Opening Extract from...

OF ANTS AND DINOSAURS

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Prologue

Bright Sparks

If the entire history of the Earth were condensed into a single day, one hour would equate to 200 million years, one minute to 3.3 million years and one second to fifty-five thousand years. Life would appear as early as eight or nine o'clock in the morning, but human civilisation would not emerge until the last tenth of the last second of the day. From the morning that philosophers held the first ever debate on the steps of a temple in Ancient Greece… from the day slaves laid the first foundation stone of the Great Pyramid… from the minute that Confucius welcomed his first disciple into the candlelit gloom of his thatched hut… right up until the moment you turned the first page of this book, only one-tenth of a tick of the clock would have elapsed.

But in the hours before this tenth of a second, what was life on Earth doing? Was every single living being doing nothing but swimming, roaming around, breeding and sleeping for… well… billions of years? Was every other organism universally and unremittingly stupid – for aeon after aeon? Of the countless branches on the tree of life, was our small twig really the only one to have been graced with the light of intelligence? It seems unlikely.

Nevertheless, for a germ of intelligence to grow into a great civilisation is no easy feat. It requires that many conditions be met simultaneously, a one-in-a-million coincidence. Nascent intelligence is as precarious as a tiny flame in an open field. It's liable to be snuffed out in the slightest breeze, and even if it does catch and manages to set the surrounding weeds alight, the little fire will likely find its path blocked by a stream or an empty clearing, causing it to die out without so much as a whimper. Should it somehow muster sufficient energy and spread like wildfire, a heavy rainstorm will probably extinguish it. All in all, the chances of a tiny flame becoming a raging conflagration are exceedingly slim. And so we can assume that, through the

endless night of antiquity, budding intelligences flickered on and then off again like the brief, brilliant twinkles of fireflies.

At approximately twenty minutes to midnight – that is, approximately twenty minutes before our arrival – two flames of intelligence appeared on Earth. We might call them bright sparks. This twenty-minute period was no mere flash in the pan, for it equates to more than sixty million years. It's an era unimaginably distant from ours. Humanity's ancestors would not emerge for another few tens of millions of years. There were no humans back then, and even the continents were shaped very differently than they are today. On the geologic timescale, it was the Late Cretaceous period.

At that time, gigantic animals called dinosaurs inhabited Earth. There were many different types of dinosaurs, and most of them were ludicrously large. The heaviest weighed eighty tonnes, or as much as eight hundred people, and the tallest grew to thirty metres, the height of a four-storey building. They had already lived on Earth for seventy million years, which is to say that they appeared on Earth more than a billion years ago from now.

Compared with humanity's several hundred thousand years on Earth, seventy million years is a very long time indeed. Time enough for the patter of raindrops drip-dripping steadily onto the same spot to carve great chasms out of the Earth; time enough for the gentlest of air currents blowing continuously against a mountain to level it. A species undergoing continual evolution over the same timespan, no matter how stupid to begin with, will become intelligent. And that's what happened to the dinosaurs.

Over those millions of years, the dinosaurs discovered how to uproot the biggest trees, strip away the branches and leaves, and tie massive boulders to their ends with rattan. If the boulder was round or square, the tree became a hammer so humungous that it could have flattened one of our cars with a single blow. If the stone was flat, the dinosaurs used it as a megalithic axe. If the stone was pointed, they left intact some of the tree's upper branches and crafted the trunk into a spear tens of metres long. The branches stabilised the spear during flight, and it flew like a dud missile.

The dinosaurs formed primitive tribes and dwelt in enormous caves they excavated themselves. They learnt to use fire, preserving the embers left by lightning strikes to illuminate their cavernous abodes and to cook food. For candles they co-opted entire pine trees several arm-spans around. They even wrote on the walls of their caves with

the charred tree-trunks, recording in simple strokes how many eggs were laid yesterday and how many baby dinosaurs hatched today. More importantly, the dinosaurs already possessed a rudimentary language. To our ears, their conversations would have sounded like the whistling of trains.

At the same time, another species on Earth was showing signs of budding intelligence. Ants. They too had undergone a long process of evolution; in fact, by this point, the scale of ant society far outstripped that of dinosaur society. Ants had raised cities on every continent – some of these took the form of towering ant-hills, others were subterranean labyrinths – and many of their kingdoms had populations exceeding a hundred million. These vast societies developed ingenious, tightly organised structures and hummed along to an efficient, systematic rhythm. The ants communicated with each other using pheromones – extremely sophisticated odour molecules that could convey the most detailed information – and this endowed them with a more advanced language than that of the dinosaurs.

However, although the first glimmers of intelligence had appeared in two species on Earth – one great and one small – both species were beset with fatal flaws, and their respective paths to civilisation were strewn with insurmountable obstacles.

The dinosaurs' biggest disadvantage was that they lacked dexterous hands. Their huge, clumsy claws were matchless in a fight (one type of dinosaur, *Deinonychus*, had claws as sharp as sabres, which it used to disembowel its rivals) and could fashion crude tools, but they were incapable of performing fiddly tasks, manufacturing sophisticated implements or writing anything complicated. This was problematic because manual dexterity is a prerequisite for the development of civilisation. Only when a species has versatile hands can a virtuous circle form between brain evolution and survival activities.

The ants, conversely, could execute extraordinarily fiddly tasks, and they constructed the most intricate architecture both above ground and beneath it. But they lacked flair and a certain richness of thought. When a gathering of ants reached critical mass they exhibited a collective intelligence that was literal and unerring, much like a computer program. Guided by these programs, which developed over extended periods of time, ant colonies built city after labyrinthine city. Their society operated like a vast, precisely engineered piece of machinery, but separate an ant cog from that machine and you'd find that the individual's thought processes were disappointingly shallow and pedestrian. This was the ants' downfall, for the sort of

creative thinking required to progress civilisation is the province of individuals – individuals like our Newton and Einstein, for example. The very nature of collective intelligence, its intrinsic principle of redundancy, is antithetical to the production of advanced thought; a hundred million of us humans, though we might rack our brains as hard as we can, would still not come up with the three laws of motion or the theory of relativity.

In the ordinary run of things, therefore, neither ant society nor dinosaur society could have continued to evolve. As with countless such examples before and since, the flames of intelligence that had flared into life within these two species should have fizzled out in the waters of time, a couple of ephemeral bright sparks in the long night of Earth's history.

But then a curious thing happened.

Chapter 1

The First Encounter

It was an ordinary day in the Late Cretaceous. It is impossible to determine the exact date, but it was truly an ordinary day, and Earth was at peace.

Let us examine the shape of the world that day. At that time, the profiles and positions of the continents differed radically from their current forms. Antarctica and Australia made up a single landmass greater in size than either continent today, India was a large island in the Tethys Sea, and Europe and Asia were two separate landmasses. Dinosaurs were found predominantly on two supercontinents. The first, Gondwana, had been Earth's only continuous landmass several billion years earlier. It had since broken up, and its area was greatly reduced, but it was still as big as present-day Africa and South America combined. The second, Laurasia, had split from Gondwana and would later come to form what we now know as North America.

That day, every creature on every continent was occupied with the business of survival. In that uncivilised world, they knew not where they'd come from and cared not where they were headed. When the Cretaceous sun was directly overhead and the shadows cast by the leaves of the cycads were at their smallest, their sole concern was where they were going to get lunch.

In a sunlit clearing amid a stand of tall sago palms in central Gondwana, one as yet quite unexceptional *Tyrannosaurus rex* had just lynched a plump, good-sized lizard for its midday meal. With its fearsome claws it ripped the still wriggling lizard in two and tossed the tail end into its gaping jaws. As it munched away with relish, the dinosaur felt entirely happy with the world and its own place within it.

Things below ground were far from calm, however. The *Tyrannosaurus*'s pursuit of the lizard had caused a powerful earthquake in the subterranean ant town located a mere metre from the dinosaur's left foot. Fortunately, the town had just avoided being trampled, but now hordes of its thousand or so residents scuttled to the surface to see what had happened.

The *Tyrannosaurus* had blocked out more than half their sky; it was like a towering peak piercing the clouds. For the ants massed in the mountain's shadow, it was as if the day had suddenly become overcast. They squinted up, up, high into the sky, watching as the lizard's tail arced through the air and into the fathomless mouth of the *Tyrannosaurus*. They listened to the sound of the dinosaur chewing, to the cracking and rumbling that was like thunder from the heavens. On previous occasions, this thunder had often been accompanied by a heavy downpour of splintered bones and chunks of flesh. Even a light drizzle of the dinosaur's leftovers would provide lunch for the entire town. But this *Tyrannosaurus* kept its mouth tightly closed, and nothing rained down from the sky. After a few moments, it tossed the other half of the lizard into its mouth. Thunder boomed overhead again, but still the shower of bones and flesh held off.

When the *Tyrannosaurus* had finished, it took a couple of steps back and lay down contentedly for a nap in the shade. The ground shuddered, the peak collapsed into a distant mountain range, and brilliant sunshine flooded the clearing once more. The ants shook their heads and sighed. The dry season was long this year, and life was getting harder by the day. They had already gone hungry for two days.

Just as the crestfallen critters were turning back towards the entrance to their town, another earthquake rocked the clearing. The mountain range was rolling agitatedly back and forth across the ground! The ants watched intently as the *Tyrannosaurus* stuck one of its monstrous claws into its mouth and began to dig furiously between its teeth. Immediately, they understood why the dinosaur could not sleep: lizard flesh had got stuck in its teeth and was getting on its nerves.

The mayor of the ant town had a sudden idea. It climbed onto a blade of grass and released a pheromone towards the colony below. As the pheromone spread, the ants understood the mayor's meaning and passed the message on. Antennae waved as a tide of excitement swept through the crowd.

Led by the mayor, the ants marched towards the *Tyrannosaurus*, streaming across the ground in orderly black rivulets. At first the mountain range seemed impossibly far away, visible on the horizon but unreachable. But then the restless *Tyrannosaurus* rolled towards them again, closing the gap between itself and the procession of ants in an instant. As it shifted, one of its huge claws fell from the sky and landed with an earth-shaking thump right in front of the mayor. The impact bounced the entire

procession clear off the ground, and the dust it raised mushroomed before the ants like an atomic cloud.

Without waiting for the dust to settle, the ants followed their mayor onto the dinosaur's claw. The dinosaur's palm had come to rest perpendicular to the ground, forming a craggy, precipitous cliff. But to the ants, who excelled at climbing, this was no obstacle. They quickly darted up the cliff-face and onto the dinosaur's forearm. Still in formation, they navigated the rough skin of the forearm, winding their way across its plateau-like surface, down and up the steep sides of its countless gullies and on towards the upper arm and the *Tyrannosaurus*'s maw.

Just then, the *Tyrannosaurus* raised its massive claw to pick at its teeth again. The ants advancing across its forearm felt the ground beneath them tilting, followed by an alarming increase in G-force. They clung on for dear life. Half their view of the sky was now taken up by the dinosaur's colossal head. Its slow breathing was like wind gusting through the heavens and its oceanic eyes peering down at them made them tremble with fear.

Spotting the ants on its forearm, the *Tyrannosaurus* raised its other arm to brush them off. Its palm blotted out the midday sun like a vast stormcloud, casting a threatening shadow over the ant army. They stared up at it in horror, twitching their antennae frantically. The mayor quickly raised one of its front legs and the rest of the troop immediately did the same, the entire colony now one long, quivering black arrow pointing at the dinosaur's mouth.

The *Tyrannosaurus* was stunned for a few seconds but eventually grasped the ants' intention and lowered its arm. The stormcloud dispersed and sunlight returned. Then the dinosaur opened its mouth wide and placed a single clawed finger against its titanic teeth, forming a bridge between arm and jaw. There was a fraction of hesitation, but the mayor took the lead once again and the rest of the colony marched on without demur.

