

'A gripping,  
Technicolor  
account'  
GUARDIAN



Chris  
Thorogood  
**PATHLESS  
FOREST**

The Quest to Save the  
World's Largest Flowers



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PATHLESS FOREST

'Chris Thorogood is a self-described "plant junkie". The plant on which he is hooked is a bizarre one called *Rafflesia*, a parasitic monster found growing only in the Philippines and Indonesia and notable for its enormous, fleshy blossom. *Pathless Forests* is a sort of travelogue describing Thorogood's journey around this part of the world in search of the beasts in bloom . . . has all the hallmarks of adventure: nearly drowning in a river, scaling cliffs while dangling on lanas, being bitten by giant ants and stung by toxic trees . . . But it was worth it . . . and he also makes a serious broader point. *Rafflesia* . . . are threatened and on the edge of extinction. For all their strangeness, the very rarity of these gigantic living objects symbolizes our continuing carelessness towards nature'

Charles Elliott, *Literary Review*

'A vivid account of this gruelling expedition, combined with his fierce determination to find the pungent plants that have obsessed him for decades' *Daily Mail*

'In *Pathless Forest* he recounts his time in the remote jungles of Southeast Asia, from Sumatra to the Philippines, searching for *Rafflesia* . . . Thorogood's dazzling descriptions light up the faraway forests with an impassioned commitment' Sophy Roberts, *TLS*

'What is truly inspiring about this book is the positive collaboration that is going on between experts around the world (including indigenous people with knowledge of these plants) to try to put conservation strategies in place and protect these species from extinction'

Elanor Wexler, *Association of Botanical Artists*

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#### ABOUT THE AUTHOR

Chris Thorogood is a botanist and lecturer at the University of Oxford, where he holds the position of Deputy Director and Head of Science at Oxford Botanic Garden and Arboretum, and a Visiting Professor at the University of the Philippines. His research focuses on the evolution of parasitic and carnivorous plants, taxonomic diversity in biodiversity hotspots around the world, and biomimetics – exploring the potential applications of plants in technology. An author and broadcaster, he makes regular appearances on TV and radio and is also an award-winning botanical illustrator and wildlife artist. Obsessed with plants, he is on a mission to make us see them differently and realize how we, they, and our planet, are all connected.

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# *Pathless Forest*

*The Quest to Save the World's Largest Flowers*

CHRIS THOROGOOD

*With illustrations by the author*



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This book is dedicated to all Rafflesia's faithful  
custodians in Southeast Asia

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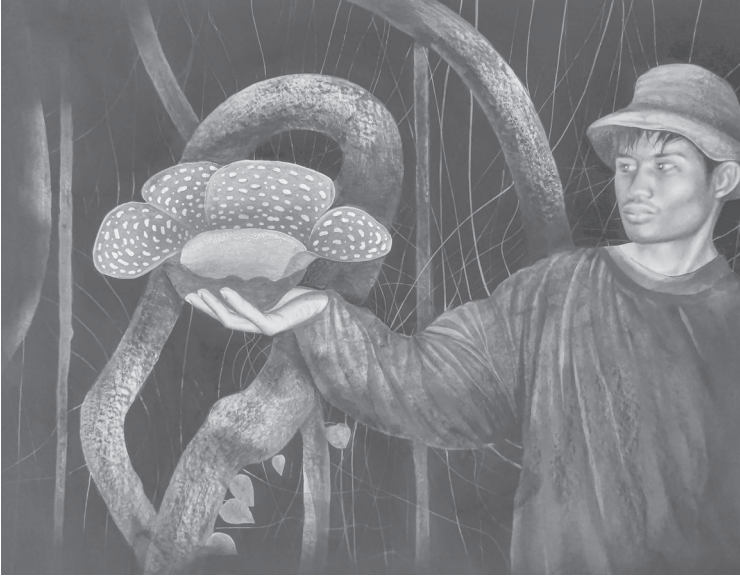
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A book's roots run deep. Thanks to all my loved ones for encouraging me to do what makes me happy. And thank you Simon Hiscock for making me a botanist. As for my lodestars to Southeast Asia – the eight species of *Rafflesia* that pushed me to the brink – any errors are down to them.

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## Prologue



*Rafflesia is the genus containing the world's largest flowers.*

When we were eight, my friends and I talked about what we wanted to do when we grew up. Our ambitions ranged from athletics and zoo-keeping, to flying to the moon. As we mapped our undetailed lives I realized my own plans were a little unusual: I wanted to spend my life searching for the world's most extraordinary plants.

