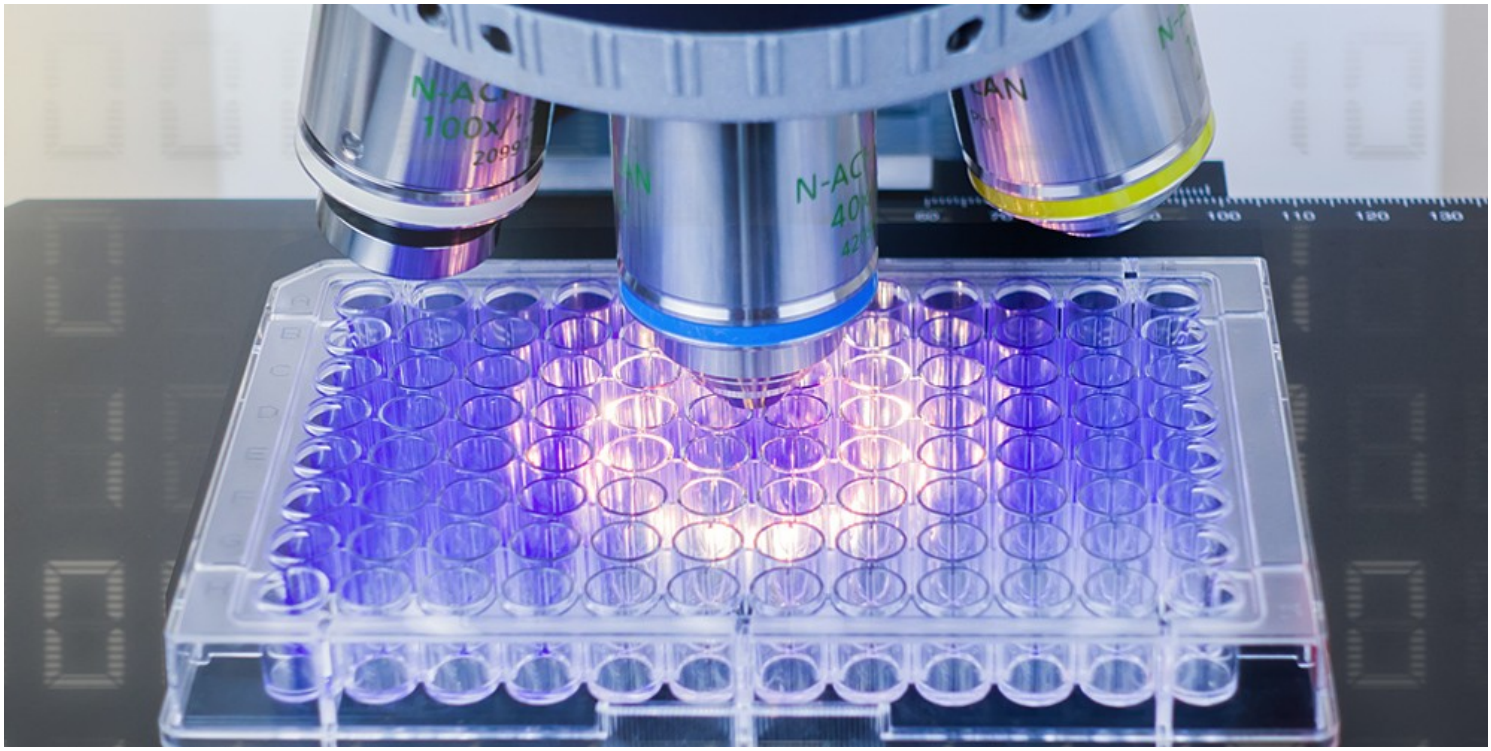
We Are What We Eat: AI and the Human Microbiome



“Trust your gut,” it turns out, is great advice — literally. Researchers are striving to show that what goes on in our stomachs, intestines and elsewhere in our bodies has a huge, and often unseen, effect on our quality of life.

The bacteria, fungi, viruses and protozoa in our digestive tracts and on our skin — known as the microbial biome, or microbiome — could prove to play an enormous role in determining our health, well-being, moods, longevity and even weight. Microbiome researchers would argue that the microbiome may play as important a role as DNA in shaping our individual destinies.

