The Constant Journey to Improve Our Baby's Health

A Bacterial and Probiotics Study

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Introduction

To start off, this book will be referring to the population of bacteria in your gut as the "microbiome."

As discussed in our previous article, the microbiome, also known as the trillions (yes, trillions!) of bacteria on our body has become a hot topic in scientific study. This book provides a glimpse into the relevance of the microbiome to you and your child's health. Numerous scientific journals are suggesting the microbiome is important in various aspects of human physiology, such as: nutrient processing, stimulation of blood vessel formation, protection against pathogens, and regulation of fat storage [1]. In recent years, scientists have found evidence suggesting that the microbiome communicates with our central nervous system (CNS) through a set of pathways called the gut-brain axis - a biochemical signaling between the gastrointestinal (GI) tract and our nervous system - ultimately affecting the outcome of our memory, mood, and much more [2]. With over 100 trillion microorganisms residing inside and outside our body, it is not surprising to believe that they play an important role in maintaining our overall health. Unlike adults, newborns and infants under the age of three years old are more susceptible to pathogenic exposure from the environment due to a lack of microbes in their gut. By nurturing the microbiome in early life, the immune system and GI tract will properly develop and lead to improved health and wellness [3]. Throughout this book, we will cover the multiple factors that affect your child's microbiome, gut health, and the immediate steps you can take to nurture your child's microbiome.

The Role of Bacteria in You and Your Baby

As you anxiously wait for your newborn child to join the ranks of your family, you're most likely reading books and articles on how you can take care of your child. Prenatal vitamins, a healthy diet and regular exercise are all well known elements of a healthy pregnancy. However, up until recently, the microbiome hasn't been a major topic of discussion. "When studying the role of the microbiome in pregnancy, it is crucial to consider the stage at which the essential interaction between the host and its microbes begins" (Nuriel-Ohayon, Neuman, & Koren, 2016). Negative results from an imbalance of bacteria in the gut (dysbiosis) have been associated with, but are not limited to, the development of celiac disease, asthma, type 1 diabetes, and obesity. There are multiple stages of bacterial exposure during prenatal and postnatal care. Contact with the intestinal flora and during vaginal delivery was first seen as the initial environmental introduction of microbes; however, recent discoveries have led scientists to believe that, "a bacterial presence already exists within the fetoplacental unit" [4]. During the postnatal phase, babies are exposed to bacteria during childbirth, breastfeeding, and solid food introduction. By exploring the specific process at each point of contact, you will be able to create a foundation for maintaining your baby's health.

Recent discoveries have led scientists to believe that, "a bacterial presence already exists within the fetoplacental unit"

Stages of Bacterial Contact and Factors That Changes the Bacterial Diversity of The Gut

