GROW HEALTHY BABIES

CHAPTER 2

THE MICROBIOME: HOW GUT BACTERIA SHAPE YOUR BABY'S HEALTH

You have some 40 trillion bacteria living in and on your body. They're on your skin and in your intestines, your mouth, and your genitals—they're everywhere. You even emit your personal microbial signature like an "aura," to the point where researchers can distinguish which people have been in a room based on the bacteria in the surrounding air.[30] In all, you carry around between two to six pounds of bacteria of more than 10,000 different species, and they outnumber your own body's cells by about 10 trillion.[b] Collectively, these bacteria are called your microbiome.

The human genome has around 22,000 genes, but our micro-

b Researchers used to think that bacteria outnumber human cells by 10 to 1. New research is showing that the ratio is closer to 1.3 to 1.[31] Not that it really matters: the key takeaway is that you are the host of many, many bacteria, and they play a central role in your health.

biome has around 8 million—that's 360 times more bacterial genes than human genes.[32]

In fact, we've come to understand that our own genes alone aren't sufficient to carry out all our bodily functions.[33] Instead, a significant part of how the human body functions is determined by bacterial genes. These bacterial genes work for us as if they were our own. They enable our gut bacteria to help us break down foods, make nutrients available to us, and produce beneficial vitamins and anti-inflammatory compounds our bodies can't produce themselves. Our microbiome is involved in almost every aspect of our health, from acne and dental cavities to diabetes, obesity, ulcers, and cancer, to psychological states like anxiety and depression—as well as allergies, asthma, and eczema.[34] Perhaps this is less surprising if you know that 70 percent of all of our immune cells live in the gut, where they interact with, and are regulated by, our gut microbiome.[35] That's why immunologists describe gut bacteria as "a buffer and interpreter of our environment."[33]

To understand how gut bacteria influence our health from conception onwards, let's take a look at how the microbiome starts to develop in babies. Around 1900, French paediatrician Henry Tissier was one of the first to study the microbiome of newborn babies. He thought that the womb was sterile and that babies get their first dose of bacteria from their mother's birth canal during delivery and later through breast milk. Only in the past few years did researchers discover that healthy wombs *do* contain a small but measurable amount of bacteria: in the placenta, in the amniotic fluid, in the umbilical cord, in the developing foetus itself, and in the first poo (meconium) of newborns![36] The bacteria travel from the mother's mouth and intestines to the womb via the bloodstream, and likely also upwards from the

vagina.[c] This is completely normal and nothing to worry about. For the growing baby, this is the first contact with beneficial microbes even before birth.

Tissier, however, was right in that birth is a key event for the developing microbiome. During birth, the baby is colonised by beneficial bacteria picked up while passing through the birth canal. For the first few weeks of life, the baby's microbiome closely resembles the mother's vaginal and skin microbiome.[d] When a baby is born by C-section, the bacteria it encounters aren't primarily the mother's but those of the operating room environment and medical staff. C-section babies have significantly fewer of a group of beneficial bacterial families called *Bifidobacteria*.[37] We'll return to the health implications of C-sections in chapter 10 of this book.

For the next three years, babies pass through a critical window for the development of their microbiome. The first one hundred days in particular are key to creating a healthy, diverse microbial ecosystem that prevents chronic disease. If this ecosystem tilts out of balance—a state called "dysbiosis"—the child's likelihood of developing inflammatory chronic diseases later in life increases.[37,38]

---

c This could explain why pathogenic (disease-causing) bacterial infections in the mouth (like periodontitis/gingivitis) and in the vagina (like bacterial vaginosis) are both linked to preterm births—the body's immune system launches a Th1-mode inflammation to kick out the bacterial invaders, and the foetus gets caught in the crossfire.[33]

d Unfortunately, in many cultures, women are made to feel that their vagina is unclean or somehow "icky." Some women may cringe at the thought of having vaginal bacteria, let alone at those being a good thing for their baby. Yet, that's exactly what they are: they are natural, they're not unclean, and they play a really important role in protecting both the mother's and the baby's health.