The first group of ants swiftly reached the end of the finger. Standing on the smooth, conical claw-tip, they gazed into the dinosaur's mouth in awe. Before them was a night-time world where a storm was brewing. A fierce, damp wind reeking of gore blasted their faces, and rumblings rose up from the dark, chasmic depths. When the ants' eyes adjusted to the gloom, they could just make out a patch of even denser darkness in the distance, the borders of which kept changing shape. It took them a long time to realise that this was the dinosaur's throat. It was also the source of the

rumbling, which was coming from the *Tyrannosaurus*'s stomach. The ants instinctively recoiled in fright. Then, one by one, they climbed onto the dinosaur's huge teeth and crawled down the smooth white enamel cliffs.

With their powerful mandibles, the ants tore at the pink lizard flesh that was lodged in the ravines between the teeth. As they chewed, they stared up at the enormous white columns rising skywards to either side of them. High above them, on the dinosaur's palate, another row of gnashers gleamed menacingly in the sunlight, looking for all the world as if they might come chomping down at any moment. But the *Tyrannosaurus* had already moved its finger to its upper jaw, and an unbroken stream of ants was now scaling those teeth and devouring the meat stuck between them, creating a mirror-image of the scene on its lower jaw.

More than a thousand ants bustled about the dozen or so crevices and soon the scraps of meat had been picked clean. The dinosaur's dental discomfort had been dealt with! The *Tyrannosaurus* was not yet evolved enough to say thank you, so it merely let out a long sigh of satisfaction. This sudden hurricane blasted every last ant out of the dinosaur's mouth and into the air in a cloud of black dust, but because their bodies were incredibly light, they landed unscathed about a metre from the *Tyrannosaurus*'s head. With their stomachs now full, the ants pattered back to the entrance of their town, thoroughly sated. The *Tyrannosaurus*, meanwhile, rolled over into the cool shade and fell into an easy sleep.

And that was that.

As the Earth quietly turned, the sun slid silently towards the west, the cycad shadows lengthened, and butterflies and bugs flitted through the trees. In the distance, the waves of the primeval ocean lapped against the shores of Gondwana.

Unbeknown to all, in this most tranquil of moments the history of the Earth had taken a sharp turn in a new direction.

Chapter 2

The Age of Exploration of the Dinosaur Body

Two days after the encounter between the ants and the dinosaur, on an equally sweltering afternoon, the inhabitants of the ant town were shaken by another quake. They scampered up to the surface and were met by the towering figure of a *Tyrannosaurus*, which they straightaway recognised as the same one from before. It had hunkered down and was scouring the ground for something. When it saw the colony, it lifted a claw and jabbed at its teeth. The ants understood immediately, and in a single uniform gesture all one thousand of them waved their antennae excitedly. The *Tyrannosaurus* placed one of its forearms flat on the ground and allowed the ants to climb on. And just like that, the scene from two days earlier was replayed: the colony made a meal of the scraps of meat stuck between the dinosaur's teeth, and the dinosaur was relieved of a minor dental discomfort.

For some time after that, the *Tyrannosaurus* routinely sought out the town of ants so they could pick its teeth. The ants could feel its footfalls from a kilometre away and were able to accurately distinguish them from those of other dinosaurs. They could even tell from the vibrations in what direction the *Tyrannosaurus* was moving. If it was heading towards the town, the ants rushed eagerly to the surface, knowing that their food supply for the day was assured. Even though one party in this cooperative endeavour was very large and the members of the other party were undeniably very little, it didn't take long for the interactions between the two to become well honed.

One day the vibrations coming through the ants' earthen ceiling sounded different, unfamiliar. When they streamed up into the clearing to investigate, they saw that their partner had brought along three other *Tyrannosaurus rex* and a *Tarbosaurus bataar*! All five dinosaurs gestured at their teeth, requesting the ants' help. The mayor, recognising that its colony couldn't possibly undertake such a massive task on its own, sent several drones post-haste to contact other ant towns in the area. Soon, three

mighty rivers of ants came pouring in from between the trees, and an army of more than six thousand ants converged on the clearing. Each dinosaur required the services of one thousand ants, or, rather, the meat between the teeth of one dinosaur could satisfy one thousand ants.

The next day, eight dinosaurs came to have their teeth cleaned, and a few days later that number increased to ten. Most of them were exceedingly big carnivores and they had a correspondingly big impact on their surroundings. They trampled the nearby cycads, enlarging the clearing significantly, and at the same time they solved the food problems of a dozen ant towns in the vicinity.

However, the basis for this cooperation between the two species was by no means secure. For a start, compared to the myriad hardships faced by the dinosaurs – hunger when prey was scarce, thirst when water sources had dried up, injuries sustained in fights with their own or other kinds of dinosaurs, not to mention a host of fatal diseases – getting meat trapped between their teeth was a mere piddling inconvenience. Quite a few of the dinosaurs who sought out the ants for a teeth-clean did so out of curiosity or for a lark. Equally, once the dry season was over, food would become plentiful again for the ants, and they would no longer need to rely on this unorthodox method of sourcing their daily meat. Attending those terrible banquets in the dinosaurs' mouths – so very like the gates of hell – was not something most of the ants relished.

It was the arrival of a *Tarbosaurus* with tooth decay that marked a major step forward in dinosaur–ant cooperation. That afternoon, nine dinosaurs had come to have their teeth cleaned, but this particular *Tarbosaurus* still seemed restless even after its procedure had been completed; one might even describe its mood as antsy. It held its forearm high to prevent the cleanser ants from leaving and with its other claw gestured insistently at its teeth.

The mayor in charge of that colony led a few dozen ants back into the *Tarbosaurus*'s mouth and examined the row of teeth carefully. They quickly discovered several cavities in the smooth enamel walls, each large enough to admit two or three ants side by side. In went the mayor, braving one of the cavities, and several other ants crawled in after it. They scrutinised the walls of the wide passageway. The dinosaur's teeth were very hard, and anything that could tunnel through material as tough as that was indisputably a digger to rival the ants themselves.

As the ants felt their way forward, a black worm twice their size suddenly erupted from a branch passage, brandishing a fearsome pair of razor-sharp mandibles. With a click, it bit off the mayor's head. A bundle of other worms then burst out of nowhere, divided the column of ants in the tunnel and launched a ferocious attack against them. The ants were too exhausted to defend themselves and in an instant more than half were slaughtered. Those that did manage to break through the encirclement raced past the black worms but quickly became disoriented in the labyrinthine passages.

Of the original crew, only five ants escaped the cavity, one of whom was carrying the mayor's head. An ant's head retains life and consciousness for a relatively long time after being separated from its body, and so, bizarre though it sounds – and how much more bizarre must it have looked – the disembodied mayor's head was able to address the thousand ants still standing on the dinosaur's forearm. In a meeting that was clearly far larger than a simple tête-à-tête, the bodiless head explained the situation regarding the *Tarbosaurus*'s teeth, issued a final command, and only then expired.

A crack team of two hundred soldier ants now marched into the dinosaur's mouth and made straight for that first tooth. Though the soldier ants were skilled at fighting, the black worms were many times their size. Owing to their familiarity with the structure of the tunnels, the worms successfully checked the soldier ants' attack, killing a dozen of them and forcing the rest to retreat.

Just as morale began to flag, reinforcements from another town arrived. These troops were a different type of soldier ant. Though smaller, they possessed a deadly power: they were able to deliver devastating attacks with formic acid. The fresh battalion surged into the tunnel, got into position, pivoted 180 degrees, aimed their posteriors at the enemy and ejected a fine spray of formic acid droplets. The black worms were reduced to scorched masses within seconds. Dark smoke poured from their remains.

Another detachment of soldier ants flooded in. They were also relatively small, but their mandibles were venomous – so venomous that a tiny bite could cause a black worm to twitch twice and drop dead. With the battle now in full swing, the ant army moved from tooth to tooth, rooting out the black worms. Acidic smoke leaked from every cavity. A team of worker ants ferried the corpses out of the dinosaur's mouth and deposited them on a leaf in its palm. Soon the leaf was piled high with dead black

worms, many of them still smoking. Several other dinosaurs gathered around the *Tarbosaurus*, looking on in amazement.

Half an hour later, the last of the black worms had been purged and the battle was over. The *Tarbosaurus*'s mouth was filled with the strange taste of formic acid, but the dental complaint that had troubled it for most of its life was gone. It began to roar excitedly, sharing the miracle with all the dinosaurs present.

The news spread quickly through the forest and there was a dramatic spike in the number of dinosaurs visiting the ants. Some of them still wanted their teeth picked, but most came seeking treatment for dental ailments, because tooth decay was prevalent among carnivores and herbivores alike. On the busiest days, several hundred dinosaurs would congregate in the clearing, striding along carefully between great streams of ants. It was a bustling, prosperous scene. Accordingly, there was also a sharp increase in the number of ants who came to service the dinosaurs, and, unlike their patients, the ants, once arrived, rarely left. And so, what had started off as a normal-sized town exploded into a megalopolis of more than a million ants. It was called the Ivory Citadel and became famous as the first gathering place of ants and dinosaurs on Earth.

With the boom in business and the end of the dry season, the ants were no longer satisfied with scraps scavenged from between the dinosaurs' teeth. Their clients began to pay for their medical services with fresh bones and meat. Since the ants of the Ivory Citadel no longer needed to forage for food, they became professional dentists. This specialisation led to rapid advances in the ants' medical technology.

In the course of their anti-toothworm campaigns, the ants often travelled along the cavities to the roots of the dinosaurs' teeth. At the junction of the teeth and the gums they found thick translucent pipes. When these pipes were touched, for example during combat, violent earthquakes would shake the dinosaurs' mouths. Over time, the ants came to understand that stimulating these pipes caused the dinosaurs pain; later, they would call these structures nerves.

The ants had for a long time known of a certain two-leafed herb that could make their own limbs go numb – numb enough that they felt no pain when a leg was torn off – and that could also put them to sleep, sometimes for several days. They now applied the juice of this herb to the nerves in the roots of the dinosaurs' teeth, and the consequence was that contact with the nerves no longer triggered earthquakes. The gums of dinosaurs with dental diseases were frequently septic, but the ants knew of

another herb whose juice could promote wound healing. So they spread the juice of this herb across the ulcers on the dinosaurs' gums, which closed up quickly.

The introduction of these two pain- and inflammation-reducing techniques not only enabled the ants to cure dinosaurs of toothworm infestations but also allowed them to treat other ailments not caused by the worms, such as toothaches and periodontitis. However, the real revolution in the ants' medical technology was brought about by the exploration of the dinosaur body.

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The ants were natural explorers, not out of curiosity – they were incurious creatures – but out of an instinctive urge to expand their living space. Every so often, while exterminating worms or pouring medicine onto a dinosaur's teeth, they would peek into the abysmal reaches of its mouth. That dark, moist, interior world awakened in them a desire to travel into the great beyond, but fear of the attendant perils had always stopped them in their tracks.

The Age of Exploration of the Dinosaur Body was eventually ushered in by an ant named Daba – the first named ant in the recorded history of Cretaceous civilisation. After much preparation, Daba capitalised on the opportunity presented by a toothworm treatment and led a small expedition of ten soldier ants and ten worker ants into the dank depths of a *Tyrannosaurus*'s mouth.

Battling extreme humidity, the expedition began its traverse of the long narrow isthmus of the tongue. Tastebuds speckled the surface like a vast megalithic structure of slimy white boulders extending far into the gloom. The ant explorers picked their way between them. As the dinosaur opened and closed its mouth, light from the outside world streaked through the gaps between its teeth, flickering like lightning on the horizon and casting long, wavering shadows behind the tastebud megaliths. When its tongue squirmed, the entire isthmus rose and fell like a stormy sea, causing shifting ripples to appear in the megaliths. And every time the *Tyrannosaurus* swallowed, viscous floodwaters gushed in from both sides, submerging the isthmus and forcing the ants to cling to the tastebuds for fear of being swept away. It was the stuff of nightmares, but the dauntless ants patiently waited for the floodwaters to recede, then pressed on.

