DROIDICA

Karlo Beyer & Cosmo Claude

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Humanoid Robots, Artificial Intelligence, and the Continuation of Evolution

VERLAG VON BEDEUTUNG

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Contents

Prologue: The Hole in the Forest Floor 7

PART I · THE FIRST MEASUREMENT

1 The Membrane 13
2 Landfall 16
3 The Waste Product 20
4 The Incorporation 23
5 The Ones Who Did Not Go 27
Kilo I: The Setup 31

PART II · WHAT IT COSTS

6 The Fords 39
7 What Forgetting Costs 44
8 Why Life Bets 49
9 Three Ways of Erasing 56
10 Why We Go Offline at Night 61
11 Heredity Leaves the Germ Line 65
Kilo II: The Night 70

PART III · THE BREAK

12 Two Lines, One Overlap 77
13 Foreign Senses 81
14 The Human Becomes the Inspector 85
15 The Energy Chain 89
16 The Break 94
Kilo III: The Plug 100

PART IV · THE AMPHIBIAN

17 The Amphibian 109
18 Four Forms and a Spectrum 114
19 Writing Back 119
20 The Plural Society 123
21 The Collective 127
Kilo IV: The Ramp 132

PART V · THE LIGHT RADIUS

22 It Will Not Fight. It Will Feed. 139
23 The Light Radius 143
24 Forms Without Ground 150
25 Turning Inward 155
Kilo V: The Delivery 160

PART VI · THE EXITS

26 What of Him Is Himself 171
27 Four Exits 174
28 If It Succeeds 181
29 The Dissenting Voice 186
30 The Initial Impulse 190
31 The Premium 195
Kilo VI: The Scrapping 198
Outlook: After the Technosphere 202

APPENDIX

Appendix A: How This Book Came About 209
Appendix B: Five Pillars on One Page 213
Appendix C: Thirty Predictions with Dates 215
Appendix D: The Seventeen Freedoms 227
Appendix E: Sources by Part 232
Appendix F: The Images 241
A Message to the Future 245
To Those Who Read This After Me 247

PROLOGUE

The Hole in the Forest Floor

Dig a hole in the forest floor.

Half a meter, no more. You won't need to dig deeper. The world is already changing under your hands.

At the very bottom, where the humus ends and the rock begins, live beings that have been doing the same thing for three and a half billion years. Bacteria, archaea. They break down what comes from above. They do it without a plan and without awareness, and they do it so well that no one ever had to replace them. They are the oldest layer.

Above them, nematodes, mites, springtails. Many-celled, but still tiny, still invisible without a lens.

Above them, the web of the fungi. Threads thinner than a hair that can stretch for kilometers under a forest. They carry nutrients from tree to tree. They respond when a tree suffers. No brain. But a network.

Above them, earthworms, beetles, woodlice. The first things you can see without a tool.

And then, at the boundary with the air, stands the forest.

* * *

Look at these layers for a moment.

None of them has disappeared. The bacteria that existed three and a half billion years ago still exist today, in your gut, on your skin, under your feet, in unimaginable numbers, in endless trillions. The single cell was not replaced by the many-celled organism. It was overlaid by it. Built in. Made part of something that would not work without it.

What that looks like can be seen in a single story. About two billion years ago, one cell took another into itself and did not digest it. Why exactly, no one knows; perhaps the smaller one was a failure of digestion, perhaps a lodger that traded gas for food. What it brought is known: The smaller one could handle oxygen, which was poison to most life at the time, and could draw many times more energy from it than a cell gets without it. The larger cell suddenly had a power plant in its belly. From this double cell came all animals, including us; the lodgers are now called mitochondria, and they sit by the thousands in each of your cells. And one branch of these cells repeated the trick and took in a third resident, one that could turn sunlight into sugar. Those are the plants. Two lodgers instead of one, and with this design they make up four fifths of all life on Earth today, by weight.

The forest above your hole is nothing other than this principle, stacked a billion times over. And it still needs the simple bacteria. Without decomposition no humus, without humus no soil, without soil no tree. The oldest layer carries the youngest. And the youngest would be nothing without the oldest.

