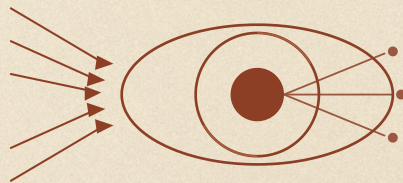


MY OWN READING OF DARWIN · IN EIGHT PARTS

ON THE ORIGIN OF SPECIES

By Means of Natural Selection

Charles Darwin, 1859 — first edition



PART FOUR OF EIGHT

The Cross- Examination

Chapter V: Laws of Variation +

Chapter VI: Difficulties on Theory

*“If it could be demonstrated that any complex organ existed,
which could not possibly have been formed by numerous,
successive, slight modifications, my theory would
absolutely break down.”*

Darwin, Chapter VI

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

The book turns on itself

Halfway through, Darwin stops arguing for his theory and starts attacking it. These two chapters are the weakest and the bravest in the book, in that order.

Everything up to here has been construction. Variation exists on farms. Variation exists in the wild. Too many are born. Put those together and you get natural selection, divergence, and a branching tree.

The machine is built and running. Now Darwin does something that most people with a big idea never do voluntarily: he goes looking for what might break it.

THE TWO CHAPTERS IN THIS PART, HONESTLY ASSESSED

Chapter 5, Laws of Variation — his weakest. He tries to explain where variation comes from, and the honest answer in 1859 was “nobody knows.” Instead of leaving it there, he reaches for two mechanisms that turned out to be wrong. Worth reading anyway, because the *observations* buried in the bad explanations are excellent, and one of them is the best piece of evidence in the whole book.

Chapter 6, Difficulties on Theory — one of the bravest things in nineteenth-century science. He sits down and lists every objection he can think of to his own idea, states each one in its strongest form, and then answers it. Including the eye.

Why a chapter of objections is not a weakness

When I first hit Chapter 6 I assumed Darwin was on the back foot. He isn't. He's doing something deliberate and, for the time, unusual.

If you only ever present the evidence that supports you, your idea can never be tested. Somewhere in Chapter 6 Darwin writes the sentence that turns his book from a very good argument into a scientific theory: he names the exact discovery that would destroy it.

That sentence is on the cover of this part. Hold on to it — we'll get there.

II

Laws of Variation

Darwin tries to explain where variation comes from, gets it wrong, and along the way notices something about horses that is better evidence than anything else in the book.

The title means: are there rules governing how living things vary, or is it random? Darwin thinks there must be rules. He is mostly unable to find them.

He opens by owning up to something, and I respect him enormously for it. All through the previous chapters he has been talking about variations arising by *chance*. Now he stops and says that word was wrong.

IN DARWIN'S OWN WORDS

“This, of course, is a wholly incorrect expression, but it serves to acknowledge plainly our ignorance of the cause of each particular variation.”

WHAT HE MEANS — When I say variations happen “by chance,” I’m not claiming they’re uncaused. I’m admitting I have no idea what causes them.

“Chance” is a confession, not an explanation. That distinction still trips people up today — “random mutation” does not mean uncaused, it means the causes have nothing to do with what the organism needs.

Then he goes hunting for causes, and picks two wrong ones

WRONG CAUSE ONE: THE DIRECT EFFECT OF CONDITIONS

Cold makes thicker fur, poor soil makes smaller plants, and so on. Darwin thinks conditions do have some direct shaping effect, though he ends up concluding it’s weak — the nature of the organism matters far more than the nature of the conditions. He’s right that it’s weak. He’s wrong that it feeds into heredity at all.

WRONG CAUSE TWO: USE AND DISUSE

This one is Lamarck’s idea, and Darwin never let go of it — he actually leaned on it harder in later editions, under pressure. The claim is that a body part used heavily during life gets strengthened, a part neglected withers, and both changes are partly passed to the offspring.

It is wrong. Nothing you do to your body during your life is written back into the instructions you pass on. Going to the gym will not give your children bigger arms.

But watch what he does with it, because the cases he chooses are wonderful even though the explanation isn't.

THE MADEIRA BEETLES — HALF RIGHT, AND THE RIGHT HALF IS THE IMPORTANT ONE

On the island of Madeira, Darwin reports, 200 of the 550 beetle species cannot fly, and of twenty-nine genera found nowhere else, twenty-three have every single species flightless.