At long last they arrived at the root of the tongue. The light was much weaker there, barely illuminating the mouths of the two enormous caves before them. In one cave, a fierce gale howled, by turns sucking and then expelling the air, reversing direction every two to three seconds. There was no wind in the other cave, just a reverberant rumbling that rose from its invisible depths – a rumbling familiar to the ants from their time working on the teeth, but much, much louder, more like continual booms of thunder. This mysterious and terrible noise unnerved the ants more than the gale, so they decided to try the windy passageway. They would later learn that this was the dinosaur's respiratory tract and that the scarily noisy passageway was its oesophagus.

With Daba in the lead, the expedition proceeded gingerly down the slick walls of the respiratory tract. When the wind was with them, they hurried forward several steps; when the wind was against them, it was impossible to walk, and they could only flatten their bodies and grip the wall tightly. They had not descended very far, however, before the tickle of their legs began to irritate the respiratory tract. With a slight cough, the dinosaur put an end to the ants' first expedition. A hurricane of unimaginable force spiralled up from the bottom of the tunnel, sweeping the expeditioners off their feet and jetting them across the isthmus of the tongue at lightning speed. Some of them were hurled headlong into the dinosaur's huge teeth, while others were blown straight out of its mouth.

Daba lost one of her middle legs in the failed expedition, but, unperturbed, she quickly organised a second attempt. This time she decided they would tackle the oesophagus instead. The preliminary stages went smoothly. The ants entered the oesophagus and began the long march down the seemingly endless and terrifyingly loud passage. Its creepy darkness was the least of their troubles, however, for the *Tyrannosaurus* had stopped beside a stream and now took a sip of water. The first the explorers knew of this was when they heard a great roar building behind them, a roar so loud that it rapidly drowned out the noise ahead of them. Daba immediately ordered the team to a halt, but before she could even begin to work out what was happening, a wall of water came cascading down the tunnel, hurtling past the ants, flinging them into its churn and propelling them at terrific speed all the way down the oesophagus and on towards the dinosaur's stomach.

Dazed and disoriented, Daba landed heavily and sank into something pulpy. She paddled her legs as hard as she could in a desperate bid to escape the ooze, but she

couldn't move at all in the sticky substance. Thankfully, the floodwaters were still pouring down, thinning the slurry and tumbling everything around, so when things finally began to settle, she was able to float to the top. She had another go at walking. The sludge beneath her was soft and watery, but solid chunks of varying sizes and shapes bobbed along on the surface, making it possible for her to crawl from one to the other. She made slow progress, the slime sucking at her feet, but at last she reached the edge of the slurry pit.

Before her rose a soft wall covered in cilia about as tall as she was, like a strange dwarf forest; the stomach wall, in fact. She began to scale it. Whichever route she took, the cilia curled around her, trying to grab her, but their reactions were sluggish and they came up empty every time. Daba's eyes had now adjusted to her surroundings and to her surprise she discovered that it wasn't totally dark in there. A faint glow suffused the space, shining through the dinosaur's skin from the outside world. In the light she spotted four fellow ants also climbing the stomach wall. She veered off to join them.

As they began to recover from the shock of their ordeal, the five ants stared down at the vast digestive sea from which they had just extricated themselves, mesmerised by the slow churn of the viscous mire. Every so often a great bubble exploded – the source of that reverberant rumbling. When a particularly large bubble burst below her, Daba saw a thick, squat object break the surface and list slowly to one side. She recognised it as a lizard's leg. Moments later, another massive, triangular object rose to the top. Its huge white eyes and wide mouth identified it as a fish head. Plenty more partially digested items followed, mostly either the bones and chewed-up remains of animals or the stones of wild fruits.

One of the ants beside Daba gave her a nudge, drawing her attention to the stomach wall beneath their feet. It was weeping clear mucus. The gastric secretions merged into rivulets that glistened in the faint light as they trickled down through the forest of cilia into the digestive sea below. Several of the ants were already coated in the juice. At first it simply made them prickle all over, but that soon intensified into a burning sensation not dissimilar to the aftereffects of a formic-acid attack.

'We're being digested!' one of the ants shouted. Daba was surprised she could still distinguish her comrade's pheromones from the pungent cocktail of strange odours in the stale air.

The ant was right. They were being digested by the dinosaur's gastric juices, and their antennae were the first things to go. Daba saw that her own antennae had been half-eaten away already. 'We need to get out of here,' she said.

'How? It's so far! We don't have the strength,' replied one of the other ants.

'We can't climb out – our feet have already been digested,' added another.

Only then did Daba notice that her own five feet had been partially consumed by the gastric juice. The feet of the other four ants had fared no better.

'If only there was another flood to flush us out,' the first ant said wistfully.

Her words sent a jolt of realisation through Daba. She stared at the ant, a soldier ant with a pair of venomous mandibles. 'You twit, you can cause another flood!' Daba shouted.

The soldier ant stared at the expedition leader in bewilderment.

'Bite it! Make it throw up!'

The soldier ant, grasping the idea at last, immediately started nipping savagely at the stomach wall. She quickly chewed through several cilia, leaving deep gouges in the wall. The stomach wall quivered violently, then began to convulse and contort. The cilia forest grew denser, a clear sign that the stomach was contracting and the dinosaur was about to vomit. The digestive sea began to roil, taking the ants with it. Engulfed by the rapidly rising sea, in a very short space of time the five ants were whooshed all the way up the oesophagus, swept over the isthmus of the tongue, catapulted across the two rows of teeth and expelled into the great outdoors, landing in the grass with a flump.

Once the five expeditioners had disengaged themselves from the slithery slick of vomit, they saw that they were encircled by a vast swarm of ants. A crowd of several hundred thousand had come to cheer the return of the great explorers. The Age of Exploration of the Dinosaur Body had begun in earnest, an era that was to prove as important to antkind as the Age of Discovery was for humankind.

Chapter 3

The Dawn of Civilisation

Following Daba's pioneering feat, one ant expedition after another plumbed the depths of the dinosaur body via the oesophagus. They discovered that the fastest way in was to hitch a ride when the dinosaur was eating or drinking something, surfing in on a gulp of river water or a ball of chewed-up food. The ants knew that a dinosaur was made up of at least two systems: the digestive system, which they had now probed many times, and the respiratory system, which they had never visited. After Daba recovered from her injuries, the five-legged, stumpy-feelered ant decided to try the windpipe again. This time her team was comprised of smaller ants and they marched at widely spaced intervals to minimise the irritation to the dinosaur's respiratory tract and prevent a repeat of the disastrous cough.

Compared with the oesophagus, the journey through the respiratory tract was gruelling: there was no food or water on which to cadge a lift, and they had to march in gale-force conditions. Only the strongest ants stood a chance of making it. But the great explorer and her team triumphed again and for the first time antkind entered a dinosaur's respiratory system.

Where the digestive system was suffocatingly humid, the respiratory system was a domain of fierce winds and unpredictable currents. In the dinosaur's lungs, the ants witnessed the awe-inducing sight of air dissolving into the bloodstream via the vast three-dimensional labyrinth formed by the air sacs. That river of blood, flowing from some unknown source, alerted them to the existence of other worlds inside the dinosaurs, worlds that they would much later come to identify as the circulatory system, the nervous system and the endocrine system.

The focus of the third stage of exploration was the dinosaurs' craniums. On their first attempt, the ants ventured in through their subject's nostrils. Light-footed though they were, their pattering caused such intense tickling that the dinosaur sneezed with tornadic ferocity, shooting the little prospectors back out of its nasal passageway like

bullets from a gun. Most of the team members on that initial mission were torn to shreds. Later cranial survey expeditions entered through the ears, with more success. En route, they investigated the dinosaurs' visual and auditory organs and analysed those delicate systems. They did eventually manage to reach the brain, though it was many years before they worked out the purpose and significance of that most mysterious of organs.

And so it was that the ants gained a detailed understanding of dinosaur anatomy, laying the foundations for the medical revolution that followed.

Ant expeditions often entered the bodies of sick dinosaurs – massive creatures that had been reduced to skin and bone, their eyes dull and heavy, their movements slow and feeble, creatures that could do little but continually moan with pain. By comparing their interior systems with those of healthy dinosaurs, the ant explorers were easily able to pinpoint the locations of the diseased organ or lesion in question. They envisioned many different methods of treating internal diseases in dinosaurs, but not a single one could be put to the test, for such mammoth undertakings would require the consent of the dinosaur itself and to date the ants had always gained access without their hosts' knowledge.

The vast majority of dinosaurs would on no account let the ants burrow into their stomachs or brains, even if their intentions were entirely honourable and therapeutic. However, an epoch-making breakthrough occurred in this regard with a *Hadrosaurus* named Alija, the earliest named dinosaur in the history of Cretaceous civilisation.

When Alija trudged into the Ivory Citadel that day, it was immediately obvious to the ants that he was in frail state. A squad of five hundred straight away scuttled forward to greet him and offer assistance, as they did with every dinosaur patient, and Alija duly opened his mouth and pointed inside with his claw. It was an unnecessary gesture, for dinosaurs only ever turned up there to get their teeth worked on. But the lead ant doctor, an ant by the name of Avi, who would later become the father of ant internal medicine, noticed that Alija was not actually pointing to his teeth but to somewhere further down – to his throat. Next, the dinosaur pointed to his stomach, grimaced to show that it hurt, and pointed to his throat again. There was no mistaking his meaning: he was asking the ants to examine his stomach.

So Dr Avi led a team of several dozen ants to conduct the first ever internal examination of a consenting dinosaur. The diagnostic team entered Alija's stomach by way of his oesophagus and quickly discovered a lesion in the stomach wall. Major

medical intervention was required, but Dr Avi knew that with the limited antpower currently available to him, this was not possible. He would need a great deal of assistance. When he emerged from the dinosaur's mouth, he made an emergency appointment with the mayor of the Ivory Citadel. At the meeting, he explained the situation and requested an additional fifty thousand ants as well as three kilograms each of anaesthetic and anti-inflammatory drugs.

The mayor waved her antennae angrily. 'Are you crazy, Doctor? We have a full schedule of dinosaur patients today. If we reassign that many ants to your team, we'll have to delay service to nearly sixty dinosaurs. Not to mention that that much medicine would be enough for a hundred treatments. That *Hadrosaurus* is sickly. He's too weak to find bones and meat. How will he pay for this super-treatment?'

'You must take the long view, Madam Mayor,' Dr Avi replied. 'If this intervention is successful, we ants will no longer be restricted to treating only dental problems – we'll be able to cure almost any disease. Our business with the dinosaurs will increase tenfold, a hundredfold. We'll earn more bones and meat than we can count, and your city will grow prodigiously.'

The mayor was persuaded and she gave Avi the ants, drugs and authority he had asked for. A great contingent of fifty thousand ants was soon assembled, and two piles of drugs were hauled in. The sick *Hadrosaurus* lay flat on the ground as the army of ants streamed into his open mouth in continuous, unbroken columns, each ant carrying a tiny backpack filled with drugs. Hundreds of giant dinosaurs gathered around in a circle, gawping at this grand undertaking.

'I can't believe that idiot's letting all those bugs crawl right into his stomach,' grumbled a *Tarbosaurus*.

'So what?' a *Tyrannosaurus* snapped back. 'We already allow them into our mouths, don't we?'

'Dental hygiene is one thing, but when it comes to matters of the stomach, well, that's a whole different ocean of fish,' the *Tarbosaurus* replied. 'Over my dead body—'

'But what if your body was very nearly dead – like with this poor *Hadrosaurus* here,' a squat *Stegosaurus* behind them interjected, craning her neck to see. 'If the ants really can cure him—'

'You mark my words, if we let them into our stomachs now, before we can so much as scratch an itch, they'll be crawling into our noses, ears, eyes – into our

brains, even. And who can anticipate what might happen then.' The *Tarbosaurus* glared at the *Stegosaurus*. 'Not in a million years would I countenance that.'

