It also quietly predicts something: the less a feature does, the better a family marker it will be. A century and a half later, that is exactly how molecular biologists build family trees — from the parts of the genome that do nothing at all.

SECTION THREE · CHAPTER XIII, CONTINUED

III

The same bones, over and over

Morphology and embryology: two facts about how bodies are built and how they get built, and one sentence of Darwin's that I think is the best single sentence in the book.

Five kinds of limb, one set of bones



Open your hand and look at it. Now consider what else is made of the same parts.

THE BEST SENTENCE IN THE BOOK

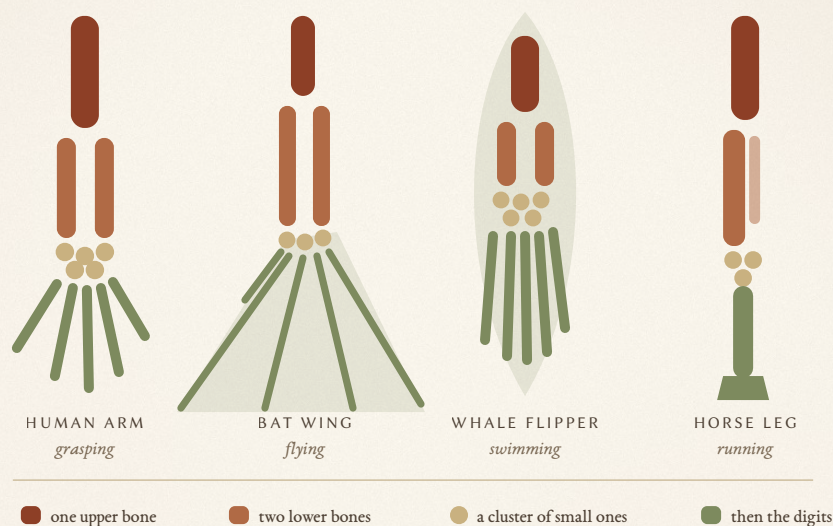
“What can be more curious than that the hand of a man, formed for grasping, that of a mole for digging, the leg of the horse, the paddle of the porpoise, and the wing of the bat, should all be constructed on the same pattern, and should include the same bones, in the same relative positions?”

WHAT HE MEANS — Five limbs doing five completely unrelated jobs — grasping, digging, running, swimming, flying — and underneath, the same bones in the same order. Not similar bones. The same ones, stretched, shortened and fused.

Naturalists had a name for this. They called it *unity of type*, and they treated it as a kind of law: within a great group, bodies conform to a common plan. It was taught as a fact about how nature is organised. It explained nothing. It was the thing that needed explaining.

His explanation takes one line. They have the same bones because they inherited the same bones. The common ancestor had a limb with one upper bone, two lower bones, a wrist of small bones and a set of digits, and every descendant has been stuck with that kit ever since — free to lengthen it, shorten it, fuse it and web it, but not free to start again.

Notice what that explains that *design* cannot. A designer is not obliged to reuse anything. If a wing and a hoof are best built differently, build them differently. Reuse is not a virtue in engineering; it is a constraint you accept when starting over is impossible. Which is precisely the situation of an animal whose only source of parts is its parents.



Four unrelated jobs. One inherited kit of parts, stretched and shortened to fit.

FIGURE 31 *What Darwin means by unity of type. An engineer solving these four problems from scratch would not arrive at the same bone count four times. A copyist working from an existing body has no way of arriving at anything else.*

A NOTE ON THE WORD

The modern name for “same bones, different jobs” is *homology*. The name for its opposite — “different bones, same job” — is *analogy*. A bat’s wing and your hand are homologous. A bat’s wing and a wasp’s wing are merely analogous; look inside and there is nothing in common at all.

Darwin didn’t coin either word. Richard Owen did, and Owen fought him. But it was Darwin who supplied the reason the distinction exists, which is the usual pattern in this book.

The same trick, at the smaller scale

Darwin then points out that the reuse doesn’t only run across species. It runs *within* a single body.

A lobster’s mouthparts, claws and walking legs look like completely different pieces of equipment. They are the same segment, repeated down the body and then modified for different work. Same in flowers: the petals, the sepals, the stamens, the parts that make pollen — Darwin follows the botanists in reading them as leaves, converted. One organ, endlessly repurposed.

This one has aged unusually well. We can now watch it happen in the genes: the machinery that builds a petal is the leaf-building machinery with a few switches thrown, and turning one switch off turns petals back