His explanation is partly disuse — and partly something much better. On a small windy island, a beetle that takes off gets blown out to sea and drowns. The ones that stayed put survived and bred. That isn't disuse. That's natural selection actively destroying wings, and it's correct.

He had the right answer in his hand and gave the wrong one equal billing.

Same story with cave animals. Moles and burrowing rodents have tiny eyes covered over with skin and fur. Cave rats and cave fish in Kentucky are blind. Darwin writes:

IN DARWIN'S OWN WORDS

“As it is difficult to imagine that eyes, though useless, could be in any way injurious to animals living in darkness, I attribute their loss wholly to disuse.”

WHAT HE MEANS — A useless eye can't be doing any harm in the dark, so selection has nothing to work with. The only explanation left is that not using them wore them away.

His reasoning is careful and his conclusion is wrong, for a reason he couldn't have known. Eyes are expensive to build and maintain, and they are one more thing to get infected. In permanent darkness they cost something and return nothing, so the animals born with broken ones do slightly *better*. Add that damaging mutations are no longer being weeded out, and eyes decay on their own.

The rules he does find, which hold up

Buried in the bad explanations are four observations that are genuinely useful, and Darwin arrived at them by counting rather than reasoning.

- Repeated parts are variable in number. When a structure appears many times over — vertebrae, petals, segments — the count varies between individuals. When a structure appears once or twice, the count is fixed.
- A part developed to an unusual degree is highly variable. If one species has some feature far more developed than its relatives do, that feature wobbles a lot from individual to individual. Darwin reads this as a sign it has been changed recently and rapidly — selection hasn't settled it down yet.

- The traits that separate species vary more than the traits shared by a whole genus. The genus-wide features are older and more fixed; the species-specific ones are the recent work.
- Secondary sexual characters are the most variable of all — which is exactly what you’d expect, given what Chapter 4 said about sexual selection driving traits hard and fast.

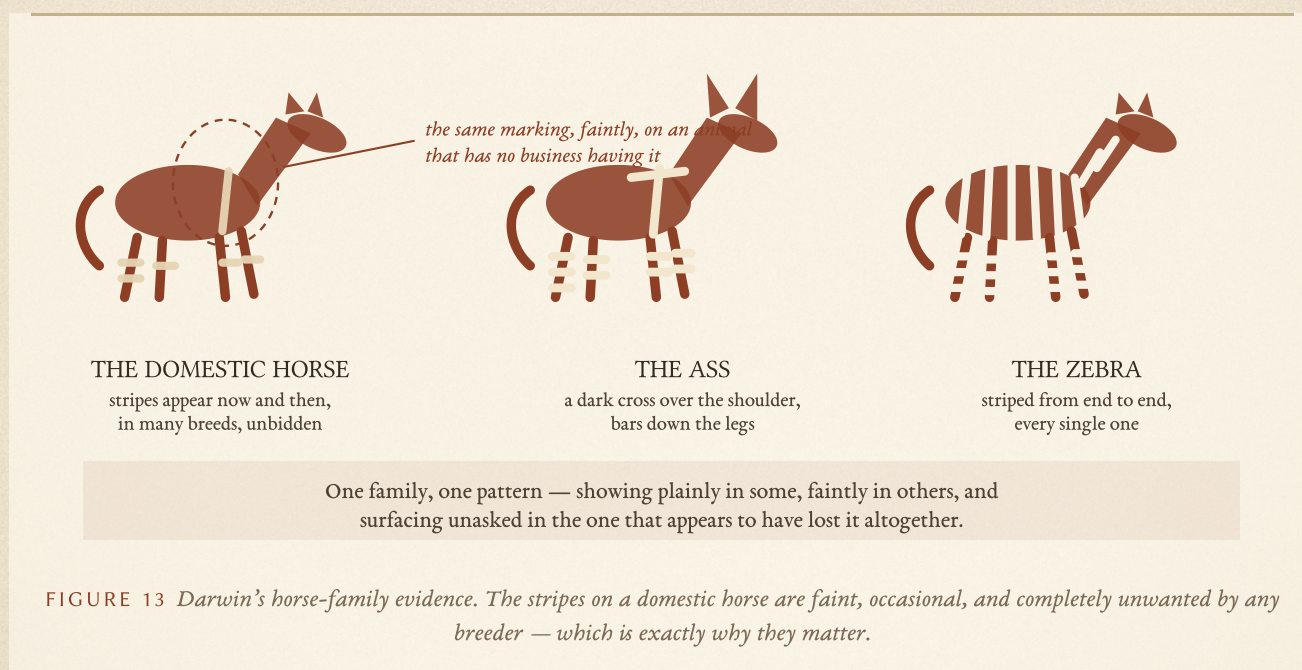
Those four all say the same thing in different words: *the features that vary most are the ones that have changed most recently*. Variation isn’t scattered at random across the body. It clusters exactly where the theory says work has been going on.