Like DNA, the microbiome is incredibly complex. It comprises more than 100 trillion organisms and contains 200 times more genetic material than the human genome. To analyze just one person’s gut flora could take lifetimes.

With the assistance of Artificial intelligence (AI) and the most advanced computing hardware the task has been reduced to minutes, identifying at a virtual glance every microbe in a person's biome, detecting patterns and changes invisible to the human eye, and analyzing interactions.

The goal of microbiome research such as "The NIH Human Microbiome Project" is to demonstrate the feasibility of characterizing the human microbiome with hopes to lead to better diagnosis and treatment of illnesses and disease.

Genetics and the Microbiome

When it comes to technology and human health, genetics has received most of the sexy press in recent years. The Human Genome Project's DNA sequencing project was completed in 2003, mapping all the 20,500 human genes made up of 3 billion chemical base pairs. Now scientists can understand which genes go where in the DNA chain and what their functions may be, enabling medical treatments to be tailored for individual patients.

Lately, to understand human health and ways to improve it, the microbial biome has been gaining attention. This interest comes in part because, although the microbiome has long been known to exist, its complex composition has limited researchers' ability to make sense of it. Until now.

Our bodies comprise at least as many microbial cells as human ones — cells that differ from our body's cells in their composition and structure. Indeed, the microbiome is a living organism unto itself, weighing an estimated five pounds. These cells populate our digestive tract; internal organs; and our mouth, nose, eyes and skin. Unique to each person in its composition, a microbiome consists of millions of genes, thought to interact with the body's genome as well as with our immune system to produce conditions of health or disease.

Like two pieces of an elaborate puzzle, genomics and biomics may prove to reveal many of the secrets that make us who we are, as Micron Vice-President Sumit Sadana noted during the recent Micron Insight '18 conference in San Francisco, "These are the codes researchers are trying to crack."

Hidden Mysteries

One of the most exciting, and puzzling, aspects of genomic and biomic research is the window into the future they might offer. What do our DNA and microbiome say about us, today and tomorrow? What prognosis for our health do they provide? What are the illnesses or diseases we are susceptible to?

In genetics, scientists look for defects in individual genes or groups of genes to determine how likely a person might be to contract certain diseases or illnesses such as Alzheimer's or diabetes. Someday, treatment may involve replacing or repairing those mutated genes (known as gene therapy). For now, though, we are stuck with our genes; the best we can do is make lifestyle choices that improve our chances of good health.

A person's microbiome, however, may be alterable — quite rapidly — through dietary changes, certain drugs and even exercise. So being able to spot the signs of developing or impending disease by scrutinizing the gut could prove invaluable to improving our health and even prolonging our lives.

Using AI and machine learning, science aims to capture the microbiomic signatures of as many people as possible over time to learn which changes signify impending disease. Researchers may also find ways to fend off or even

cure diseases by manipulating the biome.