Amniotic Fluid

Derek Nguyen @ Thryve

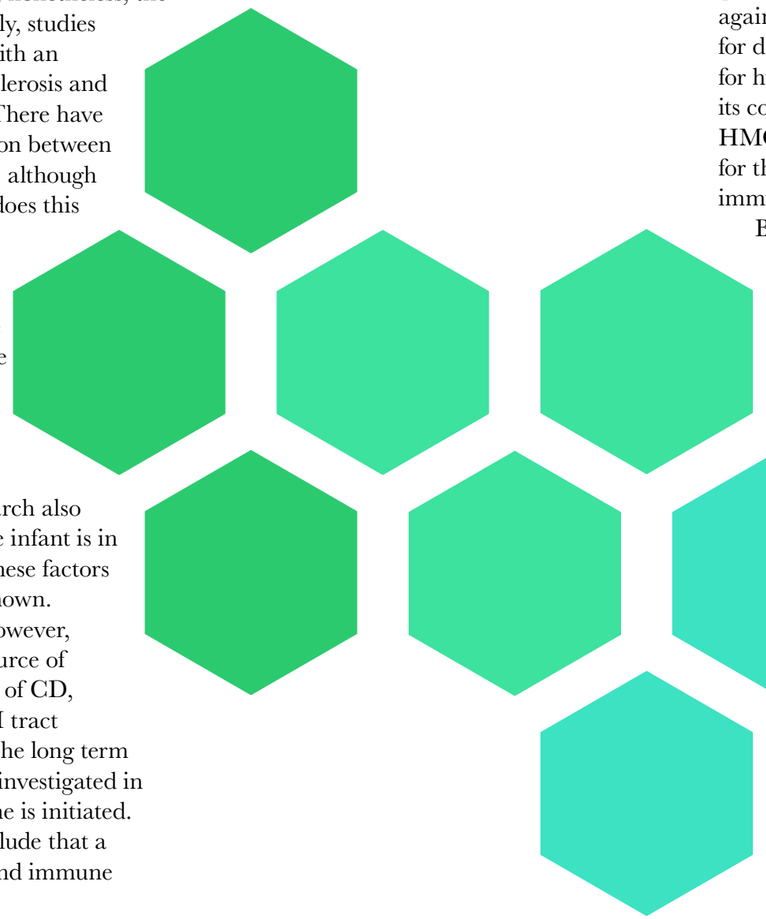
As discussed above, it has long been assumed that your child's initial exposure to microbes happens during delivery - either through the microbes from the vagina or the skin from a C-section. However, recent discoveries have found that microbes are transferred to your child through the placenta and amniotic fluids (the yellow fluid surrounding the baby during pregnancy) [4]. During the last trimester, babies are known to swallow large amounts of amniotic fluids that include bacterial microorganisms, which is evident by the existence of microbial DNA within the first excrement (aka poop) the baby has. Microbes in early life are generally associated with improved health, however, there are times when bacterial exposure may negatively impact you and your child.

One such complication is intra-amniotic infection or chorioamnionitis, which is an inflammation due to bacterial infection of the amniotic fluid [5]. Complications following exposure may include increased risk of preterm delivery, neonatal infection (sepsis, pneumonia, meningitis), seizures, cerebral palsy, or death. For mothers - bacteremia (bacterial presence in the blood), need for cesarean delivery, uterine atony, postpartum hemorrhage (excessive bleeding after childbirth), and more [6]. The only known way to treat this infection is through antibiotics.

Vaginal vs Cesarean Delivery

Ericca Steele @ Thryve

Since 1996 the rate of cesarean deliveries (CD) in the United States have increased by 48% [7]. Some of the risk factors involved in CD include fetal injury during delivery, increased likelihood of respiratory disease and complications with breastfeeding. Although C-section has provided an important tool to managing complications in pregnancy, nonetheless, the long-term effects are only starting to be realized. Recently, studies have correlated (not caused) the recent increase of CD with an increase in the prevalence of Crohn's disease, multiple sclerosis and several allergic diseases (i.e. asthma, atopic dermatitis). There have been several hypotheses postulated that show a connection between birth delivery method and immune system development, although a causal relationship has yet to be confirmed [8]. What does this have to do with microbial development? The "hygiene hypothesis" suggests that due to modern lifestyle we have eradicated most of our microbes through "clean living", which may contribute to children developing the aforementioned diseases. Some research suggests that the GI tract of a fetus is virtually sterile. During childbirth and immediately after, bacteria from the mother and surrounding environment is passed on to the child's GI tract — the method of delivery would therefore directly impact this process [9]. As mentioned earlier, some research also suggests that the microbial development occurs while the infant is in utero by ingestion of amniotic fluids — whether or not these factors are directly impacting immune development is still unknown. It is still in question which of these theories is correct. However, it is clear that vaginal delivery serves as an important source of intestinal and vaginal bacteria for the infant. In the case of CD, passing of this vital bacteria is missed and the infant's GI tract is primarily colonized by environmental bacteria [10]. The long term impact on the child's immune development is still being investigated in addition to the question of how and when the microbiome is initiated. However, with the evidence available today we can conclude that a significant relationship exists between the microbiome and immune system.