In breastfed babies, *Bifidobacteria* and *Lactobacilli*—another beneficial type of bacteria you'll encounter frequently in this book—become the dominant species in the gut during the first few months of life. They are contained in and thrive on breast milk, which contains between 1,000 to 10,000 live bacteria from 700 different species per millilitre.[39,40] In this way, breastfeeding becomes the main driver of the baby's microbiome development in the first year of life.[41]

Lactic acid bacteria like *Bifidobacteria* and *Lactobacilli* help the baby fend off harmful microbes. By fermenting lactose and other sugars to lactic acid, they make the gut environment more acidic,[42] which makes it harder for bad bacteria to survive. They also produce natural antibiotics (antimicrobial peptides) which kill harmful bacteria while leaving the good ones unharmed.[43] At the same time, both *Bifidobacteria* and *Lactobacilli* stimulate the baby's Th1 immune response and turn down the Th2 response, thus lowering the risk of allergies.[44]

The interior of the gut has an enormous surface area to enable it to absorb nutrients. If you live in a city with sky-high rents like London, New York, or San Francisco, chances are your gut bacteria have more living space than you do: roughly 32 square meters or 344 square feet,[45] the size of a decent studio apartment. This also makes your gut an ideal portal for invading germs. But both *Lactobacilli* and *Bifidobacteria* act like your guard dogs. They strengthen the gut wall by triggering the growth of new epithelial cells which line the walls of the gut, thus making it harder for invaders to get through into your bloodstream. Additionally, they stimulate the production of mucus which adds another barrier to the lining of the gut, feeds beneficial microbes, and stops pathogenic strains of bacteria like *Esche-*

richia coli (commonly known as *E. coli*)[e] from clinging to the lining of the gut.

So what's the role of a healthy gut lining in preventing asthma, eczema, and allergies? When the gut lining is damaged and porous, tiny undigested bits of food, harmful bacteria, and other toxins can leak into the bloodstream. This so-called leaky gut causes chronic inflammation and allergy symptoms because the immune system begins to fight the invaders.

Bifidobacteria have even more tricks up their sleeves. Researchers have observed that they stimulate the growth of the thymus gland—the police academy in the baby's chest where Th1 and Th2 immune cells receive their "training." The thymus plays a central role in preventing autoimmune diseases in which the immune system mistakenly attacks the body's own tissues. Thymus function is directly related to its size: generally speaking, a bigger thymus is better.

At four months of age, breastfed babies have a thymus that is, on average, twice as large as that of formula-fed babies—roughly the size of a fig versus a grape.[47] Italian researchers wanted to find out whether they could increase the thymus size of formula-fed babies by enriching formula with beneficial bacteria and their fermentation by-products. In their experiment, thirty babies were breastfed, thirty babies were given standard formula, and thirty babies received formula that had been fermented with *Bifidobacteria* and another beneficial microbe, *Streptococcus thermophilus*. After four months, the thymus glands of babies who had received

e Some strains of *E. coli* are a normal part of the healthy human microbiome and even help to defend the gut against invaders. Other strains of *E. coli*, however, are pathogenic and cause acute intestinal infections as well as chronic diseases.[46]

fermented formula resembled those of breastfed babies—larger and healthier than those of babies fed with standard formula.[48]

Bifidobacteria play yet another role in allergy prevention by interacting directly with the mast cells in the gut. Mast cells are a central player in allergic reactions. They respond to the presence of allergens by releasing histamine, which then triggers allergy symptoms like swelling, sneezing, itching, and wheezing. A particular strain of *Bifidobacteria* called *B. longum* docks onto mast cells in the gut and triggers their cellular suicide program (so-called apoptosis). This dramatically reduces the number of mast cells in the gut, which lowers or stops the allergic reaction to foods.[49] The amazing thing is that *Bifidobacteria* do this without weakening the immune response to real threats. Other immune cells that fight invaders (T-cells) remain unharmed.

