‘Thrilling, compellingly readable and paradigm-shattering’
Charles Foster, author of *Being a Beast*

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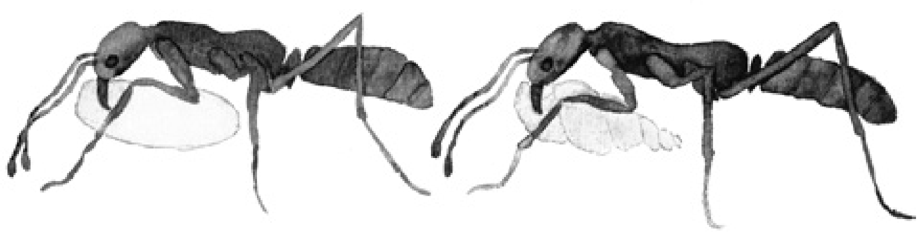
EMPIRE OF ANTS

The Hidden Worlds and Extraordinary Lives of Earth’s Tiny Conquerors

CHAPTER 3

EFFECTIVE ANARCHY



Army ants of the species Leptogenys distinguenda *move home every few months, carrying with them their larvae and pupae (left) as well as the occasional guest, such as a snail.*

If any large group is to function, someone has to have the final say. At school, it's the teacher; at work, it's the boss; and in a nation, it's the president, the prime minister, or chancellor. When humans began showing an interest in the lives of ants, kings were still at the top of this hierarchy. Their rule was absolute, their word was law, and their subjects built cities, harvested crops, and waged wars all in accordance with their whims. Exactly—as early researchers were thrilled to discover—like ants do when ruled by a queen. What a wonderful analogy, what a fantastic proof of the God-given nature of monarchy! . . . And what a huge mistake.

At first glance, of course, there are obvious parallels between people and animals. And it is truly astounding to see how capable ants are. They live in communities, some of which comprise more citizens than countries like Denmark. They provide sufficient food for everyone, clear away waste, and regulate the temperature within their nests, making sure no one gets too hot or too cold. To achieve the same things, humans need someone to take charge, give out commands, and keep a close eye on proceedings. We need leaders, whether we call them chiefs, mayors, kings, or emperors.

Ants, on the other hand, do it all without a leader in sight.

Their so-called queen has no real duties within the colony. She is essentially a stay-at-home mom, the colony's egg-laying machine. After all, that's what a queen does, day in, day out: She eats, and she lays eggs. From the moment she establishes her colony, her life is as dull as it gets. It's her many daughters, the workers, who have the real say. And so the form of government seen inside an ant colony is less reminiscent of absolute monarchy than it is of democracy—and anarchy is always a threat underneath the surface.

WANTED: 1,000-BED PROPERTY WITH KITCHEN EN SUITE

To examine how ants make decisions, we are going to take a closer look at the biggest logistical challenge that any ant colony must master: relocating the colony.

There are many reasons why an old nest may no longer serve its purpose. Over time, colonies living in small twigs or acorns on the forest floor may find their nest chambers collapsing of their own accord or accidentally trampled by a deer or bear. Often, the community will simply have become too great in number, requiring more expansive accommodation. They may also have munched their way through all nearby food sources and move on to seek more elsewhere, as is often the case for army ants. Perhaps an aggressive neighbor has just moved in and it makes sense to get out of the way. Sometimes it's the fault of nasty researchers who dig up the nest and take part of the colony back to their laboratories. Whatever triggers the move, the colony faces a huge project, which, depending on its size, can be akin to relocating a megacity as big as Tokyo. Before embarking on this mammoth task, the colony must first take an urgent look at the local property market.

A handful of prospective buyers—scouts—move out, checking every available nook and cranny to determine whether one would be suitable for their colony. Their list of requirements is a long one. First, the new home must be accessible on foot because ant workers cannot fly. It must be large enough for the entire colony and provide protection from predators and bad weather; it must be made of materials that allow walls to be demolished and reinstalled; it must offer pleasant levels of moisture, even during the dry season, but not become dripping wet when it rains; it must keep out the cold in winter without being baking hot in summer—and so on and so forth.

It's quite a stroke of luck when said scouts happen upon a suitable location. Before making a decision, they carry out extensive checks. They run in and out of the potential nest several times, examining every square inch of the space. Inspections of this kind can last up to an hour and only afterward do the ants decide. After all, it's up to them to decide. Though these little scouts are just some of dozens, hundreds, thousands, or maybe millions of ants, it all comes down to their instinct, their experience, and perhaps even their taste. Nobody is whispering in their ear, telling them what to do next. No real-estate agent, no sisters, and certainly no queen.

It's a lot for a little ant's brain to handle.

SIX-LEGGED COMPUTERS

Yes, ants do have brains. They are not especially large and, depending on species, may be smaller than forty thousandths of an inch (1 cm^3), weigh just a few millionths of a gram, and get by with around 250,000 nerve cells. But the real problem is trying to dissect them. How do we do it? With a razor blade, delicate instruments, and near-infinite patience.