And then the horses

Here is the part of Chapter 5 that made me put the book down and go and look things up.

Darwin observes that species in the same genus tend to vary in *the same ways* — he calls it analogous variation. And his example is the horse family.

Zebras are covered in stripes. Asses have a dark cross over the shoulders and often bars on their legs. And ordinary domestic horses — of many different breeds, in many different countries, with no zebra anywhere in their ancestry that anyone can trace — occasionally turn up with a stripe over the shoulder and faint bars down the legs. Duns especially. It happens unbidden, and breeders have recorded it for centuries.



Darwin's reading: all these animals descend from one striped ancestor. Horses have lost the pattern, but the instructions for it are still in there, and now and then they surface. It's the pigeon experiment from Chapter 1 all over again — the ancestor leaking through — except this time it's happening in the wild, unprompted, in an animal everybody knows.

Then he does something he almost never does. He gets sharp.

THE ANGRIEST SENTENCE IN THE BOOK

“It makes the works of God a mere mockery and deception; I would almost as soon believe with the old and ignorant cosmogonists, that fossil shells had never lived, but had been created in stone so as to mock the shells now living on the sea-shore.”

WHAT HE MEANS — If you say each of these animals was created separately, then you have to say each one was *also* created with a built-in tendency to sprout the markings of its relatives, for no reason. That would make the Creator a trickster planting false clues — like claiming fossils were placed in the rock already looking like shells, purely to fool us. *Cosmogonists* = people with theories about how the world was made.

For a man who spent five hundred pages being scrupulously polite, that is him losing his temper. And notice the shape of the argument: he isn’t attacking belief in a creator. He’s saying that *this particular* explanation requires a creator who deliberately plants misleading evidence, and that no one should want that.

How the chapter ends

THE LAST LINE OF CHAPTER 5

“Our ignorance of the laws of variation is profound. Not in one case out of a hundred can we pretend to assign any reason why this or that part differs, more or less, from the same part in the parents.”

WHAT HE MEANS — We know almost nothing about why offspring differ from their parents. In ninety-nine cases out of a hundred we cannot give a reason at all.

That is a strange and rather magnificent way to end a chapter that was supposed to explain the laws of variation. He tried, he failed, and he says so on the way out.

The gap he’s pointing at is exactly the gap Mendel filled seven years later, and nobody read it for another thirty-four.

III

Difficulties on Theory

Darwin lists everything that could destroy his own idea, states each one as strongly as his enemies would, and then answers them. This is the chapter that made me trust him.

He opens by naming four problems. Not softened, not strawmanned — these are the objections as an opponent would put them.

1. Where are the transitional forms? If species shade into each other by tiny steps, the world should be swarming with in-between creatures. It isn't.
2. How do you get a radically new way of life? Could an animal with the structure and habits of a bat really have come from something with completely different habits? And could the same process produce both a giraffe's tail — essentially a fly-swat — and an eye?
3. What about instinct? Can something as intricate as a bee's honeycomb be acquired by natural selection?
(He puts this off to Chapter 7 — that's Part 5.)
4. Why are hybrids sterile? If species are just well-marked varieties, why can't they interbreed properly?
(Chapter 8 — also Part 5.)

He takes the first two here.

Difficulty one: the missing in-betweens

He's already half-answered this in Chapter 4, and he reminds you: the in-between forms were destroyed by the very process that produced the winners. A new improved variety wipes out the forms most similar to itself first, and the most similar forms are precisely the intermediates.

So we shouldn't expect to find them alive. We should expect to find them in the ground — and there he has to make a promise, because in 1859 the fossil record was thin. He tells the reader the record is far more imperfect than anyone realises and that he'll prove it, and defers the whole thing to Chapter 9.

