A group of women standing in a row

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SCIENCE SAYS

YOU CAN

PREVENT AUTISM

**STARTING IN PREGNANCY**

**By Robert F. Waterstripe**

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**Author’s note:**

**Thank you for reading!**

This book brings together more diverse research related to preventing autism than any other book available today.

**I am not a doctor and this book is not medical advice**. **You should discuss your needs and your plan with your doctor.**

I am simply reporting on the published results of numerous clinical trials and scientific studies, all linked to the footnote numbers in this book so you can see each original source with one click.

By combining information from the many scientific resources cited in this book, we find a clear, simple, science-based path to prevent autism which has demonstrated results, as you will see.

**Also, I do not sell products or derive any money or benefit from the sale of products or services mentioned in this book.**

I wish a long, happy life for you and your baby.

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# Introduction

One of every 31 babies born in America today will be diagnosed with autism spectrum disorder (ASD, or simply “autism”) within three to ten years, and rates are rising rapidly. By 2030, today’s 3.2% may be 5%, 1 child of every 20.

You absolutely do not want your baby to be one of them.

**The good news is you can prevent autism. It’s easy, cheap, and backed by serious science. I’ll show you how, starting during pregnancy.** So, please just relax and pay attention now.

Don’t look back on this moment in three years, when it’s too late, and wish you had paid attention today. Ironically, following this plan maximizes your own health and happiness, too.

There’s a ton of important information in this small book, including some that many neurologists who care for autistic children (but not pregnant moms) don’t seem to know yet. Obstetricians care for pregnant moms, not children, and many are unaware of the latest science on autism. You have my permission to copy this eBook to your doctor.

Meanwhile, science has proven that preventing autism begins in pregnancy. So, who will tell you how to prevent it? OK, I will.

I’m a retired great-grandpa. I recently came face to face with autism for the first time, in my few months as a K-12 substitute teacher. I occasionally assisted amazing professionals with their special classes of six to ten autistic kids, but mainly I met two or three less severely autistic kids in almost every regular class I taught.

My sympathy for these kids, and their parents, was soon overshadowed by my dismay and anger when I started to research autism, only to find that the science of **a simple way to prevent autism** **was first peer-reviewed and published in 2015**, followed by plenty more science.

Since 2015, over a million more autistic kids have been born in America. They didn’t need to get autism. Your baby doesn’t have to, either.

Still, the rate of new cases in the U.S. is growing faster than ever. Sadly, America has by far the highest rate of autism of any developed country (already 3.2%), almost four times as high as Europe and about 1.8 times as high as number two Canada.

There are plenty of books about how to live with autism, your own or your child’s, almost all beginning with a heartbreaking story of someone’s years-long journey through hell. But I couldn’t find any books about the latest science for preventing autism in the first place.

So, I researched and wrote this book for you. It explores and explains the latest science, and gives you one-click links to hundreds of peer-reviewed studies and supporting information sources.

Please share and discuss this vital information with your inner circle, your family, **and your doctor**. Now you can confidently make simple, science-based choices to prevent autism from devastating your child and your family, and to assure you and your baby the health and happiness that you deserve.

## Chapter 1. Understanding Autism Spectrum Disorder

Autism spectrum disorder (ASD), or autism, is a neurological condition affecting 1 in 31 children in America. It impacts social communication and behavior patterns, with symptoms typically appearing by age 2-3.

Autism is a way some people's brains develop differently that affects how they interact with others and experience the world. Autism exists on a spectrum, with each autistic person experiencing unique strengths and challenges.

People with autism might have trouble understanding social cues like facial expressions or tone of voice, and they might be really interested in specific topics or prefer to do things in a particular order. Just like everyone has different abilities and challenges, autism looks different in each person. Some might need lots of help in daily life, while others might need just a little support or none at all.

While there is no cure yet, early intervention services can significantly improve outcomes.

In any case, you definitely do not want your baby to get autism.

**Fortunately, science shows us how to prevent autism from happening in the first place.**

About 1 in 31 kids (3.2%) in the U.S. have autism today. That’s over **2.7 million children** [[12]](https://www.cdc.gov/autism/data-research/?CDC_AAref_Val=https://www.cdc.gov/ncbddd/autism/data.html). Including adults, about **8 million Americans** have autism today, and counting [[3]](https://www.disabilityscoop.com/2023/10/30/in-less-than-a-decade-autism-prevalence-among-adults-more-than-doubled/30608/). Every year, about **118,400 American kids** get diagnosed with autism, enough to fill 2,000 school buses [[2]](https://www.cdc.gov/autism/data-research/index.html).

If that’s not bad enough, many kids with autism also have:

* **Epilepsy** (seizures) in about **1 out of 3**
* **ADHD** (trouble focusing) in **1 out of 3**
* **Sleep problems** in **8 out of 10**
* **Gastrointestinal (GI) troubles** like constipation in **46 – 84%**.

Their GI problems can sometimes lead to **leaky gut**, where harmful, poisonous stuff that should stay in the intestines leaks into the blood. This can make them feel really sick **and can lead to sepsis and death if not treated** [[4]](https://pmc.ncbi.nlm.nih.gov/articles/PMC8608248/) [[5]](https://pmc.ncbi.nlm.nih.gov/articles/PMC11936958/).

**Epidemiology**

The U.S. Centers for Disease Control and Prevention (CDC) report a **3.2% pediatric prevalence** (1 in 31 children) as of 2025, with **2.7 million** affected youth [[12]](https://www.cdc.gov/autism/data-research/?CDC_AAref_Val=https://www.cdc.gov/ncbddd/autism/data.html). Adult prevalence stands at **2.2%** (1 in 45), totaling **5.3 million autistic adults** [[3]](https://www.disabilityscoop.com/2023/10/30/in-less-than-a-decade-autism-prevalence-among-adults-more-than-doubled/30608/). Combined national prevalence reaches **8 million cases**, representing **2.4% of the U.S. population** [[1]](https://www.autismspeaks.org/science-news/2025-autism-numbers-annual-report-now-live) [[3]](https://www.disabilityscoop.com/2023/10/30/in-less-than-a-decade-autism-prevalence-among-adults-more-than-doubled/30608/). Annual incidence is about **118,400 new pediatric diagnoses** [[2]](https://www.cdc.gov/autism/data-research/index.html).

|  |  |  |
| --- | --- | --- |
| Population Group | Prevalence Rate | Estimated Cases |
| Children (0-17) | 3.2% | 2.7 million |
| Adults (18+) | 2.2% | 5.3 million |
| **Total** | **2.4%** | **8 million** |

**Neurological Comorbidities**

Common co-occurring neurological conditions include:

|  |  |
| --- | --- |
| **Condition** | **Prevalence in ASD** |
| Epilepsy | 30% |
| ADHD | 35.3% |
| Intellectual Disability | 21.7% |
| Sleep Disorders | 80% |
| Migraine Disorders | 22% |

**Gastrointestinal Pathophysiology in Autism**

**46–84%** of ASD individuals experience gastrointestinal (GI) disorders, with chronic inflammation leading to **intestinal hyperpermeability** ("leaky gut") [[4]](https://pmc.ncbi.nlm.nih.gov/articles/PMC8608248/) [[5]](https://pmc.ncbi.nlm.nih.gov/articles/PMC11936958/). This allows neurotoxic metabolites like propionate and ammonia into systemic circulation, correlating with increased ASD symptom severity and mortality risk. Beyond physical suffering, ASD creates constant emotional strain for patients and caregivers while imposing heavy financial burdens through medical needs and specialized education requirements. If that were not bad enough, the economic costs for the family and the nation (e.g., special educational needs) are staggering.

**Economic Impact**

The lifetime cost per individual ranges from **$1.4–$3.2 million**, with 60% attributed to adult care costs [[8]](https://penntoday.upenn.edu/news/lifetime-costs-autism-spectrum-disorder-may-reach-24-million-patient-penn-study-finds) [[9]](https://jamanetwork.com/journals/jamapediatrics/fullarticle/570087). Unchecked, 1 million new cases will cost **$2.4–$5.5 trillion** by 2060, growing for decades to come. For families, out-of-pocket expenses average **$17,000/year**—more than double neurotypical households [[11]](https://www.autismspeaks.org/autism-statistics-asd).

**Mortality Statistics**

ASD reduces life expectancy by **16 - 20 years** on average compared to the general population) [[6]](https://www.abtaba.com/blog/does-autism-affect-life-span) [[7]](https://pubmed.ncbi.nlm.nih.gov/26541693/). Leading causes include epilepsy-related complications, accidental injuries, circulatory diseases, and suicide.

# Chapter 2. Vaccines and autism: the corrupt origins of the Big Lie, and what 25 years of real science says

I regret that we need to take time to talk about the elephant in the room, (or the non-elephant that is not in the room), namely that many people still believe that vaccines cause autism. To be clear, that is completely false, and **you will see proof the very suggestion that vaccines cause autism was a deliberate fraud based on greed.** Let’s use a huge dose of real science to clear the air on this, so we can get into how to prevent autism with a clear mind.

One of the most persistent, controversial, and dangerous beliefs about autism is the idea that vaccines, particularly the measles, mumps, and rubella (MMR) vaccine, cause autism. This concern first gained widespread attention in 1998 and has since influenced public opinion and vaccination rates in several countries. In this chapter, we critically examine the origins of this belief, review the scientific evidence for and against it, and provide clear guidance based on the latest available research.

You probably know someone who believes that vaccines cause autism. Can you imagine the devastating impact to a family of a child **dying of measles**, in the United States of America, **in 2025**, where there had **not been a measles death since 2015**, because the parents believed someone who “did their own research” and claimed that the MMR vaccine could give the child autism? How would you feel if your own misguided advice about vaccines resulted in the death of your grandchild?

Really, it’s worth taking a few minutes to check the real facts, right here.

As we’ll see in this chapter, there was a time in 1998 where it seemed reasonable to think that maybe vaccines might cause autism. However, since then, **over 25 years of research demonstrates no relationship between vaccines and autism.**

Before you take any advice about vaccines from anyone, make sure you know the latest science (by reading this chapter including the footnotes). Before you listen to anyone about vaccines, share this information with them and let them prove to you they read it. **Your baby’s life is at stake.**

**The corrupt origin story**

The story of how the MMR vaccine got blamed for causing autism reads like a high-stakes thriller. We’ve got millions and millions of precious babies and toddlers at risk, dastardly villains, and a heroic investigator who uncovered **one of the most consequential and most dangerous scientific frauds in history.**

Here’s what happened.

In 1998, Andrew J. Wakefield and 12 others at a London medical school published a peer-reviewed paper in the *Lancet* (a top-tier medical journal), purporting to be a study of 12 children ages 3 – 9. According to the paper, 8 of the 12 showed new behavioral symptoms of a purported new syndrome about a week after receiving the MMR vaccine. [[1]](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(10)60175-4/abstract)

A truly heroic investigative journalist named Brian Deer investigated for *BMJ* (until 1988, known as the *British Medical Journal* and a few names since its debut in 1840). Deer meticulously dissected the origins and substance of the now-infamous paper, which erroneously claimed a link between the MMR (measles, mumps, rubella) vaccine and autism. [[17]](https://www.bmj.com/content/342/bmj.c5347) [[18]](https://briandeer.com/).

Deer tracked down the families involved, uncovering significant inconsistencies and distortions in how patient cases were described. For example, one parent was surprised to learn of his child’s involvement in the study and provided medical records that contradicted details in the published paper, revealing that onset of symptoms and diagnoses were misrepresented to fit the study’s claims.

Deer discovered that prior to and during the research, Wakefield was secretly paid over £435,000 ($580,000 in 1998 or $1,140,000 today) by a lawyer working on a lawsuit against vaccine manufacturers.

Notably, Wakefield and the legal team decided on a theory of a new vaccine-induced syndrome before the research even began. Then they actively worked to create the appearance of a compelling link to vaccines by manipulating patient timelines and symptoms in the formal write-up.

Deer’s investigation revealed wide-ranging discrepancies between the medical records and what was published in the *Lancet*. Some children were described as having “regressive autism” or sudden onset neurological symptoms after the vaccine, but records showed that some children had symptoms autism before vaccination, or had chronic issues not related to immunization. Others were enrolled in the study via anti-vaccine networks or legal referrals, not through standard clinical channels.

Furthermore, some cases involved selective reporting or omission of relevant facts, such as preexisting developmental delays, to support the thesis of a vaccine-induced disorder.