At night I would sit cross-legged on my bed poring over cherished, dog-eared books. One had foxed, vanilla-scented pages, depicting curious plants in a faraway land. It contained a black and white photograph of a curious flower growing in the rainforests of Southeast Asia. I can still picture it now: an astonishingly large,

vaguely grotesque-looking pentagon, draped over the floor like a lumpy great starfish. This was the largest flower in the world, the book told me, spanning over a metre across. I was possessed by it and wanted to see one growing in the wild more than anything. *Rafflesia* had cast its spell on me.

But Southeast Asia may as well have been the moon to me back then. There was no way in which I could see the plants that haunted me from the other side of the planet. So I conjured them up in a pretend rainforest behind my family's back garden. We lived next to an old cemetery, a place reclaimed by nature, where foxes skulked among fallen tombstones netted with ivy and briars. Here I scrambled up yew trees and swung from the branches, pretending I was in the jungle. I made 3D replicas of exotic plants out of papier mâché and clay, all carefully sculpted and painted. Then in a wild corner of the cemetery I staged a life-sized *Rafflesia* model among the mossy branches, and sat on a fallen gravestone, staring at it. This was the closest I could get to an encounter with the world's most magnificent plant. My story put down roots there, in that quiet cemetery in southeast England.

Today I am a botanist. I work at the University of Oxford's Botanic Garden and I have dedicated my life to studying the biology of extraordinary plants such as *Rafflesia*, getting to know them, revealing their secrets. First things first: *Rafflesia* is a parasite that steals its food from other plants. A thief. Parasitic plants make up about 1 per cent of all flowering plants and they're no aberration. In fact they've evolved twelve times – they are all around us. Some abandoned photosynthesis and are completely dependent on other plants, their so-called hosts, for their existence. They have always intrigued me. Their curious leafless forms and ghostly flowers have a spellbinding beauty and their sinister biology animates them somehow – gives them personality. Many parasitic plants are poorly known to science, and most have never even been cultivated. Yes, these botanical enigmas, which are the focus of my research today, still keep me awake at night just as they did when I was a child.

How did such a striking work of nature as *Rafflesia* come to exist?

I have worked with other botanists around the world, seeking to answer this question. Together with Professor Charles Davis and colleagues at Harvard, I have shown that *Rafflesia*, which spends its entire life cycle within the tissues of other plants, exhibits a startling similarity to fungi: they lead secret parallel lives.<sup>1</sup> Fungi are not plants. They belong to their own kingdom, distinct from plants and animals, from which they diverged a billion years ago. And yet, just like fungi, *Rafflesia* exists for most of its life as a microscopic thread, creeping about within the tissues of another plant, sending out ‘sinkers’ to absorb food. Something like a tapeworm. In the metamorphosis to this hidden existence, genes have gone walkabouts along the way. It is for this reason that the genes needed for photosynthesis are missing in many parasitic plants, meanwhile those encoding certain enzymes are redundant in some fungi; in both cases, they have no need for them, living as they do entirely at the expense of their hosts. There’s more: they have also acquired *new* genes by Horizontal Gene Transfers (HGTs) – the rare exchange of genetic material between non-mating organisms. Extinct ancestors of *Rafflesia* have even been shown to possess genes from relatives of the cucumber and carrot due to former associations with these plants: encrypted in their genomes lurk ‘DNA fossils’ that hint at their evolutionary journey.<sup>2</sup>

But this is a story that goes beyond biology. This is the tale of a man who longed for something, and was drawn to it from the other side of the globe by invisible threads: something that made him recklessly bold. Like Apollo he was struck by an arrow, and he dared; like him too, he was driven to extremes for an unrequited love – and the more he chased the flower that tore at his heart, the more he got rejected by it. Dragged helplessly to heaven through hell and back, he became half-sick with his obsession to find it.

Perhaps as you turn these pages and read how, delirious with sleeplessness, he saw flowers the size of people, personalities in plants, and listened to them speak – you’ll wonder if he lost his mind.

God knows, I wondered.

But so it was that, smacking off leeches and hanging off vines,

wading through rivers and wrestling the forest, I followed tribes to the very depths of the abyss to find Rafflesia's hidden flowers: dripped blood, sweat and tears on them. And felt something inside me change for ever.

This is the story of a botanist, a flower, and a forester, and how our lives intertwined.

## I.



Mr Chris, one day I show you big *Rafflesia* in Indonesia. Yes, Mr Chris visit Bengkulu Selatan and Muara Sahung – we see big flower there together. Big, big flower.

Mr Chris, come to hear my story. My forest – it will be destroyed by people. They do not know how special it is, Mr Chris. The forest is crumbling and soon my children can find *Rafflesia* only on Google.

Come while the forest still exists, Mr Chris. Come soon.