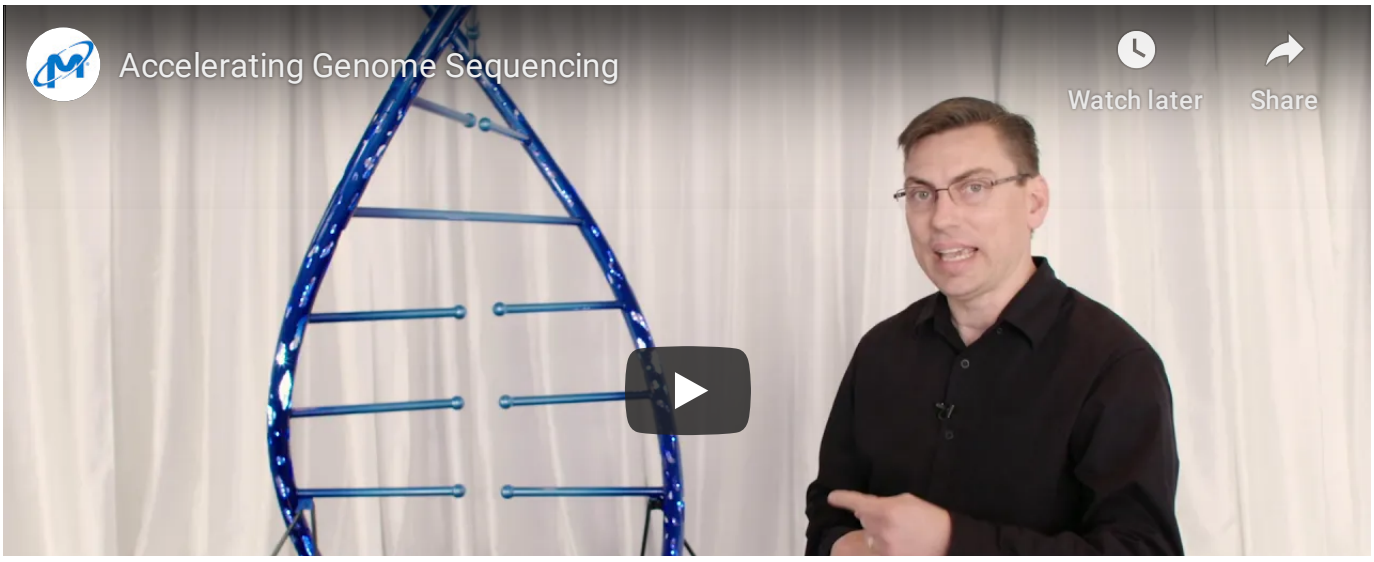
If the idea is that every microbiome is different; then every treatment might be tailored to individual genetic mutations and biomic composition as well. As such, researchers are striving to move from simple diagnostics to preventative and personal medicine.

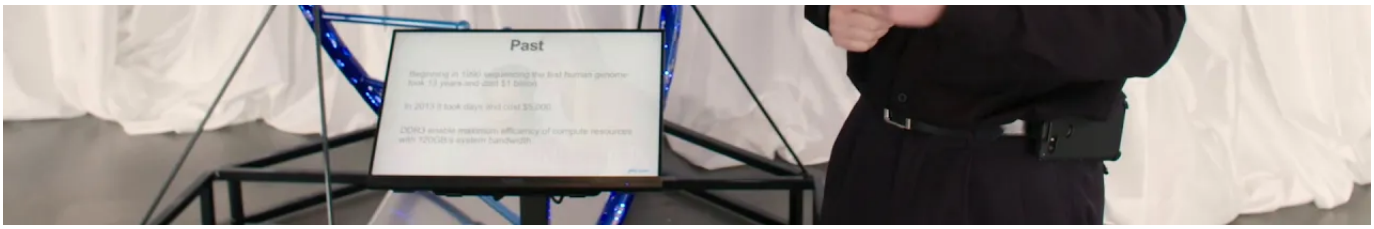
- **Predictive:** Changes are thought to occur in a person's microbiome months and even years before illness or disease develops. But diet, stress, exercise and other factors can also alter the microbiome. Medical scientists are striving to understand which variations are due to differences in lifestyle and which indicate a nascent illness or disease. Examining the microbiome of a healthy person can provide a baseline from which to analyze any changes over time.
- **Preventive:** Researchers are looking to use the types of microbes populating a person's system and their activities to help make recommendations that may ward off illnesses including diabetes, cancer and dementia. When combined with genetic data, researchers hope to use the microbiome data as a one-two punch for preventive care.
- **Personal:** Until now, "personalized" or "precision" medicine, in which treatments vary according to a person's unique biology, has relied largely on family history and DNA analyses. Researchers are looking to make treatment options even more precise with data from the microbiome included.

With hundreds of trillions of microbes to examine in each person's biome, analysis has been slower than some desired. With improvements in artificial intelligence powered by advanced computer systems — and enabled by Micron memory — researchers look to do in minutes what humans would need many years to accomplish, if they could do it at all.