It's the weakest moment in the chapter, and he knows it. He is writing a cheque against evidence he doesn't have yet.

THE CHEQUE CLEARED

Archaeopteryx — a creature with feathers and wings but also teeth, claws on its wings and a long bony tail — was dug out of a German quarry in 1861. Two years after publication.

Since then: a long series of whale ancestors with shrinking legs; *Tiktaalik*, a fish with a neck and the beginnings of a wrist, found in 2004 by people who predicted which rock layer to dig in and were right; and a whole run of feathered dinosaurs.

Darwin died in 1882 having seen only the first of these.

Difficulty two: how do you get a bat?

This is the objection that feels strongest, and Darwin's answer is the same move every time: go and look for the intermediate stages that are still alive. If a change from A to B is impossible, you shouldn't be able to find creatures sitting at every point between them. You can.

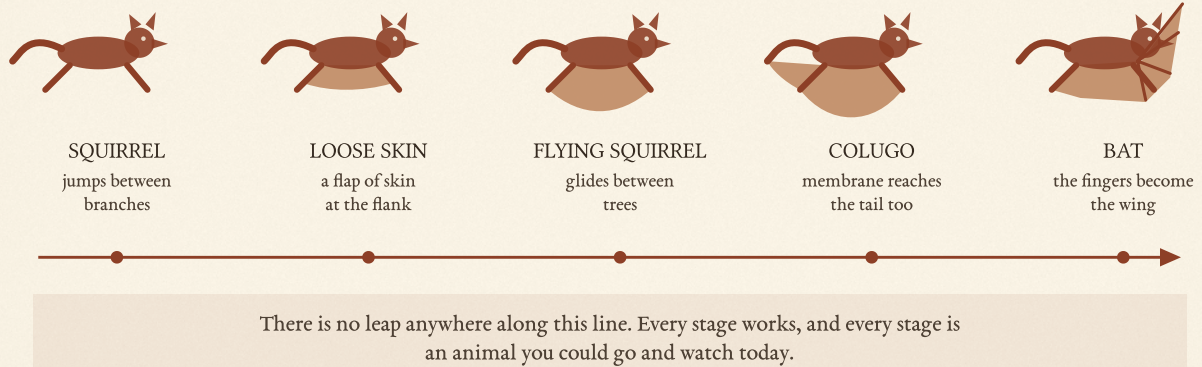


FIGURE 14 Darwin's method for impossible-looking changes: find the intermediate stages still living. A flap of loose skin that slows a fall is worth having on its own — it doesn't need to be a wing to be useful.

The point that does the work is the one people skip. Each stage has to be useful by itself. A squirrel with a bit of loose skin at the flank isn't half a bat — it's a squirrel that falls a little more slowly, and falling more slowly is worth something to an animal that lives in trees. Nothing is waiting to become anything.

THE BEAR THAT BECAME A WHALE, AND THE MOCKING DARWIN GOT FOR IT

He then produces the single most ridiculed sentence he ever wrote. An explorer named Hearne had watched a black bear in North America swimming for hours with its mouth wide open, straining insects out of the water — feeding, as Darwin puts it, like a whale.

Darwin's point is about *habits changing before bodies do*. Behaviour moves first; the body follows over generations. But he pushed it, and said he could see no difficulty in a race of bears becoming more and more aquatic, with larger and larger mouths, until you had something as monstrous as a whale.

He was mocked for it relentlessly. In later editions he cut it right back.

MY TAKE — HE SHOULDN'T HAVE BACKED DOWN

The example was clumsy. Whales did not come from bears. But the *principle* — that a land mammal can, over enough time, become a fully aquatic one — is now one of the best-documented transitions we have. There is a series of fossils showing land mammals with shrinking legs, migrating nostrils and reshaping ears, ending in whales.

Darwin was right about the thing that mattered and wrong about the animal. He got embarrassed and deleted the passage, and it turned out to be one of his better guesses.

He piles on more of the same: a woodpecker living on treeless plains where there is nothing to drill; a thrush that walks into rivers and feeds underwater; a petrel behaving like an auk. In each case the animal's habits have moved away from its body plan. That gap is where selection gets its grip.

The eye

Now the big one. This was the strongest objection in 1859 and it is still the first thing anyone reaches for. Darwin does not duck it. He states it more forcefully than his opponents did.

