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Mapping a city's invisible residents

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Mapping A City’s Invisible Residents

"This is one of the worst spots," says Jason Burr, as he swabs the handrail leading down the stairs to the subway platform. Burr is a graduate student who is working with lead researcher Chris Mason on a microbe map of New York City. He carefully places the dirty Q-tip inside a test tube and screws on the cap. Burr looks out of place on the grimy subway platform with his gloved hands and sterile swabbing kit. People in the subway cart stare at us as Burr rigorously swabs the doors, seats and poles and I hold out test tubes for him to drop the samples in.

There are over 450 subway stations in New York and Burr and other students have been swabbing them for months. The team hasn't analyzed all the samples yet, but Burr says the some of the early results are disturbing. They've already identified several hundred strains of bacteria and some are infectious like Pseudomonas that can cause pneumonia or blood infections and Staphylococcus that can cause staph and other skin diseases.

That doesn't mean city dwellers need to start walking the city in hazmat suits, Mason said. Microbes are the microscopic bacteria and bugs that stick to subway handrails, sit on the tops of tables in public plazas and blow through the air in midtown, but most of them are completely harmless. A spokesman from the CDC, Christopher Braden, said that the type of microbes and amount of microbes the team has discovered is pretty normal for a city with over 8 million people.

"I think the experiment is a useful one and could provide us with a lot of insight about how bugs get around a city," Braden said, "but that doesn't mean anyone needs to panic. Our bodies have natural defenses and that's also why we wash our hands and shower regularly."

Mason said his goal is not to scare anyone, even though he and the team of microbial pioneers are collecting samples of the microbes that show up in high-traffic areas around the city. The continuous sampling has allowed them to start building a map with real-time microbe data. The
team uses DNA analysis to categorize the microbes and pick out the dangerous bugs from the many harmless ones. The idea, Mason says, is to build a citywide pathogen monitor. If a particularly nasty bug starts gaining ground in the city, Mason and his team will know.

"The end goal is essentially a real-time disease tracker," Mason said. "We'll be able to stop bacteria in its tracks before it has the chance to sweep through a population."

The microbiome of humans – the colony of bacteria that lives on our bodies – has gotten a lot of attention over the past few years. More and more studies show that the type of bacteria on the body and in the gut can influence a person's overall health. But the microbiome of the built environment has gotten almost no attention. Big cities like New York are prime breeding grounds for microbes. The buildings, animals and residents squished together in a 27,000 people per square mile density, makes it easy for microbes to get around.

Mason’s map is revealing the concentration of microbes in the city and how they spread. Understanding how the bugs move, Mason says, is the key to forming successful containment strategies that could stop a harmful bug in its tracks. The map could also be used to track and stop any pathogens planted by bioterrorists. The map is also illuminating what kind of microbes hang around buildings. The average city dweller now spends almost 90 percent of his or her time indoors, so knowing what kind of bugs they’re sitting in all day is important, Mason said.

**The human microbiome**

Mason came up with the idea for the microbe map while watching his daughter playing at daycare one day. He watched children pick up toys from the dirt and put them in their mouths. Then other children would use the same toy. Mason said just thinking about the bacteria breeding at the daycare kept him up at night. He read about experiments that mapped the bacteria in places like daycares and schools, but Mason realized he could go bigger than that: He could map the entire city.
The problem is that the unsanitary daycare scene that horrified Mason so much is actually completely natural, according to James Meadow, research associate at the Green Lab at the University of Oregon. Meadow said as a modern society we’ve lost touch with our ancestral colony of microbes.

Our ancestors used to spend almost all their time outdoors, trekking through soil and mud, raising crops and livestock, and living in homes with dirt floors. But then we became obsessed with cleanliness. We replaced dirt floors with glossy hardwood, moved our livestock and crops out onto far away farms, and built huge sterile shelters – apartment buildings, split-levels, office parks. We began spending more time inside than outside. And while modern sewer and water filtration systems helped rid us of many of the germs that cause disease, in the process we also lost contact with the microbes that boost our immune systems and keep us healthy. We declared war on bacteria that cause diseases like Cholera and Typhoid fever, but we didn’t realize we also declared war on healthy bacteria.

Our bodies are teeming with these microscopic bugs. We have around 100 trillion of them living on us right now: 10 times more than the total number of human cells. We shed 10 billion skin cells every day that take some of these microbes with them. That means that as we move around our cities, through subways, parks and buildings, we are trailing thousands of microorganisms. These bugs collect in corners, on walls and floors, and float through the air.

And we don’t only shed these bugs; we pick up them up as well, by touching surfaces like tables, chairs, and doorknobs—or simply by breathing. Most of the city microbiome is considered harmless, but a few of these creatures do make us sick, Meadow said.