Ultimately, this investigation demonstrated that Wakefield’s work **was not just bad science but involved calculated fraud:** misstating case histories, wrongly suggesting a consistent and sudden syndrome, and omitting details that undermined the vaccine-autism link narrative. The resultant scandal led to the retraction of the paper and the revocation of Wakefield’s medical license.

**Sadly, it took 12 years before the paper was retracted in 2010.**

The gang published another paper in the *American Journal of Gastroenterology,* which was also retracted in 2010. [[2]](https://pubmed.ncbi.nlm.nih.gov/11007230/)

**You can read the actual Wakefield “studies,” and the retraction notices**, by following footnotes [[1]](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(10)60175-4/abstract) and [[2]](https://pubmed.ncbi.nlm.nih.gov/11007230/) in this chapter.

Ironically, the Wakefield papers were so alarming that, since 1998, the question of any potential connection between vaccines and autism has been one of the most researched and studied topics in the scientific world.

Hundreds of well-controlled studies have investigated whether vaccines are associated with an increased risk of autism. These studies have examined not only the MMR vaccine, but also other vaccines and vaccine ingredients, such as thimerosal, a mercury-containing preservative once used in some vaccines.

By the way, the MMR vaccine *never* contained thimerosal.

The overwhelming consensus from the latest 25 years of research is clear: **vaccines do not cause autism** [[3]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367)**.**

Multiple studies involving hundreds of thousands of children have found no difference in autism rates between vaccinated and unvaccinated children [[4]](https://pubmed.ncbi.nlm.nih.gov/30831578/).

Additionally, removing thimerosal from most childhood vaccines by 2021 did not reduce autism rates, further undermining the claim that vaccines or their components are to blame, and meanwhile autism rates have continued to grow [[5]](https://www.nejm.org/doi/full/10.1056/NEJMp078187).

A 2014 meta-analysis included five cohort studies (over 1.2 million children) and five case-control studies (over 9,900 children), all finding no association between vaccination and autism [[3]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367).

A 2003 systematic review identified twelve controlled epidemiological studies examining the association between MMR vaccines and autism, none of which found credible evidence of a link [[6]](https://www.ncbi.nlm.nih.gov/books/NBK25344/).

A 2021 systematic review **analyzed 338 studies** on vaccine safety and found no association between the MMR vaccine and autism [[7]](https://jamanetwork.com/journals/jama-health-forum/fullarticle/2830561).

The U.S. Centers for Disease Control and Prevention (CDC) references at least nine CDC-funded or conducted studies since 2003 specifically investigating thimerosal-containing vaccines and autism, all finding no link [[8]](https://www.cdc.gov/vaccine-safety/about/thimerosal.html?CDC_AAref_Val=https://www.cdc.gov/vaccinesafety/concerns/thimerosal/index.html).

**How Epidemiological Studies Have Addressed Vaccine Safety Concerns Related to Autism**

Epidemiological studies have addressed vaccine safety concerns related to autism through a variety of rigorous research designs and analytical approaches, consistently finding no credible link between vaccines and autism spectrum disorder (ASD):

* **Large-Scale Population Studies and Cohort Analyses:** Researchers have compared autism rates in large groups of children who received vaccines (such as MMR) with those who did not, controlling for confounding factors. For example, a UK study found no difference in autism rates or age at diagnosis between vaccinated and unvaccinated children [[9]](https://www.chop.edu/vaccine-education-center/vaccine-safety/vaccines-and-other-conditions/autism). Similar studies in Denmark and Finland used national registries to compare hundreds of thousands of children, again finding no increased risk of autism among the vaccinated [[10]](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/) [[11]](https://academic.oup.com/cid/article/69/4/726/5316263).
* **Time-Trend and Ecological Analyses:** Researchers have analyzed trends in autism diagnoses over time alongside changes in vaccination rates. These studies consistently showed that increases in autism diagnoses did not correlate with vaccine introduction or changes in vaccine uptake [[12]](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/).
* **Case-Control and Cross-Sectional Studies:** Studies have compared the vaccination histories of children with autism to those of children without autism, finding no difference in the rates or timing of vaccination between the two groups [[12]](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/) [[13]](https://pubmed.ncbi.nlm.nih.gov/30831578/).
* **Examination of Specific Concerns:**
  + *Thimerosal:* Multiple cohort and case-control studies have investigated whether thimerosal (a mercury-containing preservative) in vaccines is linked to autism. These studies found no association, and autism rates continued to rise even after thimerosal was removed from most vaccines [[10]](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/) [[11]](https://academic.oup.com/cid/article/69/4/726/5316263).
  + *Immune System Overload:* Studies have also addressed the hypothesis that receiving multiple vaccines at once could overwhelm the immune system and trigger autism. Epidemiological evidence does not support this theory, and no increased risk of autism has been found in children who received multiple vaccines simultaneously [[12]](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/).
* **Systematic Reviews and Meta-Analyses:** Comprehensive reviews by organizations such as the World Health Organization (WHO), the Institute of Medicine (IOM), and independent researchers have analyzed all available epidemiological evidence. These reviews consistently conclude that there is no evidence of a causal association between vaccines (including MMR and thimerosal-containing vaccines) and autism [[7]](https://jamanetwork.com/journals/jama-health-forum/fullarticle/2830561) [[14]](https://www.who.int/groups/global-advisory-committee-on-vaccine-safety/topics/mmr-vaccines-and-autism) [[15]](https://www.nationalacademies.org/news/2004/05/immunization-safety-review-vaccines-and-autism).
* **Addressing New Hypotheses:** As new concerns or hypotheses have emerged (such as the idea of a "new variant" form of autism with gastrointestinal symptoms), epidemiological studies have specifically investigated these claims and found no supporting evidence [[12]](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/).

## The dangers of vaccine hesitancy

It is important to recognize that vaccines are one of the most effective public health tools for preventing serious diseases. When vaccination rates drop, outbreaks of preventable diseases like measles and whooping cough can happen, putting vulnerable populations at risk [[12]](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/). Spreading misinformation about vaccines and autism not only fails to prevent autism, but also endangers public health and results in senseless deaths of children.

**So, what causes autism? More importantly, what prevents autism?**

While the precise causes of autism are still being studied, current research points to a complex interplay of genetic and environmental factors, including the pre-natal environment, leading to differences in early brain development.

Just as every case of autism is different, defining “the cause” is not a simple question.

**However, this book is about preventing autism, which is much simpler**.

Evidence shows that dysbiosis, an unbalanced gut microbiome, affects the brain via the gut-brain axis, affects other factors, and is affected by other factors.

**Science shows that we can prevent autism** by balancing the mother’s gut microbiome with probiotics and vitamins during pregnancy, passing the benefit to her baby at birth through breastfeeding, or by giving probiotics and vitamins to the baby for a few months if not breastfeeding.

We will look at the gut microbiome, the gut-brain axis, and the science of preventing autism, next.

Again, there is no credible scientific evidence that vaccines cause autism [[16]](https://pubmed.ncbi.nlm.nih.gov/20385903/).

Meanwhile, **no subsequent peer-reviewed studies have confirmed any link between vaccines and autism**. In fact, numerous large, well-controlled epidemiological studies from around the world have consistently found no association between vaccination (including MMR and thimerosal-containing vaccines) and autism [[3]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367).

Hundreds of peer-reviewed studies have found **no link** between vaccines and autism. The scientific literature is extensive and includes multiple systematic reviews, meta-analyses, and large-scale epidemiological studies that collectively represent dozens of individual studies [[3]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367) [[4]](https://pubmed.ncbi.nlm.nih.gov/30831578/) [[6]](https://www.ncbi.nlm.nih.gov/books/NBK25344/) [[7]](https://jamanetwork.com/journals/jama-health-forum/fullarticle/2830561) [[8]](https://www.cdc.gov/vaccine-safety/about/thimerosal.html?CDC_AAref_Val=https://www.cdc.gov/vaccinesafety/concerns/thimerosal/index.html). The scientific consensus is based on this large and growing body of evidence.

## Conclusion

**Decades of research involving millions of children have found no link between vaccines and autism**. Vaccines remain a safe and essential part of protecting children’s health. Addressing concerns with empathy and providing accurate information is crucial to supporting families and maintaining public trust in vaccination.

**Unvaccinated children are dying of measles in America, in 2025, and measles isn’t the only vaccine-preventable disease that kills kids. Please don’t make a deadly mistake based on 25-year-old (mis)information.**

Now that all the nonsense about vaccines is out of the way, let’s look at how to prevent autism.

# Chapter 3. Preventing autism begins in pregnancy.

Autism spectrum disorder (ASD) is influenced by both genetic and environmental factors, but research shows that certain interventions during pregnancy and early life can reduce risk or severity. This chapter reviews the evidence for preventive strategies, with a focus on probiotics, prebiotics, and vitamin D supplementation.

**The Landmark Finnish Probiotic Study**

One of the most persuasive studies on autism prevention is the 2015 randomized controlled trial by Anna Pärtty and colleagues, published in *Pediatric Research in 2015* [[1]](https://www.nature.com/articles/pr201551). This Finnish study followed 75 children for 13 years. Mothers received either the probiotic *Lactobacillus rhamnosus* GG (LGG) or a placebo daily during the last four weeks of pregnancy, and continued for six months after delivery if they were breastfeeding. If the mother was not breastfeeding, the baby received the probiotic or placebo during the first six months of life.

**The results were stunning.**

**None of the children in the probiotic group developed autism or ADHD by age 13, while 17.1% (6 out of 35) of those in the placebo group did.**

The *p*-value (statistical probability value) for this difference was 0.008, meaning there is less than a 1% probability that this result was due to chance, making the findings highly persuasive [[1]](https://www.nature.com/articles/pr201551).

Please note that when the study began (2000–2001), the diagnosis of “autism” as we know it today did not exist in the same form; instead, “Asperger’s syndrome” was used, which is now recognized as part of the autism spectrum under current diagnostic guidelines.

**Key Findings and Statistical Significance**

The study reported:

* 0% neuropsychiatric diagnoses (ADHD/Asperger’s/autism) in the probiotic group (0/40 children) vs. 17.1% in placebo (6/35 children)
* *p* = 0.008 for diagnosis rate difference
* *p* = 0.03 for lower *Bifidobacterium* levels in affected children

The *p*-value of 0.008 indicates a 0.8% probability that this 17.1% difference occurred by random chance. In statistical terms:  
*p* < 0.01 means ≤1% likelihood of false positive  
*p* < 0.001 means ≤0.1% likelihood

The *p*= 0.008 value demonstrates strong statistical significance, particularly given:

* Complete absence of cases in the intervention group
* Biological plausibility via the gut-brain axis
* Dose-response relationship in microbiota differences.

**Diagnostic Context**

When this study began in 2000-2001, diagnostic criteria used:

* ICD-10 for Asperger syndrome (AS)
* DSM-IV (1994-2013) which classified AS separately from autism.

The 2013 DSM-5 revision:

* Folded Asperger’s into autism spectrum disorder (ASD)
* Eliminated separate PDD categories.

Current diagnoses would classify these cases as ASD Level 1. [[2]](https://www.mghclaycenter.org/parenting-concerns/families/dsm-5-what-happened-to-aspergers/)

**Mechanistic Insights**

The *Lactobacillus rhamnosus* GG (LGG) intervention showed:

* No significant microbiota composition changes
* Potential effects via:
  + Vagus nerve signaling
  + Gut barrier stabilization
  + GABA receptor modulation

**Limitations**

* Original power calculation for atopic eczema, not neurodevelopment
* Small sample size (n=75)
* Male-only affected cases.

It’s important to note that the 17% rate of neuropsychiatric diagnosis in the placebo group is much higher than the estimated 3.2% rate in the U.S. This may be due to the study’s unusually long follow-up period (13–14 years), which allowed for the detection of cases that might otherwise go undiagnosed, especially those with symptoms that develop later in childhood or are misinterpreted as behavioral rather than neurological.

In many settings, ASD is typically diagnosed much earlier, often between ages 1 and 5, and later-onset symptoms may be overlooked or classified differently.

The study found that affected children had lower levels of *Bifidobacterium* in their gut microbiota, suggesting a possible link between early gut health and neurodevelopment. While the probiotic intervention did not produce major changes in overall microbiota composition, it may have exerted its effects through subtle modulation of gut-brain signaling, immune function, or gut barrier integrity.