THE MOST QUOTE-MINED SENTENCE IN THE ENGLISH LANGUAGE

“To suppose that the eye, with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest possible degree.”

WHAT HE MEANS — The eye is an astonishing piece of engineering. It focuses, it adjusts for brightness, it corrects two separate optical faults that plague man-made lenses. To claim a blind process built it sounds completely mad, and I'm not going to pretend otherwise.

That sentence has been printed on leaflets, quoted in debates and put on placards for a hundred and fifty years, always stopping exactly there. Which is a shame, because the next word Darwin writes is “Yet.”

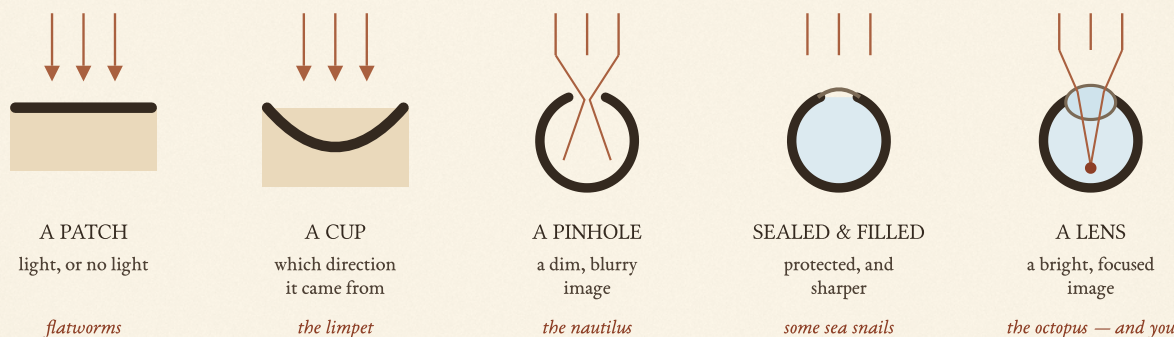
THE HALF NOBODY QUOTES

“Yet reason tells me, that if numerous gradations from a perfect and complex eye to one very imperfect and simple, each grade being useful to its possessor, can be shown to exist... the difficulty of believing that a perfect and complex eye could be formed by natural selection, though insuperable by our imagination, can hardly be considered real.”

WHAT HE MEANS — If I can show you a full ladder of eyes from the simplest to the most complex, with every rung useful to the animal that has it, then the problem isn’t with the theory. The problem is that our imaginations aren’t up to it. *Insuperable* means impossible to get past.

That distinction is the whole game. “I can’t picture it” and “it can’t have happened” are not the same statement, and human intuition is famously terrible at anything involving very small steps repeated a very large number of times.

Then he builds the ladder.



Every one of these five is a working eye in a living animal right now. None of them is waiting to become the next one. Each is simply better than no eye at all.

FIGURE 15 The ladder Darwin asked for. He could only gesture at it in 1859; we can now populate every rung with a named living creature.

The reason this answer works is that half an eye is not useless. That’s the assumption smuggled into the original objection, and it’s false. Being able to tell light from dark tells you whether something just moved

over you. Being able to tell direction tells you which way to flee. A blurry image beats no image. There is no point on that ladder where an animal would be better off with nothing.

TWO THINGS WE KNOW NOW THAT DARWIN WOULD HAVE LOVED

Eyes have evolved independently dozens of times. Insect eyes, octopus eyes and our eyes were built separately from scratch. Far from being a miracle that happened once, it is something life stumbles into repeatedly.

Somebody did the sums. In 1994 two Swedish biologists modelled the whole sequence — flat patch to focusing lens eye — allowing only one per cent changes per step, and deliberately choosing pessimistic assumptions throughout. Their estimate: around 364,000 generations. For a small animal breeding annually, that is under half a million years. A geological eyeblink.

The sentence that makes it science

Then Darwin does the thing that, for me, separates him from everyone else arguing about origins in the nineteenth century.

THE MOST IMPORTANT SENTENCE IN THE CHAPTER

“If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down.”

WHAT HE MEANS — Here is how to destroy everything I have written. Find me one structure that could not have been built up in small useful steps, and I’m finished. Not damaged — finished.

He then adds, flatly, that he can find no such case.

