

## The Invisible Beings

Whoever said “The meek shall inherit the Earth” must have been a microbiologist. Except that was thousands of years before microbiology even existed. In fact, microbes (microscopic organisms, or “invisible beings”) already own the Earth, have always owned the Earth, and are allowing humans to borrow it, briefly. Once we humans kill ourselves off through pollution, consumption, greed, hatred, warfare, disease, and extinction, our brief time on this planet will end and microbes will carry on as though nothing had happened, as they’ve already done for billions of years.

Scientists believe the Earth to be about four and a half billion years old, but for the first half billion years or so, they believe there was nothing on Earth that could be considered life as we know it today. Yet somehow, complex molecules were created by natural forces (think heat, pressure, maybe lightning, and meteorites). The molecules combined and coagulated to the extent that single-celled organisms eventually evolved on this planet eons ago, as evidenced by three-and-a-half-billion-year-old microbial remnants found in Australia and South Africa.<sup>1</sup>

I well remember the day I stood on a mountainside in remote Africa to conduct an outdoor presentation about compost toilets for the local tribe. “Half of all life on Earth is invisible,” I told them. “Furthermore, if you scraped up all the microorganisms in and on your body, single-celled organisms that are not *you*, the resulting mass would weigh as much as your brain.” They stared at me as if what I had just said didn’t register at all, and it probably didn’t (with you either). Allow me to elaborate.

The number of individual microbes on our planet today is estimated to be as high as  $10^{30}$  (a “nonillion”).<sup>2</sup> Ten to the 9th power is a billion, so ten to the 30th power is a number that’s impossible to grasp. To put it in perspective, scientists estimate that there are  $10^{24}$  stars in

the universe, roughly equal to the number of grains of sand on Earth (i.e., much fewer than a nonillion). The number of microbes on Earth eclipses the number of stars in the known universe by a factor of somewhere between a million and 100 million, depending on whom you ask. The number of single-celled organisms (“invisible beings”) on our planet, with an estimated ten million to one billion species, is so immense that their collective mass is greater than that of all of Earth’s visible plants and animals combined.<sup>3</sup>

A hundred million microbes can be found in only a liter (roughly a quart) of pond or sea water, containing maybe thirty-five thousand different kinds of bacteria. Incredibly, the number of different kinds of microbes in soil can be much greater than in sea-water.<sup>4</sup>

Then there are viruses, the most abundant biological entities on the planet.<sup>5</sup> There can be ten million viruses in the form of bacteriophages (a virus that kills bacteria) per milliliter of sea water, which means ten billion in a quart of water, outnumbering bacteria by a hundred to one. Viruses are noncellular, parasitic, non-living critters (wrap your brain around that) that must infect bacterial host cells to reproduce.<sup>6</sup> They appear to play crucial and beneficial roles on our planet.<sup>7</sup>

Humans evolved on a planet that was already teeming with life, most of it microscopic. If you stretch out your arm and use it as a measure of time since life began on Earth, humans would only represent the edge of the farthest fingernail, or if life on Earth were compacted into twenty-four hours, humans showed up two seconds ago.<sup>8</sup>

This means the microbes were already here and had been for billions of years before humans arrived. It means humans didn’t evolve independently of microbes; instead, we evolved in a *soup* of microbes; we *coevolved* with microbes, as did every other living thing. Microbes are in us and they are on us and they belong there. The statistics are astonishing. For example, scientists estimate that there are at least ten times and maybe a hundred times more bacterial cells living on our skin, in our mouth, and in our gastrointestinal tract (our digestive system from mouth to anus and everything in between) than there are human cells in our bodies. Did you get that? Ten to one hundred times

as many cells in and on us that are *not our* cells!

These might represent ten thousand nonhuman species or strains of microbes<sup>9</sup> housing themselves in and on you and me. That's hundreds of trillions of bacterial cells in every person, whether we like it or not.<sup>10</sup> We *should* like it because the microbes play a critical role in our immune and digestive systems and they help us to resist disease.<sup>11</sup> We would find it difficult, if not impossible, to eat, breathe, and survive on this planet without our resident microorganisms, but the Earth's microbes would carry on just fine without *us*.<sup>12</sup> What's another billion years to them? We humans are hoping climate change or nuclear war doesn't kill us off by the end of *this century*.