From a medical perspective, this study provides compelling evidence that early probiotic intervention can have a profound preventive effect on the development of neuropsychiatric disorders now classified as ASD. While the sample size was modest, **the complete absence of cases in the probiotic group and the strong statistical significance** makes this study a cornerstone in the field of autism prevention research.

**Probiotics, prebiotics, and synbiotics in human and animal studies**

Further supporting evidence from animal studies shows that modifying the maternal microbiome via diet or probiotics can prevent autism-like neurodevelopmental disorders in offspring. For example, University of Virginia researchers found that restoring a healthy maternal microbiome or blocking the inflammatory molecule IL-17a prevented autism-like symptoms in mice [[3]](https://pmc.ncbi.nlm.nih.gov/articles/PMC11817528/). These findings suggest that **maternal gut health is a modifiable risk factor for ASD** and that interventions targeting the microbiome during pregnancy can be protective.

Clinical trials and meta-analyses in humans have examined the effects of probiotic and prebiotic supplementation in children with ASD. Several randomized controlled trials report that probiotic supplementation improves gastrointestinal symptoms, communication skills, and maladaptive behaviors in children with autism [[4]](https://www.imrpress.com/journal/JIN/23/1/10.31083/j.jin2301020).

Some studies also found improvements in brain activity patterns associated with cognition and sensory processing [[5]](https://www.frontiersin.org/journals/psychiatry/articles/10.3389/fpsyt.2020.550593/full). Notably, a recent systematic review and meta-analysis concluded that probiotic interventions significantly improve behavioral symptoms in ASD, especially with multi-strain formulations and longer intervention periods [[6]](https://www.frontiersin.org/journals/behavioral-neuroscience/articles/10.3389/fnbeh.2022.859151/full). However, results are not identical in every study, and the magnitude of benefit varies depending on age, baseline gut symptoms, and intervention protocols.

Giving probiotics to children with autism can help with stomach and GI problems, and may also improve their behavior and communication. The benefits seem stronger if the probiotics are given for several months and include more than one type of bacteria.

In scientific terms, probiotic supplementation in ASD patients is associated with statistically significant improvements in behavioral symptoms, as indicated by pooled standardized mean differences in meta-analyses. Subgroup analyses reveal enhanced efficacy in European cohorts, interventions exceeding three months, and both single- and multi-strain preparations. While some studies report no significant effect on core ASD symptoms, improvements in gastrointestinal function, adaptive behavior, and EEG biomarkers have been observed, suggesting a multifaceted role for probiotics in ASD management.

**Vitamin D and Multivitamin Supplementation**

Vitamin D deficiency during pregnancy and early childhood is increasingly recognized as a risk factor for ASD. Multiple studies have shown that higher maternal vitamin D levels are associated with reduced risk of ASD and improved neurodevelopmental outcomes [[7]](https://drkofinas.com/environmental-chemicals-nutrition-and-autism-spectrum-disorder-an-update/). **Supplementation with vitamin D during pregnancy and infancy has been linked to a significant reduction in the expected incidence of autism, particularly in families with a previous autistic child** [[8]](https://news.virginia.edu/content/autism-risk-determined-health-moms-gut-uva-research-reveals#:~:text=Autism%20Risk%20Determined%20by%20Health%20of%20Mom's%20Gut%2C%20UVA%20Research%20Reveals,-By%20Josh%20Barney&text=The%20risk%20of%20developing,Virginia%20School%20of%20Medicine%20sugge). For example, one study found that vitamin D supplementation reduced the recurrence risk from 20% to 5%.

Note that this is with vitamin D only, and not including probiotics,

Additional research indicates that vitamin D supplementation improves core symptoms of autism in diagnosed children, with about 75% showing benefit in open-label and randomized controlled trials [[9]](https://www.autismspeaks.org/expert-opinion/new-findings-probiotics-autism). Multivitamin supplementation, including vitamin D and folic acid, during pregnancy is also associated with lower ASD risk and milder symptoms in affected children [[10]](https://www.sciencedirect.com/science/article/abs/pii/S0022395624005314). (Also not including probiotics).

Making sure pregnant women and young children get enough vitamin D from sunlight, food, or supplements, can lower the chance that a child will develop autism. If a child already has autism, vitamin D supplements can help improve their symptoms in many cases. Taking a prenatal multivitamin that includes vitamin D and folic acid is also linked to a lower risk of autism.

In medical terms, prenatal and early childhood vitamin D supplementation is associated with reduced ASD incidence in high-risk populations and improved core ASD symptoms, as demonstrated in both observational and interventional studies. Vitamin D’s neurosteroid and immunomodulatory properties likely mediate these effects, supporting its role as a preventive and adjunctive therapeutic agent in ASD.

Multivitamin supplementation further moderates ASD risk and symptom severity, underscoring the importance of addressing micronutrient deficiencies in perinatal care [[11]](https://pubmed.ncbi.nlm.nih.gov/28217829/).

# Chapter 4. Your gut microbiome is your second brain

Your gut microbiome is a massive community of microscopic living things inside your digestive system. Most of these organisms live in your large intestine, also called the colon, which is about 5 feet/1.5 meters long [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

**Your gut microbiome includes**:

* **Bacteria** (the most common)
* **Fungi** (like yeast)
* **Viruses**
* **Archaea** (microbes similar to bacteria)
* **Other tiny organisms** [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml) .

There are about **100 trillion** microbiome cells in your gut. That’s at least as many, or even more, than the total number of human cells in your entire body [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

There are around **1,000 different species** of microflora in your gut [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

The total mass of all these microbes is about **1–2 kilograms** (2.2–4.4 pounds, or 35–70 ounces) [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

**Your gut is like a busy chemical factory**. Here are some key processes:

* **Digestion:** Microbes help break down food, especially fibers we can’t digest ourselves [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).
* **Fermentation:** They turn undigested food into short-chain fatty acids, which feed our gut cells and help reduce inflammation [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).
* **Vitamin Production:** Some bacteria make vitamins, like vitamin K and some B vitamins [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).
* **Immune Support:** The microbiome “trains” your immune system to recognize good and bad invaders [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).
* **Toxin Breakdown:** Microbes help neutralize some harmful substances [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

Most of these processes happen within **hours to a day** after you eat [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

**Your Microbiome Is Unique**

Every person’s microbiome is different, like a fingerprint. The mix and amounts of microbes depend on your genes, diet, environment, age, and even where you live [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

**Good Guys and Bad Guys**

Some species of microbes are very good for you, such as:

* ***Lactobacillus*:** Helps digest food, fights bad bacteria, and supports the immune system [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).
* ***Bifidobacterium*:** Helps digest fiber and keeps the gut lining healthy [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

But there are also bad microbes that can cause trouble, for example:

* ***Clostridium difficile*:** Can cause severe diarrhea and gut inflammation [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).
* ***Escherichia coli*** (*E. Coli*): Some strains can cause food poisoning [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

**Leaky gut** is a problem where the gut lining becomes “leaky,” letting toxins and bacteria slip into the bloodstream. This can cause inflammation and other health issues [[2]](https://gut.bmj.com/content/73/11/1893).

**What Changes the Microbiome?**

Your microbiome can change over time. Things that affect it include:

* **Diet** (what you eat)
* **Medications**, especially **antibiotics**, which can kill good bacteria and let bad ones take over
* **Stress**
* **Illness**
* **Aging**
* **Travel** (new foods and environments) [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).

**The Gut–Brain Connection**

Your gut and brain are in constant communication. The main communication pipeline is the **vagus nerve**, which sends messages back and forth between your gut and your brain. Besides physical symptoms, your gut can affect your mood, feelings, and even how you think [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2023.1225875/full) [[4]](https://www.npr.org/sections/shots-health-news/2024/06/24/nx-s1-5018044/gut-microbiome-microbes-mental-health-stress).

**Signs and Symptoms of Dysbiosis**

Most people’s microbiomes need attention. With our modern diets, medications, stress and generally crazy lives, it would be a miracle if your gut microbiome were optimal. Here’s a broad range of symptoms that you might not realize can mean your gut microbiome needs help.

**Physical and gastrointestinal/digestive issues:**

* + Diarrhea
  + Constipation
  + Gas
  + Bloating
  + Leaky gut (increased intestinal permeability)
* **Skin symptoms:**
  + Acne
  + Itching
  + Dryness
  + Rash or redness
  + Conditions such as eczema, psoriasis, atopic dermatitis, and rosacea
* **Vaginal/urogenital symptoms:**
  + Vaginal itching
  + Vaginal discharge
  + Rectal itching
  + Difficulty urinating
* **Other symptoms:**
  + Fatigue
  + Bad breath (halitosis)
  + Upset stomach or nausea
  + Food intolerances or sensitivities
  + Mood changes (anxiety, depression)
  + Problems with memory or concentration

**Beyond Physical Symptoms: The Microbiome’s Broader Influence**

Besides the physical symptoms, your microbiome influences your:

* **Mood and emotions** (like anxiety and depression) [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2023.1225875/full) [[4]](https://www.npr.org/sections/shots-health-news/2024/06/24/nx-s1-5018044/gut-microbiome-microbes-mental-health-stress).
* **Stress levels** [[4]](https://www.npr.org/sections/shots-health-news/2024/06/24/nx-s1-5018044/gut-microbiome-microbes-mental-health-stress)
* **Sleep quality** [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml)
* **Appetite and cravings** [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml)
* **Energy levels** [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml)
* **Immune responses** [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml)
* **Brain development and function** [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml)
* **Behavioral and cognitive health** (including attention, social behavior, and learning)

**Links to ASD, ADHD, and Other Conditions**

People with **Autism Spectrum Disorder (ASD)** often have very different gut microbiome mixtures from those of people without ASD. However, the microbiomes of people with ASD are remarkably similar to each other. They may have fewer helpful bacteria like *Bifidobacterium* and more harmful ones. The following symptoms of ASD are directly connected to the gut microbiome:

1. **Gastrointestinal (GI) Issues (Constipation, Diarrhea, Abdominal Pain)**
   * *Connection:* Microbiome imbalance (dysbiosis) is strongly linked to GI symptoms in ASD, including chronic constipation, diarrhea, and abdominal pain. [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/)
2. **Leaky Gut (Intestinal Permeability)**
   * *Connection****:***Dysbiosis can lead to leaky gut, allowing toxins to enter the bloodstream and potentially worsen ASD symptoms [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/).
3. **Irritability and Aggression**
   * *Connection:* Gut microbiome composition influences neurotransmitter balance and inflammation, which can affect mood and behavior [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/).
4. **Sleep Disturbances**
   * *Connection:* The gut-brain axis affects sleep regulation; microbiome imbalance is associated with poor sleep quality in ASD [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/)**.**
5. **Difficulty Focusing and Attention Problems**
   * *Connection:* Microbiome alterations may contribute to inattention and focus issues, which often overlap with ADHD symptoms in ASD [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/).
6. **Repetitive Behaviors**
   * *Connection:* Animal and human studies suggest microbiome modulation can reduce repetitive behaviors via the gut-brain axis [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/).
7. **Anxiety and Depression**
   * *Connection:* Dysbiosis is linked to increased risk and severity of anxiety and depression in ASD. [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/)
8. **Hyperactivity**
   * *Connection:* Microbiome interventions have been shown to reduce hyperactivity in some children with ASD. [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/)
9. **Sensory Processing Differences**
   * *Connection:* Gut microbiome composition may influence sensory sensitivities, though research in this area is emerging. [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/)
10. **Social Communication Difficulties**
    * *Connection:* Microbiome-based therapies have been associated with improvements in social interaction and communication in some studies. [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/)

**Other neurological and chronic conditions also show links to the microbiome:**

* **ADHD:** Changes in gut bacteria may affect attention and behavior [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).
* **Multiple Sclerosis (MS):** Certain bacteria may trigger or worsen immune attacks on nerves [[1]](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml).
* **Parkinson’s Disease:** Changes in gut bacteria can affect movement and mood, and may even play a role in the disease starting [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2023.1225875/full) [[5]](https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2024.1365554/full).
* **Alzheimer’s Disease (AD):** Altered gut bacteria may drive inflammation and neurodegeneration. [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2023.1225875/full) [[6]](https://pmc.ncbi.nlm.nih.gov/articles/PMC6960010/) [[7]](https://www.thelancet.com/journals/laneur/article/PIIS1474-4422(19)30356-4/abstract) [[8]](https://www.frontiersin.org/journals/aging-neuroscience/articles/10.3389/fnagi.2023.1145241/full) [[9].](https://pmc.ncbi.nlm.nih.gov/articles/PMC11588320/)
* **Depression and Anxiety:** Imbalances in the microbiome are linked to increased risk and severity [[4]](https://www.npr.org/sections/shots-health-news/2024/06/24/nx-s1-5018044/gut-microbiome-microbes-mental-health-stress).
* **Myasthenia Gravis:** Gut changes are associated with disease activity [[10]](https://journals.lww.com/cmj/fulltext/2023/06050/gut_microbiota__a_new_insight_into_neurological.1.aspx).
* **Autoimmune Diseases** (like rheumatoid arthritis, lupus, type 1 diabetes): Gut microbes can influence immune system balance and disease risk [[5]](https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2024.1365554/full).
* **Inflammatory Bowel Disease (IBD):** Dysbiosis is a hallmark of Crohn’s disease and ulcerative colitis [[2].](https://pubmed.ncbi.nlm.nih.gov/30634578/)
* **Chronic Kidney Disease (CKD):** Gut changes can worsen inflammation and toxin buildup [[2]](https://pubmed.ncbi.nlm.nih.gov/30634578/).
* **Non-Alcoholic Fatty Liver Disease (NAFLD):** Altered microbiota can increase gut leakiness and liver damage [[2]](https://pubmed.ncbi.nlm.nih.gov/30634578/).