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## 2.



‘There are two paths and we must choose one.’

Adriane stares at me expectantly then folds his arms neatly on the table.

‘Which one is most likely to take us to the flower?’ I ask. I feel like we’re solving a riddle.

‘The longer one.’

‘How long, Adriane?’ I drink my green tea down to the clinking ice and hold his gaze. A waiter busies himself taking away our plates of little unfinished pyramids of rice.

‘Days. We would need to sleep in the forest.’

‘That’s OK,’ I reassure him. ‘I can do that.’ I say this a lot out here.

‘But there are risks,’ he continues, his eyes fixed on mine, impassive. We say nothing for a while, waiting for me to speak.

‘What risks?’ I finally ask him.

‘Someone was shot by an arrow in the forest, not long ago. They died.’

There: we’ve reached the answer. I nod silently as we trace our fingertips along the shorter route on the map spread out in front of us. It leads to a plant called *Rafflesia leonardi* – one of the forty or so species in the genus *Rafflesia*, which contains the world’s largest flowers. Few people have ever set eyes on this plant. It is one of a handful we hope to encounter during the expedition here in the Philippines.

A neural pathway in the non-executive part of my brain has latched on to that longer path and can’t shake it off now. There is

something deliciously reckless about it, the notion of fleeing tribes and arrows in pursuit of *Rafflesia*. My imagination takes me ducking under branches, tripping over buttress roots, looking back over my shoulder, then jack-knifing to the floor as I narrowly miss taking an arrow to my heart . . .

‘Here,’ Adriane says, tapping the map, yanking me back into our little street-side restaurant in Los Baños.

He is pointing to a green ink stain of forest spreading along the creases of the eastern seaboard of Luzon Island. As we linger over the map, I wish Adriane would *dare* us to do it, risk everything for the flower. He would – I know he would – just as he knows I would too. Except I am his guest here, and I cannot ask this of him. So, silently, we concede to playing it safe. Relatively speaking that is – for nothing is truly safe on an adventure like this one. I’m not exactly sure what perils await us in the jungle but I’m damned sure of this: whatever path we take, I’ll do anything to find that flower.

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Meet the cast: Adriane is my guide and friend, and together we have been planning this expedition for months. He is twenty-six but looks eighteen. He has short muscly legs, a crop of black hair, and a serious demeanour that softens when someone mentions the place *Kalinga* (I’ll return to that); actually the very word makes his eyes flash wild and bright, like a lemur’s. Professor Pastor Malabrigo Jr, or ‘Pat’, is Adriane’s boss. He is double Adriane’s size (Pat enjoys a beer) and has a big, happy face with high-arched eyebrows that hover permanently somewhere between mirth and surprise. It’s impossible not to like him. His knowledge of the flora of the Philippines is unparalleled; he knows every plant.

We’ll be accompanied intermittently by Glen, the Philippines’ resident expert on dipterocarps – those iconic rainforest trees used for food and medicine by local communities across Southeast Asia – fern specialist Marge, and expert field botanist Ana. Together with the country’s knife- and gun-clad foresters and tribes, we are about to bore into the very depths of the Philippines’ last green wilderness

in pursuit of plants. Later we will join Septian Andriki, known as Deki, in Sumatra – a man who cares deeply about the plight of his rainforests, and Joko Witono, a botanist in Java who holds the key to growing the ungrowable.

Together, our mission is to chart Southeast Asia's most poorly known species of *Rafflesia*, and to conserve them. We will probe their secret lives, and determine where one species ends and another begins: for if we don't know how many exist (and we don't), then how can we possibly protect them?

As the forest burns around us, we'll discover we're in a race against time.

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My first day in Los Baños, a town sweltering in the folds of Mount Makiling's jungled slopes. Everywhere smells overripe and tropical, like fruit and fried chicken. I am itching to explore the rainforest but there are permits to sort out. Our driver Kuya ('elder brother') Mante is taking us to the offices of the Forestry Department. He pulls up outside our apartment, and Adriane and I hop into the boxy blue Toyota van. On the way to the administration offices, we pass an ever-changing ribbon of life under a torrent of cables: tricycles zooming; children being yanked out of the road; blue flip-flops; blue rooftops; chickens running, chickens frying; two men peeing – each with one hand to the wall; and a politician beaming proudly from triplicate posters, one of them upside down. Smile. Smile. Frown.

We park outside the offices, where a horde of students are crouching on the road. I am introduced to their professor, who is presiding over a blue polythene sheet stretched across the tarmac, on which leaves have been cast about. 'They are identifying figs,' he tells me, pointing to the plastic ocean with green jigsaw pieces floating on its surface.