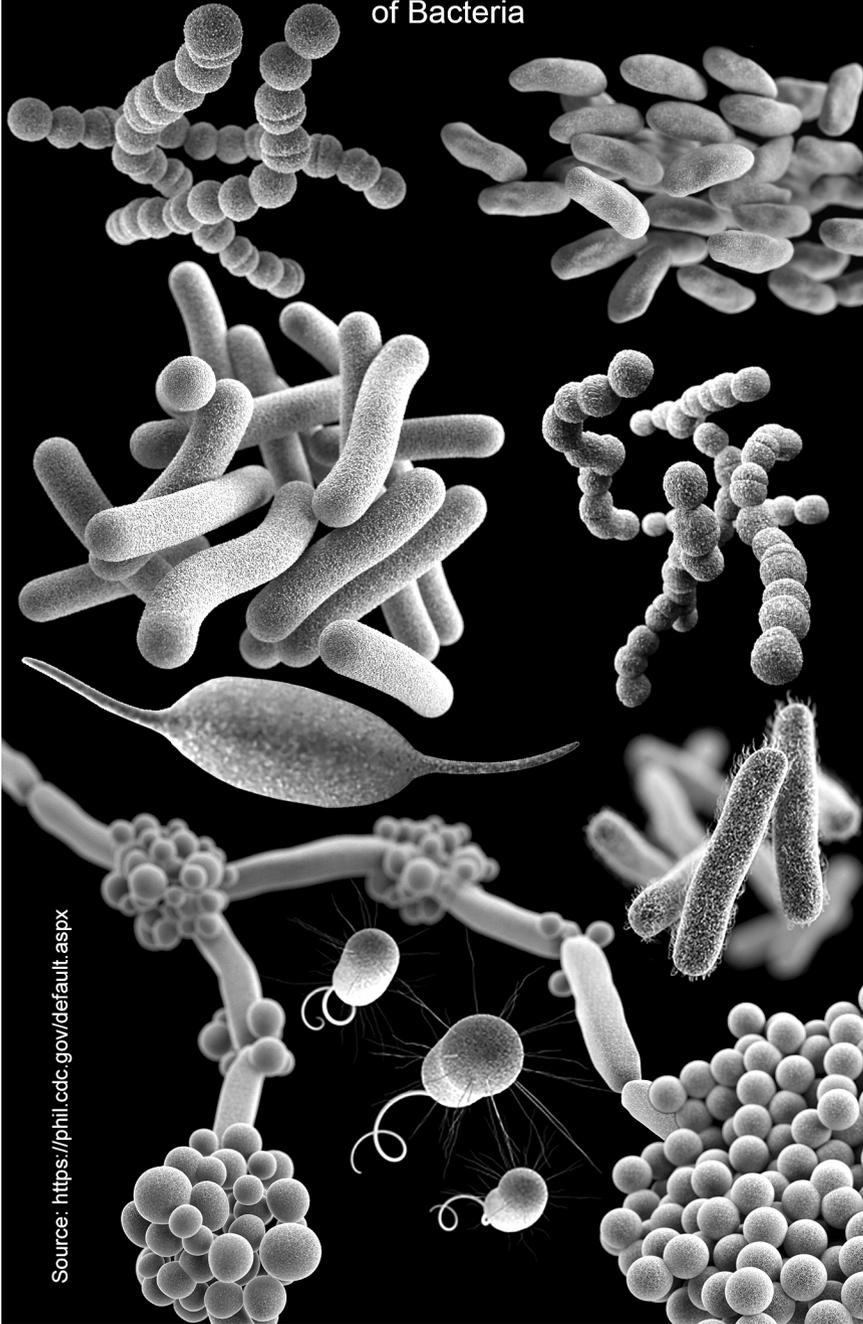
According to the dictionary, a "biome" is "a large naturally occurring community of plants and animals occupying a major habitat." If those "plants and animals" are microscopic, it's called a "microbiome." This is a term that everyone should know and remember. That's the population of microorganisms we have in and on us, our microbiome, and not only is it important, but we each have our own unique one, almost like a personal fingerprint.<sup>13</sup>

Every human body is an ecosystem in itself. For example, in most mammals (such as humans) studied to date, the most densely populated areas of the gastrointestinal tract, or "gut," can contain a hundred billion single-celled organisms per gram, totaling 3.3 pounds in an average human.<sup>14</sup> For perspective, a quarter teaspoon of sugar weighs a gram; add a hundred billion bacteria to that, and you get the idea of what it's like inside your body. So if your body contains 3 pounds of microbes, you now have something new to think about every time you get on the bathroom scale and look at your weight. You're not just weighing yourself; you're weighing your resident microbes too, your invisible neighbors.