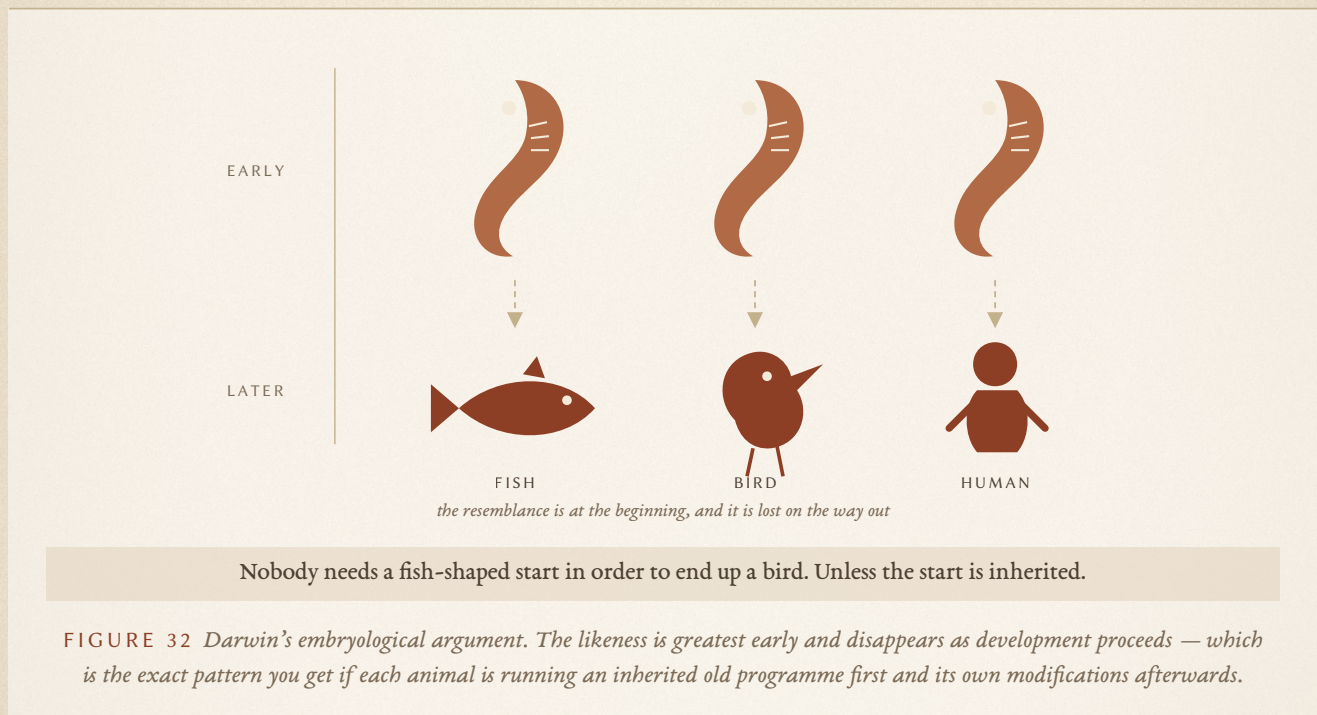
into leaves. Darwin guessed at this from the outside, with a hand lens. It turned out to be literally true on the inside.

Embryos, and the argument I didn't expect

Then he turns to the strangest evidence of the lot.

Take a fish, a lizard, a chicken and a human being. As adults, four wildly different animals. Now look at them a few weeks after conception, and they are so alike that a trained anatomist can't reliably tell them apart. Darwin quotes von Baer, one of the great embryologists of the age, admitting he had two embryos in jars whose labels had come off and he could no longer say what they were — lizards, small birds or very young mammals, he could not tell.

And it isn't just overall shape. The young of animals that will never go near water have slits in the neck where a fish would grow gills. A human embryo has a tail — a real one, with vertebrae — for a few weeks, and then reabsorbs it. Baleen whales, which are born toothless and feed by filtering, grow teeth in the womb and dissolve them before birth.



Why would that be? Darwin's reasoning is careful and worth following, because it is the kind of argument he is best at.

Variations tend to appear at a particular age, and they tend to be inherited at the corresponding age. And selection can only act on a stage that is actually exposed to the world. An embryo, sealed in an egg or a womb, is barely tested against anything. An adult, hunting and hiding and competing, is tested constantly. So modifications pile up at the adult end of life and hardly touch the beginning.

Which means the early stages are the least edited part of the whole animal — the oldest surviving draft.

“Community in embryonic structure reveals community of descent.”

WHAT HE MEANS — If two creatures start out the same, they came from the same place. The embryo, he says elsewhere, shows us the structure of the ancestor.

A CAUTION — WHAT THIS ARGUMENT IS NOT

You may have heard the slogan *“ontogeny recapitulates phylogeny”* — the claim that an embryo replays its entire evolutionary history, passing through a fish stage, then a reptile stage, and so on. That is Ernst Haeckel’s version, from the 1860s, and it is an overstatement. Haeckel’s famous embryo drawings tidied up the resemblances to make his case, and he was rightly criticised for it in his own lifetime.

Darwin’s claim is weaker and it survives. He does not say the embryo replays the adult ancestors. He says the embryo is the *less modified* state, and so it resembles the embryo of the ancestor. The gill slits in your neck at four weeks were never gills. They are the same starting structures that, in a fish, go on to become gills, and in you go on to become parts of your jaw, your ear and your voice box.

SECTION FOUR · CHAPTER XIII, CONTINUED

IV

The parts that do nothing

The strongest evidence in the whole book is the evidence that does no work at all — and I think it is the only argument in it that is genuinely difficult to answer.