Watching the students examining their specimens calls forth a memory of teaching undergraduate field botany in Portugal. Every spring for over a decade I taught there, marching sun-frazzled students into the spiny thicket. On the last day of the trip, the other

lecturers and I would raid the vegetation to set our students an identification test. We'd arrange the specimens on the hotel's breakfast tables, then watch as the students consulted every leaf and flower. One year, when the test was over, the students decided to carry the magnificent wand-like stem of a *Thapsia* into the town. Some sort of mascot, I suppose. I remember tourists staring as we poured out of our hotel onto the street, brandishing the sturdy, fennel-like sprout of yellow blossom. In the bar that night, I told the students that some plants can be identified by their smell or taste alone. Before I could stop her, Chantelle, one of our livelier students, reached for the *Thapsia* and gnawed off a frond with her teeth, gulping it down with sangria.

'Tastes of nothing,' she said, looking unimpressed, flicking back her hair.

'Chantelle, I'm pretty sure that plant is poisonous!' I said, panicking. I couldn't believe what she'd done.

'Oh my god! How poisonous?' she gasped.

I said I wasn't sure, as the other students picked up their phones and started googling frantically.

'Got it!' announced a more studious student, breathless with the importance of her announcement. She cleared her throat. '*Thapsia* is extremely toxic, even in small doses,' she read, then paused for effect: 'it is also known as the deadly carrot'. She sat back to watch our reaction as Chantelle sprinted to the ladies' room. The following morning, we couldn't assign the symptoms that presented themselves with certainty either to the deadly carrot, or to an excessive quantity of sangria.

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Adriane sorts the paperwork alongside an administration lady in her mid-sixties with a whisky voice who calls herself his granny. I absorb my surroundings from a sagging sofa in the corner. An eclectic assortment of items including an old propped-up guitar, some mounted butterflies strung to the wall, and last year's Christmas tinsel strewn about the ceiling. Glen wanders over and sits beside me. We talk about our shared love of dipterocarps. These are the

trees you sometimes see in rainforest documentaries on TV, filmed from the sky, rising from the canopy like broccoli. Glen tells me they are being used here in Los Baños in computerized models to predict the impacts of climate change. ‘That’s good,’ I say, lamely, as Adriane shuffles paper in the background. We don’t talk about how climate change is sending biodiversity into freefall, that the dipterocarps – and all the other indicators – show this; or that we, as botanists, are powerless to change it.

Once the paperwork is in order, Adriane, Glen, and I leave the cool hush of the polished offices to visit the university’s arboretum. We walk along a road half repossessed by roots and vines, where birds and insects echo and click about the trees. Glen and Adriane wander side by side, chatting in Tagalog (the national language of the Philippines) a few metres ahead of me. As I shuffle through the leaf litter behind them, something catches my eye along the roadside’s scribbled edge: a crescent moon of fallen flowers showering the floor. I pick one up. It has the outline of a parrot’s beak and spans the width of my four fingers. Its shapely form alone is intriguing, but the colour – the *colour* – that belongs to another world: it is a shade of turquoise like nothing else. And I do mean turquoise – neither blue nor green. I flip it over with my index finger and peer at it on the palm of my hand. Its surface is minutely dimpled and darker around the edges, like a pool of tropical seawater. Glen and Adriane glance back at me over their shoulders then wander over. Their eyes flit from the flower in my hand to the daft smile on my face.

‘Look Chris,’ whispers Glen, pointing to the sky, ‘there are more!’

Up in the branches above our heads dangles the source of the sublime flowers: a jade vine (*Strongylodon macrobotrys*). I stare at the suspended marvel – a cylinder of claw-shaped blossom that, now I see it from beneath, has a mint-green cast to it. In fact it is almost glowing. I look at Glen and Adriane, lost for words. They laugh. They see this flower almost every day; to them it is no more exotic than a foxglove is to me. I have read that the jade vine’s luminous flowers are attractive to bats, but I’ve not met anyone who has seen the creatures in action to prove this. Standing here among the trees,

I can imagine a bat fluttering in; can almost see it knocking the flowers in front of us.

Last year the jade vine at work pushed out some flowers unenthusiastically against the glasshouse roof at Oxford Botanic Garden. I was excited at the time, as we huddled around the curious blue vision. Well, to see such a striking work of nature anywhere would be special, wouldn't it? But to see one in the wild – that's a gift. Later I learn that we're standing close to where this species was first collected officially, here on the forested slopes of Mount Makiling, during the United States Exploring Expedition led by Charles Wilkes in 1841. Perhaps like me, the nineteenth-century explorers couldn't shake the flowers from their minds – were spellbound by them.