First, you break the razor blade in two and attach one half to a scalpel. Then you decapitate the ant—a pleasant death, if we are to believe Dr Joseph-Ignace Guillotin, a man who did not invent the instrument of capital punishment named after him, but who recommended its introduction during the French Revolution on "humanitarian grounds," saying, "The victim will feel little more than a refreshing cold sensation." An ant's head is too small to hold or move, so you place it in liquid wax, allowing this to solidify in a dissection tray on ice.

Now for the tricky part. You make three cuts through the ant's hard exoskeleton, known as the cuticle. A sort of flap will appear that you must open carefully, like a window. You will now be able to see the brain. Scientifically, an ant's brain is referred to as the supraesophageal ganglion due to its position in the upper part of the oral cavity and—despite its diminutive size—is split across several different centers, each performing specific tasks. Signals from the antennae are picked up in the antennal and dorsal lobes, new images from the eyes are received in the optic lobes. Things get really interesting in the central bodies and particularly in the mushroom bodies, so named because under the microscope they look like mushrooms with hats. This is where the ant's brain processes incoming information, storing experiences that will be of use to its owner over the course of her life. You don't have much time to get a good look at everything because RNA molecules are sensitive and disintegrate if you don't work fast enough, meaning all your work will have been for nothing. Swap your razor blade scalpel for a pair of ultrafine tweezers, carefully remove the brain from the surrounding tissue, and lift it out of the head.

And voilà! You have extracted your first ant brain. Now all you need to do is repeat the process a few dozen more times until there's enough material for your investigation.

THE WISDOM OF GENES

The size of an ant's brain not only depends on the ant's species and caste, it boasts a fascinating link to the ant's principal job. Contrary to what you might expect, queens' brains are not all that big. Once the nuptial flight is over, they have established their own nests and the first workers have set to work, queens experience a radical form of mental degradation. All the areas that are no longer needed—since the queen's sole focus now is egg-laying—shrink. This includes flight control, as well as the center for foraging and caring for the brood. So it's not entirely true to say that the queen no longer *needs* to work—in reality, she simply can't. She is now too dumb to do so.

For her workers, it's a different story. The workers continue to accumulate experiences throughout their lives, accruing so much experience that, in some species, it leaves an anatomical trace. The mushroom bodies in the brains of young workers in the hatchery are still very small, because they have known nothing other than their queen, her eggs, larvae and pupae, and the inside of the nest. Experienced workers employed outside the nest, however, are constantly having to memorize paths to valuable food sources, and consequently have much larger mushroom bodies.

The anatomical differences are not enough for us to understand why an ant does what it does. Instead, we have to look at what the ant was doing shortly before her untimely death and which genes were active when she was decapitated. Each individual worker possesses all the genetic material necessary for a whole host of tasks, but she uses only the portion that she requires at the given time. She makes copies of this in the form of RNA molecules, which we then isolate using biochemical methods, enabling us to identify them by their structure. Comparing workers tasked with a variety of jobs with their accompanying RNA mixtures tells us which genes are responsible for which specific behaviors. This method allows us to demonstrate that workers employed to take care of the brood exhibit a particularly active gene for the protein *Vitellogenin-like A*. If we restrict this activity in living ants, they suddenly lose interest in larvae and pupae and begin instead to care for the adult ants with which they share a nest. In nature, scents control gene activity, and it appears that the *Vitellogenin-like A* gene is important when it comes to allotting tasks.

YOU ARE ALL INDIVIDUALS!

The combination of differently interconnected nerve cells in the mushroom bodies and other brain centers with different gene activities gives rise to an unexpected quality that few would believe ants to possess: They all have different personalities.

After a particularly grueling period of study, Evelien Jongepier, a doctoral student of mine, was able to demonstrate precisely this. She "interviewed" 3,842 workers from 102 colonies of the species *Temnothorax longispinosus* from upstate New York to ascertain their professional preferences. To do this, she placed each insect one by one in front of either a pupa in need of help—to draw out broodcare behavior—or dead ants from a foreign colony, to provoke a defensive response. If ants were the mindless robots we humans sometimes believe them to be, every worker would have reached out mechanically for either stimulus, tending to the pupa or attacking the insurgent ant. But the ants did not all respond according to Evelien's predictions. Some did not even think about being roped into specific tasks. A few paid particular attention to the pupa but were not prepared to be drawn into a fight with the foreign ant worker. Others lunged at their enemy, paying no heed at all to the helpless pupa. Another subgroup ignored both the pupa and the enemy ant and simply did nothing. In all probability, different genetic activities predetermined which stimulus the ants would respond to.

The significance of personal experience is demonstrated by observing workers of the clonal raider ant *Ooceraea biroi*. They are predatory creatures, feeding principally on the larvae of other species of ant, having forced their way into their nests. In the lab, a group of workers prevented from preying on others will eventually give up and forgo its raid altogether. Instead, the ants will focus on caring for the brood, whereas the control group whose attempts to hunt are not sabotaged feels emboldened by its successes, obtaining more food. So even ants feel frustrated with their lack of success from time