Consider, for instance, how technologies have accelerated genomic sequencing (and also reduced its cost), according to the National Human Genome Research Institute:

- The first human genome sequencing, begun in 1990, took 13 years to complete and cost $1 billion.
- One decade later, DNA sequencing took two or three days and cost $5,000.
- Today, sequencing a person's complete genome takes 20 minutes and costs $600.





The time and cost to complete this important analysis for human health will only diminish as memory technologies improve, Micron Business Development manager Eric Caward said. The same is true for microbiome analysis, enabled by faster, higher-capacity, and ever more sophisticated artificial intelligence technologies.

In 2021, we expect that servers used for AI will need seven times more DRAM memory than standard, non-AI servers and twice as much NAND flash memory, according to Sadana. “Memory is the raw material that AI ultimately needs more and more of.”

A Plethora of Projects

Researchers are studying the benefits of microbiome sampling and analysis for health diagnosis and care. Soon, caregivers may collect a sample of our microbiome along with blood and urine as part of a routine wellness checkup.

To analyze these samples in a meaningful way, however, scientists need a database. The National Institutes of Health’s “All of Us” initiative aims to collect data, including microbiome sampling data, from more than 1 million people to benefit precision medicine. The NIH’s now-discontinued Human Microbiome Project produced many studies of the role gut flora play in various aspects of human health. Many other projects are ongoing, with hopes of improving the following:

- **Immune system improvements.** The microbiome’s role as modulator of the immune system is already widely accepted. From the time we were infants, the bacteria in our gut began teaching our immune system “how to behave,” according to an article in ScienceNordic. These organisms also influence levels of inflammation in our digestive tracts and other organs.

- **Cholera prevention.** Researchers from Duke University, Massachusetts General Hospital, and the International Centre for Diarrheal Disease Research in Dhaka, Bangladesh, are using machine learning algorithms to detect patterns in communities of bacteria living in digestive systems — patterns that humans would almost certainly be unable to see. Since not everyone exposed to cholera contracts the disease, which causes diarrhea, AI could help researchers understand who is at risk and why. It could also help with the development of vaccines.

- **Drug interactions.** The composition of our microbiome is hypothesized to affect how well we respond to pharmaceutical treatments and how well we metabolize certain drugs according to US National Library of Medicine abstracts.

- **Aging.** The microbiome’s role in healthy aging is one focus of UC San Diego and IBM Research’s Artificial Intelligence for Healthy Living Center. The center studies the effects of genetics, environmental factors, daily habits and the human microbiome on older adults’ cognitive abilities. Already it has confirmed that Parkinson’s and other diseases linked to aging have a basis in the microbiome. The center uses artificial intelligence technologies to sift through and analyze the enormous quantities of data that research and sampling provide.

Navel-gazing, or Scrutinizing the Gut

Artificial intelligence algorithms could help the medical field to better understand the microbiome's complex composition and interactions and to find associations that human researchers cannot. The result may be breakthroughs in treatment for a host of diseases including diabetes and cancer. Today, however, analyses are mostly limited to comparing one individual's microbiome with others in the database.

Micron's own Patricia Reiter commissioned an analysis of her microbiome by one of a number of companies offering the service. To participate, customers send a small amount of fecal matter in the mail and then receive a written analysis. Reiter opted for the service because she was having digestive problems. The report surprised her: Although a pescatarian, the company made the case that she wasn't eating a diverse enough diet.

"They ruled out a lot of things," including celiac and Crohn's diseases, said Reiter, adding that she'd felt skeptical about the process when she sent her sample in. "I thought there must be a disease or something causing these problems. It provides peace of mind for me to know those tendencies are not within my body and that, hopefully, I will not get them if I increase diversity in my diet."

Of special note were suggestions that she increase consumption of "prebiotic" (asparagus, bananas, oats and apples) and "probiotic" foods (yogurt, kombucha, kimchee and other fermented foods and beverages). Some recommended items such as Jerusalem artichokes and burdock root were strange to her, but she is hopeful the dietary changes can improve her overall wellness.

The Power of AI

To analyze the composition, structure and interactions of these complex microscopic organisms, humans need the help of machines. Fortunately, advances in bandwidth, memory and speed are paving the way for AI technologies — with Micron leading the pack.