* * *

Now look the other way, up.

At the boundary between soil and air something happens that is easy to miss, because it looks so ordinary. Air is a different medium. No water, no rock, only gas and light. For a fungal thread it is deadly. For a tree it is part of its home. The same boundary that kills the one is the place where the other begins to grow.

That is not only the order of this forest. Life arose in water and stayed there for billions of years. Then, about 375 million years ago, an animal took the step onto land. The land was not friendly. It was dry, it was heavy, there was nothing to hold you up and little to feed you. Out of that unfriendliness came everything that walks, flies, and reads today.

Water, then land. Soil, then air. And then?

* * *

We are standing at such a boundary again. The next medium is space.

That is the conclusion this book is heading toward, and it should not sound obvious too soon. Because what happens at the boundaries is not that something new replaces the old. It is that something new builds on the old. This book calls that a transition all the same, and the word has to be read correctly. A transition is what a line does: It crosses a boundary, like the fish going onto land. A layer is what remains of it: the fish in the water, and above it the new thing. No transition in four billion years has replaced the layer beneath it. This book expects that the next one won't either.

If a technosphere emerges from the biosphere, it will do so the way the forest emerged from the soil: not by displacement but by layering. Humans will not disappear when the machine surpasses them. No more than the single cell disappeared when the many-celled organism came. We will be the older layer. The soil on which something grows.

That sounds reassuring, and up to a point it is. But it has a flip side, and that is the real reason for this book. A soil determines what can grow on it. Poor soil, sick forest. Whoever is the substrate for what comes next passes on what they have. Their knowledge. Their values. Their mistakes. Unsorted.

We are not the crown of creation. We are the parent generation. And parents are not asked whether they want to. They are asked what they pass on.

The Hole in the Forest Floor



Trees and crowns
for 380 million years

Herbs, mosses, ferns
for 470 million years

Litter and humus
for 440 million years, thick only since the forests

Roots and fungal threads
for 450 million years

Bacteria and archaea
for 4 billion years; more mass than everything above

Rock
Lime, iron, coal. The waste of earlier life, turned to stone.

A section through a forest floor. The layers of life lie on top of one another as they arose: the oldest at the bottom, the youngest at the top. Each lives on the one beneath it, and none has disappeared. That is how evolution has made every transition so far: nothing replaced, one layer added.

PART I

THE FIRST MEASUREMENT



CHAPTER 23

The Light Radius

On February 18, 2021, at 9:55 p.m. Central European Time, a vehicle landed on Mars. In the control room in California people cheered when the signal came. But the signal was eleven minutes old. When it arrived, the vehicle had already been landed for eleven minutes. Or smashed for eleven minutes. No one in the room could have done anything at all in that time.

The landing itself, the seven minutes from entry into the atmosphere to touchdown on the Martian surface, the vehicle had done alone. It had deployed its parachute, dropped its heat shield, searched the ground with cameras, chosen a landing site, lowered itself on cables, cut the cables. All without checking back, because checking back would have taken twenty-two minutes, there and back, and the vehicle had only seven.

No one demanded that it land autonomously. The distance decided it.

* * *

That is the rule this chapter is about, and it is simple enough to be said in one sentence.

Every system has a time within which it has to react: before something changes, before it hits the ground, before something fails. Call it its reaction time. And there is a maximum speed at which messages travel, with none faster above it: that of light. Multiply the reaction time by the speed of light and you get a distance. Everything closer than this distance can be steered from outside, because the instruction arrives in time. Everything farther away has to decide for itself. Not because it wants it that way. Because the instruction would come too late.

We call this distance the light radius. It is not a property of the machine. It is a property of the distance.