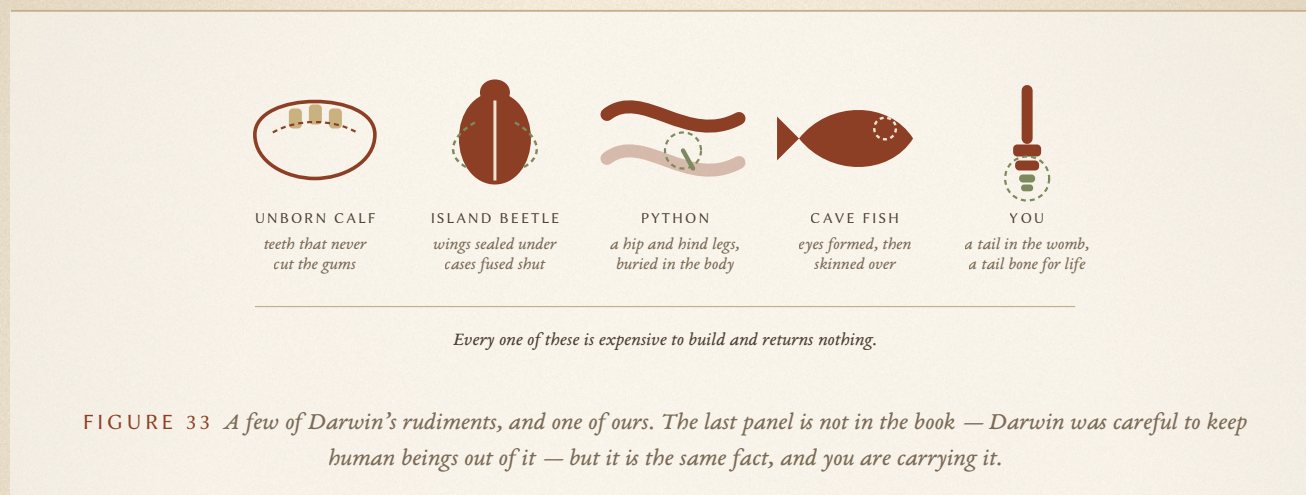
Arudimentary organ is a body part that is plainly a version of something useful, and is not useful.

Not *less* useful. Not useful in a surprising way. Present, formed, named, in the right place — and doing nothing. Darwin lists them with obvious enjoyment, because every naturalist knew about them and nobody had ever asked what they were for.

- Unborn calves grow teeth in the upper jaw. The teeth never cut the gums, and the adult cow has no upper front teeth at all. They form and are absorbed, in the dark, for no reason.
- Beetles on windy islands have shrunken wings — sealed permanently beneath wing cases that are fused shut. A wing under a lid that never opens.
- Male mammals, including men, have nipples and the milk glands to go with them, in a working arrangement that will never be used.
- Flowers carry stamens that make no pollen and pistils that receive none, standing in exactly the positions where the working parts stand in their relatives.

- Animals that live in caves have eyes in the right place, sometimes complete with a lens, sometimes buried under skin that has grown over them.

And then there is the one that gets me every time. Some snakes — pythons, boas — have the stumps of a hip and hind legs, buried inside the body wall, holding up nothing and going nowhere. A hip bone in an animal with no legs.



What the old answer was, and why it collapses

The standard explanation before Darwin was that these organs were there for the *sake of symmetry*, or to complete the plan of the group. A mammal has this bone, therefore every mammal has some version of it, whether or not it is any use. The plan requires it.

Darwin is unusually direct about what he thinks of that. It isn't an explanation, it's a restatement. Saying a useless organ exists to complete a pattern only pushes the question back a step: why does the pattern have to be completed, at cost, in an animal that would be better off without it?

And there is a detail the old answer can't touch at all: rudiments are usually *more* developed in the embryo and shrink later. The whale's teeth are there and then dissolved. The calf's teeth form and are absorbed. If the organ existed to complete a pattern, building it and then destroying it before birth is a strange way to go about it.

THE LINE I WOULD PUT ON A WALL

“Rudimentary organs may be compared with the letters in a word, still retained in the spelling, but become useless in the pronunciation, but which serve as a clue in seeking for its derivation.”

WHAT HE MEANS — Think of the silent letters in English. The *k* in *knee*. The *b* in *doubt*. They do nothing when you say the word. They are only there because the word was inherited from an older word where they were pronounced — and that is exactly why they are useful to a scholar trying to work out where the word came from.

I want to slow down on this, because it is the single best analogy in the book and it does more work than it first appears to.

A silent letter is not a design decision. Nobody sat down and decided that *knee* would be improved by an unpronounced *k*. It is a leftover, and leftovers only exist in things with a history. So a spelling with silent letters is proof that the word was not invented in its present form — and the letters tell you what it used to be.

Rudimentary organs are the silent letters of anatomy. Useless in the present. Informative about the past. Impossible in anything genuinely made from scratch.

MY TAKE — THIS IS THE ARGUMENT THAT DOES NOT HAVE AN ANSWER

You can, if you want to work at it, answer most of the arguments in this book. Fossil gaps can be attributed to bad luck. Island distributions can be attributed to a plan we don't understand. Even homology can be called a design language — a shared vocabulary, used because it is elegant.

But a rudiment is a cost with no return. It takes materials and time to build a hip in a snake and teeth in a calf that will never chew. Under Darwin's account it is unavoidable — you inherit the whole instruction set, including the parts that stopped paying, and reduction takes a very long time. Under any account where the animal was made as it is, it is a deliberate expense on a part that was designed not to work.

That is why Chapter 13 is the strongest chapter. It doesn't argue that the theory is possible. It points at things that are hard to explain any other way.

What the last 165 years did to this argument

Rudiments did not stay a nineteenth-century curiosity. They multiplied, and then they went molecular.

