Chapter Four

The War on Microbes

It was British scientist Alexander Fleming who is credited with discovering the first antibiotic, *penicillin*, in the late 1920s. His team of scientists was able to produce a wonder drug just in time for World War II, in the early 1940s. Fleming received the 1945 Nobel Prize in Medicine for his work.[1] Humans had discovered bacteria, figured out they were causing diseases, and now had ammunition to battle them — antibiotics!

Fast forward a few generations and humans start to look like drug addicts on a binge they can't stop or even slow down. We're attacking the microbes that reside in our bodies and we don't really know what we're doing. Yes, some bacteria can cause disease, but most are beneficial and necessary to our health, but that's not going to stop us from trying to kill them all. Our mass slaughter of microbes is inadvertently breeding antibiotic resistant bacteria, or superbugs, in the process.

Antibiotics have become big business, with worldwide production now at more than two hundred million pounds annually[2]. Global antibiotic consumption increased by 65 percent just between 2000 and 2015.[3] Thirty-eight million pounds of antibiotics are consumed in the United States each year, 80 percent of which is consumed by animals raised for meat production.[4] Remember that no antibiotics were consumed on Earth before 1940, since the beginning of time.

In 2015, approximately 21.4 million pounds of antibiotics considered important for human use were sold for use in animal agriculture.[5] Animals dosed with antibiotics breed antibiotic-resistant bacteria. These nasty bacteria end up in the meat, then access your body when you handle the raw meat in your kitchen. Evidence now suggests that forty thousand or more people each year in the US get urinary tract and kidney infections from *E. coli* that originated in poultry.[6]

By 2010, 258 million courses of human antibiotics were prescribed in the United States alone, amounting to 833 prescriptions for every

one thousand people, many of which were prescribed to babies. In fact, babies in the US were getting 1,365 courses of antibiotics per one thousand bambinos. The average American child receives nearly three courses of antibiotics just in the first two years of life, then an additional course every year for the next eight years; seventeen courses on average by the time he or she is twenty-one and thirty courses by the age of forty.[7] Every course of antibiotics can have a profound effect on the body's microbiota, and that effect can last for years.

In 2014, outpatient providers in the US wrote over 266 million antibiotic prescriptions, or 835 antibiotic prescriptions for every one thousand people.[8] Yet, at least 30 percent of oral antibiotics prescribed are unnecessary. Of the total excess prescriptions, nearly three-quarters are for acute respiratory conditions, including asthma, allergies, colds, and other infections not caused by bacteria, which therefore do not respond to antibiotics. On top of this, a third of patients given antibiotic prescriptions for three common respiratory conditions were given the wrong antibiotic anyway.[9]

Seventy percent of kids who walk into a pediatrician's office walk out with an antibiotic prescription, even when they have an upper respiratory infection caused by a virus, on which an antibiotic has no effect.[10] About 40 percent of American women get antibiotics during delivery, and virtually all hospital-born babies are given an antibiotic immediately after birth.[11] Our world has become so saturated with antibiotics that a child who now drinks two cups of cow's milk a day will consume about fifty micrograms of the antibiotic tetracycline every day, residual in the cow's milk from dairy management practices.[12]

So what? Isn't the *War on Microbes* keeping us cleaner and safer? The answer, in a word, is no. Overuse of antibiotics creates very serious problems. It screws up our microbiome, the invisible beings that naturally populate our bodies. Some of those microbes, however, can adapt to our antibiotic onslaught by developing antibiotic resistance — their defense against our ammunition. The ones that survive the antibiotics can be very nasty, and since our natural protective population of microbes has been wiped out by the antibiotics, the bad bugs are free to

multiply like crazy, and maybe even kill us.

We humans discovered microbes; then eventually we figured out how to destroy them. But now the littler buggers are outsmarting *us*. Or in the words of scientists, *The early hope that antibiotics would eradicate infectious diseases has turned out to have been hopelessly naive and wrong. We failed to realize that the use of antibiotics. . . would actually engage us in a long-term war against the entire bacterial world.*[13]

Considering that microbes have inhabited the Earth for almost four billion years and are still the most abundant forms of life on the planet,[14] maybe we should be showing them some respect. Some bacteria, *E. coli,* for example, can reproduce every twenty minutes. That means that a single cell starting reproduction in the morning can become ten billion cells by the afternoon.[15] That's a lot of generations in a short time, meaning lots of opportunity for evolution to occur — you know, genetic mutation, that sort of thing. Speaking of which, bacteria have an uncanny ability to exchange genes across different species; they can also transfer antibiotic resistance to other bacteria by a process known as horizontal gene transfer.[16] And guess what? That's exactly what they're doing. When we pump ourselves and our children full of antibiotics, the microbes that develop resistance to the antibiotics are the ones that continue living and multiplying. We're *creating* antibiotic resistant bacteria, a practice which may be looked back on historically as a medical blunder similar to blood-letting. What were we thinking?