The next major shift in the baby's gut microbiome happens when you start feeding solids. This introduces a much wider variety of dietary fibres. Fibres are carbohydrates from plants which our bodies can't digest on their own, but which are a food source for the microbes in our guts. After weaning, the ratio of *Bifidobacteria* and *Lactobacilli* decreases, and other bacterial species begin to colonise the gut. Your baby's diet determines which types of species grow most rapidly. In babies fed lots of meat and animal fats (common in our Western diet), *Bacteroides* and *Clostridia* become dominant, whereas in babies fed carb- and fibre-rich diets (common in developing countries), *Prevotella* becomes the largest group.[49,50] While *Bacteroides*, *Clostridia*, and *Prevotella* are all part of a normal gut microbiome, there can be problems when one group becomes overly dominant. You could think of it like a democracy: it's fine to have the largest party assume the role of government, but you need the opposition to

keep them in check. Once you let things slide into a one-party dictatorship, bad things happen.

Around two to three years of age, your baby's gut microbiome stabilises and starts to resemble an adult one. When the microbiome is healthy and balanced, your baby's gut bacteria fulfil a range of important duties as part of their regular day job. One of them is the production of short-chain fatty acids (SCFAs). When it comes to SCFAs, the bacteria's trash is our treasure: SCFAs are the waste product of gut bacteria munching and fermenting dietary fibre. The most abundant SCFAs are acetate, propionate, and butyrate—and all of them are highly anti-inflammatory. Butyrate is the main source of energy for the cells in our colon, where it has been found to kill cancer cells and prevent tumour growth. Acetate and propionate provide energy to the liver, the kidney, the heart, and other muscles. Together, they supply roughly 10 percent of the energy our bodies burn.[51] Without butyrate, our colon cells undergo autophagy—that is, they literally eat themselves.[52] Butyrate is also, in case you want to know, what gives vomit its distinctive smell. That's right—our bodies are fuelled by bacterial waste that smells like vomit and protects us from colon cancer. The wonders of biology!

SCFAs like butyrate and propionate also kill bad bacteria that try to invade our guts, while leaving beneficial bacteria unharmed. Butyrate, for example, is used to treat acute *Salmonella* infections. Propionate is added to food as an antimicrobial agent. Both of these SCFAs stimulate the production of gut mucus and strengthen the gut wall—so much so that they are prescribed as medication or dietary supplements to treat the leaky-gut syndrome which is so often associated with allergic and autoimmune disease.[53] And it turns out that kids with aller-

gies have significantly lower levels of butyrate and propionate in their guts than non-allergic kids.[54]

MICROBES, MOODS, AND BRAIN DEVELOPMENT

The effects of the microbiome extend way above your baby's belly. One of the hottest topics in neuroscience right now is the influence of gut microbes on our moods, behaviour, and even brain development and personality. According to John Cryan, a leading neuroscientist at the University College Cork in Ireland: "If you look at the hard neuroscience that has emerged in the last year alone, all the fundamental processes that neuroscientists spend their lives working on are now all shown to be regulated by microbes."[55]

In your baby's belly, in the lining of the gut, there is another nervous system—the enteric nervous system (ENS). The ENS is often overlooked but so extensive that scientists have nicknamed it our "second brain." It stretches nine metres from the oesophagus to the bum, has an estimated 500 million neurons (five times as many as the brain of a rat), and connects to the brain through the vagus nerve and spinal cord. Scientists used to think that the brain was sending signals to the ENS to coordinate our digestion. Hence, they were shocked to discover that 90 percent of the signals passing through the vagus nerve were being sent from the ENS to the brain, not the other way around![56]

You'll know from your own experience that the "gut feelings" the ENS sends to our brain can have an enormous effect on our moods and well-being—think of "butterflies," the "sinking feeling" in your stomach, or simply the bad egg sandwich from this morning. In fact, even "artificial gut feelings" can

produce that effect. In a small British study, eleven patients suffering from chronic depression which hadn't responded to any other treatments were implanted a small, pacemaker-like device to electrically stimulate the vagus nerve. More than half improved significantly, and three of the eleven patients were free of depression symptoms after a year.[57,f]