- Whales kept theirs. Modern whales carry small hip bones inside the body, disconnected from the spine. Fossil whales with actual working legs — animals that walked into the water — were found through the 1980s and 1990s, exactly the intermediates Darwin was accused of not having.
- You have several. A tail bone. Wisdom teeth that often don't fit. The muscles that would move your ears, still wired up and still twitching in response to sound. Goose pimples, which raise hairs you no longer have enough of to trap any warmth.
- Broken genes are the strongest case of all. Most mammals make their own vitamin C. We can't — and the reason is that we still carry the gene for it, sitting in the genome, disabled by a specific fault. So do chimpanzees and gorillas. Broken in the same gene, in the same way.

That last one is the argument from silent letters, in its purest possible form. Darwin was pointing at organs. It turns out the same thing is written into the text itself — the same misspelling, inherited by the same relatives, which is precisely how scholars trace copied manuscripts.

WHERE I THINK CARE IS NEEDED

“Vestigial” does not mean “useless.” It means reduced from an ancestral function, and a reduced organ can be quietly recruited for something else. The appendix is the standard example: long taught as pointless, and now understood to have a modest role in the immune system and in holding a reserve of gut bacteria.

This doesn’t weaken the argument, and I want to be clear why. The evidence isn’t “this organ does nothing.” The evidence is “this organ is a shrunk version of a working organ in relatives, sitting in the same place, built by the same development.” A small job found for a leftover is still a leftover.

SECTION FIVE · CHAPTER XIV OF THE BOOK

V

Recapitulation, and the objections he carries to the end

Darwin makes his own case against himself one final time, answers it, and then does something scientists are not supposed to do — he tells you what the world will look like if he turns out to be right.

Chapter 14 is a long chapter and it moves in three stages.

First he gathers up every difficulty in the book and states it again, in its strongest form. Then he sets the whole argument out in order, so you can see it as one thing. Then he looks forward — and the forward-looking pages are, for me, the most surprising in the book.

The difficulties, restated by the man himself

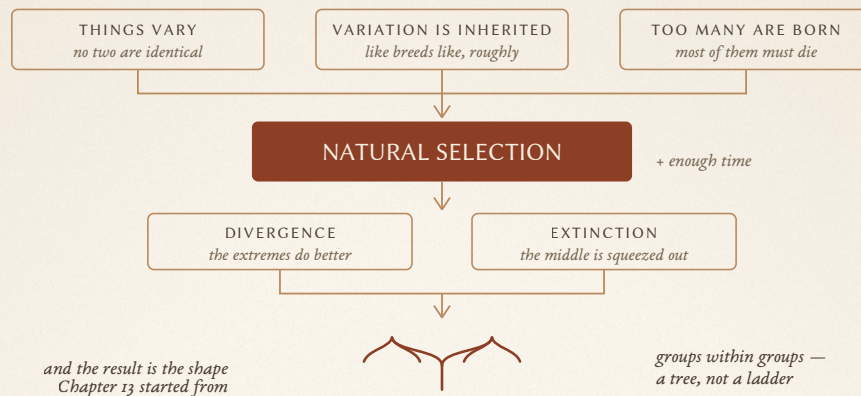
He begins where a defence lawyer would never begin: with the case against.

Why don’t we see innumerable intermediate forms everywhere? Why isn’t the rock full of them? How can natural selection have produced an eye, or an instinct? Why are species so often sterile with each other when varieties are not? He does not soften any of it. He restates each objection, and then answers it in a paragraph, and then concedes what he cannot answer.

I have read a lot of arguments in my life. This one is unusual in that the author is his own best opponent. Part of me thinks that is intellectual honesty. Part of me thinks it is tactics — if you state the objection first, and better than your critic could, you own it. Probably it is both, and after twenty years of sitting on this idea he had heard every objection in his own head anyway.

The whole theory in one breath

Then he assembles it. And it is worth seeing how few moving parts there actually are.



Three observations, one consequence, and enough time. That is the entire machine.

FIGURE 34 *The argument of the book as a single sum. Every input at the top is something anybody can check without a theory. Nothing is added along the way except duration — and the output at the bottom is the filing system biologists had already built.*

What strikes me, laid out like that, is how little Darwin is asking you to accept. The three inputs are not theories. They are observations. Farmers knew all three. He needs no force, no drive, no inner tendency to improve — the things his contemporaries kept trying to insert. The mechanism is a subtraction, and the tree is what subtraction leaves behind.

Why he thinks people will resist

Then he asks the question that has been under the whole book: if the case is this plain, why will so many naturalists refuse it?

His answer isn't that they are stupid or wicked. It is that the mind is badly built for this particular subject. We cannot see the changes happening — they are far too slow. We cannot feel the length of the ages the argument requires. And we have all been taught, since childhood, to see a species as a fixed kind of thing.

THE IMAGE I KEEP COMING BACK TO

“...when we no longer look at an organic being as a savage looks at a ship, as at something wholly beyond his comprehension...”

WHAT HE MEANS — Someone who has never seen shipbuilding sees a ship as a single marvellous object that simply *is*. Someone who has seen the yard sees a history — a keel, then ribs, then planking, each stage explaining the next. Darwin is saying that a living body has been looked at the first way for the whole of human history, and he is offering the second.

His phrasing is of his time and place, and it reads badly now. The thought underneath it is about ignorance, not about people, and it is a fair thought: an object whose making you have never seen looks like a miracle.

He also predicts, correctly, that the argument will be won by the young. Older naturalists with a lifetime invested in fixed species will not change; students who come to the subject fresh will simply find his account easier. That is roughly what happened. It took about a decade.

