FOOD
COMPOSTING

Organic matter *matters*. Sir Albert Howard, English agriculturalist and ardent, prophetic champion of compost, knew this instinctually. Conducting experiments from England to India in the early twentieth century, Howard saw proof in his plants that healthy, living soil was the key to thriving, resilient crops. Though he did not fully understand the web of interactions, he knew that somehow organic matter, soil fertility, and plant health are intrinsically linked. To that end, he orchestrated large-scale composting schemes and probed root structures for answers. Perhaps, Howard thought, compost enhanced the relationship between the roots of plants and mycorrhizal fungi in the soil. Throughout his life, he battled the establishment of the time, which advocated for the use of chemical fertilizers to supply the nutrients plants need. It was the era of the Haber process, the German discovery of how to manufacture affordable nitrogen fertilizers. In its wake, compost and top-dressing fields with organic matter began to be seen as old-fashioned and uneconomic.

The new fertilizer manufacturing processes gained worldwide attention. Fritz Haber and Carl Bosch were awarded separate Nobel Prizes. But Howard was onto something. Human beings have long used compost and manure to feed their crops and gardens, without understanding the mechanics of its benefits. The oldest surviving work of Latin prose, *De Agricultura*, by Cato the Elder, includes guidance on compost—deemed a must for farmers. Shakespeare also knew the power of the true black gold. "Do not spread the compost on the weeds," Hamlet cautions in metaphor. Dutch scientist Antoni van Leeuwenhoek first saw "wee beasties" through a prototypical microscope in the 1670s, but society is only just now coming to understand the power of microbes at the heart of soil ecology.

Fertile soil depends, as was once conjectured, on a mix of weathered rock fragments and decaying organic matter, and there are more microbes in a teaspoon of healthy soil than there are people on the planet. These soil microorganisms play two interlocking roles. They help to break down organic matter from dead plants and animals, putting key nutrients back into circulation within an ecosystem. They also help supply those key nutrients to plants' roots, precisely where they are needed, in exchange for exudates, carbohydrates released by plants—food for bacteria and fungi. From nitrogen to potassium to phosphorus and beyond, microbes keep the plant world thriving, and have their role to play in addressing climate change.

Like all living beings, humans create waste, but that waste can be uniquely problematic. Nearly half of the solid waste produced around the world is organic or biodegradable, meaning it can be decomposed over a few weeks or months. A key contributor to that rubbish flow is food waste, as well as wastelike leaf litter from yards and parks. For millennia this waste made its way back into the natural economy; today, much organic waste ends up in landfills. It decays in the absence of oxygen, producing the potent greenhouse gas methane, which is up to thirty-four times more powerful than carbon dioxide over one hundred years. A quarter of anthropogenic global warming may be due to methane gas alone. While many landfills have some form of methane management, it is far more effective to divert organic waste for composting, both dramatically reducing emissions and putting microbes to work. Composting processes avert methane emissions

2.28 GIGATONS REDUCED CO2	-$63.7 BILLION NET COST	-$60.8 BILLION NET SAVINGS

with proper aeration. Without it, the emissions benefits of composting shrink.

Composting can range in scale from backyard bins to commercial operations. Whatever the scale, the basic process remains the same: ensuring sufficient moisture, air, and heat to cook up an ongoing microbe feast of organic material. Bacteria, protozoa, and fungi chow down on organic matter rich in carbon. It is a process of decomposition that happens constantly, in every single ecosystem. The earth itself has a thin compost heap spread across its various landscapes. Rather than generating methane, as decomposition in a landfill would, the composting process actually converts organic material into stable soil carbon and makes it available to plants. Compost is an incredibly valuable fertilizer, retaining water and nutrients of the original waste matter, and can aid soil carbon sequestration. It is like going from refuse to riches.

Thanks to the work of Howard and others, industrial composting has existed since the early twentieth century. It is especially useful for cities today. With their dense populations, managing urban food waste is no small task. In 2009, San Francisco passed an ordinance that makes composting the city's food waste mandatory. Seattle monitors curbside bins and now tags and fines those who violate its composting requirement. Copenhagen, Denmark, has not sent organic waste to landfill in more than twenty-five years, reaping compost's win-win-win of cost savings, fertilizer production, and carbon mitigation.

Traditionally, landfilling has been cheap and convenient, but that is changing as land-use pressures and landfill regulations grow. These shifts are boosting the appeal of composting, as are its ease and diversity of approaches. Like recycling, successful compost operations require efforts to educate the public about disposal; develop the necessary infrastructure to gather, transport, and process waste; and deploy targeted collection strategies. Compost is nothing new, but needed now are fresh ways to make it a reality at scale. Leonardo da Vinci professed, "We might say that the earth has the spirit of growth; that its flesh is the soil." Composting is a way to both enhance that flesh—its spirit of growth—and keep emissions out of the atmosphere.

IMPACT: *In 2015, an estimated 38 percent of food waste was composted in the United States; 57 percent was composted in the European Union. If all lower-income countries reached the U.S. rate and all higher-income countries achieved the E.U. rate, composting could avoid methane emissions from landfills equivalent to 2.3 gigatons of carbon dioxide by 2050. That total excludes additional gains from applying compost to soil. Compost facilities cost less to construct but more to operate, which is reflected in the financial results.*

Large-scale composting of household green waste in the United Kingdom.