According to the World Health Organization, antimicrobial resistance is now one of the three greatest threats to human health and is one of the biggest public health challenges of our time. In February of 2017, WHO published its first-ever list of antibiotic-resistant "priority pathogens" — twelve families of bacteria that pose the greatest threat to human health. These bacteria resist antibiotics and can transfer genetic material to other bacteria to make them also antibiotic resistant.[17]

Every year in the United States, at least two million people get an antibiotic-resistant infection, and at least 23,000 die.[18] A 2009 study in several US cities even found antibiotic-resistant bacteria in all of the tested tap water.[19] Increasingly resistant bacterial strains are often

spread in the medical environment where rates of handwashing rarely exceed 60 percent, with physicians, believe it or not, reported as having the worst hand-washing record.[20] This could be one reason a 2013 Johns Hopkins study claimed that more than 250,000 people in the US die every year from medical errors, making it the third leading cause of death behind heart disease and cancer. Other reports claim the numbers to be as high as 440,000.[21]

Then there's your personal microbiome. Your body's resident microbe population is important in the development of your immunity as well as in protecting your body from specific pathogens. Those microscopic critters protect your health and help you more efficiently utilize your food. Since some bacteria grow better in the presence of other bacteria, destruction of specific bacterial strains by antibiotics may disrupt our microbiota in ways that we can't imagine.[22]

The disruption of our resident microbes is linked to inflammatory bowel disease and many other maladies. These include reflux disease, asthma, obesity, diabetes, gluten intolerance, food allergies, celiac disease, Crohn's disease, lupus, osteoporosis, and autism, not to mention direct infections, including infections from antibiotic resistant bacteria such as *Clostridium difficile* (*C. diff*).[23] A one-week course of antibiotics can lead to the persistence of antibiotic resistant organisms in your body for years.[24]

Some forms of autism and autism spectrum disorder can be related to a dysfunctional gut microbiome. When researchers fed the probiotic bacteria *Bacteroides fragilis* to mice with such disorders, the resultant changes in their gut microbiome improved autism-related behaviors and alleviated symptoms of autism spectrum disorder.[25]

Regarding infections, when mice were fed with the disease-causing bacteria *Salmonella enteritidis*, a quantity of one hundred thousand bacteria caused an infection in about half the mice. But if the mice were first given a single oral dose of the antibiotic *streptomycin* several days prior to being given the pathogen, it took only about *three* bacteria to cause an infection! Other antibiotics, including *penicillin*, had the same effect. This phenomenon was shown to occur in humans as well.[26] In-

creased susceptibility to new infections is a side-effect of antibiotic use, presumably because the microbes that live in you and naturally defend you (you are their home, after all) are wiped out by the drugs.

The loss of friendly gut bacteria during early childhood can lead to obesity,[27] which is now an epidemic problem in the US. The Centers for Disease Control and Prevention released a study in 2017 stating that almost 40 percent of adult Americans and nearly 20 percent of adolescents are obese — the highest rates ever recorded for the US.[28] Coincidence? The overall diversity of microbiota is reduced in obese persons.[29] Sounds like antibiotics may be playing a role in this. The fact that sugar is added to most store-bought foods doesn't help. Some bacteria have coevolved with the human species to the extent that their secretions can theoretically stimulate their host person to eat certain foods.[30] Imagine single-celled bacteria driving their host like a giant robot straight to the donut counter or the chocolate milk. There may be a lot more to the obesity epidemic than we currently understand!

Antibiotic use in the first year of life is associated with a significantly greater chance of having asthma at the age of seven.[31] One wonders if the altered microbiome of a small child leads to long-term health problems later down the road. How did kids get their microbial roommates anyway? Theoretically, they have no bacteria in the womb, but they become inoculated as they exit through the vagina.[32] Passage through the birth canal by means of natural birth provides us with our first bacterial inoculation, primarily by *lactobacillus*, bacteria that naturally reside in the vagina and that help babies digest milk.[33] The coevolution of humans and bacteria should be obvious here. Babies born by C-section miss this initial bacterial indoctrination into the world, and C-sections in the US in 2011 were performed on one in three mothers![34] Most of our bacteria live in the colon, which is the lower part of the large intestine, where a milliliter of stuff (one fifth of a teaspoon) contains more bacteria than there are people on Earth.[35] So when you're coming out the birth canal, chances are you're getting some of those bacteria too. Next time you get a chance, measure the distance between a vagina and an anus. You'll find it's about an inch and a half, close

enough for bacterial transfer to a newborn baby.

If antibiotics are limited or avoided altogether, such as with a lifestyle consisting of organically grown or fermented foods, a microbiome with a higher bacterial diversity can be expected.[36] Organic dairy farms have lower levels of multiple drug resistance than do conventional farms,[37] which could be attributed to the avoidance of antibiotics.

Some people may wonder how anyone can avoid antibiotics. You need them, don't you? There's no way anyone can raise kids these days without giving them antibiotics, is there? As I write this, at age sixty-six, I can honestly say that I never gave any of my kids antibiotics. My thirty-three-year-old son has never had an antibiotic and presumably has an intact natural microbiome, as do most of my offspring. That makes his shit valuable in this day and age. Why? FMT, that's why.

Yes, there's a cure for a screwed-up microbiome, and you aren't gonna like it. It's shit. Fecal microbiota transplantation (FMT), to be precise — the deliberate transfer of feces from one person to another. A person with an intact, fully diversified natural microbiome can transfer those microbes to someone suffering from what we might call antibiotic poisoning, or the overuse of antibiotics to the extent that toxic antibiotic resistant bacteria have taken over and are killing their host. *C. diff* is one such dangerous antibiotic-resistant bacterium. Treating *C. diff* with FMT in one trial had a 94 percent success rate in comparison to 31 percent using drugs,[38] which is pretty incredible considering how easy it is to obtain fecal material versus pharmaceuticals. This shows how important the natural microbes are to our bodies and why we should try to keep them intact. Although fecal transplantation from the correct donor might cure an ailing recipient, don't try this at home.

As you can see, humanure has some tricks up its sleeves. Or should I say the residents of humanure have tricks up their trillions of sleeves. Microbes have been on Earth for billions of years. We humans just got here, and we have to learn how to live with our invisible neighbors. If we do, we can employ them to do important work for us, like eating our shit. When we feed humanure and other organic materials to microbes, they turn it back into earth. It's called composting.