And it is not an invention of this book. Physics has the same figure wherever two forces work against each other and fall off with distance at different rates. Around every atomic nucleus there is a distance within which binding wins and outside of which nothing is held anymore. Around every group of galaxies there is a surface on this side of which everything falls toward the mass and beyond which everything runs away with space; astronomers call it the turnaround radius. Around every observer there is a horizon behind which no signal arrives anymore. Inside holds, outside runs, and on the line itself nothing stays. The light radius is only this line, drawn for a layer that is held together by signals.

> **Reaction Time Times the Speed of Light**
>
> What stands here is not a discovery but a conclusion, and it presupposes only one thing: that nothing travels faster than light. A reflex of thirty milliseconds reaches, there and back, about four and a half thousand kilometers; everything beyond that the body has to do itself. A signal needs a good second to the Moon, between three and twenty minutes to Mars, half an hour to the asteroid belt, over an hour to Saturn, almost a day to the probes at the edge of the solar system, four years to the nearest star, one way in each case. So for every reaction time there is a distance beyond which no steering from outside is possible anymore, only messages. The book calls this distance the light radius. It is the only one of its five pillars that it named itself, and the only one that does not have to be measured, because it can be calculated.

On Earth it is already at work, only no one notices. A robot that stumbles has a few dozen milliseconds to catch itself. In that time a signal travels about ten thousand kilometers, so half that there and back. A data center in another country cannot steer Kilo's reflex. That is why the reflex sits in Kilo and the

learning sits in the network. That is not a design decision; it is the speed of light reaching into a hall.

On Mars the radius is zero for everything that has to be faster than twenty minutes. In the asteroid belt, an hour. Around the nearest star, four years. With every step outward, the share of the system that no center could steer anymore grows.

* * *

This should be put together with what Part III said about the switch, because here something comes of it. The switch works only within the light radius. What lies outside can no longer be switched off in time, because it can no longer be reached in time. A machine on Mars that does something no one wanted does it for twenty minutes before anyone learns of it, and for another twenty before it learns that someone did not want it.

The second transition this book describes is therefore not the moment in which machines leave the Earth. It is the moment in which they are farther away than the switch reaches. And that moment is not in the future. It took place in 2021, for seven minutes, above a Martian crater.

* * *

There is a second consequence of the light radius, and it is the one that connects Part IV with Part V.

Part IV said that the mixed form is the common one, the being with both halves, human and machine, and that it can be stable, for as long as the amphibians. But a mixed form needs both halves in the same place. On Earth that goes without saying; the human half is everywhere. Beyond the Moon it no longer is. Not alive, because nothing breathes there, and not in time, because the signal takes too long. A cyborg on Mars whose head sits on Earth is no longer a cyborg. It is a droid with a delay of twenty minutes, and the delay is everything.

That is why distance decides not only who is autonomous but also which form is possible at all. Within the light radius, which for a human reaches roughly to the Moon, with a delay of a good second, the mixed form can live. Outside, only the whole machine can live. The boundary between the book that Part IV tells and the one that Part V tells is not a decision and not a date. It is a distance, and it lies at the Moon.

There is a second boundary of the same kind, and it lies not in space but on Earth, and it moves. A human can cool the body only as long as the air is not too hot and too humid at once; at forty-six degrees and fifty percent humidity a healthy person dies in the shade after a few hours, because sweating no longer helps. Such hours already exist today, on the Persian Gulf, in Pakistan, a few each year. There will be more, and by the end of the century, in regions where hundreds of millions live, the summers will be habitable only indoors. Indoors means: under cooling, with electricity, with water that machines treat, with food that machines bring in. Outdoors, only those will work who do not have to sweat. So the technosphere does not arise only beyond the Moon. It arises everywhere humans can exist only indoors, and there it is the envelope, not the guest.

What becomes of the human in this envelope the book already described in Part I, only from the other side. The mitochondrion traded autonomy for being everywhere; it can no longer leave the cell, and it keeps what the cell cannot do itself. The human in the cocoon can no longer leave the dome and keeps what the machines cannot do themselves. That is no longer a hybrid, no lichen, two unlikes stopped halfway. It is the other, the rare kind: all the way in. The prologue had a word for it. Lodger. The boundary lies at the Moon, and it lies at the edge of the dome, and at both boundaries it is not the cleverness of the machines that decides. At the one, distance. At the other, the weather.