'A million years, huh?' said the *Tyrannosaurus*, stroking his chin. 'But think how easy life would be if every disease could be cured.'

The other dinosaurs chipped in:

'Yeah, life would be so easy…'

'Getting sick is a massive pain…'

'We could live forever…'

The first stage of the operation required that anaesthetic be administered to the lesion in Alija's stomach. It had been collected from plants for use during dental procedures, and under the direction of Dr Avi the ants now ferried it into the *Hadrosaurus*'s stomach. After the area had been numbed, several thousand worker ants began to cut away the diseased tissue. This was a huge project, as the excised gastric tissue had to then be transported out of the dinosaur's body. Porter ants formed a long black chain, passing little gobbets of flesh from ant to ant, all the way back up the line and onto the ground outside, where the pile of stinky rotten tissue was expanding fast. Once the lesion had been cut out, an anti-inflammatory had to be applied to the wound, which required another great procession into the *Hadrosaurus*'s stomach.

The entire procedure took three hours and was completed by sundown. When all of the ants had withdrawn, Alija reported that the pain in his stomach had disappeared. Several days later, he made a full recovery.

The news spread like wildfire through the dinosaur world. The number of dinosaurs seeking treatment at the Ivory Citadel increased tenfold, and this brought multitudes of ants flooding into the city in search of work. Thanks to the healthy uptick in business, the ants' medical technology advanced in leaps and bounds. Now that they had official access to dinosaur bodies, they learnt to treat various diseases of the digestive and respiratory systems; later, their repertoire expanded to include diseases of the circulatory, visual, auditory and nervous systems – systems that required extraordinary levels of expertise to understand and heal. New drugs were being developed all the time, derived from not only plants but also animals and inorganic minerals.

The ants' endosurgical techniques also progressed rapidly. For example, when performing surgery in the digestive system, it was no longer necessary for a long line

of ants to trek down the dinosaur's oesophagus. Instead, they entered by means of an 'ant pellet'. Approximately one thousand ants would cling tightly to one another and form a ball ten to twenty centimetres in diameter. The dinosaur patient would then wash down one or more of these pellets with water, as though swallowing a pill. This technique improved surgical efficiency substantially.

As the Ivory Citadel continued to mushroom, some of the dinosaurs who came for treatment stayed on, establishing a city of their own not far from the ant megalopolis. Because the dinosaurs constructed their homes with massive stones, the ants called it Boulder City. The Ivory Citadel and Boulder City would later become the capitals of the Formican and Saurian Empires of Gondwana.

There was also significant movement in the opposite direction. Some of the dinosaurs who returned home after having received treatment took groups of ants with them to other dinosaur cities and ant colonies all across Gondwana. When the émigré ants settled in these faraway places, they passed on the Ivory Citadel's medical technology to the locals. And so dinosaur–ant cooperation gradually spread throughout Gondwana, cementing the foundations for a dinosaur–ant alliance.

Up till now, the cooperation between Earth's two dominant species could only be classified as an advanced symbiotic relationship. The ants provided medical services to the dinosaurs in exchange for food, and the dinosaurs traded food for medical care. Although the character of the transaction had evolved considerably since the ants had picked that first dinosaur's teeth, the essence of the contract had remained unchanged.

In fact, this sort of mutualistic association between different species had long existed on Earth and persists to the present day. The practice is as old as the hills – older than most hills, actually. Consider, for example, the cleaning symbioses among marine organisms. Cleaner species rid certain fish of ectoparasites, fungi and algae, as well as damaged tissue and wayward scraps of food, and in the process they get to eat their fill. They assemble at fixed 'cleaning stations' to wait for client fish to swim by. Cleaners and clients establish ways of signalling to each other: for example, when a cleaner shrimp wants to approach a large fish, it will nudge it with its antennae. If the fish wishes to be cleaned, it will tilt its body, flare its gills and open its mouth to indicate its acceptance. Only then will the cleaner shrimp proceed; otherwise, it runs the risk of being eaten. Cleaning associations are extremely important to fish, and whenever a cleaner species is removed from an area, there's a decline in both the health and abundance of the client fish species.

This type of symbiotic relationship has its limitations, however. The two symbionts come together solely for the purpose of exchanging the basic services necessary for survival. But the transition to civilisation requires symbionts to exchange something more profound, to engage in a higher level of cooperation, so that they might establish an alliance that is not merely symbiotic but co-evolutionary.

It was at this point in time that something happened in Boulder City to raise the dinosaur–ant alliance to new heights.

Chapter 4

Tablets

Tablets were as vital to the dinosaur world as the paper on which we write. They came in two types: stationary and movable. Also called ‘wordhills’ or ‘wordstones’, stationary tablets (which we might also, rather pleasingly, term ‘dinosaur *stationery*’), were hills with a relatively even slope, gentle cliff faces or enormous rocks with smooth surfaces, on which the dinosaurs carved their super-sized words. Movable tablets could be made from many different materials, but wood, stone and leather were the most common. Because the dinosaurs did not yet use metal, let alone saws, they were unable to manufacture wooden boards; instead, they used their megalithic stone hatchets to cleave tree-trunks in two, lengthwise down the middle, and they then carved characters into the cross-section of one-half of them. Their stone tablets were flat slabs with facades soft enough for engraving; these came in all shapes and sizes, but the smallest would have been at least as big as one of our family dining-tables. Leather tablets were made from animal hides or lizard skins, and characters were drawn on them in plant- or mineral-based paint; often a single tablet required that many skins be joined together.

The dinosaurs’ thick, clumsy fingers made it impossible for them to grip small implements for carving or writing, and they lacked the dexterity needed to form small characters. As a result, the characters they produced were very large: the smallest they could manage were still the size of a football. This meant that their tablets were by necessity huge and unwieldy, and even then they could fit only a few characters on each one.

Tablets were usually held communally by a dinosaur tribe or settlement and were used to keep simple records of collective property, membership, economic output, and births and deaths. A tribe of a thousand dinosaurs would need twenty to thirty sizeable trees for a register of its members, and the minutes from one meeting might require over a hundred hides. As a result, the manufacture of tablets placed a significant strain

on the dinosaurs' resources, and furthermore, when tribes or settlements relocated (a frequent occurrence during the Hunting Era), transporting libraries of tablets proved an even greater burden. For this reason, although dinosaur society had possessed a written language for a thousand years, its cultural development was painfully slow and had nearly come to a standstill in recent centuries. Their script had remained extremely crude. With only simple, unary numerals and a handful of pictographs, it lagged far behind the sophistication of their spoken language. The sluggish emergence of writing had become the biggest obstacle to scientific and cultural progress in the dinosaur world, one which had arrested dinosaur society in a primitive state for a long time. It was a textbook example of how a species' ill-shaped hands could hinder its evolution.

The dinosaur Kunda was one of a hundred or so scribes in Boulder City. In the dinosaur world, the job of a scribe fell somewhere between that of the modern-day occupations of typist and printer. Scribes were chiefly responsible for copying tablets by hand. On the day in question, Kunda and twenty other scribes were working in front of a mountain of tablets, making a copy of the register of Boulder City's residents for safekeeping. Most of the original register had been recorded on wooden tablets. Hundreds of split tree-trunks were stacked in hill-height piles, giving Kunda's workplace the appearance of one of our timber yards.

Kunda, a blunt stone knife gripped in his left claw and one of those humungous stone hammers in his right, was transcribing the pictograms from a ten-metre-long wooden tablet onto two new, shorter tablets. He had been at this dull, draining work for days and days, but still the inselberg of blank trunks in front of him didn't seem to have got any smaller. Hurling down the stone knife and hammer, he rubbed his weary eyes, leaned back against a stack of tablets and heaved a deep sigh, feeling very dispirited about his tedious life.

Just then, a squadron of a thousand ants paraded past on the ground before him – on their way back from surgery, Kunda presumed. A sudden inspiration seized him. He stood up, picked out two dried strips of glow-lizard jerky and waved them at the colony. Glow-lizards were so-called because they emitted a fluorescent light at night, and their meat was a favourite with ants. No surprise then that the ant squadron immediately changed its direction of travel and veered towards him.

Kunda pointed first to the tablet he was copying from, then to the one he was working on – which, depressingly, he'd so far inscribed with a mere two-and-a-half

characters – and then to the ants. The ants grasped his meaning at once. They surged onto the smooth white face of the partially completed tablet and began to carve the remaining characters into the wood with their mandibles. Kunda, meanwhile, eased himself back against the stack of tablets, feeling rather smug. The ants would take much longer to finish the task than he would, but their patience and tenacity was immeasurably superior to that of any other creature and they would get it done eventually. In the meantime, he could kick back and relax for a spell.

He dozed off. In his dream he saw himself at the helm of a mighty army of more than a million ants, enthusiastically urging on his troops. The army swarmed over hundreds of blank tablets and like a black tide turned every one of them dark; before long, the tide withdrew, revealing a vast collection of tablets whose white surfaces now bore neat lines of orderly characters carved into them.

A series of slight pricks on Kunda's lower leg roused him from sleep and when he raised his head he saw that several ants were gnawing at his left ankle. This was their customary way of getting a dinosaur's attention. Seeing that he was awake, the ants gestured at the tablet with their antennae, to indicate the job was done. Kunda glanced up at the sun and realised that very little time had passed. He then looked at the tablet and promptly lost his temper. The ants had completed the half-written character at full size, but all the other characters they'd carved were many times smaller. It looked ridiculous – like a tiny tail trailing after the three large characters. Such shoddy work wasn't just inadequate, it had ruined a whole tablet.

Kunda had known all along that the ants were crafty little mercenaries, and now he had proof. He raised a broom to mete out the punishment they deserved. But just as he was about to strike, he caught another glimpse of their wooden tablet and a sudden revelation flashed through his mind. The characters the ants had carved were small, but they were fully legible to dinosaur eyes. The reason characters were normally so big was not for ease of reading but because the dinosaurs were not dexterous enough to inscribe anything smaller. It occurred to him that the ants, who were twitching their antennae frantically in his direction, might very well be trying to explain this to him.

The scowl on his face broadened into a smile and he dropped the broom. Then he set down one of the strips of glow-lizard jerky in the middle of the colony and swished the other tantalisingly. Crouching down in front of the tablet, he gestured at the three large characters and the line of small characters and tried to communicate his idea. It took the ants a while to catch on, but eventually they waggled their feelers

in emphatic confirmation: yes, they could carve characters that were smaller still. Immediately, they flooded onto the blank part of the tablet and set to work. Soon they had carved a line of even smaller characters, each about the size of the letters in the title on this book's cover. As the ants were illiterate, they were simply reproducing the shapes of the characters.

Kunda rewarded them with the remaining strip of jerky. Then he hacked off the section of the tablet carved with the smallest characters, tucked it under his arm and gleefully lolloped off to see the city prefect.

Because of Kunda's low status, the guards stopped him on the steps of the colossal stone mansion that housed the prefect's office. The guards were imposing, powerfully built dinosaurs and Kunda quickly lifted up the section of the tablet for them to see. They inspected it. Within moments, their expressions had morphed from surprise to awe; it was as if they were in the presence of a sacred relic. Turning their gaze back to Kunda, they gaped at him for a long time, as though he were a great sage, then let him pass.

'What's that you've got there – a toothpick?' the prefect asked when he saw Kunda.

'No, sir, this is a tablet.'

'A tablet? Are you an idiot? You couldn't fit half a character onto that piddly piece of wood.'

'It's hard to believe, I know, sir, but there are actually more than thirty characters on this self-same piddly piece of wood.' Kunda passed it over.

The prefect gazed at the tablet with the same wonderment as the guards. After a long time, he looked up at Kunda. 'I don't suppose you carved this yourself?'

'Of course not, sir. A gang of ants did it.'

