delivers nutrients as well as non-nutritive, bioactive molecules, including carbohydrates known as human milk oligosaccharides (HMOs). Back in the mid-1900s, Paul György, a world-renowned biochemist, nutritionist, and pediatrician from the Hospital of the University of Pennsylvania, and colleagues unknowingly referred to HMOs when they proposed the existence of a “bifidus factor,” something unique in breast milk that fed Bifidobacterium. While humans cannot digest HMOs, it turns out that Bifidobacterium, especially B. infantis, can. In 2007, our group at UC Davis used mass spectrometry–based tools coupled with microbiology to show that B. infantis gobbles up HMOs as its sole energy source, while other species of Bifidobacterium consume only some HMOs in addition to plant-, animal-, and host-derived carbohydrates.

HMOs are a diverse class of complex carbohydrate molecules synthesized by the mammary gland. With approximately 200 different molecular species, they represent the third most abundant solid component in human milk following lactose and fat. Because HMOs are complex and vary in structure, they are expensive to manufacture. Current infant formulas may contain one or two simple HMO structures, but at a fraction of the concentration found in breast milk. Infant formulas lack the abundance and complexity of HMOs to selectively feed beneficial gut microbes and to bind and neutralize pathogens from the gut.

The bacterial species in the infant gut capable of consuming HMOs can be considered the milk-oriented microbiome (MOM). Although B. infantis appears to be the most efficient consumer of HMOs, other species of Bifidobacterium, in particular, B. breve and B. bifidum, can and do consume some HMOs but also consume plant-, animal-, and host-derived carbohydrates. The Bifidobacterium species that colonize the gut change throughout life in response to available carbohydrates in the host diet. For instance, B. infantis, B. breve, and B. bifidum are MOM bifidobacteria typically found in the stool of exclusively breastfed infants, while B. longum and B. adolescentis, which preferentially consume plant- and animal-derived carbohydrates, are typically found in the stool of adults. Yet there is variation and overlap in the species present at different life stages.

Of the MOM bifidobacteria found in the infant gut microbiome, different species may have different implications for the microbiome. For example, when we gave exclusively breastfed infants a supplement with the probiotic B. infantis EVC001, their gut became dominated by the genus Bifidobacterium—upwards of 80 percent relative abundance of the gut microbiome—and potential pathogens made up less than 10 percent