To accommodate these new capabilities, Micron has developed three essential memory products: low-power, high-density DRAM; fast NAND flash memory; and 3D XPoint™ technology.

"Micron's portfolio is the most complete portfolio for AI in the cloud data center, and it spans the entire hierarchy," Sadana said.

Researchers hope to say farewell to "one-size-fits-all." Wave good-bye to guesswork. Genomics, biomics, biopsies, virtual and predictive diagnostics, and other AI-assisted fields strive to enable precision medicine that is more preventive, predictive and personal than ever before, for a longer, better, happier life.

"Artificial intelligence is going to change medicine," Sadana said. Those transformations are happening now — from the inside out.

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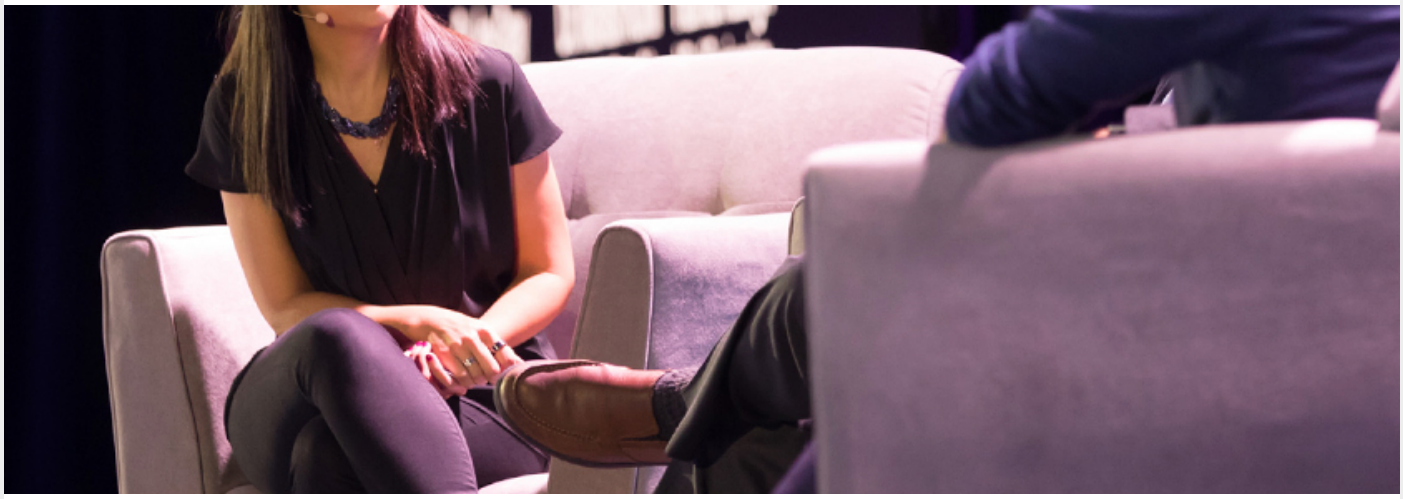

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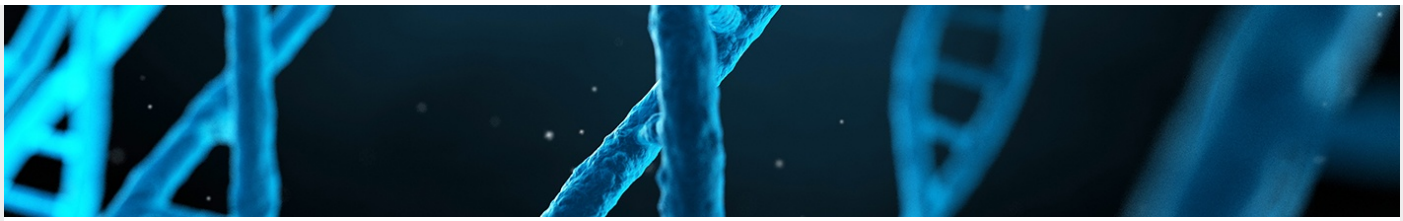

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