Breast vs Formula Fed

Grace Liu, PharmD, AFMCP, The Gut Institute

Human Breast Milk Is Unique and Not Sterile

Milk from mom is the perfect, precious food for baby and its origins are ancient going back in time more than 250 million years ago to mammalian-like reptiles called synapsids which oozed immunoprotective, nutrient-rich fluid out of sacs on their skin that offspring could lick off [11,12]. Breast Milk for human babies is not only immunoprotective against common pathogens, colds and infections, but it is customized for different stages of baby's growth. Human breast milk is so special for human babies that no other mammalian milk on Earth compares to its complexity or unique abundance and diversity of over 200 different HMOs (human milk oligosaccharides) [13]. Breastmilk is rich in nutrients for the baby. Born with a naive immune system, baby relies on mom's immunoglobulins for immunity which are deposited in breast milk [14].

Breast Milk also protects baby by containing probiotics from mom's gut flora which are delivered to the mammary glands via the mesenteric lymph circulation in mom's gut [14]. Healthy mom's guts translates to healthy baby's guts! Breastmilk indeed is not sterile but rich in probiotics to fuel baby's new biome.

Formula v. Breastmilk

In healthy, disease-free, breastfed, full-term babies, Bifidobacteria predominate over potentially pathogenic bacteria and candida, whereas in formula-fed infants, E. coli, coliforms, enterococci and Bacteroides predominate [15,34,35]. Without enough protective Bifidobacteria and HMOs, the microscopic wild things can colonize and terrorize baby's gut which may later lead to health issues [16]. HMOs not only feed and selectively stimulate the growth of the guardian angel probiotics in baby's gut (B. infantis; B. longum) but also serve as 'decoys' for pathogenic bacteria like Campylobacter and E. coli to attach to and be neutralized [16,17]. HMOs have direct

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antifungal, antiviral and antibacterial action against invaders such as Candida fungal overgrowths, Norovirus and Group B Streptococcus, respectively [18,19]. These invaders can be commonly associated with eczema, asthma, irritable bowels, constipation, anxiety, and neurologic issues. Mother Nature is so clever, no? We humans are fortunately getting clever as well and placing probiotics and HMOs into commercial infant formula and adult gut-healing formulas for what may be lacking.

Breastfeeding Protects infants: Immediate and Long-Term

Countless studies verify that breastfeeding has beneficial and long lasting benefits for baby [20]. By building oral tolerance, baby can tolerate more diverse foods and have defenses for colds and infections. More Bifidobacteria in baby's guts are associated with improved antibody responses with vaccines. Later in life, breastfeeding has been correlated with decreased obesity, Type 2 diabetes, multiple sclerosis, cancer, cardiovascular disease, and inflammatory bowel disease [22-24,30,33,].

My second child breastfed until age 5 and would've longer if she had her way. Since she was old enough to talk and obviously enjoyed breastfeeding, I remember asking her what did breastmilk taste like and she said 'ice cream!' Not all breastmilk is equal (just as not all ice cream is equal). Apparently studies show diversity and quality of the HMOs in breast milk may decrease with mother's genetics, chronic conditions, diet, maternal obesity, blood-type (FUT2 non-secretor), and nutrient-poor diet (retinol, fiber) [21,25,26,28,31,32]. Breastmilk from obese mothers compared with normal-weight mothers has been shown to carry a pro-inflammatory profile and lacking in Bifidobacteria, omega-3 and carotenoids which are vital for brain and eye development [27,29].

In conclusion, keeping our bosom buddies in both mom and baby's gut microbiomes as happy as possible may lead to more joy, freedom and health.