The gut is not just inhabited by bacteria; it also contains resident protozoa, yeast, and fungi,<sup>15</sup> making it one of the most densely inhabited ecosystems on Earth. Even your mouth can contain over six hundred species of bacteria.<sup>16</sup> In some parts of your body ten million bacteria may be living on a square centimeter of your skin (a centimeter

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## Modern Electron Micrographs of Bacteria



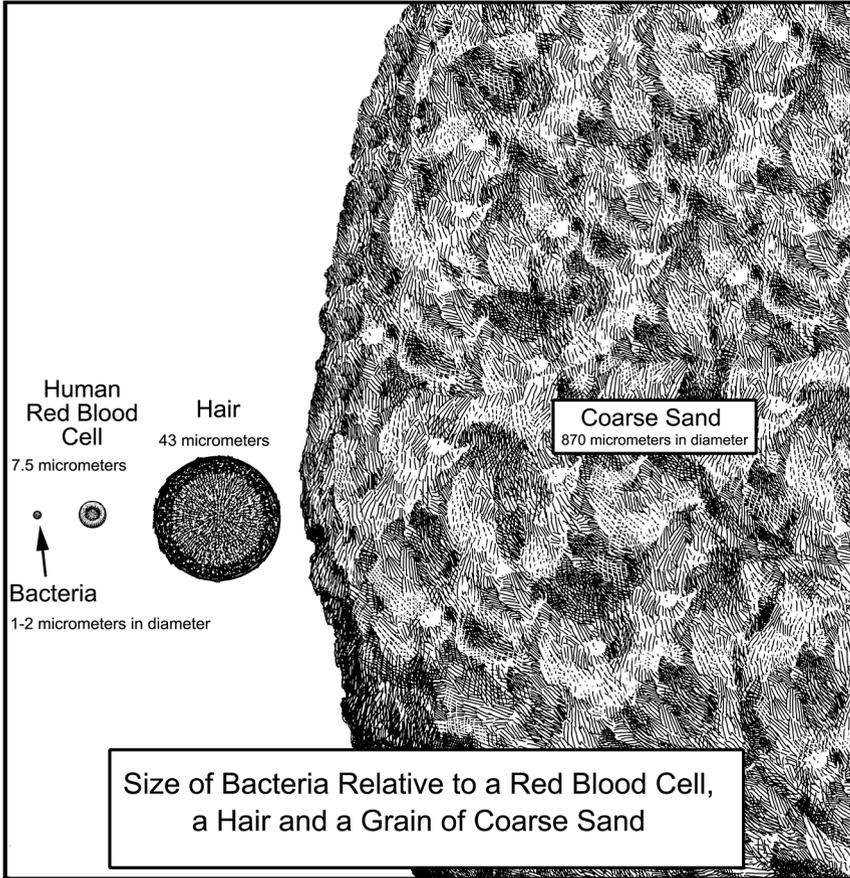
Source: <https://phil.cdc.gov/default.aspx>

is less than half an inch). On average, 150 different species of bacteria can be living on the palm of your hand.<sup>17</sup> Think about that the next time you get your palm read or shake someone's hand!

Of course, microbes coevolved with everything else on the planet, too,<sup>18</sup> and their relationships with other animals can be remarkable. In fact, each animal species appears to contain its own gut microbiota.<sup>19</sup> Termites digest wood because of the bacteria in their guts. Mammals can't digest plant cellulose<sup>20</sup> without the microbes that coevolved with them in *their* stomachs. Cows and other ruminants therefore digest grass thanks to their gut bacteria,<sup>21</sup> although their stomachs also contain viruses, fungi, and protozoa.<sup>22</sup> Fish with light organs owe their light to bioluminescent bacteria.<sup>23</sup> The symbiotic relationship between leaf cutter ants and fungi dates back fifty million years.<sup>24</sup> The ants chew leaves into pulp, add poop (antmanure?), then inoculate it with fungus, which produces food for the ants. There are a half million bacteria inside a single female aphid helping to digest the sap it eats, a symbiotic relationship that goes back two hundred million years.<sup>25</sup>

Microbes make Earth a living entity; call it Mother Earth, Gaia, or Mother Nature, but without it we're toast. Earth's delicate atmosphere, a thin layer of gases blanketing the planet with all life huddled beneath it, can be traced back to microbes. In fact, half of all photosynthesis, which is what produces atmospheric oxygen, is attributed to microscopic phytoplankton in the oceans, the smallest and most abundant of which (*Prochlorococcus*) was only discovered by humans in 1986.<sup>26</sup> A symbiotic relationship between viruses and phytoplankton in the oceans seems to increase the ability of the phytoplankton to keep photosynthesis going longer than would be possible otherwise. Since ten million of these viruses can reside in a milliliter of seawater, a significant portion of the oxygen in the atmosphere may be attributable to the influence of viruses on oxygen-producing bacteria.<sup>27</sup>

The relationship of microbes to ourselves, to our bodies, and to our planet is incredibly complicated and largely unknown. Our primitive attitudes tend to consider microbes to be dangerous — something to be destroyed and eliminated. We couldn't be more wrong.



Source: Gest, Howard (1993). Vast Chain of Being. Perspectives in Biology and Medicine. Volume 36, No. 22, Winter 1993. University of Chicago, Division of Biological Sciences. p. 186.