'Bugs' do battle in our bodies

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There's a war going on, right under our noses, and we're just too blind to see it.

Well, maybe not that blind.

We can see these tiny combatants, all 100 trillion of them, just fine under a microscope.

But they're not always under our nose.

Some of them are in our nose.

And in our mouths. And our intestines. Even in our breast milk and the birth canal.

They're microbes, living on and in the human body, and they outnumber human cells 10-to-1. Collectively, the microbes and their genes have come to be called the microbiome, says Lita Proctor, who leads the National Institute of Health's Human Microbiome Project, which last month released its initial map of a "normal" microbial makeup.

It's true that no man is an island. Scientists say we're closer to a coral reef, with an estimated 10,000 species of bacteria, fungi, yeasts and assorted others making up our ecosystem.

And while a few of these microbes can make us sick if they get out of control, 99% are benign or even protect us from harm. Bacteria have evolved with humans for millennia, helping us digest our food, synthesize vitamins, regulate our immune system and more, Proctor says.

Yet our microbes are under threat -- and the enemy is us.

Modern life is changing the composition of critters that inhabit our bodies, and not always for the better, says Martin Blaser, a professor of microbiology at the New York University School of Medicine. Through a combination of clean living and industrialization, modern living could be causing our ancient microbes to become extinct.

"People think bugs are out to get us," Proctor says. "But we're the ones changing our inner ecosystem."

Although scientists can't yet prove direct cause-and-effect, researchers have linked changes in our microbial inhabitants with rising rates of obesity, allergies, autoimmune diseases and other chronic illnesses.

Scientists note that developed countries have drastically altered the environment in the past century or so. Our water is cleaner. Food is more processed, so our guts have less need for bacteria to help us digest leafy plants and whole grains. We use more antibiotics -- to treat disease, fatten livestock, even wash our hands, Blaser says.

The story of H. pylori

Scientists already have traced the steep decline of one key species of bacteria: Helicobacter pylori, or H. pylori, Blaser says.

Over the past century, the number of American children carrying H. pylori in their stomachs has dropped from nearly 90% to fewer than 10%, Blaser says. That decline may be both good and bad. H. pylori has been shown to cause ulcers and stomach cancer; as the bacteria has disappeared, so have cases of stomach cancer, once one of the nation's leading cancer killers.

But it may be too soon to celebrate, Blaser says.

Recent research suggests H. pylori also helps prevent diseases, including esophageal cancer and childhood asthma, which have become more common in recent decades. H. pylori may even help prevent obesity, Blaser says. Studies show that getting rid of H. pylori increases levels of hormones that tell the body to keep eating but suppresses hormones that tell the body it has consumed enough.

Scientists are studying links between changes in our microbial inhabitants and a variety of increasingly common ailments, such as eczema, which is now twice as common in the USA as it was 20 to 30 years ago, says Julie Segre, a scientist at the National Institutes of Health. About 15% of American children now have eczema, which causes redness and itching. About half of children with eczema go on to develop asthma or hay fever, whose rates also are rising.

Children in developing countries have far lower rates of these disorders, says James Versalovic, a professor at Baylor College of Medicine and Texas Children's Hospital in Houston.

A new field of medicine?

The science of the microbiome is still relatively new, however, and complex conditions such as cancer, asthma, allergies and obesity have multiple causes, says Kjersti Aagaard, an associate professor and maternal-fetal medicine specialist also at Baylor College of Medicine.

But Blaser says the microbiome could open up a whole new sort of medicine. He envisions a future in which children might be deliberately exposed to H. pylori to reduce their risk of asthma, then treated with antibiotics as adults, to kill the bacteria before it has a chance to cause cancer.

Some of the greatest changes to the microbiome are occurring in the first moments of life.

"Babies are microbe magnets," Proctor says.

Until just a few decades ago, virtually all babies were born vaginally, a process that exposes newborns to billions of microbes in the birth canal, Proctor says. Babies are "painted" with microbes as they pass through the vagina, says J. Bruce German, a professor at the University of California-Davis. Passage through the vagina helps ensure that a baby's microbiome looks just like its mother's, which may help prepare it for the outside world.