Other Dysbiotic Risk Factors

Malnutrition

Susan Hewlings Ph.D, RD CSO IgY Nutrition

Malnutrition is a term that is often used to cover both undernutrition and overnutrition, but most people think of it in reference to undernutrition. Under-nutrition can be caused when an individual is [36] not getting enough food, [37] not getting the right balance of different sorts of food, such as not enough protein relative to total calories, or [38] not digesting and/or absorbing nutrients efficiently. Under-nutrition is one of the most serious problems affecting global health with almost 15% of the world's

population identified as malnourished [36]. Malnutrition affects the entire body and creates a repeating cycle of ill health and ultimately a threat to mortality. For example, a link between gut microbiota (GM) and malnutrition has been established [37], with several studies reporting predominance of pathogenic intestinal bacteria in the guts of malnourished children compared to healthy controls [38–41]. In addition, low diversity has been identified in malnourished children [42]. Undernutrition in children is particularly concerning due to its association with long-term health consequences. Including inadequate development of the immune system, impaired cognitive function, increased risk of coronary heart disease and diabetes [43]. It has been suggested that the abundance of pathogenic bacteria leads to long term inflammation in the GI tract, increased permeability of the lining of the GI tract and therefore results in nutrient malabsorption and further exacerbation of the malnutrition and related conditions [44].

Bifidobacteria, which is known to be a predominant species in the healthy infant microbiome, has been shown to be absent or in low numbers in the microbiome of malnourished children. This may help to explain the connection between intestinal dysbiosis and malnutrition. It may also suggest that preventing dysbiosis in at risk populations may help to offset malnutrition and its complications. It has been suggested that probiotics are potentially protective against the development of malnutrition [45]. Studies involving Indian children have shown that specific probiotics can significantly reduce the occurrence of diarrhea, and significantly increase the weight and height of the children, relative to those fed a supplement with similar caloric value, but lacking probiotics [46-48]. The success of these studies raises the possibility of using probiotics (and/or prebiotics) to improve the outcomes of nutritional interventions in the treatment of undernourished children [36].

This prevention can even be potentially addressed in utero by treating pregnant women [49,50]. Gut microbiota is altered during pregnancy especially between the first and third trimesters, with a decrease in the overall bacterial diversity as women progress from the first to the third trimester [51]. There is no clear definition of a “healthy” microbiome during pregnancy but a connection between maternal microbiome and pregnancy outcomes has been established. In addition, the maternal microbiome establishes the infant microbiome. Therefore, dysbiosis in the mother could potentially create the same in the infant increasing the risk for malnutrition as well as the aforementioned health concerns later in life [52]. While there are few studies conducted on this population, a few small studies have shown that consumption of probiotic-rich food during pregnancy has been associated with lower rates of pregnancy complications such as preterm birth, preeclampsia, gestational hypertension, and excessive gestational weight gain most likely by modulating placental inflammation [52].

Under-nutrition is one of the most serious problems affecting global health with almost 15% of the world’s population identified as malnourished

While research is promising that probiotic supplementation can help to offset malnutrition by modulating the microbiome of both mother and infant; however, more research is needed. For example, timing and duration of treatment, the optimal probiotic strain(s), and factors that may alter the composition and function of the microbiome are still in need of further research [45].

Antibiotic Treatments

Christina Tsai, Ph.D in Chemistry and Biochemistry

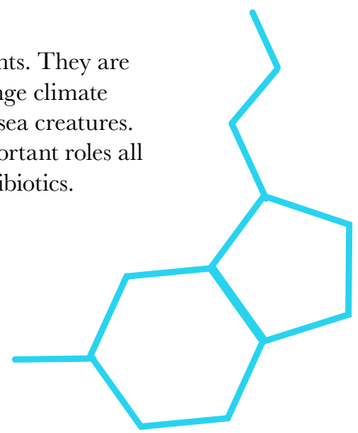
My name is Christina Tsai. I received my Ph.D in Chemistry at Texas A&M University and did my postdoctoral research at the Department of Bioengineering, Stanford University. My main professional expertise is in protein engineering and metabolic engineering in microbial organisms. I currently work in a biotech startup focusing on microbiome engineering. I am also a mom of two kids, they are 4 years old and 2 years old. I grew up in Taiwan and experienced two different cultural environments, including healthcare systems.