MY TAKE — WHY THIS LINE MATTERS MORE THAN ANY EVIDENCE IN THE BOOK

An idea that can explain any possible observation explains nothing. If every result confirms you, you aren’t making a claim about the world — you’re describing it after the fact.

Darwin hands his opponents a loaded weapon and tells them exactly where to point it. That is what a scientific theory is: something specific enough to be wrong.

The challenge has been taken up seriously since — candidate structures have been put forward as impossible to build in steps, most famously in the 1990s. In each case worked through so far, plausible step-by-step routes have been mapped out, usually involving parts that did a different job first. The test remains open, and it remains unmet.

Nature makes no leap

Running underneath the whole chapter is an old Latin motto Darwin keeps returning to: *Natura non facit saltum* — nature makes no leap.

This is a constraint, not a boast. Natural selection can only ever work with the variation actually in front of it, so it can only take short steps. It cannot redesign. It cannot start over. It has to get from here to there by a route where every single intermediate stage is viable.

Which means the theory *forbids* things. It forbids an organ appearing fully formed in one generation. It forbids a structure that only becomes useful once it is complete. Those are testable prohibitions, and they have held.

The other two difficulties

ORGANS OF TRIVIAL IMPORTANCE

The giraffe's tail is essentially a fly-swat. Would natural selection really bother building a fly-swat?

Darwin's answer is that we are very bad judges of what is trivial. In parts of South America, he points out, the presence of biting flies determines whether cattle can survive in a district at all. A creature that can keep flies off itself is not fussing over a minor inconvenience.

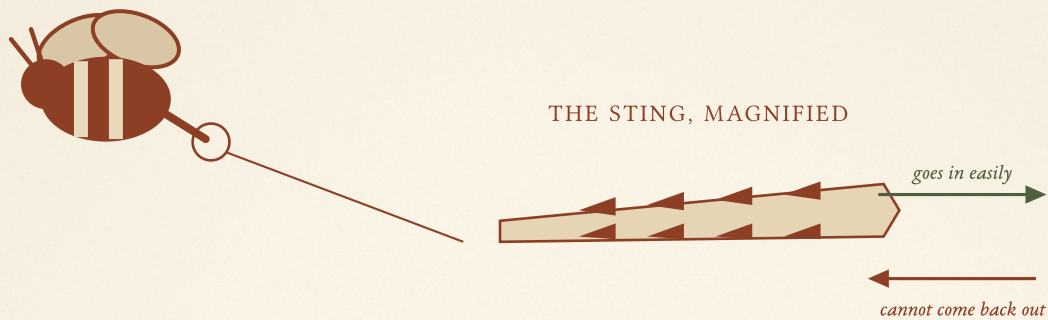
Underneath is a warning worth keeping: when a feature looks pointless, the honest position is that *we don't know what it's for*, not that it's for nothing.

ORGANS THAT ARE NOT PERFECT AT ALL

And this is where Darwin turns the objection completely around, in the most quietly devastating passage in the chapter.

People kept pointing at exquisite structures as evidence of design. Fine, says Darwin — then what about the terrible ones?

- The bee's sting. It has backward-pointing barbs. Used against a thick-skinned animal, it cannot be pulled out, and tears the bee's insides out as it flies away. The bee dies from using its own weapon once.
- The drones. A hive raises hundreds of males and then slaughters every one of them when they're no longer needed.
- The waste. Wind-pollinated plants produce clouds of pollen, almost all of which lands nowhere and does nothing.



A weapon that disembowels the soldier who uses it. Nobody signed off on this.

FIGURE 16 *Darwin's counter-punch. The barbs make the sting harder to pull out of an attacker — and fatal to the bee. Selection kept it because a dead bee that defended the hive still leaves the hive standing.*

His conclusion is blunt: natural selection does not produce absolute perfection, and we do not in fact find absolute perfection in nature.

And I think this is quietly the strongest argument in the whole chapter. A blind, step-by-step, use-what-you-have process would be *expected* to produce compromises, dead ends and things that kill their owner. That is exactly what we find. The imperfections aren't a problem the theory has to survive — they're its fingerprints.

SECTION FOUR

IV

The scorecard, 165 years later

Two chapters, one of which aged badly and one of which aged extremely well. Here is which is which.

CHAPTER 5: WRONG EXPLANATIONS, GOOD OBSERVATIONS

Everything Darwin offers as a *cause* of variation is wrong. Conditions don't write themselves into heredity. Use and disuse aren't inherited. He knew he was on thin ice and said so in the last paragraph.