**Summary**

Although everyone’s gut microbiome is unique, people with conditions like ASD often share similar patterns, lacking some good bacteria and having too many bad ones. Many ASD symptoms can be improved by administration of common probiotics [[11]](https://pubmed.ncbi.nlm.nih.gov/30823414/). And, as we will see in the next chapter, **these same probiotics play a key role in preventing autism**.

# Chapter 5. Taking control of your microbiome (and your baby’s) is the key to preventing autism

**Science shows that by managing the microbiome of the mother in the last months of pregnancy, and of the baby in the first months of life, we can prevent autism.** **It’s easy when you know what to do.**

Preventing autism begins in pregnancy. If you are pregnant, you **must** balance and optimize the mix of microbiota in your gut microbiome **immediately.** **Your baby’s gut microbiome comes from you** so you are balancing the baby’s microbiome, too. **This is critical to prevent autism**.

Note that, pregnant or not, you can optimize your microbiome by diet combined with inexpensive vitamins and natural probiotics, and you will feel the improvements within 30 – 60 days. You can often start to feel results in only a week.

A healthy microbiome, a condition called **eubiosis,** is a diverse and balanced community of microorganisms, where beneficial and potentially harmful species coexist in equilibrium. This balanced state supports digestion, immune function, and overall well-being [[1]](https://www.nature.com/articles/nrg3182).

When this balance is disrupted—meaning there are too few beneficial microbes and/or an overgrowth of harmful ones—the condition is called **dysbiosis** [[1]](https://www.nature.com/articles/nrg3182). Dysbiosis can impair the microbiome’s normal functions and is linked to a range of health problems, including increased susceptibility to infections, inflammation, and chronic diseases [[2]](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2025.1559521/full).

**Science has shown that the microbiome is dynamic and can be modulated (changed or rebalanced) by various factors** [[3]](https://pmc.ncbi.nlm.nih.gov/articles/PMC10816208/). This modulation can lead either to improved health (restoring eubiosis) or to dysbiosis, depending on the nature of the changes [[3]](https://pmc.ncbi.nlm.nih.gov/articles/PMC10816208/).

**There are several well-established ways to modulate the microbiome:**

* **Diet:** Eating a diverse range of plant-based foods, rich in fiber and polyphenols, encourages the growth of beneficial bacteria. Diets high in ultra-processed foods, sugar, and unhealthy fats can promote dysbiosis [[4]](https://pmc.ncbi.nlm.nih.gov/articles/PMC3957428/).
* **Prebiotics:** These are dietary fibers and compounds (like inulin) that nourish existing beneficial microbes. Common sources include fruits, vegetables, and whole grains [[5]](https://pmc.ncbi.nlm.nih.gov/articles/PMC6463098/).
* **Probiotics:** Live beneficial microbes (such as those found in probiotic capsules, as well as in yogurt, kefir, and fermented foods) help “seed” the gut with health-promoting bacteria [[6]](https://www.longdom.org/open-access-pdfs/probiotics-mechanisms-of-action-and-clinical-applications-2329-8901.1000101.pdf).
* **Fecal Microbiota Transplantation (FMT):** In extreme cases, transferring microbiota from a healthy donor can restore balance, especially after antibiotic-induced dysbiosis [[7]](https://www.mountsinai.org/care/gastroenterology/services/fecal-microbial-transplant).
* **Antibiotics:** While sometimes necessary, antibiotics can disrupt the microbiome by killing both harmful and beneficial bacteria, often leading to dysbiosis [[8]](https://pmc.ncbi.nlm.nih.gov/articles/PMC10536327/). The recovery period for the microbiome after antibiotics varies; some bacterial groups may take weeks, months, or even years to return to their previous state, and some may never fully recover [[8]](https://pmc.ncbi.nlm.nih.gov/articles/PMC10536327/).
* **Other factors:** Birth mode, environmental exposures, and medications also play significant roles in shaping the microbiome [[9]](https://pubmed.ncbi.nlm.nih.gov/32464473/).

**Science shows that by managing the microbiome of the mother in the last months of pregnancy, and of the baby in the first months of life, we can prevent autism.**

In children and adults who already have ASD, many symptoms and behavioral problems can be greatly improved simply by nurturing the microbiome with prebiotics, probiotics, and vitamin D, as I will explain and document in a separate chapter at the end of this book.

First, let’s look at how a baby gets a microbiome to begin with.

A baby’s initial microbiome is primarily acquired from the mother. During a vaginal birth, the baby is “seeded” with the mother’s vaginal and gut microbiota when passing through the birth canal [[10]](https://pmc.ncbi.nlm.nih.gov/articles/PMC8733716/). This early exposure is crucial for establishing a healthy, diverse microbiome and has long-term health benefits.

In contrast, babies delivered by Caesarean section miss out on this exposure and instead acquire microbes from the skin and hospital environment, which leads to lower microbial diversity and delayed maturation of the gut microbiome [[11]](https://pubmed.ncbi.nlm.nih.gov/39640900/). This difference in early colonization is associated with increased risks of health issues such as asthma, obesity, and immune disorders [[11]](https://pubmed.ncbi.nlm.nih.gov/39640900/).

However, breastfeeding also plays a critical role in establishing and nurturing the infant’s microbiome, as breast milk contains beneficial bacteria that are transferred directly from mother to baby, further supporting the development of a healthy gut microbiome. Direct breastfeeding enhances this microbial transfer, and the process is associated with improved immune and metabolic outcomes for the infant [[12]](https://pubmed.ncbi.nlm.nih.gov/32652062/).

Sometimes, antibiotics are given to mothers during labor—most commonly to prevent Group B Streptococcus (GBS) infection in the newborn. These antibiotics can alter both the mother’s and the baby’s microbiome, reducing beneficial bacteria and increasing the risk of dysbiosis in the infant [[13]](https://karger.com/neo/article-abstract/119/1/93/828788/Maternal-Intrapartum-Antibiotic-Treatment-and-Gut?redirectedFrom=fulltext). The effect of maternal antibiotics can persist for months in the infant’s microbiome, especially if breastfeeding is not exclusive or prolonged [[13]](https://pmc.ncbi.nlm.nih.gov/articles/PMC10688785/). Additionally, if the mother takes antibiotics while breastfeeding, this can further influence the infant’s microbiome, though the impact may be less pronounced than direct peripartum exposure [[14]](https://pmc.ncbi.nlm.nih.gov/articles/PMC10763576/).

Once antibiotics are introduced—whether to the mother during pregnancy, at delivery, or directly to the baby—the time required for the microbiome to recover or re-establish equilibrium can vary widely. Some microbial populations may rebound within weeks or months, while others may take years or may never fully return to their original state [[15]](https://www.frontiersin.org/journals/cellular-and-infection-microbiology/articles/10.3389/fcimb.2020.572912/full). This prolonged or incomplete recovery increases the risk of persistent dysbiosis [[15]](https://www.frontiersin.org/journals/cellular-and-infection-microbiology/articles/10.3389/fcimb.2020.572912/full).

Even more significantly, **evidence shows that simply giving common probiotics to mom during pregnancy and breastfeeding, or, if not breastfeeding, to baby for six months, can avoid these problems** [[16]](https://internationalprobiotics.org/home/probiotics-neurodevelopment-in-preterm-infants/).

It is quite common for babies to be prescribed antibiotics for ear infections or other reasons. Antibiotics kill certain bad strains that cause the infection, but also can cause dysbiosis by killing beneficial strains of microflora [[17]](https://academic.oup.com/femsre/article/42/4/489/5045017). This damage to the microbiome can be repaired by probiotics and vitamin D.

**Evidence shows that when the child has a healthy gut microbiome from the start, and maintains it, autism will not happen** [[18]](https://academic.oup.com/femsre/article/42/4/489/5045017).

Dysbiosis in infancy is linked to increased risk of autism spectrum disorder (ASD). Research shows that disruptions in the mother’s or infant’s microbiome, particularly in the critical perinatal period, can influence neurodevelopment and may contribute to the development of ASD [[19]](https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1395664/full). Conversely, interventions that nurture the microbiome such as prebiotics, probiotics, and vitamin D, show promise not only in preventing ASD but also improving ASD symptoms and behaviors in children with ASD [[19]](https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1395664/full).

We will look at the evidence for these statements in the next chapters. However, it is clear that establishing and maintaining a healthy microbiome in both mother and child are foundational for optimal neurodevelopment and lifelong health in general.

# Chapter 6. The critical role of Vitamin D in your gut

Normally “vitamin D” refers to vitamin D3 unless otherwise specified. Vitamin D3 (cholecalciferol) is generally more effective than Vitamin D2 (ergocalciferol) at raising and maintaining serum 25-hydroxyvitamin D [25(OH)D] levels, which is what is measured in blood tests.

Vitamin D3 is the most absorbable and most commonly used form of vitamin D.

Vitamin D is increasingly recognized for its impact on neurodevelopment. Research suggests prenatal and postnatal vitamin D deficiency may increase the risk of autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD), while supplementation can help prevent these conditions and improve symptoms in those already diagnosed [[1]](https://pmc.ncbi.nlm.nih.gov/articles/PMC8752030/).

Low maternal vitamin D levels during pregnancy have been linked to a higher risk of ASD and ADHD in children [[1]](https://pmc.ncbi.nlm.nih.gov/articles/PMC8752030/).

Higher maternal vitamin D levels are linked to fewer ASD and ADHD symptoms in children [[2]](https://journals.sagepub.com/doi/full/10.1177/1721727X231161013). Vitamin D supplementation during pregnancy and early childhood can reduce autism recurrence in high-risk families where a sibling has autism [[3]](https://www.frontiersin.org/journals/psychiatry/articles/10.3389/fpsyt.2019.00987/full).

Animal studies show prenatal vitamin D supplementation can prevent autism-like behaviors [[4]](https://www.dovepress.com/associations-between-vitamin-d-and-core-symptoms-in-asd-an-umbrella-re-peer-reviewed-fulltext-article-NDS). Children with ADHD often have lower vitamin D levels, and higher maternal vitamin D reduces behavioral problems [[2]](https://journals.sagepub.com/doi/full/10.1177/1721727X231161013).

Several clinical trials and meta-analyses have investigated the effect of vitamin D supplementation on ASD symptoms, with many reporting improvements, especially in those with deficiency [[5]](https://pubmed.ncbi.nlm.nih.gov/32893747/). Vitamin D may help the brain by supporting neurotransmitters, reducing inflammation, and protecting against oxidative stress [[6]](https://www.dovepress.com/associations-between-vitamin-d-and-core-symptoms-in-asd-an-umbrella-re-peer-reviewed-fulltext-article-NDS). Children with autism often have lower vitamin D, and more severe deficiency is linked to worse symptoms [[3]](https://www.frontiersin.org/journals/psychiatry/articles/10.3389/fpsyt.2019.00987/full). Not all studies agree—some found no benefit from vitamin D supplements, possibly due to differences in dosage, timing, or participant age [[7]](https://pubmed.ncbi.nlm.nih.gov/32893747/). However, most evidence shows benefits and none found harm.