Arboreta I have visited in the past have been clipped, pruned, and mulched – places where nature is managed and bent into shape. Not this one. It feels wild, reclaimed by trees. We pick our way down a root-webbed path and pass a fig tree shooting up into the canopy like an arrow. It has yellow, speckled fruits the size of ping-pong balls, bubbling out of the bark. Oddly, I'm reminded of that lumpy yellow foam that builders use to fill cracks in the wall. I run my fingers over the little golden baubles.

Figs are fascinating. They include some of the earliest domesticated crops and they have been cultivated in some parts of the world for over 11,000 years. But what has always excited me about them is their pollination. First things first: a fig is *not* a fruit, nor is it a flower. Let me explain. Botanically speaking, a fig is a *syconium* – an infolded structure within which the tiny flowers are enclosed – they never see the light of day. So a fig comprises a whole collection of tiny flowers, all crammed into a ball, like seeds in a pumpkin.

There's more: figs are intimately associated with fig wasps – insects they have evolved alongside for 60 million years. The little wasps haul themselves through a tight passageway called an *ostiole*, losing wings and other body parts along the way. I can just make out the ostioles on the specimens in front of me – they look like the bottoms of apples. Upon arrival in the fig's central cavity, the wasps dust themselves down. Pollen they have brought from other figs fertilizes some of the flowers; meanwhile eggs are

deposited in others. The flowers that receive eggs nourish the wasps' developing grubs; meanwhile those that receive only pollen develop seeds. Then, a new generation of wasps emerges within the confines of the fig. Wingless males mate with winged females who pick up pollen as they crawl about. The males bite an exit tunnel through which the insects escape; they soon die, while the pollen-laden females zoom off into the wilderness, and the process repeats itself. I can picture it all taking place unseen within the hidden worlds in front of me. I peer up at them, hoping to see a fig wasp fly out. But all I see is a line of ants, marching purposefully to the sky.

A few metres away, the forest floor is spangled with gigantic fallen leaves, snatching light along their sawn edges. They are the shape of oak leaves, only astonishingly large – about 60 centimetres long. I pick one up and it sways about like a sail. It belongs to a nearby tree known as 'antipolo' (*Artocarpus blancoi*), which is found only here in the Philippines and is a distant relative of the fig we have just been admiring. Near it I find the fallen fronds of yet another giant, this time a dipterocarp. These are like triple XL chestnut leaves, the length of my arm. It is as if I have stepped into a woodland from the Land of the Giants. As we pause for breath beneath the cathedral of over-sized trees, Pat wanders down the path to join us. He slaps me on the back and looks me up and down.

'You're too *thin*, Chris!' he exclaims. 'You need more beer!'

The conversation quickly shifts from beer to *Rafflesia*. Pat whips out his mobile phone and calls a forest ranger in Aurora Province to see if the flower has been seen there recently. An animated exchange in Tagalog follows, after which Pat turns to me, smiles, and says: '*Rafflesia leonardi* has been seen in bud this week.' He pauses. 'If we are lucky,' he continues, 'it will be open when we arrive in two weeks.'

'You have chosen the right time to come here, Chris.' He grins.

As we pick our way quietly out of the netted shade, I feel a surge of adrenaline wash through me. I think they feel it too.

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Later that afternoon, somewhere down a hospital-like corridor, we bang on a green steel door. Adriane and I are standing deep in the bowels of a concrete, municipal-looking building, with plants poking out of the walls and greened over with abandonment. Radio music and cigarette smoke seep through the door as we bash our fists against the metal. Eventually the curator of the herbarium appears, and we file into his kingdom of dried plants, cabinets, and formaldehyde. The air is thick with smoke and the panic of hastily sprayed air freshener. It looks like a locker room, with ranks of floor-to-ceiling metal cases and posters tacked to its doors.

Herbaria are collections of preserved plants stored, catalogued, and arranged systematically. They are magical places, chock-full with botanical treasure, collected over the course of centuries. Each herbarium specimen holds vital information about a plant's whereabouts at a given place and time, when it was in flower, and its DNA. The most important specimens stashed away in these cabinets are the *types*. A type is the definitive go-to specimen for quibbling botanists. Herbaria can assist plant conservation too. Scientists are in a race against time to describe species, to make sense of biodiversity while it still exists. Of the estimated 70,000 plant species still out there waiting to be described, over half may have already been collected and sit waiting in herbaria,<sup>1</sup> pressed for time.

