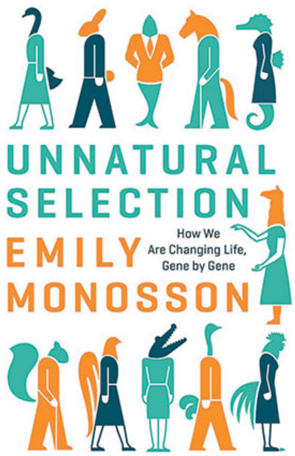
Book Excerpt from *Unnatural Selection*

In chapter 5, "Resurgence: Bedbugs Bite Back," author Emily Monosson chronicles the rise of the pesky pests in the face of humanity's best chemical efforts.



"A Miraculous Insecticide"

Desperate for a good night's sleep, early-twentieth-century homeowners welcomed highly toxic products into their homes as chemical treatments became increasingly available. Mercuric chloride, benzene, sulfur fumes, cyanide gas, and even Zyklon B pellets (a form of cyanide subsequently used in Nazi gas chambers) promised some respite, even if this came at a risk to home and health. Then entomologists finally hit upon a chemical that worked *and* was relatively nontoxic to humans—DDT. It was nothing short of a miracle. Just after World War II, bedbugs virtually disappeared from the developed world. Although the chemical, a compound of chlorine, hydrogen, and carbon, was first synthesized in 1874, its insecticidal properties weren't discovered until 1939.

Seeking a cheap, effective agricultural pesticide, Swiss chemist Paul Mueller rediscovered DDT only after testing hundreds of other chemicals. DDT was so lethal that flies dropped dead in their experimental cages shortly after contact with treated surfaces. The residues were so persistent that the cages had to be aired for a month before they could be used again. In an age with few options for preventing or treating insect-borne diseases like typhus and malaria, DDT was a godsend. It targets the insect's nervous system by effectively propping open protein channels, allowing an endless flow of biochemical signals. Repeated and spontaneous firing of neurons ensues, followed by death. The chemical became the go-to treatment for lice, fleas, mosquitoes, and eventually bedbugs. Mueller won the Nobel Prize.

In World War II military camps, typhus carried by lice was rampant, as was malaria, depending on the region. Controlling these insect vectors was critical. Not only could DDT do that, but the concentrations necessary to kill insects caused little observable toxicity to humans. Even better, DDT's persistence meant that it stuck around for weeks or months so the killing continued even as insects hatched out over time. Plus, it worked on contact rather than orally. This was particularly good for targeting pests that fed exclusively on blood. In these post–World War II years of industrial-chemical zealotry, some even suggested that with DDT humans may someday banish "all insect-borne disease from the earth." By 1972, well over a billion pounds of the chemical had been applied to homes, gardens, wetlands, and millions of acres of US cropland.

Of course, the story of DDT didn't end well. One of the chemical's most favorable characteristics, persistence, combined with its tendency to accumulate in the fatty tissues of insects, birds, fish, and mammals, made it the scourge of the twentieth century, as so eloquently revealed by Rachel Carson. In 1972, its registration for domestic use was canceled. Eventually, residues of DDT and its metabolites, detectable in both humans and wildlife for decades, subsided. Yet DDT continues to haunt us today in a most unexpected way.

Return of the Bedbug

For nearly five decades after the discovery of DDT (followed by other pesticides no longer sold here in the United States), we enjoyed relief from bedbugs. But those days are over. There isn't any one reason for the resurgence. Increased world travel and immigration, particularly from parts of Africa, Asia, and Europe where bedbugs were never really controlled; our own complacency; even demographics played a role. Because bedbugs breed stigma, infestation is a sensitive issue which can make dealing with it all the more difficult. "Reservoirs of bedbugs have been created especially in poor segments of populations," says Romero. "They cannot afford bedbug treatments, many live in low-income housing where resources for pest control is limited, many are undocumented and do not want to call attention with bedbug issues. These vulnerable segments of the population can leave bedbugs behind in public places where other people can get infested." The bugs are so omnipresent that in-home health-care workers are now trained to detect infestation and avoid tracking the bugs back to their own homes and offices.

Even as many of us remained blissfully ignorant, bedbugs were never *fully* eradicated from the United States or Western Europe, and pockets remained throughout the 1980s and '90s. Romero says that though there were few cases, bedbugs were still around. How did they slip through the DDT era and beyond? During its heyday DDT had been applied to sheets, pillows, and bedding. By the 1950s, primarily because of DDT, bedbugs had become so scarce that researchers turned to other problems. But in response to massive spraying, bedbugs, along with houseflies and mosquitos, did what bacteria, plants, and other animals have been doing since life began. They evolved—in this case, under selection pressure from a toxic chemical. And they evolved rapidly, aided by their short generation time and their formidable ability to go forth and multiply. Like penicillin, DDT was a short-lived miracle, with the first signs of resistance bubbling up in houseflies as early as 1946. But still the chemical continued to be used, and overused. A few years after DDT was marketed for bedbugs, they too evolved resistance. By 1957, resistant bedbugs could be found in locations around the world.

Currently more than 570 insect species, from bedbugs to houseflies, mosquitos, and fleas, are known to be resistant to at least one insecticide; as with weeds and bacteria, by the time you read this chapter there will be more. Evolution has rendered some 338 different insecticides useless in one species or another. And, like antibiotics, chemotherapy, and herbicides, resistance to more than one insecticide is all too common. The traits responsible for resistance are by now familiar. No matter the species, a limited number of options are available for surviving toxic threats: exclude, excrete, detoxify, sequester. While some bedbugs transform pesticides into harmless byproducts, others acquire a mutation at the intended target. Enhanced capacity to metabolize and excrete DDT made the chemical ineffective. So too does a mutation in neuronal ion channels. And like other species, insects draw upon both standing genetic variation and novel mutations for resistance.