People used to fear bacteria, it was a common belief that they caused most of our diseases. When we got sick in Taiwan with a sore throat, cough, upset stomach or fever, our common practice was to go to doctor's office and ask for medication. Very often, antibiotics were the solution.. We thought the sickness went away because of the antibiotics we were taking. However, it might be that our immunity won the battle after an extensive amount of rest. Current science provides more interesting indications about killing bacteria in the body.

We now know that bacteria is populated all over the human body, including the skin, nasal cavity, gastrointestinal tract, reproduction systems, etc. The thousands of types of bacteria on the human body are like animals living in a giant tropical forest, they live on us like a little ecosystem.The greater diversity of microorganisms in our body, the better we feel. Bacteria that surround us are often not to make us sick, rather, to balance our health. Some of the bacteria in our gut help us digest fiber from vegetables and others help us fight pathogens, for example, when we eat non-sterile food.

Research says that about 3% of our body mass comes from these bacteria [53]. This means a 70 Kg person has 2.1Kg of bacteria in their body. The microbiome is often referred to as another organ in our body, and by the overuse of antibiotics, the good bacteria are killed, thus making this 'organ' compromised. It sounds brutal! In addition, the antibiotics we cannot finish, we often throw them in the trash can. When this trash is dumped to the environment, antibiotics are fed into soil which may cause the bacteria in the soil to have antibiotic resistance. Aquaculture, livestock and poultry later consume those antibiotic resistant bacteria from the soil and they get sick. These animals are treated with stronger antibiotics and become our food, thus the residual antibiotics in them will cycle back into our diet. It sounds scary, but antibiotic resistant bacteria is actually threatening our health.

Microbial communities are also found in other environments. They are in soil to support plants and crops to thrive, the air to change climate system, and the ocean to provide food for algae and small sea creatures. Therefore, we should respect these microbes that play important roles all around us and make sure we are cautious when taking antibiotics.



What You can do to Improve Your Child's Microbiome

Prebiotics

Jun Kim Ph.D, CSO @ Thryve

Providing a continual supply of probiotics to the gut seems to have important health benefits, both for pregnant women and their infants. Yet for probiotics to be maximally effective, they need to be paired with another group of compounds: prebiotics.

A prebiotic is "a nondigestible compound that, through its metabolization by microorganisms in the gut, modulates composition and/or activity of the gut microbiota, thus conferring a beneficial physiological effect on the host" [54]. Essentially, prebiotics act as 'fertilizer' for the growth of beneficial intestinal microbes. They contribute to better health by boosting populations of desirable bacteria, especially famous health-promoting groups of microbes like bifidobacteria and lactobacilli.

Prebiotics act as 'fertilizer' for the growth of beneficial intestinal microbes

Almost any compound—even a drug—could qualify as a prebiotic if a research study showed it had the ability to change the community of microorganisms in the colon and affect health, but all of the currently known prebiotics are specific types of dietary fiber. (Not all dietary fibers are prebiotics, however—the only ones that can qualify are those that lead to particular changes in the gut microbiota!)

Prebiotics are found in many foods, but they can also be added to foods that wouldn't normally contain them. The most important and frequently-studied prebiotics include:

- **Inulin**: A polysaccharide naturally occurring in many plants, often extracted from chicory.
- **Fructo-oligosaccharides** (FOS, or "foss"): Oligosaccharides found in foods or produced commercially by degrading inulin. These are often used as a low-intensity sweetener or to replace fat in foods.
- **Galacto-oligosaccharides** (GOS, or "goss"): a mixture of substances in syrup or powder format, produced from lactose (a component of cow's milk) and sometimes added to infant formula.
- **Lactulose**: Lactulose: a synthetically-produced sugar consisting of galactose and fructose units.