Adriane pulls out a bulging, mushroom-coloured folder from a shelf and places it on a wooden table congested with other, similar-looking folders, and jars of pickled plants; he moves with authority – he knows his way about. The curator leans against the table watching us as Adriane leafs through the folder, pausing at a brown page folded along each side to create a sort of shallow box. Inside this sit two wrinkled black flowers the size of hands. They look like dried mushrooms. Each has a paper label attached to it with string, like a price tag. We peer at the labels, which tell us these *Rafflesia* samples were collected in 1982 from Mount Makiling, just a few miles from where we are standing. The next page is mounted with a photograph of a much larger *Rafflesia*, along with a polyethylene bag containing what looks like a desiccated cabbage.

'*Rafflesia banaoana*, Adriane whispers. 'This is its bud.'

The curator wanders back to the cabinet and returns with a large, clear plastic bottle in which an enormous brown flower is bobbing in fluid stained the colour of urine. It looks like a monster from the deep.

‘The type,’ Adriane says, nodding solemnly as we squint at the bottled alien yawning at us from behind the plastic.

I smile, showing my quiet appreciation for what’s been shared with me. Then, carefully we return the specimens to their trove. The parade of wizened-brown flowers may not look like much, but I know they’re precious.

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Back at our apartment in Los Baños, our host, a lady called Tita (‘aunty’) Rose, has rigged up a karaoke bar in the hallway. Tita Rose, who tells us proudly that she is younger than her years, doesn’t look a day under seventy-five (she is sixty-one, I find out later). She has cropped grey hair and a square face with kind eyes. She serenades us with love songs, hopping from one slippered foot to the other and staring intently at the screen, while Adriane writes his field report and I push out tweets about the jade vine we saw this morning. After an hour of ballads loud enough to wake the dead, Tita Rose settles on the sofa to watch a travel documentary about Venice.

‘Love Italy,’ she says, pointing to herself.

‘Have you been?’ I ask her.

‘Never been. More than *anything*, want go,’ she says, then sighs.

‘Where would you like to go most in Italy, Tita Rose?’

She pauses to consider this, then nods decisively.

‘Bethlehem’.

Later that evening we join Pat and Glen for beer, food, and more karaoke. Pat asks what I’d like to eat. ‘Oh I’ll eat anything,’ I lie, as little bowls of *chicharon bulaklak* (chickens’ intestines), *tokwa’t baboy* (pigs’ ears), and *sisig* (pigs’ faces) are passed about. I wash them all down with a beer and a smile. We chat about Leonardo Legaspi Co (known as Leonard), the legendary Filipino botanist and plant taxonomist, after whom *Rafflesia leonardi* was named. I learn that he was Pat’s teacher.

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‘There wasn’t a plant he couldn’t name,’ Pat tells me, then pauses. I detect a quiet sadness clinging to the group. ‘Leonard was shot dead on a botanical expedition,’ he explains. ‘Soldiers in the forest. They mistook him for a rebel.’

We say nothing for a while. Then, sensing the need for a lift in the mood, I tell the party how excited I was to see the jade vine today – how much it means to me to have seen it growing wild, here in the Philippines.

Then Pat beams and says, ‘Well, Chris, my friend: our adventure hasn’t even started.’

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Let me tell you about my passion for mountains. I’ve always needed to conquer them. Not for the views, to test my stamina or my endurance – no, none of that. I need to conquer mountains to see *plants*. As a child, I would close my eyes and dream of hauling myself into the cloud forests of Southeast Asia, clambering onto anvils of rock bathed in mist, and spending golden moments with orchids and pitcher plants dangling from the branches. In my early twenties, that dream came true. Like the plant junkie I am, I spent a month feverishly trekking up and down the mountains of Borneo in pursuit of plants, getting skinnier and more wild-eyed by the day. I took a boat down the lazy brown Kinabatangan River, and while the tourists were busy pointing their binoculars at the monkeys and hornbills, I was looking in the other direction: I feigned interest in the orangutans, bluffed astonishment at a crocodile, and pretended I wanted desperately to locate the elephants whose tracks we found in the rainforest like everybody else. But, in truth, all I wanted to see was plants.

So you can imagine my excitement this morning at the prospect of climbing a mountain teeming with pitcher plants and jade vines; a place reputed to contain more woody species than the whole of the United States of America. Mount Makiling is a volcanic cone rising to an elevation of 1,090 metres, with softly forested pleats that pitch gently onto the plains of Laguna. According to legend, the

mountain's summit is home to the goddess Maria Makiling. Today, I see a zeppelin of white cloud looming above her roof, as I peer through the mud-dappled window of our driver Kuya Mante's blue van. We pull into a bus stop to pick up Marge, a fellow botanist who will be joining Pat, Adriane and me on the climb today. She clambers into the vehicle, smiling brilliantly.

