IT IS AUGUST 1854, AND LONDON IS A CITY OF SCAVENGERS.

Just the names alone read now like some kind of exotic zoological catalogue: bone-pickers, rag-gatherers, pure-finders, dredgermen, mud-larks, sewer-hunters, dustmen, night-soil men, bunters, toshers, shoremen. These were the London underclasses, at least a hundred thousand strong. So immense were their numbers that had the scavengers broken off and formed their own city, it would have been the fifth-largest in all of England. But the diversity and precision of their routines were more remarkable than their sheer number. Early risers strolling along the Thames would see the toshers wading through the muck of low tide, dressed almost comically in flowing velveten coats, their oversized pockets filled with stray bits of copper recovered from the water’s edge. The toshers walked with a lantern strapped to their chest to help them see in the predawn gloom, and carried an
eight-foot-long pole that they used to test the ground in front of them, and to pull themselves out when they stumbled into a quagmire. The pole and the eerie glow of the lantern through the robes gave them the look of ragged wizards, scouring the foul river's edge for magic coins. Beside them fluttered the mud-larks, often children, dressed in tatters and content to scavenge all the waste that the toshers rejected as below their standards: lumps of coal, old wood, scraps of rope.

Above the river, in the streets of the city, the pure-finders eked out a living by collecting dog shit (colloquially called “pure”) while the bone-pickers foraged for carcasses of any stripe. Below ground, in the cramped but growing network of tunnels beneath London's streets, the sewer-hunters slogged through the flowing waste of the metropolis. Every few months, an unusually dense pocket of methane gas would be ignited by one of their kerosene lamps and the hapless soul would be incinerated twenty feet below ground, in a river of raw sewage.

The scavengers, in other words, lived in a world of excrement and death. Dickens began his last great novel, Our Mutual Friend, with a father-daughter team of toshers stumbling across a corpse floating in the Thames, whose coins they solemnly pocket. “What world does a dead man belong to?” the father asks rhetorically, when chided by a fellow tosher for stealing from a corpse. “'Tother world. What world does money belong to? This world.” Dickens’ unspoken point is that the two worlds, the dead and the living, have begun to coexist in these marginal spaces. The bustling commerce of the great city has conjured up its opposite, a ghost class that somehow mimics the status markers and value calculations of the material world. Consider the haunting precision of the bone-pickers’ daily routine, as captured in Henry Mayhew’s pioneering 1844 work, London Labour and the London Poor:

It usually takes the bone-picker from seven to nine hours to go over his rounds, during which time he travels from 20 to 30 miles with a quarter to a half hundredweight on his back. In the summer he usually reaches home about eleven of the day, and in the winter about one or two. On his return home he proceeds to sort the contents of his bag. He separates the rags from the bones, and these again from the old metal (if he be luckily enough to have found any). He divides these also into a separate parcel. When he has finished the sorting he takes his several lots to the ragshop or the marine-store dealer, and realizes upon them whatever they may be worth. For the white rags he gets from 2d. to 3d. per pound, according as they are clean or soiled. The white rags are very difficult to be found; they are mostly very dirty, and are therefore sold with the coloured ones at the rate of about 5 lbs. for 2d.

The homeless continue to haunt today's postindustrial cities, but they rarely display the professional clarity of the bone-picker's impromptu trade, for two primary reasons. First, minimum wages and government assistance are now substantial enough that it no longer makes economic sense to eke out a living as a scavenger. (Where wages remain depressed, scavenging remains a vital occupation; witness the perpendadores of Mexico City.) The bone collector's trade has also declined because most modern cities possess elaborate systems for managing the waste generated by their inhabitants. (In fact, the closest American equivalent to the Victorian scavengers—the aluminum-can collectors you sometimes see hovering outside supermarkets—rely on precisely those waste-management systems for their paycheck.) But London in 1854 was a Victorian metropolis
trying to make do with an Elizabethan public infrastructure. The city was vast even by today’s standards, with two and a half million people crammed inside a thirty-mile circumference. But most of the techniques for managing that kind of population density that we now take for granted—recycling centers, public-health departments, safe sewage removal—hadn’t been invented yet.