The neurons in the ENS and in our brain communicate using tiny chemical messenger molecules called neurotransmitters. You have surely heard some of their names before, because many of them also act as hormones in your body:

- Adrenaline/epinephrine, which jolts you into "fight or flight" mode.
- Melatonin, which makes you feel sleepy.
- Oxytocin, which gets you to bond with others and feel cuddly.
- Serotonin, which makes you feel happy and content.
- Dopamine, which gives you a sensation of pleasure and reward (many drugs work by activating the dopamine system).
- Gamma-Aminobutyric acid, more commonly known as "GABA," which gives you that "aaaaah" sense of relaxation (alcohol works by mimicking GABA in the brain).

And this is how our gut bacteria interact with our "second brain": They produce many of these neurotransmitters or stimulate their production in our gut. For example, our good friends *Bifidobacteria* and *Lactobacilli* produce GABA. That would

f However, several patients in the study experienced severe side effects, like vocal cord paralysis lasting for months. Fortunately, if you are looking for ways to stimulate the vagus nerve, there are much safer and more natural options: aerobic exercise, deep breathing, meditation, yoga, tai chi, or cold exposure.

explain why breast milk, which helps these bacteria thrive and release lots of GABA, turns babies into "boobaholics"! Other species of bacteria have been found to produce serotonin, dopamine, noradrenalin—which also acts as an antidepressant—or acetylcholine, which is important for memory and learning.[58]

In a fascinating experiment at University of California, Los Angeles's Medical School, a group of healthy women ate two small cups of yoghurt daily, for four weeks. The yoghurt was enriched with "probiotics" (live beneficial bacteria)—*Bifidobacteria*, *Lactobacilli*, and two other species, in total about 28 billion living microbes per day. Before and after the study, the participants were shown a series of photos of angry and fearful faces, designed to trigger a stress reaction. Brain scans revealed that the women who had eaten the probiotic yoghurt had changed connections in some parts of their brain (again, after just four weeks!), which led them to react much more calmly to the stressful images than the placebo group who hadn't received probiotics.[59] Yet more studies have discovered similar results. In one, taking a daily probiotic supplements of 3 billion units *Lactobacillus helveticus* and *Bifidobacterium longum* for a month led to lower levels of anxiety, anger, hostility, and physical stress symptoms as well as better problem-solving in healthy volunteers. In another, 6.5 billion units of *Lactobacillus casei* per day for three weeks improved moods in people who were initially depressed.[60–63]

Feeding your beneficial bacteria achieves similar results. The term for fibres which our bodies can't break down on their own but which provide fuel to beneficial gut bacteria is *prebiotics* (as opposed to probiotics, the live bacteria themselves). One such prebiotic has the somewhat unwieldy name galactooligosaccharides (GOS). GOS is the substance in breast milk

that helps *Bifidobacteria* and *Lactobacilli* thrive. In an experiment at the University of Oxford, healthy adult volunteers were given just 5.5 grams, about a teaspoon, of GOS per day for three weeks. The effect was similar to taking antidepressants. The prebiotic group scored lower on measures of anxiety and depression than the placebo group, and they also had lower levels of the stress hormone cortisol.[64,65] What's important to know is that these types of prebiotic fibres are not just in breast milk—they are a major component of plant-based foods.

As you can see, our gut bacteria have an enormous influence not just on our physical health, but also our mental health. Changing your diet will literally change your and your baby's brain. We'll return to the relationship between diet, the microbiome, and health in more detail in chapters 4–7, where we discuss which foods and supplements are most beneficial during pregnancy.

HOW TO CHANGE YOUR BABY'S GENES THROUGH EPIGENETICS

You may think of your genes as something that is set in stone when you're born, and you have either won the "genetic lottery" or you haven't. But we now know that this isn't entirely true—only to a certain degree. Your genes may give you a better chance of good health or a higher risk for certain illnesses, but those outcomes aren't fixed. Your odds for health or illness are fluctuating constantly during your lifetime because the activity of your genes is changed by your diet and lifestyle, and *those changes can be inherited by your kids.* This process is called epigenetics—the *expression* of genes. Epigenetics influence your children's health, and possibly even your grandchildren's, long before they are born.