'The mountain is *incredible*,' she says wide-eyed, smiling. 'But last time I saw *Rafflesia* there, it was still in bud,' she tells me with a furrow between her eyes. 'Perhaps today we will be lucky.'

'I think we will,' I say.

Pat, Marge, and I turn to look out over a tangle of candy-coloured heliconia stems and ragged banana leaves flopping onto the road; Adriane's eyes remain fixed on his phone. Twenty minutes later, we've come as far as the Toyota can take us. Kuya Mante pulls up and we hop out into the hot chaos, then baste ourselves in toxic-smelling insect repellent. We wander over to the entry point, which is shielded by wasp-coloured metal barriers and an assertive-looking guard and an unassertive dog, asleep at his feet. Pat waves all this away with authority, and we are permitted entry, despite the official hiking season being weeks away. We have the whole mountain to ourselves.

The ascent begins with a hard-surfaced path, winding gently up the slope. A warm breeze stirs the canopy and sends down leaves that sway about our heads. Everywhere I look, there is a profusion of vines creeping up the trees, hanging from the branches, and spooling out into the road. Some have even tied themselves in knots. Everything is connected.

Speaking of vines, enter the strangler fig. I stare up at the silvery lattice cascading from the canopy. The web of tributaries seems molten somehow, seeping into the floor like flowing lava. Let me say a few words about this murderous plant. It begins its life of crime in the fork of another tree. After germinating, it sends forth creeping roots that curl around the trunk. They swell like boa constrictors, steadily taking possession. The roots touch down on the rainforest floor, refuelling the struggle. Eventually the encased

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victim suffocates, and the job is done: the strangler fig has become its own free-standing tree, living on the dead. Cut-throat.

We pause for water at Station Three where, to my delight, we encounter the great leafy parasol of *Amorphophallus longispathaceus* spiralling out of the gloom. I pull the blotchy, pole-like stem towards me and the umbrella of leafy diamonds quivers. From time to time, people ask me how a plant gets its name. Now seems like as good a time as any to dissect a *binomial*. All scientific names are made up of two words that often describe an organism's appearance in some way, a system introduced in the eighteenth century by the Swedish botanist, zoologist, and physician Carl Linnaeus, who later became known as 'the father of modern taxonomy'. Take for example the specimen in front of me. *Amorphophallus* literally means 'distorted penis' (I kid you not). The nineteenth-century Dutch botanists who chose the name must have been referring to the great phallic protrusion in its flowering structure, known as the spadix. *Amorphophallus* is the generic name – it identifies the genus to which the species belongs. The second part – called the specific name – distinguishes the species within that genus. Let's consider *Amorphophallus titanum* – a relative of the plant I am standing with, from the rainforests of Sumatra. *Titanum* means 'of the titans'. So what we have in this case is a 'giant distorted penis'.

Sweat trickles down my temples as we ascend the mountain's eastern shoulder. The forest has unleashed dark sugary smells, like wet compost in summer. The thicket has become dark and impenetrable, but every now and again we reach a clearing and catch glimpses over the canopy: green drapery, with necklaces of little heart-shaped leaves looping endlessly into the depths. I look down and see a brown snake vanish into the scribble. Adriane looks up at an arthritic branch veiled in fernery. He points to a lipstick vine (*Aeschynanthus*) woven into the green. It is impossible to identify it to species-level from down here, so we turn our attention instead to a stand of *Alpinia* – a relative of root ginger – leaning enthusiastically out of the gloom. It has nodding white flowers with gaping mouths the colour of fire, circling stems, canted with their own

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effort. Behind the *Alpinia*, apricot-coloured trees have clamped themselves to the earth with great collar-like roots, weaving and folding into the soil. Birds echo about the trees while insects throb and hiss. It is a riot of nature up here on the mountain, and everywhere I look, I see *plants, plants, plants*.

Adriane wanders over to walk beside me.

'Do you like it, Dr Chris?' he asks quietly, looking around him, indicating that he is referring to the forest.

'I do,' I tell him, nodding.

'Then you will *love* Kalinga. In the forest, there is no path. We must make our own,' Adriane says looking at me with his wild, child-like eyes. Then he looks at his feet and whispers, 'The first time I went there and saw *Rafflesia*, I nearly cried.'

Adriane doesn't often speak of his emotions (to me anyway). What is it about the place that haunts him?