And so the city itself improvised a response—an unplanned, organic response, to be sure, but at the same time a response that was precisely contoured to the community’s waste-removal needs. As the garbage and excrement grew, an underground market for refuse developed, with hooks into established trades. Specialists emerged, each dutifully carting goods to the appropriate site in the official market: the bone collectors selling their goods to the bone-boilers, the pure-finders selling their dog shit to tanners, who used the “pure” to rid their leather goods of the lime they had soaked in for weeks to remove animal hair. (A process widely considered to be, as one tanner put it, “the most disagreeable in the whole range of manufacture.”)

We're naturally inclined to consider these scavengers tragic figures, and to fulminate against a system that allowed so many thousands to eke out a living by foraging through human waste. In many ways, this is the correct response. (It was, to be sure, the response of the great crusaders of the age, among them Dickens and Mayhew.) But such social outrage should be accompanied by a measure of wonder and respect: without any central planner coordinating their actions, without any education at all, this itinerant underclass managed to conjure up an entire system for processing and sorting the waste generated by two million people. The great contribution usually ascribed to Mayhew’s London Labour is simply his willingness to see and record the details of these impoverished lives. But just as valuable was the insight that came out of that bookkeeping, once he had run the numbers: far from being unproductive vagabonds, Mayhew discovered, these people were actually performing an essential function for their community. “The removal of the refuse of a large town,” he wrote, “is, perhaps, one of the most important of social operations.” And the scavengers of Victorian London weren’t just getting rid of that refuse—they were recycling it.

Waste recycling is usually assumed to be an invention of the environmental movement, as modern as the blue plastic bags we now fill with detergent bottles and soda cans. But it is an ancient art. Composting pits were used by the citizens of Knossos in Crete four thousand years ago. Much of medieval Rome was built out of materials pilfered from the crumbling ruins of the imperial city. (Before it was a tourist landmark, the Colosseum served as a de facto quarry.) Waste recycling—in the form of composting and manure spreading—played a crucial role in the explosive growth of medieval European towns. High-density collections of human beings, by definition, require significant energy inputs to be sustainable, starting with reliable supplies of food. The towns of the Middle Ages lacked highways and container ships to bring them sustenance, and so their population sizes were limited by the fecundity of the land around them. If the land could grow only enough food to sustain five thousand people, then five thousand people became the ceiling. But by plowing their organic waste back into the earth, the early medieval towns increased the productivity of the soil, thus raising the population ceiling, thereby creating more waste—and increasingly fertile soil. This feedback loop transformed the boggy expanses of the Low Countries, which had historically been incapable of sustaining any-
thing more complex than isolated bands of fishermen, into some of the most productive soils in all of Europe. To this day, the Netherlands has the highest population density of any country in the world.

Waste recycling turns out to be a hallmark of almost all complex systems, whether the man-made ecosystems of urban life, or the microscopic economies of the cell. Our bones are themselves the result of a recycling scheme pioneered by natural selection billions of years ago. All nucleated organisms generate excess calcium as a waste product. Since at least the Cambrian times, organisms have accumulated those calcium reserves, and put them to good use: building shells, teeth, skeletons. Your ability to walk upright is due to evolution’s knack for recycling its toxic waste.

Waste recycling is a crucial attribute of the earth’s most diverse ecosystems. We value tropical rain forests because they squander so little of the energy supplied by the sun, thanks to their vast, interlocked system of organisms exploiting every tiny niche of the nutrient cycle. The cherished diversity of the rain-forest ecosystem is not just a quaint case of biological multiculturalism. The diversity of the system is precisely why rain forests do such a brilliant job of capturing the energy that flows through them: one organism captures a certain amount of energy, but in processing that energy, it generates waste. In an efficient system, that waste becomes a new source of energy for another creature in the chain. (That efficiency is one of the reasons why clearing the rain forests is such a shortsighted move: the nutrient cycles in their ecosystems are so tight that the soil is usually very poor for farming: all the available energy has been captured on its way down to the forest floor.)