So how does this work? To begin with, each of the 37 trillion

cells in your body starts out with exactly the same DNA and genes. But if they're genetically all the same, how does a cell know whether to become a part of your eye, a part of your gut, or a part of your skin? How does it know how to do its job once it has become an eye cell, gut cell, or skin cell?

Imagine each cell as a little factory. These factories are pumping out proteins which do all the essential work in our bodies—like fighting infections, breaking down foods, transporting oxygen, making muscles contract and move, or carrying messages to other cells in other organs. The factory itself is controlled by a bunch of software—your genes. Each gene is like a line of code in a tremendously complex software program. Together, these lines of genetic code make up your unique genome. Your genetic code is stored in tightly wound spirals, the famous double-helix strands of DNA.

Each new cell starts out with a complete copy of your DNA and genes, but not all genes are being activated at the same time—that would be a disaster, as the cell would grow out of control. Instead, different genes are switched on in different cells, determining what kind of cell it will become. For example, in cells that become part of your eyes, genes are turned on to produce proteins that respond to light.

But what switches the genes on or off? Primarily, this is done by other genes within your genome: Roughly 8 percent of your genes produce proteins (so-called transcription factors) that activate or silence other genes.[66] Since these transcription factors are permanently encoded in your genome, there isn't much

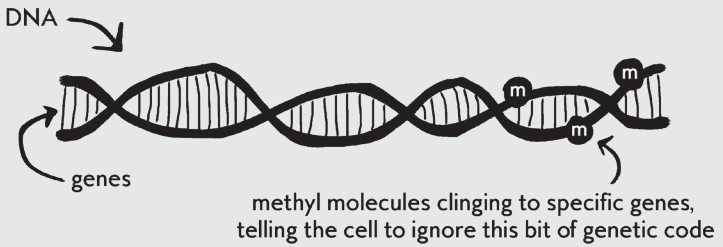
you can do to change them—yet.[g] The other way that genes get turned on and off, and this is a relatively recent discovery, is external to your genome. Genes can be turned on and off by chemical compounds from our environment and lifestyle: food, medicines, pesticides, and everything else our bodies are exposed to. The sum of these chemical compounds is called the epigenome—literally meaning "above/upon the genome"—and the study of how these chemical compounds influence the expression of our genes is called epigenetics.[67]

There are two main mechanisms for turning genes on and off. They are called DNA methylation and histone modification. If you are curious about how they work, the "DNA Methylation and Histone Modification" box contains some more technical details—if not, feel free to skip right past it.

g That might change in the future as gene therapy or genome editing become more common, especially using new technologies like CRISPR—a way to cut, copy, and paste genetic code into gene sequences with incredible precision.

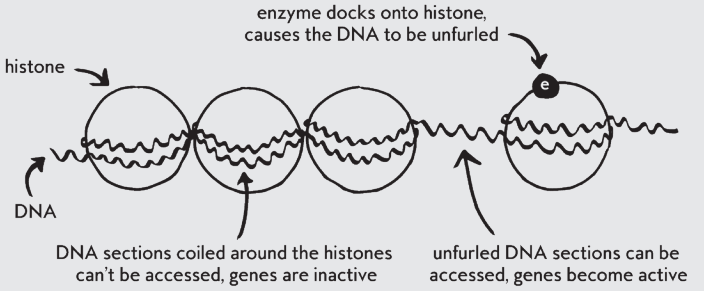
DNA METHYLATION AND HISTONE MODIFICATION

There are two main ways in which chemical compounds activate or deactivate genes. The first is called DNA methylation and has been likened to an "on/off switch." In DNA methylation, a gene remains switched off, or methylated, as long as a small methyl molecule clings to the gene. This "off switch" acts like a marker on the gene that tells the cell to ignore this particular bit of genetic code. Once the methyl molecule is removed from the gene, the gene is "switched on," and its genetic code is used to control the activity of the cell. DNA methylation is a fairly stable epigenetic modification that can be inherited, and it can also be changed by diet and lifestyle over time. Here's a little sketch to illustrate DNA methylation:



The second way in which chemical compounds activate or deactivate genes is called histone modification and has been likened to a "volume dial." Within our chromosomes, the strands of DNA are tightly coiled around proteins called histones. Imagine a string of beads: the DNA is like a string that ties the histone beads together and also wraps around them. Certain chemical compounds, so-called enzymes, can dock onto a histone bead and cause it to unravel the section of DNA that is coiled around it. Once that particular section of DNA is unravelled, the cell can access the genes. It reads the genetic code and begins to produce

the corresponding proteins. The more unravelled the section of DNA, the more proteins are being produced–like a "volume dial." When the DNA is rolled back up into a tight coil around the histone, the genetic code becomes inaccessible and the gene is switched off. This "volume dial" is pretty flexible and reacts to short-term changes in your environment, e.g., stress or alcohol. Here is a sketch of how it works:



Let's now talk about a specific example of how epigenetic modification can affect your health and, through inheritance, that of your children. Take BPA, the plastic compound often used in the lining of cans and, until recently, also in baby bottles and sippy cups. Researchers at the Duke University Medical Center studied the effect of BPA on a particular gene, the so-called agouti gene. All mammals have the agouti gene, and the mouse version is 85 percent identical to the human one.

In the experiments at Duke, healthy mice were fed foods laced with BPA. The BPA removed the DNA methylation markers from the agouti gene, thus switching it on. The babies of the BPA-fed mice inherited this switched-on agouti gene. As a result, they developed yellow fur (as opposed to the regular brown fur of their parents), became obese, prone to cancers and other

diseases, and had a shorter lifespan. However, when the parent mice were fed *both* BPA and a methyl-rich diet (with essential nutrients like folic acid and choline), the gene remained methylated—thus switched off. The parent mice remained healthy, and their babies were born healthy as well.[68] Impressively, a methyl-rich diet was even able to *reverse* the damage: when obese yellow mice with switched-on agouti genes were fed a methyl-rich diet during pregnancy, their babies were born healthy and with brown fur, their agouti genes having been turned off.[69]

A quick side note on BPA and plastics: the same link—BPA exposure during pregnancy causing obesity in children—has been found in humans.[70] BPA is an "endocrine disruptor" that messes with your hormones, which can result in cancers, birth defects in your children, and other health problems. Unfortunately, "BPA-free" plastics are not necessarily better. It turns out that most of the plastics that have replaced BPA—and which are now used in baby bottles and sippy cups instead—are endocrine disruptors, too.[71] Therefore, it's better to go with glass or stainless steel whenever you can. For a look into the dirty politics behind BPA-free plastics, check out Mariah Blake's investigation, "The Scary New Evidence on BPA-Free Plastics."[72]

Another example of epigenetics at work: shockingly, more than 12 percent of pregnant women in the United States still smoke daily despite the many well-known health risks to their baby. When researchers analysed the DNA of their babies, they found that it resembled that of adult smokers—with genes switched on which are linked to smoking-related cancers, impaired lung and nervous system development, and birth defects like cleft lip and palate.[73]

Of course, fathers don't get a free pass for unhealthy habits. Smoking, junk food, or other chemical exposures leave epi-

genetic traces in their DNA which are passed on through their sperm.[74,75] The laws of epigenetics apply to fathers just as they do to mothers—and under some circumstances, even more so. A large meta-analysis investigated the parental alcohol consumption of nearly 42,000 babies born with congenital heart diseases.[76,77] The result was surprising. Overall, the father's alcohol consumption had a larger effect on the baby's congenital heart disease risk than did that of the mother's. When fathers engaged in binge drinking (defined as five or more drinks per sitting) in the three months before conception, their baby's risk of congenital heart defects increased by 52 percent, compared to fathers who didn't drink at all. When mothers did the binge drinking before conception, the baby's congenital heart disease risk increased by only 16 percent.