Then he tells you what is coming

The last few pages are a forecast, and they are startlingly confident from a man who has spent 400 pages apologising.

- Classification will become genealogy. Naturalists will stop searching for the essence of the term *species* — Darwin calls it the search for an undiscovered and undiscoverable essence — and start drawing pedigrees.
- Whole new fields will open on variation, on inheritance, on the causes of change. He says plainly that he does not know the laws of variation and that somebody will have to find them.
- Psychology will be rebuilt on the idea that every mental power was acquired by gradation, like every physical one.
- And there is one sentence about us.

THE MOST CAREFULLY PLACED SENTENCE IN THE BOOK

“Light will be thrown on the origin of man and his history.”

WHAT HE MEANS — That’s it. That is the entire treatment of human beings in a book about the origin of species. One short sentence, in the passive voice, buried in a list of predictions, with no argument attached to it and nothing following it.

MY TAKE — WHY THAT SENTENCE IS WRITTEN LIKE THAT

He is not being coy, and he is not hiding. He is being strategic, and I think he was right to be.

Darwin knew that the moment he applied this to human beings, nobody would discuss anything else. Every argument in the book about pigeons and barnacles and beetles would be read through that one question, and the evidence would never get a fair hearing. So he makes the argument about everything else, states the human consequence in nine words so that no one can accuse him of concealing it, and stops.

Then he waited twelve years and published *The Descent of Man*, in 1871, when the ground had been prepared. It is one of the most patient decisions I know of in the history of ideas.

He also says, once, that he sees no good reason why the views in the book should shock anybody’s religious feelings. Whether he believed that or whether it was a shield, I can’t tell you — he was a careful man who had a devout wife and a great deal to lose, and his private letters are more complicated than the book. But he put it in writing, and it is part of what he actually said.

VI

The last page

One paragraph about a bank of weeds, and then the most famous closing sentence in the history of science. He earns both.

Here is how Darwin chooses to finish.

THE PASSAGE EVERYBODY REMEMBERS

“It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us.”

Read what he has actually done there before admiring it.

He does not end on a mountain, or an ocean, or anything grand. He ends on a scruffy bank of weeds at the side of a lane — the most ordinary scrap of England he could have chosen, the kind of thing you would walk past without looking. And he says: this, here, is the whole thing. Everything the book has been about is happening in this hedge.



plants, birds, insects, worms — and every thread between them made by the same laws

FIGURE 35 *The entangled bank. Darwin ends the book not on something magnificent but on a roadside hedge, because the point is that the extraordinary explanation is required by the completely ordinary scene.*

The sentence hiding inside the passage

What comes next is the part almost nobody quotes, and it is the cleverest thing on the page. Having said “produced by laws acting around us,” Darwin then lists the laws:

HIS OWN TABLE OF CONTENTS, DISGUISED AS A SENTENCE

“These laws, taken in the largest sense, being Growth with Reproduction; Inheritance which is almost implied by reproduction; Variability from the indirect and direct action of the external conditions of life, and from use and disuse; a Ratio of Increase so high as to lead to a Struggle for Life, and as a consequence to Natural Selection, entailing Divergence of Character and the Extinction of less-improved forms.”

Growth and reproduction. Inheritance. Variability. A rate of increase that guarantees a struggle. Natural selection. Divergence. Extinction. That is Chapters 1 through 4, in order, in one sentence — the entire book folded up and slipped into the last paragraph.

Then the turn. He looks straight at the ugliest part of his own theory and refuses to soften it:

THE HARDEST LINE IN THE BOOK

“Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows.”

WHAT HE MEANS — The good things came out of the bad ones. Not despite the starving and the dying — *through* them. He does not apologise for this and he does not dress it up. It is the honest cost of the mechanism, and he puts it on the last page rather than burying it in the middle.

And then, finally:

THE LAST SENTENCE

“There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.”

A CAUTION ABOUT THAT PASSAGE

Two things get misquoted here, and both are worth knowing if you are going to quote it yourself.

“By the Creator.” The version most people know reads “originally breathed *by the Creator* into a few forms.” Those three words are not in the first edition. Darwin added them to the second, in 1860, under pressure from critics — and years later he wrote privately that he regretted it, saying he had truckled to public opinion, and that what he actually meant was that life appeared by some process entirely unknown.

“A tangled bank.” That is how the phrase is almost always quoted, and it is how I first learned it. The 1859 text I read says *an entangled bank*.

The word I keep returning to is *grandeur*. He is answering an accusation that had followed the idea around for decades — that if life made itself, life is cheapened. Everything before this sentence is evidence. This sentence is Darwin, once, saying what he thinks it means. He thinks it is the more magnificent story, not the lesser one, and he says so in a single line and then stops.

THE SENTENCE I'D KEEP FROM THIS PART

Darwin spends four hundred pages showing that living things were not made for the world they live in.

And then, on the last page, he insists that this makes them more remarkable rather than less — because a hedge full of creatures that assembled themselves is a stranger and larger thing than a hedge full of creatures that were placed there.

SECTION SEVEN · THE SCORECARD

VII

One hundred and sixty-five years

What held, what broke, what he never imagined — and the two debts the book leaves unpaid on its final page.

Darwin finishes the book owing two things, and he knows it.

He cannot say how inheritance works. And he cannot say how old the earth is. Both gaps are load-bearing — the first because his mechanism needs variation to be passed on intact, and the second because the whole thing needs time on a scale nobody could yet measure. He hands the book over with both accounts open.