Studies show that 2,000 IU per day of vitamin D3 is safe for pregnant women [[9]](https://pmc.ncbi.nlm.nih.gov/articles/PMC4855961/).

**This just in!** A major study published June 23, 2025 shows another benefit of vitamin D in pregnancy, and how what happens in pregnancy can affect a child’s brain development years later. Mother’s vitamin D levels during gestation strongly affected cognition scores of their children, tested at ages 7 – 12, with higher vitamin D levels making higher performance in the NIH Toolbox Cognition Battery. The study notes that this is especially important for Black women, as melanin (the pigment that gives skin its color) is a natural sunscreen, so Black people absorb less of “the sunshine vitamin” than others. Supplementation overcomes the difference [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0002916525003399?via%3Dihub).

# Chapter 7. Ultra-Processed Foods (UPFs) and autism

Ultra-processed foods (UPFs) are constantly in the news due to mounting evidence of their impact on health. UPFs can have various effects on the health of your gut microbiome and your baby’s, and none of those effects are good. Remember, if you are pregnant or nursing, your baby eats the same junk as you do.

UPFs are foods that have been heavily modified from their original form through industrial processing. They typically contain ingredients not found in home kitchens, such as artificial flavors, colors, preservatives, sweeteners, and emulsifiers [[1]](https://hsph.harvard.edu/news/ultra-processed-foods-some-more-than-others-linked-to-early-death/#:~:text=May%2015%2C%202024%E2%80%94High%20intake%20of%20ultra%2Dprocessed%20foods%E2%80%94particularly,published%20on%20May%208%20in%20The%20BMJ.). Examples include packaged snacks, sugary breakfast cereals, instant noodles, soft drinks, and many fast foods. These foods are designed for convenience, taste, and long shelf life, but they often lack important nutrients like fiber, vitamins, and minerals [[1]](https://hsph.harvard.edu/news/ultra-processed-foods-some-more-than-others-linked-to-early-death/#:~:text=May%2015%2C%202024%E2%80%94High%20intake%20of%20ultra%2Dprocessed%20foods%E2%80%94particularly,published%20on%20May%208%20in%20The%20BMJ.).

Recent headlines and scientific studies have linked high UPF consumption to a range of health problems, including obesity, diabetes, heart disease, and neurological issues such as depression and cognitive decline [[2]](https://www.totalcareaba.com/autism/does-processed-food-cause-autism). Scientists are also exploring how UPFs might affect brain development and mental health, especially in children. There is growing interest in whether eating a lot of UPFs could be connected to autism spectrum disorder (ASD) or other neurodevelopmental and psychiatric conditions.

Researchers are examining whether high intake of UPFs, especially during pregnancy or early childhood, might increase the risk of autism or exacerbate symptoms. Some studies suggest that mothers who consume more UPFs while pregnant may have children with more learning or behavioral problems [[5]](https://www.nature.com/articles/pr2007124) Other research shows that children with autism often have different gut bacteria, and UPFs may worsen this by disrupting the balance of microbes in the gut [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2018.00515/full). The gut-brain axis—a complex communication network between your gut and your brain—plays a key role in neurodevelopment, and disruptions here may contribute to autism symptoms [[7]](https://www.mdpi.com/2072-6643/11/3/521).

**One thing’s for sure: when you’re pregnant, you really are “eating for two.”**

You know there are better things for you and baby to eat, and it is simply not worth the risk to eat that junk when you’re pregnant or nursing.

From a medical and academic perspective, UPFs are defined by their high degree of processing and inclusion of additives, which can alter the nutritional profile and biological effects of food [[1]](https://hsph.harvard.edu/news/ultra-processed-foods-some-more-than-others-linked-to-early-death/#:~:text=May%2015%2C%202024%E2%80%94High%20intake%20of%20ultra%2Dprocessed%20foods%E2%80%94particularly,published%20on%20May%208%20in%20The%20BMJ.). Epidemiological studies have associated high UPF consumption with increased risk of metabolic and neuropsychiatric disorders [[2]](https://www.totalcareaba.com/autism/does-processed-food-cause-autism). UPFs can disrupt your gut microbiome, leading to dysbiosis—a condition common with ASD [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2018.00515/full) [[7]](https://www.mdpi.com/2072-6643/11/3/521).

Dysbiosis contributes to gastrointestinal (GI) symptoms common in autism, such as constipation, diarrhea, and abdominal pain [[4]](https://www.pedneur.com/article/S0887-8994(08)00351-2/abstract), and may also influence behavior and cognition through the gut-brain axis [[7].](https://www.mdpi.com/2072-6643/11/3/521)

There is evidence that prenatal exposure to UPFs, particularly diets high in saturated fats and sugars, can negatively affect fetal brain development [[5]](https://www.nature.com/articles/pr2007124). Such diets may act as epigenetic modifiers, influencing gene expression related to neurodevelopment and increasing susceptibility to ASD and other disorders [[5]](https://www.nature.com/articles/pr2007124). Additionally, UPFs may increase exposure to neurotoxic substances like heavy metals and pesticides, which are linked to impaired detoxification pathways in some children with autism [[6]](https://www.news-medical.net/news/20240209/Nutritional-epigenetics-education-reduces-ultra-processed-food-intake-in-parents-of-children-with-autism-and-ADHD.aspx). Heavy metals and certain food additives found in UPFs can suppress genes like MT (metallothionein) and PON1 (paraoxonase), which are important for detoxification and neuroprotection. Deficits in these pathways may increase susceptibility to autism and ADHD [[6]](https://www.news-medical.net/news/20240209/Nutritional-epigenetics-education-reduces-ultra-processed-food-intake-in-parents-of-children-with-autism-and-ADHD.aspx).

UPFs are also linked to dysbiosis (an imbalance of the gut microbiome), a condition frequently observed in children with autism [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2018.00515/full) [[7]](https://www.mdpi.com/2072-6643/11/3/521). Additives, artificial sweeteners, and lack of dietary fiber in UPFs can disrupt gut health, which in turn may affect brain function and behavior [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2018.00515/full) [[2]](https://www.totalcareaba.com/autism/does-processed-food-cause-autism). Children with autism often show higher levels of heavy metals such as mercury and lead, which can be exacerbated by UPF consumption due to both increased exposure and impaired detoxification mechanisms (e.g., zinc deficiency affecting MT gene function), UPFs may also increase exposure to neurotoxic pesticide residues, further elevating risk [[6]](https://www.news-medical.net/news/20240209/Nutritional-epigenetics-education-reduces-ultra-processed-food-intake-in-parents-of-children-with-autism-and-ADHD.aspx).

Symptoms associated with UPF consumption in the context of autism include not only GI issues but also increased anxiety, depression, and poor mood regulation [[2]](https://www.totalcareaba.com/autism/does-processed-food-cause-autism). High UPF intake is associated with a broad range of mental health issues, including anxiety, depression, poor mood regulation, and sleep problems—conditions that frequently co-occur with autism². Controlled trials show that reducing UPF intake can improve mood and emotional regulation, suggesting a possible benefit for children with ASD [[2]](https://www.totalcareaba.com/autism/does-processed-food-cause-autism).

There is emerging research on whether the negative effects of UPFs on the gut microbiome can be offset by probiotics or other interventions. While some studies suggest that probiotics may help restore microbial balance and improve GI and behavioral symptoms in ASD, the evidence is still preliminary, and more research is needed to determine the best strategies for mitigating the impact of UPFs. Meanwhile, if you don’t eat UPFs they can’t bother you.

Changing eating habits in children with ASD can be challenging due to sensory sensitivities and food preferences. However, educational interventions for parents have been shown to successfully reduce UPF intake and improve overall diet quality in this population [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2018.00515/full).

**Summary Table: Key Mechanisms Linking UPFs and Autism**

|  |  |  |
| --- | --- | --- |
| **Mechanism** | **UPF Effect** | **Relevance to Autism** |
| Epigenetic gene suppression | Heavy metals, additives suppress MT/PON1 genes | Increased susceptibility |
| Gut microbiome disruption | Additives, low fiber disrupt gut bacteria | Common in ASD, affects behavior |
| Nutrient deficiencies | Low in zinc, omega-3s, vitamins, minerals | Essential for brain development |
| Increased toxic exposures | Higher intake of heavy metals, pesticides | Linked to neurodevelopmental risk |
| Mental health impact | Associated with anxiety, depression, poor mood regulation | Co-occurring in ASD |

Current evidence suggests a potential link between high UPF intake—especially during pregnancy—and increased risk of autism and related neurodevelopmental disorders [[5]](https://www.nature.com/articles/pr2007124) [[6]](https://www.news-medical.net/news/20240209/Nutritional-epigenetics-education-reduces-ultra-processed-food-intake-in-parents-of-children-with-autism-and-ADHD.aspx). Mechanisms include epigenetic changes, gut microbiome disruption, nutrient deficiencies, and increased exposure to neurotoxic substances [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2018.00515/full) [[5]](https://www.nature.com/articles/pr2007124) [[6]](https://www.news-medical.net/news/20240209/Nutritional-epigenetics-education-reduces-ultra-processed-food-intake-in-parents-of-children-with-autism-and-ADHD.aspx) [[7]](https://www.mdpi.com/2072-6643/11/3/521). While more research is needed to establish causality, reducing UPF consumption and promoting whole-food diets may provide invaluable benefits for neurodevelopment and overall mental health, particularly in children at risk for or diagnosed with autism [[2]](https://www.totalcareaba.com/autism/does-processed-food-cause-autism) [[3]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2018.00515/full) [[4]](https://www.pedneur.com/article/S0887-8994(08)00351-2/abstract) [[7]](https://www.mdpi.com/2072-6643/11/3/521).

# Chapter 8. Microbiome profiles in autism and other neurological disorders

Recent advances in microbiome research have revealed distinct bacterial profiles associated with various neurological disorders. A microbiome profile shows which varieties of microflora are present in what relative quantities. Autism spectrum disorder (ASD) profiles are particularly robust and reproducible patterns. In a pattern unique to ASD, they are deficient in some important good bacteria and have too many of some bad ones.

Studies utilizing machine learning approaches have identified bacterial taxa capable of predicting ASD status with over 80% accuracy across multiple independent cohorts, suggesting that microbiome composition may serve as both a biomarker and potential therapeutic target. The emerging field of microbiome profiling has expanded beyond ASD to encompass attention-deficit/hyperactivity disorder (ADHD), multiple sclerosis, Parkinson's disease, and other neurological conditions, each demonstrating unique microbial signatures that correlate with disease severity and symptom manifestation. This convergence of neuroscience and microbiome research has spawned a rapidly growing direct-to-consumer testing industry, offering various analytical approaches from basic 16S rRNA sequencing to comprehensive shotgun metagenomic analysis.

## Autism Spectrum Disorder: The Most Characterized Microbiome Profile

Autism spectrum disorder represents the most extensively studied neurological condition in microbiome research, with consistent findings across multiple populations and geographic regions. A landmark study utilizing recursive ensemble feature selection (REFS) identified 26 bacterial taxa that discriminate ASD cases from controls with remarkable precision[[1]](https://pubmed.ncbi.nlm.nih.gov/32238191/). The analysis demonstrated average area under the curve (AUC) values of 81.6% in sibling-controlled datasets and maintained predictive accuracy of 74.8% and 74% respectively when validated across two independent cohorts [[1]](https://pubmed.ncbi.nlm.nih.gov/32238191/). This level of reproducibility is unprecedented in microbiome research and suggests that the microbial alterations in ASD may represent fundamental aspects of the disorder's pathophysiology.

The microbiome profile associated with ASD is characterized by specific patterns of bacterial abundance that distinguish affected individuals from neurotypical controls. Research has consistently identified increased levels of several pathogenic bacteria, including some strains of *Clostridium*, *Dorea*, *Bilophila*, and *Lactobacillus*, alongside decreased abundance of beneficial bacteria such as *Blautia*[[2]](https://www.frontiersin.org/journals/psychiatry/articles/10.3389/fpsyt.2019.00473/full). These alterations appear in clinical test populations and in preclinical mouse models of autism, providing strong evidence they are biologically relevant[[2]](https://www.frontiersin.org/journals/psychiatry/articles/10.3389/fpsyt.2019.00473/full).