Boulder City's municipal officials gathered round and the tablet was passed from claws to claws, much like we might hand round an ivory figurine to be admired. These dinosaurs constituted the city's ruling class and they now launched into fervent discussion.

'Incredible – such tiny characters…'

'… and totally legible too.'

'Over the millennia, so many of our ancestors have tried to write like this, but to no avail.'

'Those itsy-bitsy bugs really are quite capable.'

‘We should have known they’d be good for more than medical care.’

‘Just think of all the materials we’ll save…’

‘… and how easily we’ll be able to transport our tablets. You know, I might be able to carry the entire register of the city’s residents by myself! No need to employ a hundred-strong division of dinosaur movers any more.’

‘And that’s just the start of it, I’d say. We can now consider changing the materials we use for the tablets too.’

‘Quite so. After all, where’s the merit in using tree-trunks? For characters this small, bark would surely be lighter and more portable.’

‘Precisely. And a lot cheaper too. Small lizard skins as well.’

The prefect interrupted the chatter with a wave. ‘Right then, from now on the ants will be our scribes. We shall start by raising a writing force of a million ants or more. Let’s see…’ He surveyed the room, his eyes finally falling on Kunda. ‘You will lead this campaign.’

So Kunda realised his dream, and Boulder City, along with rest of the dinosaur world, saved a great deal of wood and stone and an enormous quantity of hides. But compared with the real significance of this event in the history of Cretaceous civilisation, those savings were trivialities.

The advent of fine antprint made it possible to transcribe vast volumes of information, and at the same time the dinosaurs’ script grew richer and more sophisticated. At long last, the alpha and omega of the dinosaurs’ experience and knowledge could be fully and systematically recorded using the written word and mathematical equations. It could also be disseminated far more widely, reliably and permanently, no longer subject to the vagaries of dinosaur memory and oral tradition. This remarkable advancement gave fresh impetus to Cretaceous science and culture, sending the long-stagnant Cretaceous civilisation into a period of whirlwind development.

Meanwhile, new applications for the ants’ fine-motor skills were found in all sectors of the dinosaur world. Take timekeeping technology as an example. Dinosaurs had invented the sundial long ago, but because they used large tree-trunks as gnomons and drew rough hour lines around them, these had to remain fixed in place. Thanks to the ants, sundials could now be made smaller and the hour lines rendered more precisely, allowing dinosaurs to carry them around. Later, dinosaurs would invent the hourglass and the water clock, and though they might have been able to make the

containers themselves, only ants could bore the crucial holes. The manufacture of mechanical clocks was even more dependent on ant labour, for though a grandfather clock might be taller than a dinosaur, it still contained numerous tiny parts that could only be machined by ants.

But the area in which the ants' skills made the most meaningful contribution to the advancement of civilisation, besides writing, was scientific experimentation. Thanks to the ants' capacity for intricate work, it was now possible to take measurements with an exactitude that had eluded dinosaurs, allowing a shift in experimentation from the qualitative to the quantitative. Research once thought impossible became a reality, leading to rapid strides in Cretaceous science.

Ants were now an integral part of the dinosaur world. Dinosaurs of high standing were never without a miniature ant nest. Most of these nests resembled a wooden sphere and housed several hundred ants. When a dinosaur needed to write, it would unfold a strip of bark or hide parchment on the table and set down its ant nest beside it. The ants would scurry out onto the parchment and etch the words dictated to them by the dinosaur. They used a very particular system of concurrent writing, quite different from our own. Where we humans write one character at a time, the ants teamed up and inscribed multiple characters simultaneously. This allowed them to complete a transcription very rapidly, at a pace that would far outstrip our own handwriting speed. Naturally, a dinosaur's pocket-sized ant nest also came in handy for all sorts of other tasks that required a light touch.

For their part, the ants received much more than just bones and meat from the dinosaurs. After their new collaboration began, the first invaluable asset the ant world gained was written language. Ants had never had a written language before, and even as they became the dinosaurs' scribes, they remained illiterate, which meant they were limited to simple reproduction work, copying out the characters from the dinosaurs' outsized tablets. Their efficiency was relatively poor, as they could only transcribe one stroke at a time. But the dinosaurs were in dire need of ants who could take dictation like secretaries, and the ants, who were well aware of the importance of written language to society, were eager to learn. Thanks to a concerted effort on both sides, the ants quickly mastered the dinosaurs' script and co-opted it for use in their own society.

For Cretaceous civilisation, this was of immeasurable significance because it forged a bridge between their respective worlds. Over time, the ants came to

understand dinosaur speech, but dinosaur anatomy meant that dinosaurs would never be able to understand the ants' pheromone-based language. Consequently, only simple exchanges took place between the two worlds. But the ants' mastery of written language brought about a fundamental change in this, for the ants could now communicate with the dinosaurs through writing. To facilitate this, they invented an astounding new method. Within a square patch of ground, thousands of ants would quickly arrange themselves to form lines of text. This drill composition technique grew more polished by the day. Eventually, the transition between drill formations was so swift that the block of ants resembled the instantaneous output of a computer screen.

As communication between the two worlds improved, the ants absorbed more and more knowledge and ideas from the dinosaurs, for each new scientific and cultural achievement could now be promptly disseminated throughout antkind. And so the critical defect in ant society – the dearth of creative thinking – was remedied, leading to the simultaneous rapid advancement of ant civilisation. The result of the dinosaur–ant alliance was that the ants became the dinosaurs' dexterous hands, while the dinosaurs became a wellspring of vision and innovation for the ants. The fusion of these two budding intelligences in the late Cretaceous had finally sparked a dramatic nuclear reaction. The sun of civilisation rose over the heart of Gondwana, dispelling the long night of evolution on Earth.

Chapter 5

The Steam-Engine Age

Time flew by, and one thousand years passed. Cretaceous civilisation entered a brand-new era as the ants and dinosaurs established their own vast empires.

The dinosaur world moved into the Steam-Engine Age. Though the dinosaurs had not yet harnessed electricity, they mined minerals on a massive scale, smelted a variety of metals and powered their complex machines with huge steam engines. They constructed cities across the continent and linked them via a web of broad-gauge railways serviced by a fleet of ginormous trains. These were comprised of carriages the size of our five- or six-storey buildings and were drawn by steam locomotives so behemothic that they made the ground shake beneath them and left billowing clouds lingering on the horizon. There were also high-altitude transport balloons, whose shadows enveloped entire cities as they floated by, and mighty ships plying every major ocean; these too were powered by steam engines or sometimes by magnificent sails. Fleets of these ships, as high and hefty as a seaborne mountain range, carried Gondwanan dinosaurs and ants to other continents, and so their particular model of civilisation, based on the dinosaur–ant alliance, spread right across the Late Cretaceous world.

By their own standards, the ants' empire was also incomparably vast. No longer confined to subterranean nests, the ants now resided in cities that dotted every continent like a constellation of stars. Just as it is hard for us to grasp the immense scale of dinosaur civilisation, it is difficult to imagine the miniature nature and intricate structures of ant civilisation. Though ant cities were generally no larger than one of our football fields, the detail and complexity of these megalopolises was dizzying. Ant buildings were typically one to two metres tall, with elaborately filigreed interiors that functioned like three-dimensional labyrinths. Their trains were the size of our smallest toy cars, and their transport balloons were like soap bubbles

drifting with the wind. These vehicles could only cover short distances, so if an ant wanted to travel further afield, they had to board a dinosaur train, balloon or ship.

The ant and dinosaur worlds maintained a closely cooperative, mutually dependent relationship. By then the dinosaurs had invented technology that enabled them to quickly print long tracts of text on paper, and they had also created typewriters with keys the size of our computer screens, to accommodate their fat fingers. Though the dinosaurs therefore no longer needed ants for scriptorial work, in many other sectors their fine-motor skills were more important than ever – indispensable, in fact. After all, it would have been impossible to manufacture printing presses and typewriters without the countless precision parts machined by the ants. And with the emergence of large-scale industry in the dinosaur world, there was a greater demand for fine manipulation. The manufacture of everything from steam-engine valves and meters to ocean-liner compasses required the ants' pinpoint accuracy. The field of medicine, which was where the dinosaur–ant alliance originated, was now more ant-dominated than ever, as dinosaurs, with their clumsy claws, had never learnt to operate on their own kind.

The dinosaur and ant worlds may have been interdependent civilisations, but they were also independent entities, and this necessitated the development of a more sophisticated economic relationship. Globally, there were two currencies in circulation: paper bills the size of our extra-large yoga mats, as used by the dinosaurs, and tiny slivers of shredded paper, as used by the ants. The two currencies were exchanged on a one-for-one basis.

For the first thousand years of Cretaceous civilisation, relations between the ant and dinosaur worlds were harmonious and, on the whole, frictionless. This was due in large part to their interdependence, for had the alliance broken down, it would have precipitated a deadly crisis for both worlds. Another important reason was that the ants lived in a low-consumption society. Their material requirements were easily satisfied, and they took up very little space. Much of the Formican Empire's territory overlapped but did not interfere with that of the Saurian Empire, allowing the dinosaurs and the ants to coexist without intense competition.

There was, however, a deep and unbridgeable cultural gulf between the two civilisations – a manifestation of the sharp differences in the physiologies and social structures of the two species. Because of this, the ant and dinosaur worlds never truly became one. And as civilisation advanced, intercultural conflict became unavoidable.

With the expansion of their respective intelligences, both the ants and the dinosaurs showed a growing awareness of the vastness of the cosmos, but exploratory research into the underlying laws of the universe was still in its infancy. Science seemed weak and inadequate, so religion was born, and religious fanaticism rapidly reached fever pitch in both worlds. As the differences between the two civilisations were expressed through increasingly distinctive religious beliefs, the latent crisis came to a head and dark clouds gathered over Cretaceous civilisation.

A Dinosaur–Ant Summit was held annually in Boulder City. At this meeting, the sovereigns of the Saurian and Formican empires discussed the major issues of the day. Boulder City and the Ivory Citadel were still the imperial capitals, and although the latter, relatively tiny as it was, seemed no more conspicuous than a postage stamp pasted onto the side of the magnificent Boulder City, the two were nevertheless equal in status. When Queen Lassini of the Formican Empire entered the lofty imperial palace of the Saurian Empire, she was therefore accorded a grand reception. As happened whenever an important ant official travelled, she was accompanied by a contingent of soldier ants known as a word corps, whose function was to assume the formations necessary to facilitate negotiations with the dinosaurs. The size of a word corps was determined by the rank of the official, and the corps that came to Boulder City with the ant queen was, of course, the largest of them all.

And so it was that as the dinosaur guard of honour sounded their fanfare of bugles, a phalanx of one hundred thousand soldier ants escorted their queen into the hall. Tightly packed into a dense black quadrilateral of precisely two square metres, the ants advanced slowly across a floor as smooth and shiny as a mirror and halted before the dinosaur emperor, who had come to receive the queen.

Emperor Urus greeted his opposite number. ‘Hello there, Queen Lassini! Are you out in front of that black square?’ He stooped and peered intently at the ground in front of the word corps, then shook his enormous head. ‘How long has it been since we last saw each other – a year? The last time we met, I could still see you, but that’s quite impossible now. Ah, but I am old, and my eyes are not what they were.’

The black square broke apart and rapidly re-formed as a line of dinosaur-sized text: ‘Perhaps the colour of the floor is to blame. You should really use white marble here, so that you can see me. Her Imperial Majesty Lassini, Sovereign of the Formican Empire, presents her compliments to His Imperial Majesty, Emperor Urus.’

Urus smiled and nodded. ‘Well now, my compliments also to Her Imperial Majesty. I presume the imperial emissary has notified you regarding the agenda of this summit?’