Based on that unsettling statistic that says the average American spends 90 percent of their time indoors, we’re sitting around in clumps of bacteria, Meadow said.

“It was a really big moment to say that whoa the place where we spend all our time is the place that we know almost nothing about,” Meadow said. “And the question becomes ‘what is that doing to our health?’”
Tracking diseases

Burr hails a cab from Central Park where we just finished swabbing park benches. We climb in the back seat and Burr opens up his kit. He starts furiously scrubbing the door handle of the cab with a Q-tip. Eventually the driver notices and asks Burr what he's doing. Burr tries to explain the project and the microbe map, but the driver doesn't understand and is getting increasingly suspicious of us. Eventually he swerves across two lanes of traffic and stops at the curb.

"Get out," the driver says to us.

"Fine," Burr says. "I already got my samples anyway," he whispers to me. "I wonder what he's worried we're going to find."

Maybe some people, like the cab driver, don't want the bacteria of their city mapped. They'd rather go about their day normally, not wondering what kind of bug is lurking on their office chair or on the door handle to the bathroom or on the floor of their apartment. Mason said he's worried that the project could create a panic if people take the results at face value.

"Yes, we've found some dangerous stuff," Mason said, "but that doesn't mean the strains can infect you just because you put your hand on a subway rail."

He mentions the Ebola outbreak and the fear inspired by the New York City doctor who became infected. Just because the bacteria is on the subway or on a bowling ball, and you ride the same subway or use the same bowling ball, doesn't mean you're going to contract Ebola, Mason says.

Mason said after the latest round of samples from taxis, parks and plazas, the map is starting to take shape. There's not enough samples yet to track bacteria in real time, but Mason said it's heading that way. Right now he and the team can tell that each subway station and park has its own distinct microbial profile. They'll be able to spot bugs that show up at a new location and look out of place. Better yet, they should be able to trace where it came from, Mason said.
The implications, Mason said, are incredible. Eventually automatic sample collectors will replace the primitive swabbing that Burr has been busy with for months. With a constant stream of data from all over the city, the map could track an outbreak and even predict where it will spread next. If healthcare workers know where the bacteria is likely to go next, they can stop it in its tracks. For example, the Staph bacteria that Mason found at a few subway stops could be traced if one person picks it up and takes it with them to another stop.

Graham Rook, professor of microbiology at University College London, says the project is a useful one, but microbiologists are going to need a lot more samples before they can start tracking diseases as they move through a city.

But Rook says that the most harmful bugs aren't even the ones we should necessarily be worrying about the most. Spending so much time indoors is decreasing the diversity of our microbiome. We are cut off from natural plant and soil microbes that bolster our immune system. We've seen a huge spike in the development of asthma and allergies and some scientists blame the lack of diversity in our microbiome. When we come in contact with a bug we're not usually exposed to, our body attacks it even if it's harmless.

“We have trigger-happy immune system nowadays,” Rook said.

Our bodies have trouble fighting off even the most commonplace bacteria because our obsession with antibacterial cleaning products mean we are only exposed to a very small number of bacteria. This missing diversity could have serious consequences for our health. A study published in BMC Biology reported that piglets raised outside developed a completely different microbiome than piglets raised on the same diet inside. The indoor pigs had much more unhealthy bacteria in their guts at the end of a few weeks than the outdoor pigs. They also showed signs of overactive immune systems—the condition that can lead to the development of asthma and allergies in humans.

The question is, what can we do about it? Not only could the microbe map track diseases in real time, it could also inform how we might design cities in the future, Mason said. Jessica Green, a researcher at the
Biology of the Built Environment Center, said she expects architects to begin rethinking building construction and implementing what she calls "bio-informed design." That means using things like natural ventilation to bring outdoor air in instead of mechanical ventilation that just recycles stale indoor air over and over.

Further, Green said if we know the top healthy bugs and the top unhealthy bugs, architects may actually be able to design a building to encourage the growth of the healthy bugs. Mason's map could also influence what kinds of buildings city planners put next to each other. For example, it's probably a bad idea to put a school right next to a big public plaza that acts like an airport for microbes.

"Whoever is right next to those bacteria hubs (big public spaces) is most at risk for picking them up," Green said.

The city microbiome is also starting to show that we need exposure to more bugs. We need that dirt and slobber from the daycare scene that kept Mason up at night. Cities need more integrated green space if we want to build our immune systems back up, Green said.

Burr and I make it back to the lab. We've collected about 50 samples over the past two days.

"I always feel so dirty at the end of a day full of sampling," Burr jokes as he peels off his gloves.

I ask if the project has turned him into a clean freak.

"Exactly the opposite," he laughs. "Now I'm out there rolling around in the dirt on a regular basis. If I do pick up something nasty on the subway or in a cab or at the office, I want to stand a fighting chance."