The good news is that, as we have seen in the example of the agouti mice above, epigenetic damage can be reversed with a healthier diet and lifestyle.

With this, let's return to the original topic of this chapter: the microbiome. What does the microbiome have to do with epigenetics? As it turns out, quite a lot. There is evidence that our gut bacteria are one of the *main drivers of epigenetic changes* in our DNA via the chemical substances they release in our guts—not just SCFAs and neurotransmitters but lots of other amino acids, proteins, enzymes, and vitamins.[78]

Remember that we talked about how SCFAs supply our body with energy, kill cancer cells, defend us against bad bacteria, and strengthen our gut wall? We can add one more thing to the list: SCFAs also regulate the activity of inflammatory genes both via DNA methylation and histone modification. In particular, SCFAs like butyrate, propionate, and acetate turn down the

activity of genes linked to the development of allergies, inflammatory bowel disease, obesity, and cancers.[79–83]

So what is the key takeaway here? It's that your genes aren't set in stone—you can change your DNA through epigenetics. One of the main drivers of beneficial epigenetic changes is a *healthy and balanced* microbiome. Thus, the question becomes, **how do you acquire, maintain, and protect a healthy and balanced microbiome?** That's what we'll explore in the remainder of this chapter, as well as the coming ones.

WHAT THE HYGIENE HYPOTHESIS REALLY MEANS: YES TO GOOD BACTERIA, NO TO INFECTIOUS DISEASES

We're making our kids sick by keeping them too clean—that's the essence of the hygiene hypothesis. It's true, and it's also frequently misunderstood. Let's see if we can clear up the misunderstanding.

The hygiene hypothesis was first proposed in 1989 by David Strachan, a London-based doctor, who noticed a strange relation between hay fever and family size. The more siblings (especially older siblings) a child had, the lower the child's risk of hay fever. Strachan suggested that colds and flus transmitted by the older siblings could protect against allergies by "training" the immune system.[84] This was the accepted wisdom in medical research until about fifteen years ago—but it turned out to be wrong.

Researchers began to realise that exposure to colds and flus *couldn't* be essential to establishing a healthy immune system simply because the human immune system is much, much older than these infectious diseases! Most of the major infectious

diseases plaguing us today only began to emerge within the past 11,000 years, following the rise of agriculture—a mere blink of an eye in our evolutionary timeline. Around 11,000 years ago, humans moved into ever denser urban communities, which allowed these infectious diseases to spread.[85]

Our immune system, however, started to develop about 2.6 *million* years ago in the Palaeolithic hunter-gatherer era and co-evolved with the microbes then present in the environment. This gave rise to the "old friends" hypothesis: our immune system requires the company of these "old friends"—the friendly bacteria with whom we have shared our environment since the dawn of time—to develop properly.[86]

Soon enough, the evidence for the old friends hypothesis began to mount. It was *not* exposure to infectious diseases (like colds, flus, measles, or gastrointestinal infections like *Salmonella*, *Campylobacter*, or *Norovirus*) that helped prevent allergies, but exposure to friendly bacteria like *Lactobacilli* and *Bifidobacteria*! As you saw in the previous chapters, these friendly bacteria regulate your baby's developing immune system and balance its Th1 versus Th2 immune response—and they help your baby to *fight* infectious diseases. Researchers were also able to show that the more older siblings a child has, the more diverse its microbiome[87]—thus explaining Strachan's original observation that more siblings mean fewer allergies.