Craning her neck in the direction of the dinosaur emperor towering before her, Queen Lassini inclined her antennae and gave her answer in the form of a pheromone. When the commanders in the front row received the chemical signal, they swiftly relayed the instructions to the phalanx behind them. The disciplined soldiers of the words corps changed formation like a well-oiled machine, arranging themselves into the queen’s words in the blink of an eye: ‘The aim of this summit is to settle the religious dispute between our two worlds. This problem has plagued us since the reign of the late emperor, and now it has become the most serious crisis yet faced by the dinosaur–ant alliance. I expect Your Majesty is aware that Earth stands on the brink of disaster as a result.’

Urus nodded again. ‘I am indeed aware of that. No doubt Your Majesty is similarly cognisant that the resolution of this crisis presents us with a considerable challenge. Where do you propose we begin?’

The queen thought for a moment before she replied, and the word corps rearranged themselves across the marble floor at lightning speed: ‘Let us begin with the point we are agreed upon.’

‘Very good. Dinosaurs and ants are agreed that this world can have only one God.’

‘Yes, that’s correct.’

Both rulers fell briefly silent, then Urus said, ‘We should discuss what God looks like, even though we have been over this a thousand times before.’

‘Yes,’ Lassini said, ‘that is the crux of the conflict and the crisis.’

‘God undoubtedly resembles a dinosaur,’ said the dinosaur emperor. ‘We have seen God through our faith, and God’s image embodies all dinosaurs.’

‘God undoubtedly looks like an ant,’ said the ant queen. ‘We have also seen God through our faith, and all ants are reflected in God’s image.’

Urus smiled broadly and waggled his mammoth head. ‘Queen Lassini, if you were the least bit logical or had a smidgen of common sense, this problem would be sorted in a jiffy. Do you truly believe that God could possibly be a dust-mote speck of an insect like you? That such a God could create a world as vast as this?’

‘Size does not equal strength,’ Lassini replied. ‘Compared with mountain ranges or oceans, dinosaurs too are mere “dust-mote specks”.’

‘But the fact is, Your Majesty, that we dinosaurs are the fount of original thought, the purveyors of creativity. And when all is said and done, you ants are nothing but tiny cogs in a highly efficient machine.’

‘The world cannot have been created by thought alone. If it were not for our expertise, most dinosaur inventions and innovations could not have been realised. The creation of the world was clearly a precise and meticulously executed undertaking. Only an ant God could have accomplished it.’

Urus burst out laughing. ‘What I find most intolerable about you ants is your pitiful imaginations! Those bite-sized brains of yours are obviously only fit for simple arithmetical thinking. You truly are no more than desperately dogged cogs!’ As he spoke, he bent his face low to the ground and whispered to the ant queen, ‘Let me tell you, when God created the world, no action was required. God simply gave form to thoughts and – whoosh! – those thoughts became the world! Ha ha ha!’ He straightened up and guffawed again.

‘Sir, I did not come here to discuss metaphysics with you. This drawn-out dispute between our two worlds must be resolved at this meeting.’

Urus threw up his claws and boomed, ‘Ah-ha! Result! Here is the second point upon which we are agreed! Yes, we must come to an accord this time round. Your Majesty, you may propose your solution first.’

Lassini gave her answer without hesitation. In order to convey the solemnity of her pronouncement, the word corps added a border around her words: ‘The Saurian Empire must immediately demolish all churches consecrated to a dinosaur God.’

Urus and the other ministers in the room eyeballed each other then erupted into a great cacophony of chortles. ‘Ha ha, big words from a bitsy bug!’

Lassini continued undeterred. ‘The ants will suspend all work in the Saurian Empire and withdraw completely from every dinosaur city. We will not return or resume work until your churches have been demolished in accordance with our demands.’

‘I will also deliver an ultimatum from the Saurian Empire,’ bellowed Urus. ‘The Formican Empire must demolish all churches consecrated to an ant God by week’s end. When the week is up, the imperial army will stomp flat any ant city in which a church to an ant God still stands.’

‘Is this a declaration of war?’ Lassini asked calmly.

‘I hope it will not come to that. What a disgrace it would be for dinosaur troops to have to confront you itsy insects.’

The ant queen did not dignify that with an answer. She simply made a sharp about-turn and pattered away. The word corps parted to let her pass, closed ranks behind her and followed her to the palace door.

There was a general stirring now among the dinosaurs. Ants began emerging from the miniature nests that were hung about the dinosaurs’ bodies or placed on the tables before them; they spilled out in their inky-black hundreds and thousands. For although the dinosaur printing industry had been mechanised, individual dinosaurs still carried small nests with them, just as we carry pens. They relied on ants to write their personal notes and missives. The nests varied in size, and some were veritable works of art. Among dinosaurs, they had become a must-have personal ornament and a symbol of wealth and status. But the ants inside the nests were not the dinosaurs’ personal property. They had to be hired from the Formican Empire, and ultimately they answered only to their queen. Swarming down from the tables and off the dinosaurs’ bodies, these ants were now streaming across the floor to join the departing phalanx.

‘Good grief,’ rasped a dinosaur minister, ‘if all of you leave, how am I to draft and review documents?’

Urus gave a theatrical flick of his claws. ‘They’ll be back to work before long,’ he said contemptuously. ‘The ant world cannot survive without us. Fret not, we will show those upstart insects who truly has God on their side.’

At the door, Lassini turned around and spoke, and the word corps swiftly formed a line of text: ‘That is exactly what the Formican Empire intends to show you.’

Chapter 6

The Ants' Arsenal

'What? We're going to war with the dinosaurs? But that's madness! They're so big, and we're so small…' an ant minister exclaimed.

In the imperial palace in the Ivory Citadel, the imperial high command had just heard the queen's account of the Dinosaur–Ant Summit.

'Our empire has come a long way. Anyone who still takes size as a measure of strength is an idiot,' said Field Marshal Donlira, commander-in-chief of the imperial army. She turned to the queen. 'Please rest assured, Your Majesty, that the imperial army is robust enough to defeat those clumsy beasts.'

'Talk is cheap.' The minister fixed his gaze on the field marshal. 'We all know that you have personally led the army into countless battles and have sailed on dinosaur ships to wage war on other continents, but you were only fighting against uncivilised ant tribes then. When it comes to confronting creatures many times larger than ourselves, I doubt one of your divisions could beat even a lizard.'

The queen dipped her antennae to the field marshal. 'Yes, Donlira, it's not empty talk that I want but detailed strategies and carefully conceived tactics. In one week we will go to war. So, tell me, what's the plan?'

'We have been performing medical services for the dinosaurs for more than a millennium now,' Field Marshal Donlira replied, 'so we are intimately acquainted with their anatomy. The imperial army will penetrate the dinosaurs' bodies and attack their vitals. In this kind of warfare, our petite size is to our advantage.'

'How will you gain access?' another minister asked. 'While they're sleeping?'

The field marshal jiggled her antennae in disagreement. 'No, from a moral standpoint, we cannot be the ones to start the war. This attack against the dinosaurs will be carried out on the battlefield.'

'Easier said than done! On the battlefield, the dinosaurs will be awake and on the move. Will your soldiers be able to scale them? Even if they stood still to let you onto

their feet, how long would it take to climb up to their noses and mouths? By the time your army gets inside them, they'll have already trampled our capital into oblivion.'

Instead of answering directly, the field marshal scanned the gathered members of the high command with a long, deliberate look. 'Comrades,' she said, 'our most excellent Queen Lassini has long foreseen the fracturing of the dinosaur–ant alliance. Early in her reign, she ordered the imperial army to begin preparing for war with the dinosaurs. We have undertaken extensive research, as a result of which we have developed many new weapons and combat techniques. Now, if everyone will step outside, we will demonstrate two key pieces of equipment.'

The ants of the high command duly pattered out onto the plaza outside the palace. Two dozen soldier ants carried forward a peculiar piece of kit: a small catapult affixed to a long base. They pulled the catapult's elastic cord taut and hooked its pocket onto a mechanism at the far end of the base. Then they climbed into the pocket and clung tightly to one other, forming a black projectile. A soldier ant stationed beside the base pulled a tiny lever, releasing the pocket from the mechanism and twanging the black projectile a full twenty metres into the air. When the projectile reached its maximum height, it swiftly dispersed, and the two dozen soldier ants went fluttering through the air overhead, their glossy black bodies glittering in the sunshine.

'This piece of equipment is called a Formican slingshot, and it is the solution to the problems cited by the honourable minister,' explained Field Marshal Donlira.

'Looks like useless acrobatics to me,' muttered one of the ministers.

'The imperial army is meant to be take offensive action,' another minister said. 'That's the strategic principle on which it was founded. In the past, you have stated that its operational objective is "Attack! Attack! Attack!". Now it seems this has changed to "Defend! Defend! Defend!".'

'Offensive action is still the strategic principle of the imperial army,' replied the field marshal.

'But how can it be? Even if these little gadgets of yours really do work, we obviously can't use them to attack Boulder City. We'll have to wait for the dinosaurs to attack our capital.'

'Please bear with us, Minister,' the field marshal said. 'We will now demonstrate a weapon that can be used to initiate offensives against dinosaur cities.'

She waggled her antennae and several soldier ants brought over a number of yellow pellets resembling grains of rice. One of the soldiers swivelled round and

sprayed a drop of formic acid on one of the pellets. A minute later, the pellet caught fire in a blinding flash of white light. The violent blaze lasted for ten seconds and then died out.

‘This weapon is called a “mine-grain”. It’s an incendiary device with a fuse that is activated by formic acid. It can be set to ignite at any point from a few seconds to a few hours after it’s triggered. Once the formic acid has eaten through the outer shell, the device combusts, producing temperatures high enough to ignite any flammable material.’

The assembled officials shook their antennae in disbelief. ‘It’s a child’s toy!’ grumbled one of them. ‘Even if one of these things went off on the forehead of the dinosaur emperor himself, it would do him no more harm than a cigarette burn. This thing can destroy Boulder City? You are surely having a laugh, Field Marshal.’

‘Just you wait and see,’ the field marshal replied confidently. ‘All will be revealed shortly.’

Chapter 7

The First Dinosaur–Ant War

Rain had bucketed down all night, but at dawn the heavy black clouds parted to usher in a bright, sunny morning. The sky was cloudless and the air was clear. In the light of the rising sun, the land looked vivid and sharply defined, as though nature had set the stage for the battle that would decide the fate of Cretaceous civilisation.

Battle was joined on the wide plain between Boulder City and the Ivory Citadel, with each settlement only just visible on its respective horizon. Two thousand dinosaur soldiers formed a phalanx facing the Ivory Citadel; to the ants, it seemed like a sky-high wall had been raised. Unlike in past battles, waged against their own kind, the dinosaur soldiers were neither wearing armour nor carrying weapons. They'd been told that all they'd need to do would be to march across the ant city in formation. Opposite the dinosaurs, ten million ants from the Ivory Citadel were massed in more than a hundred brigades, carpeting the ground in black.

A *Tyrannosaurus* stationed at the head of the dinosaur phalanx broke the silence. It was Major General Ixta, and his voice was like a sudden clap of thunder on the horizon. 'Little bugs, only ten minutes remain until the empire's deadline expires. If you return to the Ivory Citadel right now, destroy all your churches, and then come back to Boulder City and resume work, I can grant you more time. Otherwise, the imperial army will begin its assault.'

He raised his right forelimb and gestured nonchalantly at his troops. 'Take a look at the two thousand soldiers before you. They represent less than one-thousandth of the imperial army's total strength, but they are more than capable of flattening the capital of the Formican Empire. The cities our children build from their wooden play-blocks are bigger than your Ivory Citadel. In fact, those kids could flood your entire city just by pissing on it! Ha ha ha!'

A deathly hush settled over the battlefield. The Cretaceous sun quietly rose higher, and ten minutes soon passed.

‘Attack!’ boomed General Ixta.

The phalanx began to advance. The ground trembled under the rhythmic tread of two thousand dinosaurs, creating waves in the puddles left by the rain. The ants did not budge.