This journey performs a number of key functions. First, this passages helps "educate" a baby's immune system, Proctor says, teaching the body's defensive cells which foreign substances are a threat and which should be ignored. Research shows that a woman's vaginal microbes actually change in the months and weeks before delivery, Proctor says. For example, microbes that digest milk begin to multiply, so they're likely to be swallowed by the baby during childbirth. "It's not an accident that the microbes that the baby needs to breastfeed tend to proliferate in the vagina," Proctor says.

Breast milk itself contains not just food for the growing baby but for the infant's microbial inhabitants, Proctor says. Babies can't digest these substances, but beneficial bacteria gobble them up. That helps ensure a plentiful supply of good guys in the baby's gut, which are essential to keeping infants healthy and crowding out more menacing microbes that could make newborns sick.

Many babies now miss out on this protection.

Though 75% of American mothers make some attempt to breastfeed, only 44% are still nursing after six months, according to the Centers for Disease Control and Prevention. Pediatricians recommend that mothers aim to nurse for one year or more.

And 30% of American babies today are born through cesarean section. Tests show their bodies become colonized not with microbes from the vagina but from the skin, Proctor says.

Doctors have long known that vaginal delivery offers a number of benefits for most mothers and babies. They're less likely to have allergies, asthma, celiac disease, type 1 diabetes (an autoimmune disease) and to be hospitalized for diarrhea and vomiting, according to a 2011 study co-written by Josef Neu, a professor of pediatrics at the University of Florida.

At least in theory, rising C-section rates -- along with other changes in ways of living, such as antibiotic use -- have the potential to cause dramatic changes to a population's microbiome. As mothers lose microbes, they lose the potential to pass those beneficial bugs on to their children, Blaser says. In the process, some microbes could be lost from a population altogether.

But mothers should not feel guilty if they've had a C-section, Aagaard says. Though an infant's microbes may be different if they're born via C-section, that's not necessarily bad.

"We as ob-gyns don't do C-sections without really good reasons," Aagaard says. "We don't have evidence that we get harmful or dangerous microbe profiles just because women get cesarean deliveries. I don't want to imply that there is a disease risk simply by virtue of having a cesarean until we have much more robust evidence."

Restoring a balance

Now that scientists have mapped the "normal" microbiome, researchers hope to get a better understanding of how things can go wrong and result in disease, Aagaard says.

Experiments in mice, for example, suggest that changes in gut microbes can alter the animal's personality, as well as the structure of its brain, Proctor says. Carefully bred "germ-free mice," raised without a microbiome, are fundamentally "abnormal" compared with other animals, Versalovic says. Instead of showing the normal amount of caution, germ-free mice are hyperactive daredevils.

"There are no microbes in the brain," Proctor says. "But the gut produces signaling molecules that travel to the brain."

In the future, doctors hope to find ways to manipulate the microbiome, perhaps restoring a balance that modern living has disturbed.

Food and supplement manufacturers are trying to come up with successful "probiotics," or compounds with active microbes -- such as those in yogurt -- to promote health, Versalovic says.

And doctors already are using healthy bacteria to "repopulate" intestinal tracts of people devastated by a sometimes deadly infection called C. difficile, which can cause severe diarrhea and a life-threatening inflammation of the colon, Versalovic says. The infections can be extremely difficult to eradicate with traditional methods.

To restore the infected intestines to health, doctors at a handful of hospitals are performing fecal transplants from patients' close relatives or loved ones, actually

transplanting a stool sample from one person to another via a colonoscopy-like procedure, hoping that the healthy donor bacteria replace the destructive microbes in the sick person's gut. Although the procedures are still experimental and relatively rare, patients sometimes show dramatic recoveries in a matter of days, Versalovic says.

Studying the microbiome even could help researchers make better drugs, Proctor says. Understanding how microbes metabolize the drugs we swallow could help pharmaceutical companies develop medications that are more effective, with fewer side effects.

The microbiome could be a fertile source of new compounds, such as anti-inflammatories, as well, Proctor says.

"You don't have to go to the coral reef or the rainforest to find the next new drug," Proctor says. **"Go to the gut. Nature has already made it for us."**