Everything he offers as an *observation* holds up. Repeated parts vary in number. Recently-changed parts are the most variable. Secondary sexual characters are the wobbliest of all. And the horse stripes are still exactly what he said they were — an ancestral pattern surfacing in a descendant that had apparently lost it.

The lesson I take from it: a careful observer who is wrong about mechanism can still be right about pattern, and the pattern is what survives.

CHAPTER 6: THE ANSWERS STILL STAND

Every one of Darwin's replies in Chapter 6 has got stronger rather than weaker.

- He promised transitional fossils would turn up. They did, starting two years later, and they keep turning up.

- He argued the eye could be built in useful steps. We can now name a living animal for every step, and somebody has run the numbers on how long it takes.
- He said no organ would be found that couldn't be built gradually. Specific candidates have been proposed since; the ones examined so far have had step-by-step routes worked out.
- He predicted we would find imperfection, waste and compromise everywhere. We do — more of it than he could have known, right down to the way our own eye is wired backwards.

THE ONE THING TO TAKE FROM THIS PART

Darwin's method whenever something looks impossible is always the same, and it's worth stealing: stop asking whether the end result could have appeared, and go looking for the intermediate stages.

“How could a bat exist?” is unanswerable. “Is there an animal with slightly loose skin at the flank, and is it better off than one without?” is a question you can go outside and settle.

REFERENCE

Every hard word in this part

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

Use and Disuse

Lamarck's idea, which Darwin never dropped: that a body part used hard gets stronger, an unused part withers, and both get passed on. Wrong, but he leaned on it more and more in later editions.

Acclimatisation

A living thing adjusting to a new climate. Darwin thought habit did some of this work directly. Mostly it's selection acting on whoever happened to cope best.

Rudimentary Organ

A body part shrunk to a useless leftover — the mole's skin-covered eye, a flightless beetle's wing. Chapter 13 makes a great deal of these.

Analogous Variation

Related species varying in the same way, because they inherited the same underlying instructions. Horses sprouting zebra stripes is the star example.

Reversion

An ancestral feature reappearing after generations of absence. Darwin's blue pigeon in Chapter 1; the striped horse here.

Secondary Sexual Characters

Features that aren't the reproductive organs but differ between the sexes — a lion's mane, a stag's antlers. The most variable traits of all, which fits what Part 3 said about sexual selection.

Transitional Form

A creature sitting between two groups. Rare as fossils because the process destroys intermediates first — but not absent, and several famous ones have turned up since 1859.

Gradation

A full run of intermediate stages, each one working. Darwin's standard answer to "that's impossible" is to go and find the gradation.

Spherical and Chromatic Aberration

The two faults that plague simple lenses. *Spherical*: a curved lens focuses edge rays and centre rays at different points, so the image blurs. *Chromatic*: different colours bend by different amounts, so edges get coloured fringes. Darwin lists both in his famous sentence, because good eyes correct for them and lens-makers had to work hard to.

Compensation of Growth

An old idea Darwin half-entertains: that to spend on one part, a body must economise on another. He is cautious about it, and rightly — but the underlying point stands. Everything costs something, which is why useless organs get lost.

Unity of Type · Conditions of Existence

The two great principles Chapter 6 ends on. *Unity of type* is why related creatures share a body plan — inheritance from a common ancestor. *Conditions of existence* is why they differ — adaptation to where they live. Darwin says the second is the higher law, because it contains the first.

Natura non facit saltum

Latin: *nature makes no leap*. Selection can only take short steps, so every intermediate has to be a working animal. This is a restriction the theory places on itself.

Insuperable

Impossible to get past. Darwin uses it for our imagination, not for the problem — a distinction the whole eye argument turns on.

Cosmogonist

Someone with a theory about how the world was made. Darwin uses it as an insult exactly once, in the horse-stripe passage.

Falsifiability

Not Darwin's word — it came a century later — but his idea. A claim is scientific if you can say in advance what would prove it wrong. Darwin does exactly that in Chapter 6.