‘Queen Lassini and Field Marshal Donlira,’ General Ixta roared in the direction of the massed columns of ants, ‘I have no idea whereabouts you are, but if you don’t order these critters to make way, our feet will crush them to a pulp! Ha ha ha!’

As he stared at the ant army, he noticed a distinct ripple running through their ranks. He peered more closely and saw that the ant infantry had erected countless tiny structures. To him they looked like blades of grass newly sprouted from the blackened earth. A niggle of doubt lodged in his massive dinosaur brain, but the niggle was not sufficient to give him pause, and so the dinosaur phalanx pressed on.

A second surprising change now swept through the ant army. The smooth black pool that had blanketed the ground suddenly went lumpy and separated into a multitude of miniature spheres. Ixta was reminded of the wondrous movements of the ant word corps, and for a moment he thought the ten million ants in front of him were about to spell out something. But the ant clumps did not reshape.

The dinosaur phalanx continued its advance until it was just ten metres from the ants’ frontline. Only then did General Ixta realise that those blades of grass were in fact a barrage of miniature catapults, cords stretched taut, each pocket loaded with a cluster of ants!

There now came a soft pitter-patter, like raindrops hitting the surface of a lake, as one hundred thousand ant projectiles were fired into the air. It was as if a cloud of flies had been startled into flight. The ground ahead of Ixta regained its ochre colour and the tiny compacted spheres soared above the first few lines of dinosaurs and then disintegrated. Each ball contained dozens of soldiers and now a shower of ants cascaded to the ground.

The air was thick with so many falling ants that it was almost impossible for the dinosaurs not to inhale them up their nostrils. As they frantically slapped at their heads and bodies, their phalanx fell into disorder.

Some of the ants that landed on General Ixta’s head were brushed off, but others hid from his gigantic searching claws, ducking into the wrinkles of his coarse-grained skin. When his claws moved to slap at his body, several soldier ants skittered towards the edge of his brow, seeking out his eyes. Crawling across the wide crown of the

Tyrannosaurus's head was like trudging across a plateau scored with ravines. The plateau swayed back and forth like a swing, and the ants had to cling on tight to keep from being thrown off. When they reached the edge, they peered down and were met with a breathtaking sight.

Imagine for a moment that you are standing atop the majestic peak of China's venerable Mount Tai. Now imagine that this most holy mountain is in motion: it is striding across the earth on a pair of colossal legs. Even more terrifying, when you lift your head, you see that you are encircled by a thousand other mountains and that these are also on the move!

The soldier ants located the dinosaur's right eye, which was below them. The enormous eye was like a round pond that had frozen over; its translucent surface was slightly curved and sloped sharply downwards. Three of the soldier ants cautiously picked their way onto the glassy membrane. This was the dinosaur's third eyelid – its protective nictitating membrane, to be exact – and it was as slippery as melting ice. The slightest misstep would see the ants slithering off and tumbling into the void. They began to gnaw at the wet ice with their powerful pincers, but this irritated the eye and it began to secrete tears, which surged across the frozen pond like a flash flood, flushing the three ants from the eyelid.

Just as Ixta made to rub his eye, three other ants nipped into his nostrils. Battling their way into a screaming gale, they expertly threaded their way through a tangled forest of nose hair, making a concerted attempt not to trigger a sneeze. They advanced quickly through the nasal cavity to the back of the eyeball, tracing a route that was familiar from countless surgical procedures. Following the translucent optic nerve, they now proceeded towards the brain. Here and there a thin membrane blocked their path, but they simply chewed a small hole and squeezed through. These holes were so tiny that the dinosaur felt nothing.

Finally, the three ants arrived at the brain, which was peacefully suspended in a sea of cerebrospinal fluid like a mysterious, discrete lifeform. After careful searching, they found the thick cerebral artery, the main pipeline supplying blood to the brain. Through the pellucid pipe wall they could see and hear the dark red blood coursing past with a low rumble. Ixta's brain was working overtime, trying to process the mind-blowing quantities of battlefield information being transmitted from his optic and auditory nerves, and this torrent of blood was fuelling it with the necessary energy and oxygen.

The three ants were neurosurgical techs and this was familiar territory to them. They had been dispatched to places like this countless times before, to clear clogged cerebral blood vessels and save untold numbers of dinosaur lives in the process. Now, however, they would do the opposite. With their sharp mandibles, they began to make three deep scratches in the artery wall, working with care and skill. When the incisions joined up to form a complete circle, the ants rapidly withdrew the way they'd come. They had no wish to witness the end result. As veteran surgical techs, they knew exactly what was about to happen. Blood circulated at high pressure and very soon beads of blood would well from the incisions on the artery wall. Then, as neatly as if it had been scored by a glasscutter, the lesion would rupture and the little circular section of the artery wall would come loose and create a round hole. Blood would gush out of the hole, sending tendrils of crimson curling through the brain fluid and staining it red. Deprived of its blood supply, the brain would quiver and grow pale.

On the chaotic battlefield, Ixta was yelling commands, attempting to regroup the dinosaurs into attack formation. All of a sudden, everything went dark before his eyes. As the fog descended, his surroundings began to spin. The three ants racing through his nasal cavity felt a sensation of weightlessness, followed by a shuddering crash. The world around them rolled several times and then came to a standstill. The dinosaur had fallen to the ground. The gale in his nostrils ceased, and the distant low thump of his heart went silent. The *Tyrannosaurus* Ixta, general of the Imperial Saurian Army, had been killed in action, felled by a cerebral haemorrhage.

One by one, the other dinosaurs on the battlefield toppled. Some were murdered in the same manner as their commander; many more either suffered a fatal rupturing of their coronary artery or had their spinal cord severed. The ants had infiltrated their enemies' insides via ears, noses or mouths and had racked up more than three hundred casualties. The ground was littered with gargantuan bodies and the air echoed with the unearthly yowling of dying dinosaurs. The survivors, scared witless by this nightmarish scene, fled the battlefield at breakneck speed. Broken necks, however, were not to be these deserters' downfall. Though they'd escaped the site, they'd not escaped the invasion of the brain snatchers. Ant soldiers continued their internal operations even as the dinosaurs retreated, and the route back to Boulder City was lined with monstrous corpses.

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While their comrade ants were busy resisting dinosaur incursions into the Ivory Citadel, millions of other ants were launching a major military offensive on their enemy's stronghold. Despite the declaration of war, Boulder City had continued operating much as it always had. Although the loss of the ants' services was certainly an inconvenience for the dinosaurs, it was by no means devastating, and as for the conflict itself, the dinosaur public was utterly unconcerned. They were confident that the Imperial Saurian Army could defeat those titchy insects with the absolute minimum of effort – a few swats and kicks should surely do it, they thought. To them it seemed like overkill to mobilise two thousand dinosaur soldiers just to crush that toy sandpit of a city, but they rationalised it as the emperor's way of demonstrating the empire's strength.

That morning, Boulder City rumbled to life as it did every day. At the transport terminal by the city's eastern gate more than a thousand jumbo-sized buses trundled out onto the streets. Cretaceous civilisation had not yet begun to extract oil, and so these buses, like the dinosaurs' trains, were powered by massive, ponderous steam engines. They pumped out great clouds of vapour from their roofs as they rolled, shrouding the streets in fog from morning till night.

Today, however, Boulder City's buses were transporting not only their regular dinosaur customers but also an additional cohort of unauthorised passengers. Ant-soldier stowaways! Swarms of these undercover operatives had scuttled aboard during the night. The Number 1 bus, which served the main artery through the city, carried the largest contingent – an entire division, comprised of more than ten thousand ants. They were concealed in various inconspicuous locations: under the doorsills, inside the toolbox, clinging to the undercarriage, camouflaged inside the coal bunker. On such a huge vehicle, hiding a division of the Imperial Formican Army was easy.

Ten minutes after the Number 1 bus drove onto the hectic, thunderous street, it pulled in at its first stop. Hard on the heels of several dinosaur commuters, a company of two hundred ant soldiers detached themselves from beneath the doorsill and dropped to the ground. Each one held a mine-grain in its mouth. They immediately filed into a crack in the pavement, their tiny black bodies invisible against the wet surface, and began zigzagging towards their destination. The dinosaurs stomping

along the steamy street were oblivious to their presence. The ants, on the other hand, were all too aware of the dinosaurs. Every time a hulking great *Tyrannosaurus* passed above them, their world went black; there was also the ever-present danger of being crushed to death should they poke their heads out of the cracks. No catastrophes befell them, however, and eventually they arrived at a building. It was so vast that its front door opened into the clouds, and the upper storeys were lost in the ether. The ant troops stole through the gap beneath the door and filed in.

All dinosaur architecture was high-rise. From the ants' perspective, each building was effectively its own world; for them, being indoors was no different from standing outside in an open field. This particular structure was a warehouse – a gloomy world whose only sun was a small, high-set window that let in just a little light. The ants wove they way across its wide floor, between piles of goods, until they reached a row of tall wooden casks. These contained kerosene that the dinosaurs used for lighting. Since the dinosaur world had not yet entered the Electric Age, they relied on oil lamps at night. Searching carefully, the soldier ants found several patches of moisture on the floor where the casks had leaked slightly. They removed the mine-grains from their mouths and stuck them to these oily patches. Soon, more than a hundred mine-grains had been put in place. The soldiers aimed their posteriors at the mines, and, at the first lieutenant's command, sprayed a droplet of formic acid on each one. The acid began to slowly eat through the shell of each mine-grain, activating the ignition fuse. The delay had been set for six hours, scheduling ignition for two o'clock that afternoon.

Meanwhile, at every stop made by the thousand buses crisscrossing Boulder City, other concealed detachments of ant troops alighted and slipped undetected into the streets. By midday, some one million soldier ants, representing one hundred divisions of the Imperial Formican Army, had infiltrated every corner of Boulder City and planted mine-grains on every type of flammable surface. Millions of mine-grains speckled Boulder City's government offices, marketplaces, schools, libraries and residential buildings, each one set to ignite at two o'clock that afternoon.

A little later that morning, in the imperial palace, the Saurian emperor Urus was woken from his sleep by the return of several officers from the failed attempt on the Ivory Citadel. The emperor had been up all night, wining and dining some governors from Laurasia, and hadn't got to bed until the early hours. When he heard from the officers that not only was General Ixta dead but that half of the Imperial Saurian Army had been killed along with him, his first reaction was that he was being fed a

fantastic cock-and-bull story. He was seized with an uncontrollable rage and was about to order that the good-for-nothing jokers be court-martialled, when something happened that opened his eyes to the threat posed by the ants.

It was the commander of the palace guard who alerted him. He was standing next to the emperor's bed, shaking and yelling out in alarm as he gripped a piece of cloth in his claws.

'You idiot,' Urus roared at him, 'what are you doing with my pillowcase?' Today, it seemed, he was surrounded by numbskulls and numpties, and he was tempted to have them all put to death.

'Your… Your Majesty, I just discovered this. Look…' The commander held up the pillowcase in front of Urus's face. Strings of small holes had been chewed through the fabric – a message, left by soldier ants who had infiltrated his chambers while he slept:

We can take your life at any time!

As Urus stared at the bed linen, a chill ran through him. This was not the sort of pillow talk he was accustomed to. He glanced about the room as though he'd seen a ghost. The other dinosaurs present hurriedly stooped and scoped the ground, but they could find no trace of the ants. The words on the pillowcase were the only evidence they could see.

There was more, however; it was just that the dinosaurs didn't have the eyesight for it. The ants had laid in excess of a thousand mine-grains throughout the emperor's bedchamber. The yellow pellets, which were invisible to the dinosaurs' naked eye, had been threaded into the mosquito netting, scattered around the feet of the bed, the sofa and the opulent wooden furniture, and stuffed between the mountainous stacks of documents. Formic acid was slowly eating away the surfaces of these incendiary devices, and like the million-odd other mines planted across Boulder City, their ignition time had been set for two o'clock.