Coral reefs display a comparable knack for waste management. Corals live in a symbiotic alliance with tiny algae called zooxanthellae. Thanks to photosynthesis, the algae capture sunlight and use it to turn carbon dioxide into organic carbon, with oxygen as a waste product of the process. The coral then uses the oxygen in its own metabolic cycle. Because we’re aerobic creatures ourselves, we tend not to think of oxygen as a waste product, but from the point of view of the algae, that’s precisely what it is: a useless substance discharged as part of its metabolic cycle. The coral itself produces waste in the form of carbon dioxide, nitrates, and phosphates, all of which help the algae to grow. That tight waste-recycling chain is one of the primary reasons coral reefs are able to support such a dense and diverse population of creatures, despite residing in tropical waters, which are generally nutrient-poor. They are the cities of the sea.

There can be many causes behind extreme population density—whether the population is made up of angelfish or spider monkeys or humans—but without efficient forms of waste recycling, those dense concentrations of life can’t survive for long. Most of that recycling work, in both remote tropical rain forests and urban centers, takes place at the microbial level. Without the bacteria-driven processes of decomposition, the earth would have been overrun by offal and carcasses eons ago, and the life-sustaining envelope of the earth’s atmosphere would be closer to the uninhabitable, acidic surface of Venus. If some rogue virus wiped out every single mammal on the planet, life on earth would proceed, largely unaffected by the loss. But if the bacteria disappeared overnight, all life on the planet would be extinguished within a matter of years.

You couldn’t see those microbial scavengers at work in Victorian London, and the great majority of scientists—not to mention laypeople—had no idea that the world was in fact teeming with tiny organisms that made their lives possible. But you could detect
them through another sensory channel: smell. No extended description of London from that period failed to mention the stench of the city. Some of that stench came from the burning of industrial fuels, but the most objectionable smells—the ones that ultimately helped prod an entire public-health infrastructure into place—came from the steady, relentless work of bacteria decomposing organic matter. Those deadly pockets of methane in the sewers were themselves produced by the millions of microorganisms diligently recycling human dung into a microbial biomass, with a variety of gases released as waste products. You can think of those fiery, underground explosions as a kind of skirmish between two different kinds of scavenger: sewer-hunter versus bacterium—living on different scales but nonetheless battling for the same territory.

But in that late summer of 1854, as the toshers and the mud-larks and the bone collectors made their rounds, London was headed toward another, even more terrifying, battle between microbe and man. By the time it was over, it would prove as deadly as any in the city's history.

**London's Underground Market of Scavenging Had Its Own System of Rank and Privilege, and Near the Top Were the Night-soil Men.** Like the beloved chimney sweeps of *Mary Poppins*, the night-soil men worked as independent contractors at the very edge of the legitimate economy, though their labor was significantly more revolting than the foraging of the mud-larks and toshers. City landlords hired the men to remove the "night soil" from the overflowing cesspools of their buildings. The collecting of human excrement was a venerable occupation; in medieval times they were called "rakers" and "gong-fermors," and they played an indispensable role in the waste-recycling system that helped London grow into a true metropolis, by selling the waste to farmers outside the city walls. (Later entrepreneurs hit upon a technique for extracting nitrogen from the ordure that could be reused in the manufacture of gunpowder.) While the rakers and their descendants made a good wage, the work conditions could be deadly: in 1326, an ill-fated laborer by the name of Richard the Raker fell into a cesspool and literally drowned in human shit.

By the nineteenth century, the night-soil men had evolved a precise choreography for their labors. They worked the graveyard shift, between midnight and five a.m., in teams of four: a "ropeman," a "holeman," and two "tubmen." The team would affix lanterns at the edge of the cesspit, then remove the floorboards or stone covering it, sometimes with a pickax. If the waste had accumulated high enough, the ropeman and holeman would begin by scooping it out with the tub. Eventually, as more night soil was removed, the men would lower a ladder down and the holeman would descend into the pit and scoop waste into his tub. The ropeman would help pull up each full tub, and pass it along to the tubmen who emptied the waste into their carts. It was standard practice for the night-soil men to be offered a bottle of gin for their labors. As one reported to Mayhew: "I should say that there's been a bottle of gin drunk at the clearing of every two, ay, and more than every two, out of three cesspools emptied in London; and now that I come to think on it, I should say that's been the case with three out of every four."

The work was foul, but the pay was good. Too good, as it turned out. Thanks to its geographic protection from invasion, London had become the most sprawling of European cities, expanding far beyond its Roman walls. (The other great metropolis of the nineteenth century, Paris, had almost the same population squeezed into half