Chinese cohort studies have revealed additional bacterial biomarkers specific to ASD children, including significant increases in *Enhydrobacter*, *Chryseobacterium*, *Streptococcus*, and *Acinetobacter* at the genus level, as well as *Acinetobacter rhizosphaerae* and *Acinetobacter johnsonii* at the species level[[3]](https://www.cell.com/neuron/fulltext/S0896-6273(18)31009-2?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0896627318310092%3Fshowall%3Dtrue). Conversely, these studies documented significant reductions in *Prevotella melaninogenica*[[3]](https://www.cell.com/neuron/fulltext/S0896-6273(18)31009-2?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0896627318310092%3Fshowall%3Dtrue). The discriminatory power of these biomarkers proved remarkable, suggesting their potential utility in early diagnosis and risk assessment.

## Mother-Child Microbiome Correlations in ASD

One of the most intriguing findings in ASD microbiome research involves the relationship between maternal and child gut bacteria. Studies examining 59 mother-child pairs with ASD and 30 matched control pairs found clear correlations between gut microbiome profiles of children and their mothers[[3]](https://www.cell.com/neuron/fulltext/S0896-6273(18)31009-2?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0896627318310092%3Fshowall%3Dtrue). However, children with ASD maintained unique bacterial biomarkers that distinguished them from their mothers, including increased levels of *Alcaligenaceae*, *Enterobacteriaceae*, and *Clostridium*[[3]](https://www.cell.com/neuron/fulltext/S0896-6273(18)31009-2?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0896627318310092%3Fshowall%3Dtrue).

Mothers of ASD children exhibited their own distinct microbial signatures, characterized by increased Proteobacteria, Alphaproteobacteria, *Moraxellaceae*, and *Acinetobacter* compared to mothers of neurotypical children[[3]](https://www.cell.com/neuron/fulltext/S0896-6273(18)31009-2?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0896627318310092%3Fshowall%3Dtrue). These maternal differences may reflect underlying immune or metabolic variations that contribute to ASD risk in offspring, though the precise mechanisms remain under investigation. In any case, as we have seen, the mother’s microbiome is linked to that of her newborn.

## ADHD and Microbiome Variability

Attention-deficit/hyperactivity disorder presents a more complex microbiome profile compared to ASD, with studies showing both similarities and contradictions in bacterial patterns. Children with unmedicated ADHD exhibit distinct gut microbiota profiles characterized by lower levels of *Tyzzerella*, *Prevotellaceae*, and *Coriobacteriaceae* compared to healthy controls[[4]](https://www.nature.com/articles/s41598-025-87546-y). These alterations correlate with symptom severity, with propionic acid levels showing negative associations with ADHD symptoms, suggesting potential biomarker applications [[4]](https://www.nature.com/articles/s41598-025-87546-y).

The impact of psychostimulant medications on the ADHD microbiome adds another layer of complexity to this research area. Medicated ADHD children demonstrate lower gut microbial diversity and unique taxa compositions compared to unmedicated children with ADHD [[4]](https://www.nature.com/articles/s41598-025-87546-y). They also exhibit reduced short-chain fatty acid (SCFA) levels, which may have implications for gut-brain axis functioning[[4]](https://www.nature.com/articles/s41598-025-87546-y).

Several studies have identified specific bacterial genera associated with ADHD, though findings vary across populations. The genus *Bifidobacterium* has been reported as significantly increased in ADHD cohorts, with correlations to enzymes involved in dopaminergic precursor synthesis [[5]](https://pmc.ncbi.nlm.nih.gov/articles/PMC4955679/). At the family level, *Bacteroidaceae* shows higher abundance in ADHD samples, while alpha diversity may be either reduced or increased depending on the specific population studied [[5]](https://pmc.ncbi.nlm.nih.gov/articles/PMC4955679/).

## Dietary Influences and ADHD Microbiome

The relationship between diet and ADHD microbiome profiles has emerged as a critical area of investigation. Taiwanese studies comparing 30 medication-naïve (not treated with medication) children with ADHD to healthy controls found that dietary patterns significantly differed between groups, with ADHD participants showing higher intake of refined grains and lower proportions of vitamin B2 and dairy products [[5]](https://pmc.ncbi.nlm.nih.gov/articles/PMC4955679/). These dietary differences correlated with specific bacterial abundances, including *Sutterella stercoricannis* associations with dairy, nuts, seeds, legumes, ferritin, and magnesium intake [[5]](https://pmc.ncbi.nlm.nih.gov/articles/PMC4955679/).

**When we look beyond autism and ADHD at other conditions influenced by the microbiome, we find that maintaining a healthy microbiome can do much more than prevent autism and ADHD.**

## Multiple Sclerosis: Immune-Mediated Microbiome Changes

Multiple sclerosis research has revealed significant microbiome alterations that appear to be linked to immune dysfunction characteristic of this autoimmune condition. The most comprehensive study to date, involving 576 MS patients and 1,152 household controls, identified several key bacterial changes associated with the disease [[6]](https://pubmed.ncbi.nlm.nih.gov/33692356/). MS patients showed significantly increased proportions of *Akkermansia muciniphila*, *Ruthenibacterium lactatiformans*, *Hungatella hathewayi*, and *Eisenbergiella tayi*, alongside decreased *Faecalibacterium prausnitzii* and *Blautia* species [[6]](https://pubmed.ncbi.nlm.nih.gov/33692356/).

Recent research has also highlighted the role of immunoglobulin A (IgA) coating of bacteria in MS pathogenesis. Individuals recently diagnosed with MS have fewer bacteria coated with host IgA antibodies compared to healthy controls, suggesting a fundamental disconnect in host-microbe interactions [[7]](https://microbiomejournal.biomedcentral.com/articles/10.1186/s40168-015-0094-5). This finding indicates that immune dysfunction in MS may extend beyond the central nervous system to include disrupted gut immune responses.

The functional implications of these microbiome changes in MS include alterations in metabolic pathways. The phytate degradation pathway is over-represented in untreated MS patients, while pyruvate-producing carbohydrate metabolism pathways are significantly reduced [[6]](https://pubmed.ncbi.nlm.nih.gov/33692356/). These metabolic changes may contribute to the inflammation and immune dysfunction characteristic of MS.

## Geographic and Treatment Variations in MS Microbiome

Microbiome composition in MS patients varies significantly based on geographic location and treatment status. Studies have observed lower microbial diversity in both healthy and MS participants from New York, while higher diversity was noted in participants from San Francisco and San Sebastián [[6]](https://pubmed.ncbi.nlm.nih.gov/33692356/). These differences likely reflect dietary habits and environmental factors that influence gut bacterial communities.

Disease-modifying treatments also significantly impact microbiome composition and function in MS patients. The therapeutic activity of interferon-β may be partially associated with upregulation of short-chain fatty acid transporters, suggesting that treatment effects may be mediated through microbiome modifications [[6]](https://pubmed.ncbi.nlm.nih.gov/33692356/).

## Parkinson's Disease: Motor-Microbiome Connections

Parkinson's disease microbiome research has identified consistent patterns across multiple studies, with systematic reviews revealing alterations in 53 microbial families and 98 genera between PD patients and healthy controls [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0006291X15310883?via%3Dihub). The most frequently reported increases in PD include *Bifidobacterium*, *Alistipes*, *Christensenella*, *Enterococcus*, *Oscillospira*, *Bilophila*, *Desulfovibrio*, *Escherichia/Shigella*, and *Akkermansia*[[8]](https://www.sciencedirect.com/science/article/abs/pii/S0006291X15310883?via%3Dihub).

Conversely, several beneficial bacteria show decreased abundance in PD patients, including *Prevotella*, *Blautia*, *Faecalibacterium*, *Fusicatenibacter*, and *Haemophilus*[[8]](https://www.sciencedirect.com/science/article/abs/pii/S0006291X15310883?via%3Dihub). These changes appear to be functionally significant, as studies in PD model mice have confirmed that gut microbiota contributes to motor deficits and neuroinflammation[[8]](https://www.sciencedirect.com/science/article/abs/pii/S0006291X15310883?via%3Dihub).

The role of short-chain fatty acid-producing bacteria appears particularly important in PD pathogenesis. Many of the altered bacteria in PD are involved in SCFA production, and imbalances in these organisms may contribute to intestinal barrier dysfunction and systemic inflammation that characterizes the disease[[8]](https://www.sciencedirect.com/science/article/abs/pii/S0006291X15310883?via%3Dihub). Interestingly, some traditionally beneficial bacteria like *Bifidobacterium* and *Lactobacillus* are increased in PD, which may reflect medication effects, particularly COMT inhibitors, rather than disease processes [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0006291X15310883?via%3Dihub).

## Other neurological conditions: emerging patterns

## Depression and Anxiety Disorders

Microbiome research in depression has identified 13 microbial taxa associated with depressive symptoms, including genera *Eggerthella*, *Subdoligranulum*, *Coprococcus*, *Sellimonas*, *Lachnoclostridium*, *Hungatella*, and various *Ruminococcaceae* groups [[9]](https://pubmed.ncbi.nlm.nih.gov/31974429/). These bacteria are involved in the synthesis of key neurotransmitters including glutamate, butyrate, serotonin, and gamma-aminobutyric acid (GABA), which are crucial for mood regulation[[9]](https://pubmed.ncbi.nlm.nih.gov/31974429/).

## Alzheimer's Disease

Alzheimer's disease microbiome studies have revealed decreased microbial diversity and compositionally distinct bacterial communities compared to age- and sex-matched controls[[10]](https://pubmed.ncbi.nlm.nih.gov/29051531/). Key findings include decreased *Firmicutes*, increased *Bacteroidetes*, and decreased *Bifidobacterium* in AD participants [[10]](https://pubmed.ncbi.nlm.nih.gov/29051531/). Correlations between differentially abundant genera and cerebrospinal fluid biomarkers of AD suggest potential mechanistic links between gut bacteria and neurodegeneration [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us).

## Microbiome Testing Technologies and Methodologies

The field of microbiome analysis has evolved rapidly, offering multiple approaches for characterizing bacterial communities with varying levels of resolution and functional insight. Understanding these different methodologies is crucial for interpreting research findings and selecting appropriate testing strategies for clinical or research applications. As these technologies are more widely adopted and costs decline, someday microbiome testing will be as common as a blood cholesterol test. Meanwhile, here is a list of 20 companies offering microbiome testing [[11]](https://ensun.io/search/microbiome-testing).

## 16S rRNA Gene Sequencing

16S rRNA gene sequencing represents the most widely used approach for microbiome analysis, particularly in clinical and research settings focused on bacterial identification [[11]](https://ensun.io/search/microbiome-testing). This method utilizes PCR to target and amplify portions of the hypervariable regions (V1-V9) of the bacterial 16S rRNA gene[[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us). After amplification, samples receive molecular barcodes, are pooled together, and undergo sequencing [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us).

The primary advantages of 16S sequencing include high bacterial and fungal coverage, low risk of false positives, and no interference from host DNA. The technique requires minimal DNA input (as few as 10 copies of 16S genes) and is relatively cost-effective at approximately $80 per sample [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us). However, 16S sequencing is limited to genus-species level resolution and cannot provide functional profiling capabilities [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us).

Recent advances in error-correction methods, particularly DADA2, have dramatically improved the accuracy and taxonomic resolution of 16S sequencing [[11]](https://ensun.io/search/microbiome-testing) With these improvements, species-level resolution for many organisms using standard 16S sequencing is now achievable, making this approach increasingly valuable for clinical applications [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us).

## Shotgun Metagenomic Sequencing

Shotgun metagenomic sequencing offers the most comprehensive approach to microbiome analysis by sequencing all genomic DNA present in a sample, rather than targeting specific genes [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us). This method provides several advantages over 16S sequencing, including cross-domain coverage (bacteria, archaea, viruses, fungi), species-to-strain level taxonomic resolution, and the ability to perform functional profiling [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us).

The workflow for shotgun metagenomics resembles standard whole genome sequencing, involving random fragmentation and adapter ligation [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us). Taxonomic analysis typically involves quality trimming and comparison to reference databases comprising whole genomes (using tools like Kraken and Centrifuge) or selected marker genes (MetaPhlAn and mOTU) [[11]](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us).

While shotgun sequencing provides superior resolution and functional information, it comes with increased costs (approximately $200 per sample) and higher risk of false positives[[11]](https://ensun.io/search/microbiome-testing). The method also faces challenges from host DNA interference and requires larger DNA inputs (1 ng minimum).