A flash of silver. I leave the path and force my way into the thicket to find the winged seed of a Javan cucumber (*Alsomitra macrocarpa*), lodged into a ragged trunk. The papery brown seed is the size of my thumbnail and framed by a shiny boomerang-shaped sail, the consistency of a bee's wing. Javan cucumber produces the largest of all winged seeds – the one I am holding spans the palm of my hand. The seeds are released from *pepos* – fruits the size of footballs strung up in the canopy from which they glide, rising and falling, like butterflies. The geometry of the wing – its upward-swept, twisted shape and trailing aerofoil, give it unparalleled gliding stability. The structure inspired the nineteenth-century aeronautical engineer Igo Etrich, who was fascinated by the seed's prolonged and stable soaring. He built artificial models of it, seeking to emulate its self-stabilizing properties in aircraft.<sup>2</sup> How did it evolve? Flying seeds like the one I am holding enable otherwise-stationary plants to cross vast distances and explore new habitats, which is necessary for the spread and survival of a population in a changing environment. Goodness knows how far this one has drifted.

Technology copying nature, the mimicry of biological structures or processes (known as *biomimetics* in the science biz), is far-reaching. Take self-cleaning paint, for example. The principle of self-cleaning

is inspired by the high water-repellence of sacred lotus leaves. The leaves' extreme water-repellence is driven by a combination of microstructures and wax on the leaf surface. As the water beads and rolls off the leaf, it carries dirt particles along with it – a phenomenon called the Lotus Effect.<sup>3</sup>

My own research has also forayed into biomimetics. It began in 2018, when I showed some physicists the giant Amazonian waterlily floating in the heated pond at Oxford Botanic Garden. It's been grown there on and off since the mid-nineteenth century, intriguing people with its monstrous leaves. Waterlilies can unfurl 40 centimetres a day, maxing out at three metres, and sustain the weight of a small child. Incredible. People think I'm exaggerating, but year after year we've proved it: depositing the botanic garden team's bewildered toddlers on the colossal pads, then standing back, clapping. Anyway the physicists asked me how and why the leaves grow so large. I mumbled something about photosynthesis but in truth I was as mystified as they were. So I looked it up. Astonishingly little was known about the mechanics of the thing. For two years we examined the leaves: waded into the water and prodded them, poked them, stacked weights on them and sank them. Then we compared the load-bearing properties of their smaller cousins – the denizens of duck ponds. I waded into those as well, then stank out the office with the smell of pond as we unlocked their mechanical secrets too, using measuring tapes, videography, and mathematical modelling. We even 3D printed them.

This was our discovery: the floating sheet supported by a scaffold of girders produced by the giant Amazonian waterlily has a greater rigidity for a given volume of plant matter than the simple discs of smaller waterlilies. All leaves are restricted mechanically in nature by the expense of maintenance. A larger real estate for photosynthesis is all well and good, but it uses more of a plant's energy to maintain. The structure and load-bearing properties of the giant Amazonian waterlily give it a competitive edge in an environment where it pays to cover a large area, and fast: high strength at low cost.

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Away from the glasshouse pond in Oxford, and back in its

natural habitat – the quick-drying ephemeral pools of the Amazon basin – this aquatic monster evolved an advantage in the race among plants for space and light. Its giant leaves unfolded quickly and cheaply to create a mosaic of lily pads, forcing the surrounding plants out of the way, and blocking out their light. The underside of the leaf’s flexible (and breathtakingly beautiful) framework can withstand elastic deformation to avoid damage from wading birds. Furthermore, it has minute holes on its surface to drain trapped rainwater, and spikes on its undercarriage push aside the other plants and nibbling fish. An astounding feat of botanical engineering.

Before I float away with the waterlilies, I must return to biomimetics: the remarkable structures in nature that can help us to unlock design challenges in engineering. The physicists and I published our work in *Science Advances*,<sup>4</sup> where we suggested that the form of giant Amazonian waterlilies could inspire the design of giant floating platforms, such as solar panels in the ocean. What better inspiration can there be than a natural floating solar panel, tried and tested by evolution over the course of 100 million years? There’s a lot we can learn from plants.

Back in the shrill forest, we pass a string of shacks and a bar, half gobbled-up by trees. These belong to the mountain communities who live in the green twilight. An old woman sits with an audience of children and a yellow dog fidgeting in the dirt. The mutter and *buck* of chickens competes with the hissing trees. Woman, children and dog all turn to stare as we wander past. Beyond the clearing we meet an extraordinary display of rope-like stems knotted with little brown baubles spraying out of the trunk of a tree. Another fig (*Ficus minahassae*). Pat tells me this one has edible fruits; furthermore its sap can be drunk, the leaves have anti-rheumatic properties, and the bark is used to make utensils in some parts of the Philippines. It is a truly multi-purpose tree, we agree, smiling. I scribble all this down in my notebook excitedly and ask what the people we have just passed use the tree for. I’m sure it must have a local use here – for food, medicine, or folklore – that sort of thing.

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