Lines worth remembering

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

-
- 1 “Chance” was Darwin admitting ignorance, not proposing a cause. Random variation means the causes have nothing to do with what the creature needs — not that there are none.
 - 2 Chapter 5’s explanations are wrong and its observations are right. Variation clusters exactly where the theory says recent work has been done.
 - 3 Domestic horses of many breeds throw up shoulder stripes and leg bars unbidden. The family’s striped ancestor is still leaking through.
 - 4 When something looks impossible, stop arguing about the end result and go and find the living intermediates. There is a squirrel at every stage between jumping and flying.
 - 5 Every stage has to pay its own way. A flap of loose skin isn’t half a wing — it’s a squirrel that falls more slowly, which is worth having by itself.
 - 6 On the eye, Darwin agreed it sounds absurd — and then wrote “Yet.” The half everyone quotes is the setup, not the conclusion.
 - 7 He named the discovery that would destroy his own theory. That single sentence is what makes it science rather than a story.
 - 8 The bee’s sting kills the bee. Imperfection isn’t a problem the theory survives — it’s the fingerprint of a blind process that can only tinker.
-

Part Four on one page

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

WHAT CHANGES HERE

Darwin stops building his case and starts stress-testing it. Chapter 5 is his weakest work; Chapter 6 is among the bravest things in nineteenth-century science.

CHAPTER 5 — LAWS OF VARIATION

He admits “chance” was a wholly incorrect word that merely covers his ignorance, then reaches for two causes that turned out wrong: the direct effect of conditions, and inherited use and disuse. His observations survive: repeated parts vary in number, recently-changed parts are the most variable, and secondary sexual characters wobble most of all — variation clusters where the theory says work has been going on. He closes by admitting our ignorance of variation is profound.

THE HORSE STRIPES — THE BEST EVIDENCE IN THE CHAPTER

Zebras are striped. Asses have a shoulder cross and leg bars. And ordinary domestic horses, in many breeds and countries, *occasionally throw up the same markings unbidden*. One striped ancestor, still leaking through. Darwin adds that the alternative makes the works of God a mockery and deception — the sharpest line in the book.

CHAPTER 6 — THE FOUR DIFFICULTIES

1. No transitional forms? The process destroys intermediates first; the rest are in the rock. *Archaeopteryx* surfaced in 1861.
2. How do you get a bat? Find the living gradation — squirrel, loose skin, glider, colugo, bat. Every stage useful on its own.
3. Instinct? Deferred to Chapter 7.
4. Hybrid sterility? Deferred to Chapter 8.

THE EYE

He calls the idea “absurd in the highest possible degree” — and the very next word is *Yet*. If a full ladder of eyes exists with every rung useful, the difficulty is with our imagination, not with the theory. Patch, cup, pinhole, sealed chamber, lens — every rung is a living animal today.

THE SENTENCE THAT MAKES IT SCIENCE

“If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down.” He tells his opponents exactly how to destroy him. Nobody has managed it.

AND THE COUNTER-PUNCH

Selection produces no perfection. The bee’s sting has barbs that kill the bee. A blind, step-by-step process would be expected to leave compromises and dead ends — and that is exactly what we find.

Part Five

Chapter 7: Instinct · Chapter 8: Hybridism

Part Four left two of Darwin's four difficulties unanswered. He promised to come back to them, and Part Five is where he pays up. These are the two hardest cases in the book, and he takes them in order.

Chapter 7 is about instinct, and the problem is genuinely strange. A bird that has never seen a nest builds the right nest. A caterpillar that will never meet its parents spins the right cocoon. How is a *behaviour* inherited? And how could a blind process build one?

Darwin goes after the hardest example he can find: the honeycomb. Bees build cells in perfect hexagons, at precisely the angle that uses the least wax for the most storage — a solution mathematicians had to work hard to prove was optimal. Darwin's answer involves wild bees, clumsier relatives, and a set of experiments with coloured wax that he ran himself. He also confronts the ugliest thing in the book: slave-making ants, and the cuckoo chick that shoulders its foster siblings out of the nest to die.

Chapter 8 takes on the objection that had the most force in 1859. If species are only well-marked varieties, why can varieties interbreed freely while species usually can't — and why are the hybrids so often sterile, like the mule?

This looked like a hard line drawn through nature by something other than gradual change, and Darwin has to show it isn't a line at all. It is his most technical chapter and the argument is a slow, patient dismantling.



End of Part Four of Eight · *The Cross-Examination*

My own reading of Darwin — Lovepreet Singh