The Saurian minister for war straightened up and addressed the emperor. 'Your Majesty, as I warned you some time ago, although it is true that in inter-species wars size is strength, it is also the case that being small has its advantages. We cannot take the ants too lightly.'

Urus sighed. 'Then what is our next step?' he asked.

'Rest assured, Your Majesty. We are prepared for this. I give you my word that the imperial army will flatten the Ivory Citadel before the day is out.'

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Three hours after their failed first attack, the Imperial Saurian Army launched a second offensive against the Ivory Citadel. They sent in the same number of troops – two thousand dinosaurs – and they advanced on the Ivory Citadel in the same phalanx formation, but this time each dinosaur wore a hefty metal helmet on its head.

The ant troops defending the Ivory Citadel responded with the same tactics they'd used earlier. Using the Formican slingshots, they again fired several hundred thousand ants into the air above the dinosaur phalanx, precipitating a heavy shower of ants raining down from the sky. This time, however, the ant soldiers were denied entry into their enemies' bodies. The dinosaurs' metal helmets fitted them very snugly. The visors were made from a single, solid piece of glass, the ventilation holes were covered in extremely fine steel mesh, the joints were seamless, and the helmets themselves were fastened securely at the neck with cord. They were impregnable: proper anti-ant armour.

When Commander-in-Chief Donlira landed on a dinosaur's head, she observed the helmet beneath her feet with remorse. Two months earlier, ant craftsmen had helped with the manufacture of these very helmets. They had woven the fine steel mesh that covered the ventilation holes. At the time, the dinosaur manufacturer had claimed the helmets were intended for dinosaur beekeepers. It seemed that the Saurian Empire had also been secretly preparing for war for a long time.

After the ant-rain tactic failed, the Imperial Formican Army resorted to using bows and arrows to stall the dinosaurs at the second line of defence. One and a half million ants released their arrows simultaneously. A cloud of aerial weaponry sped towards the dinosaurs like sand stirred up by a gust of wind, but the arrows were far too dainty to cause even the slightest harm to the mountainous soldiers. They merely bounced off their crusty skin and piled up on the ground around their feet.

The dinosaurs stamped their lethal way through the mass of ants, leaving trails of fatal footprints in their wake. Thousands of crushed ants filled each hollow tread. Those that escaped could only squint up helplessly from far below as the titanic figures blocked out the sky and tramped on towards their citadel.

As soon as they reached the ants' megalopolis, the dinosaurs began to stomp down extra hard and kick even more wildly. Most of the buildings in the Ivory Citadel were

no higher than the dinosaurs' calves, and whole blocks were squished beneath a single clomp of their feet.

Field Marshal Donlira had a depressingly good view of the destruction, for she and several other ant soldiers were still scurrying back and forth over the *Tyrannosaurus*'s helmet, desperately trying to find a way in. Looking down from their scarily high vantage point, they surveyed their ruined city and the fires that raged through it. This was truly a dinosaur's-eye-view of the Ivory Citadel and what a sobering experience it was: to Donlira and her soldiers, their species appeared astonishingly small and insignificant.

The *Tyrannosaurus* strode over to the Imperial Trade Tower. At three metres high, this was the tallest skyscraper in the Formican Empire and the pinnacle of ant architecture, but it only came up to the beast's hips. The *Tyrannosaurus* dropped to its haunches – the abrupt loss of height causing the ants a moment of weightlessness – and then the top of the tower appeared over the horizon of its helmet. The crouching dinosaur studied the tower for a few seconds, then grasped its base with its claws and plucked it from the ground. It stood, examining the tower curiously, as though it had found an amusing toy. The ants on the dinosaur's head gazed at the tower too. Blue sky and white clouds were reflected in its sleek navy-blue surface, and its countless glass windows sparkled in the sunlight. They still remembered how, on their very first day of school, they had followed their teacher to the top of the tower for a panoramic vista of the Ivory Citadel…

As the *Tyrannosaurus* turned the tower about in its claws, it suddenly broke in two. The dinosaur cursed and flung the pieces away, first one bit and then the other. They arced through the air and landed among a distant cluster of buildings, shattering on impact and knocking down many other homes and offices in the process.

It took only minutes for the tread of two thousand dinosaurs (who were so ridiculously bulky that they couldn't all fit into the Ivory Citadel at the same time) to reduce the Formican capital to a heap of fine rubble. As clouds of yellow dust bloomed above the ruined city, the dinosaur soldiers began to cheer. But their triumphant cries were cut short when they turned to look in the direction of their own Boulder City.

Columns of black smoke were rising from the capital of the Saurian Empire.

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Urus, with his imperial bodyguards clustered around him, lumbered from the palace through swirling smoke, only to collide head-on with the panic-stricken minister of the interior.

'It's terrible, Your Majesty – the whole city is burning!' shrieked the minister.

'What's happened to your fire brigade? Get them to help!'

'Fires are breaking out all over the city. The entire brigade has been called out, but they're fully occupied dealing with the fires in the palace.'

'Who started the fires? The ants?'

'Who else? Over a million of them infiltrated the city this morning.'

'Those blasted bugs! How did they even start the fires?'

'With these, Your Majesty…' The minister opened a paper packet and gestured for the emperor to look.

Urus stared long and hard at the packet but saw nothing until the minister passed him a magnifying glass. Through the lens, he could make out several mine-grains.

'Municipal patrol officers seized these this morning.'

'What is this – ant shit?'

'If only, Your Majesty. No, it's a type of miniature incendiary device. The ants planted over a million of them across the city, and at least one-fifth started fires that have now spread. By my calculation, that means there are currently some twenty thousand individual fires in Boulder City. Even if we were to call in fire brigades from all over the empire, extinguishing a city-wide conflagration like this would be absolutely impossible.'

Urus stared numbly at the pall of black smoke in the sky, unable to speak.

'Your Majesty, we have no choice,' the interior minister said quietly. 'We must abandon the city.'

By nightfall, Boulder City was a sea of flames. The fires cast a red glow across the night sky, bringing a false dawn to the central plains of Gondwana. The roads outside the city were choked with fleeing dinosaurs and their enormous vehicles, fire and fear reflected in every pair of eyes.

Emperor Urus and several of his ministers stood on a low hill and gazed at the burning city for a long time.

'Order all Saurian ground forces in Gondwana to attack and raze every ant city on the continent – immediately! Dispatch fast sailing vessels to the other continents and

make sure that every Saurian ground force in the world takes the same action. We shall deal a mortal blow to the ant world.'

And just like that, the conflict between the ants and the dinosaurs exploded. The flames of war soon raged across all of Gondwana, and before the month was out they were blazing through every other continent as well. A world war engulfed the entire planet. Terrible suffering ensued in both civilisations. One dinosaur city after another was consumed by fire, and ant cities were reduced to heaps of dust.

The ants also set fire to great tracts of grassland, farmland and jungle. They seeded vast areas with millions upon millions of mine-grains and the resulting infernos were impossible to extinguish. Brushfires raced across every landmass; orchards, pastures and forests burnt; and noxious smoke blotted out the sun. Less and less sunlight reached Earth and crop yields declined sharply, driving the dinosaurs, who required epic quantities of food, into starvation. It was an ecological catastrophe.

Meanwhile, crack teams of ants led raids on the dinosaurs from all quarters. Their preferred tactic was to launch their assaults from deep inside, which terrified the dinosaur public. Dinosaurs took to wearing masks at all times, not daring to remove them even while they slept, since the minuscule ants could sidle in and out of their most private spaces like a nightmarish crew of malevolent interns.

The ant world did not escape unscathed, however. Far from it. Ant civilisation took a severe beating from the dinosaurs. Almost every ant city was decimated, and the ants were forced to retreat underground. But they were not safe even there, for their subterranean bases were often unearthed by the dinosaurs and then destroyed. The dinosaurs made heavy use of chemical weapons and sowed a toxin that was harmless to dinosaurkind but deadly to ants everywhere. This not only killed innumerable ants but sharply constrained the scope of their activities. Individual ant colonies found it more and more tricky to maintain contact with other parts of the Formican Empire; because they lacked long-distance vehicles of their own, they had previously relied on dinosaur conveyances, but this option was no longer available. Communication became increasingly difficult, regions of the ant world became isolated, and the Formican Empire fragmented.

This was not all. There were more serious consequences still. Because the dinosaur–ant alliance was the foundation stone upon which Cretaceous civilisation was built, the crumbling of that alliance had a pernicious effect on societal structures

in both worlds. Social progress ground to a halt and there were clear signs of regression. The survival of Cretaceous civilisation hung in the balance.

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Though both the ants and the dinosaurs gave their all to the global war effort, neither side was able to achieve absolute supremacy on the battlefield, and the fighting degenerated into a protracted war of attrition. Eventually, the high commands of both empires came to recognise the reality of the situation: they were prosecuting a war that could not be won, a war whose ultimate outcome would be the destruction of the great Cretaceous civilisation. In the fifth year of the conflict, the two belligerents began armistice negotiations, and pivotal to these was the historic meeting between the Emperor of the Saurian Empire and the Queen of the Formican Empire.

The meeting was held in the ruins of Boulder City, on the former site of the imperial palace, where, five years earlier, the fateful summit that had triggered the war had taken place. All that now remained of that once colossal imperial seat were a jumble of shattered, fire-blackened walls. Through the cracks, the smoke-stained skeletons of other buildings were visible in the distance: the desecrated city was sinking back into the soil, its stonework colonised by thickets of lush green weeds and a lattice of creeping vines. The encroaching forest would soon swallow it up altogether.

As the sun dipped in and out of the haze cast by a remote forest fire, dappled patterns of light and shadow flitted across the old palace walls. Urus peered at the ant queen by his feet. ‘I can’t quite make you out,’ he boomed, ‘but I have a feeling that you are not Queen Lassini.’

‘She is dead. We ants lead brief lives. I am Lassini, the second of her name,’ said the new queen of the Formican Empire. On this occasion, she had brought just ten thousand word-corps soldiers with her, and Urus had to stoop to read her response.

‘I think it’s time to put an end to this war,’ he said.

‘I agree,’ replied Lassini II.

‘If the war continues,’ Urus said, ‘you ants will return to scavenging meat from animal carcasses and dragging dead beetles back to your tiny lairs.’

‘If the war continues,’ responded Lassini II, ‘you dinosaurs will return to prowling hungrily through the forests and tearing apart your own kind for meat.’

‘Well then, does Your Majesty have a specific recommendation as to how we might bring an end to this war?’ Urus asked. ‘Perhaps we should begin with the reason we went to war in the first place. There are many who’ve forgotten the whys and wherefores – dinosaurs and ants alike.’

‘I recall it had to do with the appearance of God. Specifically: does God look like an ant or a dinosaur?’

Urus cleared his throat. ‘I am happy to inform you, Queen Lassini, that for the last few years the Saurian Empire’s most erudite scholars have devoted themselves to this question. They have now come to a new conclusion, and it is this: God resembles neither an ant nor a dinosaur. Rather, God is formless, like a gust of wind, a ray of light or the air that swaddles this world. God is reflected in every grain of sand, every drop of water.’

The Formican queen’s answer came quickly and unequivocally. ‘We ants do not possess such complicated minds as you dinosaurs,’ she said, ‘and that sort of profound philosophising is challenging for us. But I agree with this conclusion. My intuition tells me that God is indeed formless. And you should know that the ant world has forbidden idolatry.’

‘The Saurian Empire has also forbidden idolatry.’ Urus could hide his relief no longer. His face cracked into a wide, snaggle-toothed grin. ‘In that case, Your Majesty, may I conclude that ants and dinosaurs share the same God?’

‘If you wish, Your Majesty.’

And so the First Dinosaur–Ant War came to a close. It was a war without victors. The dinosaur–ant alliance made a swift recovery. New cities began to appear atop the ruins of the old, and Cretaceous civilisation, after so long spent teetering on the brink of collapse, was reborn.