Inulin and FOS are found in everyday foods like asparagus, leeks, onions, and bananas, so if you increase your consumption of these foods you may see a difference in certain groups of beneficial bacteria in your gut. But in scientific studies, these prebiotics are administered as supplements in specific amounts in order to track their effects on health. Taking them in supplement form at larger doses than in foods could make it easier to see the direct impact of prebiotics on your gut microbiota.

Intake of prebiotics should result in a measurable increase in populations of beneficial gut microbes

A hot topic of scientific study is exactly how prebiotics exert their effects on health. Scientists are focusing in on molecules called short-chain fatty acids (SCFAs) that are produced when gut microbes break up dietary fiber that the human body cannot digest. It turns out these SCFAs have critical roles in the body: not only are they a source of energy for cells of the colon, but they also have effects on energy metabolism (i.e. the calories you 'harvest' from a meal), the immune system, and possibly on cancer risk [55].

Clinical research has found prebiotics could be especially promising for addressing aspects of inflammatory bowel disease, lactose intolerance, irritable bowel syndrome, constipation, and calcium absorption in cases of iron deficiency. Growing evidence on prebiotics suggests they may have other crucial applications, like supporting the development of the infant gut microbiota during important developmental windows.

By definition, intake of prebiotics should result in a measurable increase in populations of beneficial gut microbes—so they are one of the most immediate ways to intervene and make a difference to your test results. Talk to your health professional about boosting your intake of prebiotics before your next microbiota analysis!

Diet

Jessica Flanigan, Clinical Nutritionist

I have been a clinical nutritionist for 20 years. I specialize in Autoimmunity and the Microbiome.

When I first started working in the world of Autoimmunity and Autoimmune Paleo, I emphasized diet. But over the course of 4 years, the microbiome world has exploded. So much incredible research has come out and companies that allow my clients to easily assess their own microbiome. The interface of the immune system via the microbiome has become a clear path for those I work with. I see the biggest shifts in my client's oral tolerance, immune system recovery and wellbeing happen when I address the microbiome first. It is easy, effective and inexpensive to do this now.

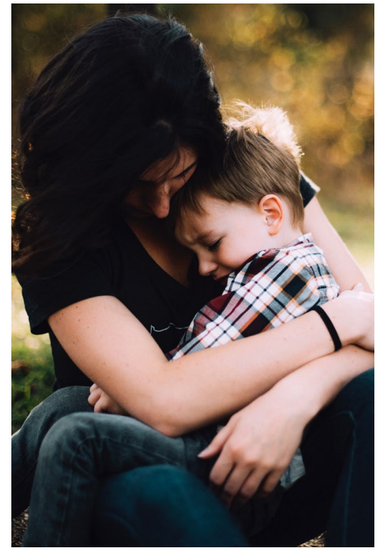
The first thing I always suggest to clients:

1. Test their microbiome
2. Find a clinician who has been trained in microbiome restoration
3. Modify the diet based on YOUR results
4. Re-test regularly to see how you are progressing
5. Find environment toxins you can lower in your life like switching to eating from glass containers and phasing out plastic

I usually don't suggest finding out what foods work best for a person's body until I know what their gut is doing. Now we know that bacteria and viral pathogens can cross-react with food antigens. So I look at the gut first, apply any necessary changes and protocols and then look at food sensitivity testing. This limits the amount of false positives and really tailors each person's diet to their physiology. Restrictive diets executed without looking at the microbiome can lower oral tolerance. Then people get "stuck" on 10-15 safe foods and if they try to add any others they get a physical reaction. Looking at the microbiome FIRST can help prevent this issue from arising.