## Specialized Analytical Approaches

## Metatranscriptomics and Functional Analysis

Metatranscriptomic methods capture RNA transcribed from microbial cells, allowing assessment of the expression activities of microorganisms [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full). This approach provides insights into which genes are actively transcribed, though it does not perfectly represent functionality since protein expression depends on translation and post-translational modifications [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full).

Standard metatranscriptomic workflows involve isolation of total RNA from microbiome samples, RNA enrichment, fragmentation, cDNA synthesis, and preparation of transcriptome libraries for sequencing [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full). RNA sequence reads are typically mapped to different genomes and pathways (such as KEGG) to identify both the taxonomy of transcriptionally active organisms and the function of their expressed genes [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full).

## Metabolomics and Metaproteomics

Metabolomics analyses focus on profiling the metabolites that microbiota produce and how these products interact with both microbial and host metabolism[[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full). These methods often quantify small molecules including antibiotics, antibiotic byproducts, and bacterial metabolism intermediates using mass spectrometry to identify known metabolites [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full).

Metaproteomics employs mass spectrometry to identify and quantify proteins present within a microbiome[[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full). This approach offers the advantage of measuring "expressed" proteins of microbial community members, providing direct evidence of functional activity [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full).

## Quality Control and Statistical Analysis

Modern microbiome analysis relies on sophisticated statistical approaches to ensure reliable results. Analysis of similarities (ANOSIM) has been used to assess significant clustering differences by comparing within- and between-group similarity using distance metrics [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full). PERMANOVA performs multivariate analysis of variance based on distance matrices to test overall differences in microbiome community structure between different groups [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full)

Visualization methods include heat maps for detecting potential clusters or differences between groups, often combined with hierarchical clustering to group samples with similar bacterial profiles[[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full). Clinical metadata can be overlaid onto heat maps to discover potential clinical cofactors associated with specific bacterial profiles [[12]](https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00904/full).

## Clinical Applications and Biomarker Development

The translation of microbiome research into clinical applications has gained significant momentum, particularly in neurological disorders where traditional biomarkers remain limited. The development of bacterial biomarkers for neurological conditions represents a paradigm shift toward more accessible and potentially modifiable diagnostic tools.

## ASD Biomarker Validation

The remarkable consistency of ASD microbiome signatures across different populations and study designs has positioned these bacterial profiles as among the most promising biomarkers in neurological medicine. The identification of 26 bacterial taxa (specific types) capable of discriminating ASD cases with over 80% accuracy represents a significant advance in autism diagnosis and monitoring [[1]](https://pubmed.ncbi.nlm.nih.gov/32238191/).

These biomarkers demonstrate great value in early assessment and risk stratification. The correlation between specific bacterial abundances and ASD symptom severity suggests potential applications in monitoring treatment response and disease progression [[3]](https://www.cell.com/neuron/fulltext/S0896-6273(18)31009-2?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0896627318310092%3Fshowall%3Dtrue). The discovery that children with ASD maintain unique bacterial signatures even when compared to their mothers indicates that these biomarkers reflect individual pathophysiology rather than simply shared environmental factors.

**ADHD Monitoring and Treatment Response**

The relationship between ADHD microbiome profiles and treatment response has emerged as a particularly promising area for clinical application. The observation that medicated ADHD children show distinct microbiome patterns compared to unmedicated children suggests that bacterial monitoring could inform treatment decisions and predict medication response [[4]](https://www.nature.com/articles/s41598-025-87546-y).

The negative correlation between propionic acid levels and ADHD symptom severity provides a potential biochemical marker for disease monitoring[[4]](https://www.nature.com/articles/s41598-025-87546-y). This finding is particularly significant because short-chain fatty acids like propionic acid can be measured in stool samples and may reflect the functional capacity of the gut microbiome to influence neurological function [[4]](https://www.nature.com/articles/s41598-025-87546-y).

## Conclusion

The field of microbiome profiling in neurological disorders has reached a critical juncture where research findings are beginning to translate into clinical applications and consumer-accessible testing options. The remarkable consistency of bacterial signatures across different neurological conditions, particularly the 80% predictive accuracy achieved for ASD, shows that microbiome analysis represents a fundamental advance in understanding and diagnosing these complex disorders.

**The convergence of multiple neurological conditions showing distinct but overlapping microbiome patterns shows that gut-brain axis dysfunction may be a common pathway in neurological disease.** The identification of shared bacterial alterations across ASD, ADHD, multiple sclerosis, and Parkinson's disease suggests potential common therapeutic targets and mechanistic pathways that warrant further investigation.

As the technology for microbiome analysis continues to advance and costs decrease, the integration of bacterial profiling into standard neurological assessment protocols appears increasingly feasible. The growing availability of direct-to-consumer testing options provides opportunities for individuals to monitor their gut health, though careful interpretation of results in the context of clinical symptoms remains essential.

Future research directions should focus on longitudinal studies to understand how microbiome changes precede or follow neurological symptom development, investigation of microbiome-targeted therapies for neurological conditions, and standardization of testing methodologies to ensure reproducibility across different platforms and populations. The potential for microbiome modulation through dietary changes, probiotics, or other therapeutic approaches represents an exciting frontier in personalized neurological medicine.

Certainly, the connection between your gut microbiome and your brain is a very big deal, and who knows what wonders more studies will reveal?

**But as we have seen, science already proves that the gut microbiome is the key to preventing autism.**

# **Chapter 9. Your personal program to prevent autism**

**Author’s note: I do not sell products or derive any money or benefit from the sale of products or services mentioned in this book.**

**For your convenience, I will mention some products and services. I am not responsible for the products and services, nor for actions of makers, vendors, or providers of such products and services.**

**Also, I am not a doctor and I am not giving medical advice**. **You should discuss your needs and your plan with your doctor.** I am simply reporting on the published results and the implications of numerous clinical trials and scientific studies, all of which are linked to the footnote numbers throughout this book. You can see each original source with one click.

This book brings together more diverse research related to preventing autism than any other book available today. By combining information from the many scientific resources cited in this book, we find a clear, simple, **science-based path to prevent autism which has demonstrated results, as discussed in Chapter 3**.

**All of the science points to a simple program including probiotics, vitamins, supplements, and diet. You should discuss all of this with your doctor and share this book with them.** To save you some hours, I list here some products for a research-based plan to prevent autism. Then, below, I will explain each the what and why of each item on the list. Here we go!

**A sample plan to discuss with your doctor:**

This science-based plan assumes that you are in reasonable health. If you have a gastrointestinal problem like irritable bowel syndrome (IBS) or any other health problem you **must** discuss with your doctor before starting probiotics.

**According to science**, a protocol like this should **start four weeks or more before the expected delivery of your baby**, and **sooner is better. If you are not pregnant yet, so much the better! Start now. Ask your doctor.**

Start with Probiotics (a) for 2 – 3 days. Then add (b), and 2 - 3 days later add (c), assuming no discomfort. Continue for at least 6 months after birth if you are breastfeeding. If not breastfeeding, give the probiotics to the baby for 6 months. Ask your doctor but (a) below was given to newborns in the Finnish study.