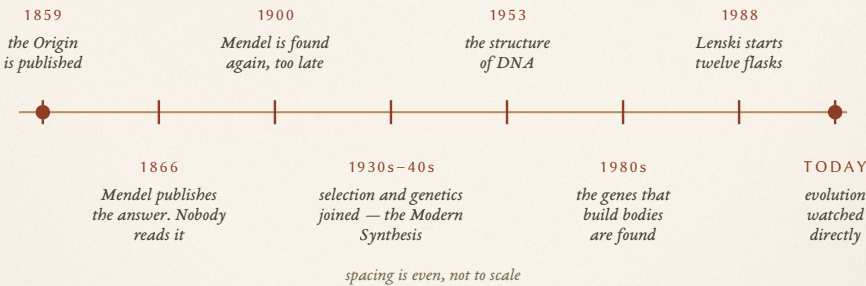


FIGURE 36 *The debt Darwin left unpaid, and how long it took. The answer to his inheritance problem was published seven years after the Origin, sat unread for thirty-four, and was not fully joined to natural selection until the 1940s.*

What held

- **Common descent.** Not merely confirmed — confirmed independently, by a method Darwin could not have imagined. Build a family tree from anatomy, then build one from DNA sequence, and the two trees agree. There was no reason for them to agree unless both are recording the same history.
- **Natural selection.** Observed, measured, and repeatedly caught in the act. It is now a routine experimental subject rather than an inference.
- **The four arguments of Chapter 13.** Every one is stronger than when he made it. Homology turned out to run all the way down to shared genes. Embryology turned out to be shared developmental machinery. Rudiments turned out to include broken genes. And classification really did become genealogy — that is now the whole discipline.
- **The tree.** Groups within groups, produced by branching and extinction, is the organising fact of biology. Darwin drew one diagram in his whole book. It was the right one.

The debts, paid

Inheritance. The answer was published seven years after the *Origin*, by a monk in Brno, and nobody read it — a story I told back in Part One. Gregor Mendel showed that inheritance works in discrete units that stay intact and get reshuffled, which is exactly the kind of inheritance Darwin's mechanism needs and the opposite of the blending he assumed. Rediscovered in 1900. Joined to natural selection through the 1930s and 40s in what is called the Modern Synthesis. Given a physical form in 1953, when the structure of DNA turned out to explain both how a message is copied and how it can be copied wrong.

Time. Radiometric dating, arriving in the early twentieth century, settled the age of the earth at around 4.5 billion years — vastly more than Darwin dared ask for, and far more than the physicists of his day were willing to grant him. I covered that fight in Part Six. He won it posthumously.

What he got wrong

- **Blending inheritance.** His working assumption — that offspring average their parents — would have destroyed his own theory, because averaging halves the variation in every generation and leaves selection nothing to work with. A critic named Fleeming Jenkin pointed this out in 1867 and it genuinely wounded him. The answer was already in print, and neither of them knew.
- **Pangenesis.** His own attempt at a theory of heredity, published in 1868: tiny particles shed by every part of the body and gathered in the reproductive organs. It was wrong, it was tested by his own cousin, and it failed.
- **Use and disuse.** He never fully let go of the idea that an organ strengthened by use could pass on that strengthening, and in later editions he leaned on it more, not less, because he was under pressure. Wrong, and it is the one place where he actually got further from the truth over time.

- The tempo. Darwin needed change to be slow and steady, and read every abrupt jump in the fossil record as a hole in the record. Some of those jumps are real. Mass extinctions have hit the planet repeatedly, at least one of them from an asteroid, and lineages can sit almost unchanged for long stretches and then move fast. The mechanism survives; the metronome doesn't.

What he never imagined

- That heredity is a text. Not a substance, not a fluid — a sequence, written in four letters, copied character by character. Which means descent with modification can be read directly, and errors can be traced the way scholars trace copied manuscripts.
- That the code is universal. The same letters mean the same things in a bacterium, a mushroom, an oak and you. Darwin ended his book with a cautious guess that life began “in a few forms or in one.” The universality of the code is the strongest evidence anyone has ever produced for the second option.
- That evolution can be watched. Peter and Rosemary Grant have measured beak size in Galápagos finches since the 1970s and recorded selection acting from one drought to the next. Bacteria evolve resistance to new antibiotics on hospital timescales. And in 1988 Richard Lenski put twelve flasks of *E. coli* on a shaker and has kept them going ever since — past 80,000 generations, with every ancestor frozen so any point in the history can be replayed. One population spontaneously acquired the ability to feed on a chemical the others can't use. That is a new trait, arising, on camera.
- That the tree has a tangled base. Bacteria swap genes sideways, which Darwin's branching diagram has no place for. And the mitochondria powering your cells are the descendants of a swallowed bacterium. Near the root, the tree is more of a net.
- That selection is not the only editor. Chance matters. In small populations, variants can spread or vanish for no reason but luck — genetic drift — and at the molecular level a great deal of change is of this kind. Darwin said natural selection was the main but not the exclusive means of modification. He was right to hedge.

THE ONE THING THAT WOULD HAVE ASTONISHED HIM

Darwin had no way to test his boldest claim — that everything alive is related. He offered it almost apologetically, as an inference from the pattern.