When it comes to prenatal microbiome hygiene theory, I suggest the following:

1. It is the lack of diversity that is problematic so test your gut before you get pregnant if possible. Increase diversity of the microbiome before pregnancy. Then, once pregnant, work on micro nutrients that support a healthy microbiome like fermentable fibers, increasing bifidobacterium species, essentially fatty acids and emulsified B-vitamins. You can add other micronutrients the good gut bugs like, like polyphenols and powdered greens.
2. Limit the amount of antibiotic exposure of the pregnant mother if possible
3. Have the Dad look at his microbiome if possible as well
4. Consider the contact points for the baby's microbiome inoculation:
    - A. Mother's vaginal canal
    - B. Mother's nipples
    - C. Mother's breastmilk
    - D. Skin to skin contact with mother and father
    - E. Microbiome of air (hospital, car, home, nursery)
    - F. The diet of the nursing mother will affect the baby's growing microbiome, so eating a microbiome healthy diet is applicable
5. Be ready to impact the baby's biome by using infant probiotics both in baby and mother recommended by a trained microbiome expert.
6. Have a conversation with your doctor about what you will do if you do not have a vaginal birth. Vaginal swabbing may be an appropriate course of action
7. Consider that hospitals and NICU's have their own microbiomes. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4583357/
8. Elimination of all anti-bacterial chemicals in daily household products
9. Adopt healthy microbiome habits that increase microbial diversity both in your living environment and individually.



Conclusion

This is an exciting time in your life and we know that above all, your biggest priority is your baby's health. The vision behind this book was to connect with mothers, future mothers, and all parents — to educate them about the vastly growing area of research that is the human microbiome (remember, over 100 trillion organisms!). As we have learned, there is growing knowledge of the connections between the microbiome and overall health, specifically within the gut. From initial development of the bacteria in their bodies to the early years of childhood, children are exposed to bacteria by means of several factors (amniotic fluids, breastfeeding, environment etc…) that will affect the ecosystem within their gut. In turn, these factors will ultimately aid in developing a healthy immune system for your child. As we mentioned earlier "Negative results from an imbalance of bacteria in the gut (dysbiosis) have been associated with, but are not limited to, the development of celiac disease, asthma, type 1 diabetes, and obesity." Although there are several therapies being developed for improving the state of the microbiome (diet, lifestyle, supplements), we are learning that this important aspect of our health begins developing at an early age.

This book is meant to serve as a tool — to help you ask questions — and make informed decisions about you and your child's health. We hope that you feel more informed about these discoveries being made in the microbiome world and will join us in the journey to improve you and your child's health.

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Disclaimer: The information in this book is an aggregate of developing research studies that should be used for educational purposes and not taken as medical advice. Remember to consult a medical professional before making any changes to your diet or before taking any supplements.

Meet the Authors

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Worked with microbial metabolic engineering to improve the desired function. Currently, Christina is working in a microbiome engineering company that uses microbiome profiling to understand the microbial population related to the health and develops proprietary antimicrobial agents that can eliminate problematic bacteria. Christina also brings her microbiome knowledge to her family with two kids.

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Dr. Grace Liu PharmD is a trained functional medicine practitioner and founder of The Gut Institute. She is a clinical pharmacist with a doctorate in practice for 20 years and specializes in complex disease management. Dr. Liu PharmD consults and helps clients gain optimal performance through rebuilding the microbiome after damage from modern living. She uses nutrigenomic tools and other advanced functional lab testing. Currently she is training some functional medicine leaders to approach gut protocols with her expertise. She has been invited to speak at Ancestral Health Symposium (2017, 2016, 2014, 2011), Paleo Convention Berlin, PaleoFx (2015, 2016, 2017), interviewed for a microbiome documentary (by 'Microbirth' producers) and Women's Health UK magazine on the skin-gut microbiome. Recently she shared the stage with Dr David Perlmutter (author Grain Brain) on the Expert Microbiome Panel at Paleof(x)16 in Austin, Texas and will again in 2017.

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