Confusingly, researchers kept using the name "hygiene hypothesis" for this new explanation. This has caused some unfortunate misunderstandings of what the hygiene hypothesis actually means. From my own experience of talking to other parents, many of them believe that exposing their kids to colds and flus—or their kids being sick often—will "strengthen their

immune system." Unfortunately, the opposite is true: the evidence is that exposure to flu viruses in particular raise a child's risk of developing asthma by making lung cells more prone to allergies.[88,89]

The same applies during your pregnancy: you should be *more* hygienic, not *less*, when it comes to avoiding infectious diseases. Foodborne pathogens like *Campylobacter*, *Listeria*, *E. coli*, *Salmonella*, *Norovirus*, and some *Clostridium* species are especially dangerous, as they can lead to stillbirth or spontaneous loss of your baby. You should completely avoid unpasteurised milk and cheeses, raw and undercooked eggs, shellfish, poultry, and meat (especially when it's ground meat like hamburgers). Also, be extra cautious with restaurant/deli counter salads (especially things like coleslaw), deli meats, and sushi. When I lived in France, I loved my Camembert unpasteurised and my *frites* swimming in fresh egg mayonnaise, but during pregnancy, I made sure that everything I ate was well-cooked. I was obsessed with hygiene and food security. I treated raw chicken as if it was radioactive: everything it touched had to be decontaminated immediately.

The key point here is, don't misinterpret the hygiene hypothesis. Exposing yourself or your kids to germs that can cause illness won't train or strengthen their immune system and can in fact do the opposite. Instead, what you want is exposure to the friendly microbes which steer our immune systems away from allergies and inflammation.[86] The challenge is that in our quest to avoid infectious diseases through better sanitation, cleaner water and cities, refrigeration, and food hygiene standards, we inadvertently also reduced our exposure to our "old friends." So where can we still find them? In nature!

DIRT AND BACTERIAL DIVERSITY

In our Western societies, we are spending roughly 70 percent of our time in our own homes and 90 percent in urban areas.[90] What we need to do, quite simply, is to get out more! Besides its beauty and stress-busting benefits, nature is also the place to meet our "old friends." One Finnish study discovered that the closer people live to farms or forests, the more diverse the composition of bacteria on their skin (mostly species that live on soil, plants, and pollen), and the less prone to allergies they are.[91]

This is what researchers have found all over the world: contact with farm animals, especially cows and their straw, during pregnancy or in the first few months of life reduces the risk of asthma, eczema, and other allergic diseases by nearly 40 percent. The more contact the better, but as little as three visits to a cowshed provided a measurable reduction in asthma risk.[92–94] The same goes for dogs and, to a lesser extent, cats. Being in frequent contact with these animals has repeatedly been shown to lower kids' risk of asthma and allergic diseases. Again, the contact with pets is most beneficial when the baby's immune system is booting up—in the womb and the first few months of life.[95] If you own a dog or cat while pregnant, your baby will be born with significantly lower levels of immunoglobulin E (IgE) in their blood—that's the antibody that clings to potential allergens and triggers the allergic response.[96] Of course, if you happen to be allergic to pets already, it's not a good idea to get one during pregnancy—you want to keep allergic inflammation (and any other kind of inflammation) in your body as low as possible during pregnancy.

What about inside your home? This is where you can dial the hygiene down a notch. The higher the bacterial diversity in your

house dust, the lower your baby's risk of developing asthma and allergies.[97,98] In a study of inner-city babies in Baltimore, Boston, New York, and St. Louis, researchers found that babies who spent their first year of life in a household that had cockroaches or mice, which contributed to bacterial diversity, had a 25–30 percent reduced risk of developing asthma and allergies.[98] Another surprising study from Sweden showed that in homes where dishes were being washed by hand rather than by machine, thus leaving tiny traces of food on the plates which allowed bacteria to grow, kids had a 32–34 percent reduced risk of developing asthma, eczema, or dust/pollen allergy.[99] The same study discovered that regularly buying food from the local farm, which meant bringing farm dirt and mucky vegetables into the house, also reduced the kids' allergy risk by about 20 percent.

Now, I'm not suggesting that hiding dirty plates under your bed to attract mice and cockroaches is a reasonable allergy prevention measure. When I was pregnant, I spotted a mouse sneaking into our kitchen (we lived in Amsterdam at the time, and there's barely a house without mice in Amsterdam), and I freaked out! However, it's okay to relax about a bit of dirt in the house, especially if it's from food, farms, nature, and being outdoors. Relaxing also means to stop scrubbing your house with aggressive chemical cleaning products—those do more harm than good, as you'll see in chapter 9.