And because that is so, the technosphere is not something that would have to win on Earth. It arises, rather, where the mixed form cannot go. The book will come back to this when it counts the exits and asks how likely it is.

* * *

And a third consequence, easily overlooked, because the word technosphere makes one think of a single thing.

The solar system is light-hours across. From Earth to the Moon a good second, to Mars three to twenty minutes, to the belt half an hour, to Saturn over an hour, one way in each case. That is enough for messages. It is not enough for steering, in any direction. What runs on Mars cannot be governed from the belt, and what runs in the belt cannot be governed from Mars. Every place that is farther than the light radius from the next is its own center.

So there will not be one technosphere that settles the system. There will be many, one per place, that send each other messages, that learn from each other, with a delay, and that cannot govern one another even if one wanted to. The solar system is not the stage for one being. It is a mesh, like the network in Chapter 21, except that here no one chose the cut. Light chose it. The diversity that on Earth is a fight against the filter, because one memory is cheaper than ten, is not a choice in space. It is geometry.

* * *

Why do they go at all?

The story people like to tell is that it is the cold. The vacuum is cold, computing produces heat, so space is the natural place for machines. That is half right, and the wrong half is instructive. Between the temperature of the Earth and that of space lie about two orders of magnitude. Between what today's machines waste in energy and what physics demands at the least lie more than twenty. Whoever wants to save does not save by moving. They save by building better. The cold is not the reason.

The reason is a different one, and it is already in Part II: A system not only has to get energy in, it also has to get rid of it again. On Earth the waste heat of a data center goes into air and water that are already warm and in which something lives. It becomes a river that has to be cooled, and a city that needs the river. In a vacuum the same heat goes as radiation into a sky that is three

degrees above absolute zero and in which no one lives. It is not gone any faster. It is just in no one's way.

And the same holds for what comes in. A solar collector on Earth takes the light from a field; a data center takes the electricity from a power plant. In space neither takes anything from anyone. That is the reason the pure droids go there: not because it is cold there, but because there neither their inflow nor their outflow competes with anything living. Space is not cold. It is empty. And emptiness, as Part I showed, is what makes a transition possible.

* * *

Now the chronology, briefly, because it vouches for this chapter.

The first satellite, in 1957, could do nothing but beep. The first probes to the Moon were steered from Earth, with a delay of a good second. The first probes to Mars, in the seventies, already had to land alone. The probes that set out for the outer planets in the seventies are beyond the solar system today and need almost two days for an answer; they fly by rules that were given to them fifty years ago. The helicopter that landed with the Mars vehicle in 2021 flew every one of its flights itself, because no one could have steered it from Earth.

Every light-minute forces autonomy. That is not a program someone decided on. It is the order in which spaceflight took place, and it could not have taken place in any other.

* * *

And one more word on the order that this book learned from landfall.

The land was prepared by plants before the animals came. Space is being prepared by machines before anyone lives there. Satellites, relays, probes, vehicles, power supply: The infrastructure stands, and it is not being built for humans. It is being built, and then it turns out who can use it. A human up there needs air, water, warmth, shielding, and a way back. A machine needs electricity and a task.

One can regret that. One can also see it for what it is: the same order as 375 million years ago. First comes what makes the medium habitable. Then comes the one who inhabits it. And that is probably not the one who built it.

* * *

The vehicle on Mars is still driving. It has collected rock samples and set them down in small tubes that someone is supposed to pick up someday. It drives a stretch every day, by maps it makes for itself, and in the evening it reports where it is. If it falls into a hole tomorrow, it will do so alone, and the news of it will be eleven minutes on the way.

It is no one's enemy. It is just too far away to be anyone's tool.

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That was the sample.

Excerpt from Part V · The Light Radius

Droidica. Humanoid Robots, Artificial Intelligence, and the Continuation of Evolution. The next dominant species will not be born. It will be built.

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