We can now open a bacterium and a human being and find the same code, the same core machinery for reading it, and in many cases the same genes doing recognisably the same job. The gene that tells a fly where to grow an eye will, when put into a frog, tell the frog where to grow an eye.

He guessed at a shared ancestor from the shape of a filing cabinet. It turned out to be legible in the text.

AND WHAT HAS NOT CHANGED AT ALL

Everything in the paragraph above is machinery Darwin didn't have. None of it altered the argument. Variation happens, some of it is heritable, more are born than can live, and the survivors' traits become commoner. That is still the whole mechanism, and it is still checkable by anybody with patience and a garden.

Which is what makes this book unusual among the great scientific works. Newton's *Principia* needs mathematics. Einstein's papers need more. The *Origin* needs a hedge, a notebook, and the willingness to keep looking past the point where it stops being interesting.

REFERENCE

Every hard word in this part

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

Mutual Affinities

Darwin's title for Chapter 13. *Affinity* means real family relationship, as opposed to mere similarity. His argument is that the affinities naturalists had been mapping for a century were pedigrees.

The Natural System

The arrangement of all living things into groups inside groups — species in genera, genera in families, families in orders. Naturalists believed they were discovering it rather than inventing it. They were right, and Darwin says why: it is a family tree.

Analogical Resemblance

Looking alike because you do the same job, not because you are related. A whale and a shark. A bat's wing and a wasp's. These are the traps of classification — the more useful a feature is, the more likely two unrelated creatures are to have hit on it independently.

Morphology

The study of how bodies are built — the shape and arrangement of parts, as opposed to what they are for.

Homology

The same part, inherited from a common ancestor, doing different jobs in different animals. Your arm, a bat's wing, a whale's flipper and a horse's leg are homologous: one upper bone, two lower bones, a wrist, digits. Not Darwin's word — Richard Owen's — but Darwin supplied the reason it exists.

Unity of Type

The old observation that all members of a great group are built on one plan, whatever their way of life. Taught as a law before Darwin. Explained by him as unity of descent.

Embryology

The study of how a creature develops before birth or hatching. Darwin's use of it: embryos of very different animals resemble each other far more than the adults do, because the early stages are the least edited part of an animal.

Rudimentary Organ

A body part that is clearly a shrunken version of something useful and does no useful work — teeth in an unborn calf, a hip bone in a python, eyes under the skin of a cave fish. The modern word is *vestigial*, which means reduced from an old function, not necessarily useless.

Pseudogene

The molecular version of a rudimentary organ: a gene still present in the genome but broken and switched off. Humans carry a broken vitamin-C gene that most other mammals use — and so do chimpanzees and gorillas, broken in the same place.

Pangenesis

Darwin's own theory of heredity, published in 1868. Every part of the body was supposed to shed tiny particles that gathered in the reproductive organs. It was wrong. He needed a theory of inheritance and, in the absence of Mendel, invented a bad one.

Recapitulation

The claim, associated with Ernst Haeckel rather than Darwin, that an embryo replays its ancestors in order. An overstatement. Darwin's weaker version — that embryos resemble the embryos of ancestors — is the one that survived.

The Modern Synthesis

The joining, in the 1930s and 40s, of natural selection with Mendel's genetics. The two halves of the answer had existed since the 1860s and took seventy years to meet.

Genetic Drift

Change by luck rather than by advantage. In a small population a variant can spread or vanish for no reason at all. It is a second editor working alongside natural selection, and Darwin had no idea it existed.

Descent with Modification

Darwin's own phrase for the whole idea, and better than the word *evolution*, which he barely uses. Things are copies of their parents, with small changes. Everything else in the book follows from that.

REFERENCE

Lines worth remembering

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

- 1 Chapter 13 stops asking whether the theory is possible and starts asking why life is shaped like this rather than any other workable way. That change of question is what wins the argument.
 - 2 Life falls into groups within groups, and nothing forces it to. Designed things borrow freely and form a tangle. Copied things nest — languages, manuscripts, families. Nesting is the signature of copying.
-

-
- 3 The useful features are unreliable evidence of family, because different lineages hit on the same solutions. The useless ones are reliable, because there is no reason to have them twice.
-
- 4 A hand, a mole's spade, a horse's leg, a porpoise's paddle and a bat's wing contain the same bones in the same order. An engineer would not do that four times. A copyist cannot do anything else.
-
- 5 Embryos of very different animals look alike because selection barely touches a stage that is sealed away from the world. The embryo is the least edited draft of the animal.
-
- 6 Rudimentary organs are the silent letters of anatomy — the *k* in *knee*. Useless now, only present because they were inherited, and therefore a clue to where the thing came from.
-
- 7 The entire treatment of human beings in the book is nine words: *Light will be thrown on the origin of man and his history*. He waited twelve years before saying more.
-
- 8 The last page ends on a scruffy bank of weeds, insists that self-assembled life is the more magnificent story, and folds the book's first four chapters into a single sentence on the way out.
-

Part Eight on one page

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

What the last two chapters are for

Everything before Chapter 13 argues that Darwin's mechanism *could* have made the living world. Chapter 13 turns round and asks why the living world is shaped like this rather than some other perfectly workable way — using facts that were already sitting in every museum in Europe. Chapter 14 sums up and looks forward.

Chapter 13 — four kinds of evidence, one explanation

1. **Classification.** Living things fall into groups within groups, and nothing forces that shape. Designed things borrow across categories and form a tangle; copied things nest. The Natural System is a family tree naturalists had been drawing for a century without knowing it.
2. **Morphology.** A human hand, a mole's digging paw, a horse's leg, a porpoise's paddle and a bat's wing all contain the same bones in the same relative positions. Reuse is not an engineering virtue; it is what you are stuck with when you cannot start over.
3. **Embryology.** Embryos of fish, birds and mammals are nearly indistinguishable early on and diverge later — because selection can only act on stages exposed to the world, and an embryo is sealed away. The early stages are the oldest surviving draft.
4. **Rudimentary organs.** Teeth in unborn calves that never cut the gums. Wings sealed under fused beetle cases. A hip and hind legs buried in a python. They cost something and return nothing — the silent letters of anatomy.

Chapter 14 — the summing up

Three observations that anybody can check — things vary, variation is inherited, more are born than can live — plus enough time, produce natural selection, divergence and extinction, and therefore groups within groups. That is the whole machine, and nothing is added to it along the way.

Darwin then predicts that classification will become genealogy, that psychology will be rebuilt, and — in nine words, with no argument attached — that light will be thrown on the origin of man. He waited twelve years before saying more about that.

The last page

He ends on an entangled bank at the side of a lane, lists the laws that made it (which are the book's first four chapters in order), admits that the good came out of famine and death, and closes by insisting there is *grandeur* in a view of life where the forms made themselves. The first edition has no "by the Creator" in that sentence. He added it in 1860 and later regretted it.

165 years on

Held: common descent, natural selection, the tree, and all four arguments of Chapter 13 — now confirmed right down to shared and shared-broken genes. Paid off: heredity, by Mendel and then DNA; deep time, by radiometric dating. Wrong: blending inheritance, pangenesis, use and disuse, and a metronome that was too steady. Never imagined: that heredity is a text, that its code is the same in every living thing, and that chance edits alongside selection.

The whole book, in eight lines

Where we have been since Part One.

PART ONE	The Setup, and the Farmyard Trick	Introduction and Chapter 1. Who Darwin was, what the world believed before him, and how pigeon-breeders and farmers accidentally prove his whole case: given variation and selection, kinds are not fixed.
PART TWO	The Wild and the Quiet War	Chapters 2 and 3. Wild things vary as much as domesticated ones, the line between variety and species is a matter of degree, and everything alive is quietly competing for food, space and a mate.
PART THREE	The Engine	Chapter 4. Natural selection itself, plus divergence of character, extinction, and the only diagram in the book — the branching tree.
PART FOUR	The Cross-Examination	Chapters 5 and 6. The laws variation seems to follow, and then Darwin attacking his own theory: missing intermediates, organs of extreme perfection, the eye.
PART FIVE	The Two Hard Cases	Chapters 7 and 8. Instinct — how a bee inherits mathematics — and hybrid sterility, the apparent hard line through nature exactly where he says there is none.
PART SIX	The Broken Record	Chapters 9 and 10. Why the fossil record is full of holes, why that is expected rather than embarrassing, and what the rocks do show, in order.
PART SEVEN	Why Things Live Where They Live	Chapters 11 and 12. Climate predicts nothing and barriers predict everything. Islands, oceans, and a man in Kent soaking seeds in salt water to prove they can cross one.
PART EIGHT	The Evidence in the Body, and the Last Word	Chapters 13 and 14. Classification, homology, embryos and useless organs — the evidence that only makes sense one way — then the summing up, the entangled bank, and the last sentence.



What I actually think, now that I've finished it

The part where I stop explaining Darwin and tell you what reading him did to me.

I said at the start that almost nobody who quotes this book has read it. I can now say why.

It is not a difficult book. It is a *patient* book, and patience is the harder thing to supply. There is no chapter where the argument is delivered. It accumulates. Darwin will spend nine pages on gooseberries and you will wonder what you are doing, and two hundred pages later the gooseberries turn out to have been load-bearing.

Three things surprised me, and they are not the things I expected to be surprised by.

How careful he is. I came in expecting a revolutionary and found a man building a legal case. He states objections before his critics can. He concedes what he cannot answer. He puts the most damaging fact about his own theory — Chapter 9, the state of the fossil record — in the middle of the book with his name on it rather than hoping nobody notices.

How much he didn't know. He had no genetics, no dates, no mechanism for variation, no idea continents move, and a theory of heredity that would have sunk him if anyone had pushed. And the core still stands, because he built it out of things anybody can check.

How ordinary the evidence is. Pigeons. Weeds. Barnacles. Mud on a duck's foot. A hip bone in a snake. The argument that changed how the species understands itself is assembled almost entirely out of things that were lying around in plain sight, and its author's real gift was refusing to walk past them.

THE THING I DID NOT EXPECT TO TAKE AWAY

You do not have to agree with Darwin to be improved by watching him work.

What I have taken from it isn't the theory — I believed that before I opened the book, the way most of us do, without having earned it. What I took is the habit: state the strongest version of the case against yourself, first, in your own words, before somebody else does. He does it on nearly every page.

If you have read all eight of these, thank you — that is a real amount of your time and I have tried not to waste it. And if they have done what I wanted, they have made you slightly less likely to take my word for any of it. The book is free, long out of copyright, and shorter than you think.

Go and read the thing.



End of Part Eight of Eight · The Evidence in the Body, and the Last Word

End of the series. My own reading of Darwin — Lovepreet Singh

On the Origin of Species, Charles Darwin, first edition, 1859