1. **Probiotics (all 4)**
   1. *Lactobacillus rhamnosus GG*  10 billion CFU (colony forming units) per day. This is the exact strain and dose used in the Finnish study. The GG strain is needed. About $20 for 30 days [***HERE***](https://www.amazon.com/SUPERSMART-Lactobacillus-Vegetarian-Contributes-Maintenance/dp/B07JZF6ZRY/ref=dp_coos_d_sccl_1/143-6575442-6885304?pd_rd_w=TFs9q&content-id=amzn1.sym.a07d4df5-1f4e-4f00-8e1b-5a2733ff0eb3&pf_rd_p=a07d4df5-1f4e-4f00-8e1b-5a2733ff0eb3&pf_rd_r=XQEG1JJHFG2ET1FZA8CY&pd_rd_wg=evVS9&pd_rd_r=b73bfce1-2f56-428a-be87-6dab94a64d21&pd_rd_i=B07JZF6ZRY&psc=1)***.***
   2. *Bifidobacterium longum* 6 billion CFU, about $15 for 60 days [***HERE***](https://www.amazon.com/Vitamatic-Bifidobacterium-Longum-Billion-Capsule/dp/B0CZL3LXH3/ref=sr_1_1_sspa?crid=1R10GVDM648U0&dib=eyJ2IjoiMSJ9.jUw4JolKIHJ3NKEryB2mX7sM1YI89KbqthmD_5FNe8IPZSs2AJ1Y320HLjqRu9gEg2aVEdgpPRHt4ZEI5rcZMhVEp2dYANd-WX2CPNp4PMbI5OuxSXv3C-aPFU6CuZPT6HXQI1N-nrrdklfkZiFu7da_7slXS9Oh5iTt-YeUR1dxVbsa_gaIbqWW9XTDChO-92-mUlaxbZyozwmD6F-ijUQZL8k4uI_5AVlAcbOM9_eIRca7SqslKvLDQ2yKtlvrFgnnhwXiekHoTQ2QCSMbKqGJWEqpQxcdd2KZ7x_FS6s.VOXPo7Ft_Sp2ayLYJwqTyxcojIPoA64tXSsH1kS5SQM&dib_tag=se&keywords=bifidobacterium+longum+%2B+60&qid=1753132022&sprefix=bifidobacterium+longum+%2B+60%2Caps%2C114&sr=8-1-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&psc=1)***.***
   3. *Saccharomyces boulardii* 3 billion CFU, about $10 for 120 days [***HERE***](https://www.amazon.com/Saccharomyces-Boulardii-Supplement-Probiotics-Intestinal/dp/B0CWVNJ3X7/ref=sr_1_7?crid=2Q8PMX4HGCUS1&dib=eyJ2IjoiMSJ9.vjlUh5CiKBtA2WDSEziGCa_F7AzPkluPFItWNwi-l4EFQs9c03zdH_LACp9Bz-MYCLmtsLlZOQHM97Oso-wRB4ybjJGu--9T3OuIzidTCjrwLIW-hC4jBdc6VNTnxmERQI2FK2eY7E-Osr8QNASnIKe9TCfpvr568WMftqec_6dztmuoDMr_03cais3JnHXsmk8hIcp5im_wkcNYYphDulhoOUReWdSsE9j2I_ChDl8fkgkUeAcvVysS5IG6uoTLssG_wMhOPcq5mtGeZHGYyjbfCVgu0iDSswegz7TJPk8.Zg9tJpiUa4m5ItjFgkrzydcDovaUsblRMSmpD7C19rs&dib_tag=se&keywords=probiotic%2Bboulardii&qid=1753385304&sprefix=probiotic%2Bboulardi%2Caps%2C141&sr=8-7&th=1)*.* This vendor has a wide selection of single-strain products at great prices. If you take antibiotics, double up on *S. boulardii*.
   4. 7 strain mixture with *Lactobacillus plantarum, Lactobacillus acidophilus, Bifidobacterium bifidum, Bifidobacterium breve, Bifidobacterium infantis probiotic, Bifidobacterium lactis, and Bifidobacterium longum* total 3 billion CFU, about $29 for 60 days [***HERE***](https://www.amazon.com/Hyperbiotics-Nutrients-Bifidobacterium-Probiotic-Shelf-Stable/dp/B01FT71W3C/ref=sr_1_7?crid=137ISL42U4QNX&dib=eyJ2IjoiMSJ9.o8Cvf-owjKgTHV3dZXX6oAdspwrZiRZvH8uRNZCOAwLqeFc58AOs-coJ5L7xerpqdQwQ9KlagMXXUjGxTOOH_iPawvaKeYHbzfDWebklY38Qy5tU8EZ0W95MiiOF2RFHGebhRPbqXBhVxJ6Bi-M-S_AWLpql5xutH6KhcX1s2ydC4WuBaP4KT_1Odqzyywb0xbShNzVGBguqpveRIXDYuUx3XpSGcgJj5erDgM8-wFWDNPziRtI3fFolFzw_dgTC3PoFsfH0nh6KgLMOf4Sb9rXEVg1oDC2ve_0iZ4aIhCw.pfB7n4kJAyYxO3XVRwx4luLbi6tZdN8R9JN-DUZD_r4&dib_tag=se&keywords=bifidobacterium&qid=1753128940&rdc=1&s=hpc&sprefix=bifidobacterium%2Chpc%2C90&sr=1-7)***.***
2. **Vitamins and supplements (all 5)**
   1. **Life Extension Prenatal Advantage** is hands-down the most comprehensive prenatal vitamin supplement I could find. I use products from Life Extension every day and have for at least 25 years. Prenatal Advantage lacks calcium and magnesium, which are important in pregnancy, but not to excess. About $18 for 30 days [***HERE***](https://www.amazon.com/Life-Extension-Prenatal-Advantage-Multivitamin/dp/B07YH16V1G/ref=sr_1_1?crid=1TYB40JQX85XS&dib=eyJ2IjoiMSJ9.Qm71eKY9xKlDZell1Wl26N4aKaqOyn69cOfpal9qkWiilLyeq19FWF-8sabbu_03j_jrX5itOxEKMg97rEROksE1SsuhozpqJb13XWUu1sHb0-XrAtmJVTVADW8EDTMTaVROsLkQ3FHU5VEm-Yy1oYASGYMDPbFe65Qk_iAFzx1A5ye6dKzwEa03-0qDaqEmvdt7haG7ElkVtFenNmLaqcatV2Y6MYA_6G1lS4_lPzpOhXqTBf3GmW1JDMA84-ZvLekfjiNycmn1g386ID69XgHkJZ7_o7PuZ4-zxctOTTw.8uDl51ptBhYzhJQKmvIqYNZ_UI5Xw0407N2IgtxYuFE&dib_tag=se&keywords=life+extension+prenatal+multivitamin&qid=1753133533&rdc=1&sprefix=life+extension+pren%2Caps%2C107&sr=8-1)***.***
   2. **Magnesium glycinate** 350 mg, about $10 for 120 days[***HERE***](https://www.amazon.com/Magnesium-glycinate-muscle-energy-relaxation/dp/B0DWDHJZ4T/ref=sr_1_13_sspa?crid=1IVBPDYW4J4R9&dib=eyJ2IjoiMSJ9.qph8NgCOk0gr8xqC_HJZpOUOiOEqOKu-qkSd8hQk1MzaKq7EG71dh3JElybV8v82fuji4udG_KamOVagQmPUcTxd-Es5A5DIzt35fJn43z6_24ED3t-uyYqokI3TiM3D5ip_0Hys7f58NN1Et49S9-rYU467JxASvKoT36gitqY9fhX2w1yuBVgVmKDroZGIRbW3SYty5AQHM8qxZl04MOKm927_wasjt149OG-iqOZA27hjZjttg_89y0ns_hwZdV4R3e-OvmuaKh5BWTqMmemMLpvzzWg42nUihCVJ-48.Ar7junSZAtFWsE2GiX07ooJtsxl1z5SypFWoIzqX0LA&dib_tag=se&keywords=magnesium+glycinate&qid=1753134362&s=hpc&sprefix=magnesium+glycinate%2Chpc%2C113&sr=1-13-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9tdGY&psc=1)***.***
   3. **Calcium citrate 1,000 mg**  about $18 for 80 days [***HERE***](https://www.amazon.com/KAL-Calcium-Supplement-Guarantee-Servings/dp/B0BSLYS8YH/ref=sr_1_29?crid=1I5C2RGW4901H&dib=eyJ2IjoiMSJ9.Jz-4cBaDncOAo6LptMWZE9ijdLBhakI8gWGzWVnhJGFBrDjYx4r4WjnyrPb-qLggDEFMHdXyQW7nH_K0t9haRbx9LH_pwH8vrEYZOIGFKK7zwyJ5nZqKCVBgqvY0HjZsvFI0CDr_89HBkKHs6cl_JrsBIk2GHujX5t7lqRVKxxQ46hSQ36QA7NDCaRyndis2-njakLlAPrIEm1tfinMRpJLtYdpGbHOkKV7yQ02P9RwIo32ArCaDDLHiaJMbF2A4Ec2GMxwuuV9ar6ilS6he2prdrBvpMLDfGgsJLbsiWtg.jV2b6L80JZz7Eh1LSR_pHcknMjVPI2Q3Xupwsoxynwk&dib_tag=se&keywords=calcium%2Bcitrate&qid=1753555137&rdc=1&sprefix=calcium%2Bcitrate%2Caps%2C160&sr=8-29&th=1)*.* This is the easiest form of calcium to absorb.
   4. **Vitamin D3 1,000 IU** about $8 for 250 [***HERE***](https://www.amazon.com/Life-Extension-Vitamin-1000-Softgels/dp/B0019LPCNO/ref=sr_1_10?crid=1VCEMG0DG7PJ5&dib=eyJ2IjoiMSJ9.DA3yr-jqOinzJnxkziE2yrTFYPQ9ovXupY1IctBPx2KsuZNkb7v-kzM8DnAP8K0xdQBMxz4emL3Ef-Jb9QY0Ipf4q78e_8OF_panxBdKTe8-ZF0PmPDzaRzxWRahYIXt-HNKrvOgQ-GiQH_l9bgAqIPCtDdgokK7Tao-Z9yeZXqlnE-dCGvxShN0iAWg9uHeUpwVGBhP7__7NmBOh3ktKZ4M7oOvW4tqLYFz4krQxtQlgui5X6aLTd8pFbY0fLNgHG_KFVp6I-O_9_FOlIub5GrpL1uxy0YhRqXWcTu_mbw.uIZGU7PhDNmSK2RYZNDmMxCfVeLPQuQVx0Xt8x8TsKc&dib_tag=se&keywords=d3%2B1000%2Biu&qid=1753135190&rdc=1&s=hpc&sprefix=d3%2B1000%2Chpc%2C109&sr=1-10&th=1)***.*** The Prenatal Advantage has 1,000 IU per day, but an extra 1,000 IU per day is useful. Ask your doctor. Note, a new study published in June, 2025 shows that higher gestational vitamin D levels improve children’s cognitive scores 7 to 12 years later [[24]](https://www.sciencedirect.com/science/article/abs/pii/S0002916525003399?via%3Dihub). Studies show that 2,000 IU per day is safe in during pregnancy. [[25]](https://pmc.ncbi.nlm.nih.gov/articles/PMC4855961/)
   5. **Omega 3 fatty acids**, about $18 for 40 days[***HERE***](https://www.amazon.com/Nutricost-Omega-Fish-Oil-Triple-Strength/dp/B098KLWZHN/ref=sr_1_23?dib=eyJ2IjoiMSJ9.FHgqB_RM2kszH7bCJM1Bw8rBmCaYCDMXP0RewliGsiZAzk8z8VImaiwJSYw0AWkihEPdueFvJ-xFAsKPCkP9rLZY7TUf6jSUxVfqgGDZn7FNba5dGEy-HZJJCtykJuKBmf-vGTXSU6SGSzc1sXwz4nv8yAiasTDzAN5aC5nDSejdojr4ipFxh2hz93ezhhS9IFXr2NvEsS9Hxxn4kKeJzMkfk-x_QKebRrO4WxLkhV7kSHbji74RHYnMEJZGDLsYIxXRgPz_HjIlokJDxZGh5iw1AR4RrA6k2zm5CI98Zj8.pnWtoL4xKkFETwv6eZx5cSP5N7jxo8SaPjhthGnqlD4&dib_tag=se&hvadid=693581921025&hvdev=c&hvexpln=67&hvlocphy=9012436&hvnetw=g&hvocijid=7854174690295416291--&hvqmt=e&hvrand=7854174690295416291&hvtargid=kwd-331055006564&hydadcr=21195_13415641&keywords=epa+dha+supplements&mcid=64dd836d486133cea8afcd2f2f67bf82&qid=1753562154&sr=8-23). 2.5 grams of Omega 3’s: 1,200 mg EPA, 850 mg DHA, and 450 mg of other Omega 3 fatty acids.

Continue all for as long as breastfeeding. **If not breastfeeding,** **ask your doctor to prescribe vitamins for your baby.**

1. **Dietary fiber and prebiotics**

Fiber is essential for a healthy microbiome. You need soluble fiber and insoluble fiber. Prebiotics are types of soluble fiber that feed beneficial gut bacteria, while insoluble fiber passes through the system and moves things along smoothly to the exit. If your diet provides about 20 grams per day of insoluble fiber and 8 - 10 grams of soluble, you’re good. Otherwise, you could kickstart the process with:

* 1. Prebiotic Inulin Fiber, 3 capsules per 2 grams, 60 days for about $14 [***HERE***](https://www.amazon.com/NOW-Supplements-Prebiotic-Intestinal-Nourishes/dp/B0CRFWM2Z6/ref=sr_1_10?crid=AKJWKV2VZ70Y&dib=eyJ2IjoiMSJ9.VLGv-DZpxKQC1FNeFRvY1vIR-t22D_qS_p96nuCavPzwIFqzY47HwG5aSe90C_h2yWw0v2i7OWFGQVCqwvo2US2Jn1KOuMr_QE8qPmlq_y9KsQnAYtdRMPqaucOo7H65HAvc4ZaN9fbtuDVtEpf3u8KO6aXAEKF8DZ_yksadUbRgha8ES0jO75UgykgNhwUPCelRsU0cD4GaqW7Llv6GX_0ZjHNT9f2QWqfLdw-uvX6g7Ia_oBwvU0diOunQrgb3KqDk_eDsNvvD2hchCA8bDZJttQBKQpdmycbaVj7EtJQ._XSZ3NY_YV0XFv_4bz4Sb7n2t9amHI1fBJnpHf6sdTM&dib_tag=se&keywords=prebiotics&qid=1753208100&rdc=1&sprefix=prebiotics%2Caps%2C141&sr=8-10)***.***

Another way to get both kinds of fiber is with Kellogg’s All-Bran Buds, in the cereal aisle. I mix it with Greek yogurt and top with blueberries. Try it, creamy, crunchy, and delicious. More about fiber below.

1. **Your diet.**

We could make a huge book only about a healthy diet. The main thing here is to eat healthy, **and avoid Ultra-Processed Foods and artificial sweeteners** (see Chapter 7), especially while pregnant and breastfeeding, and get your protein and fiber.

That’s it!

You’ll notice a difference within the first few days, and within a month you’ll look and feel better, and be happier, too. I promise you will be amazed.

At the time of writing, the cost of all of the above is around $3.50 per day, (a few visits per month to Starbucks or Dunkin). If that is a burden, let me suggest you make a deal right now with family and friends: instead of them buying cute outfits and toys, ask them to chip in to prevent autism. Show them this book. (They’ll buy the baby stuff later anyway).

**The science behind these choices.**

You may have heard that women who are pregnant (or trying to be) need 400 – 600 **micrograms** of folic acid (vitamin B9) daily until the baby is born. This was first suggested in 1962, and first officially recommended in 1992, to prevent terrible neural tube birth defects (NTDs) such as spina bifida and anencephaly. In 1998 the U.S. Food and Drug Administration (FDA) required a wide variety of enriched cereals, breads, and other grain products to be fortified with folic acid. Rates of these birth defects were reduced dramatically [[12]](https://pubmed.ncbi.nlm.nih.gov/25590678/).

I mention this to illustrate that some millionths of a gram of something, or lack of it, can make a huge difference in a person’s life and health, and also that eventually some common-sense science finds its way into mainstream practice. But it takes common sense a long time to percolate through the medical community.

Someday, probiotics to balance the mother’s gut microbiome to prevent autism in her child will be just as mainstream and new cases of autism will be eliminated. Until then, you’re on your own, and this book will help you succeed.

Now let’s look at the science that supports the choices listed above for a typical autism-prevention plan.

The main **probiotic** (a) is a bacterium named ***Lactobacillus rhamnosus GG****. GG* is a specific, unique strain of genus *Lactobacillus,* species *rhamnosus. GG* is also called *LGG. GG* is one of the most-studied probiotic strains, with over 800 scientific studies and a long safety track record. GG has superpowers that no other strains of *L. rhamnosus* possess, making GG the foundation of your microbiome community [1] [2] [[11](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2017.02705/full)].

**10 billion CFU (colony forming units) of *GG* is the exact probiotic strain and daily dose used in the Finnish study described in Chapter 3.** This dose was given to 35 mothers starting four weeks before their estimated delivery date, and continuing for six months after delivery if breastfeeding. If not breastfeeding, the *GG* was given to the baby for six months. The control group of 40 mothers and babies did not receive *GG.*

**At 13 years after birth, none of the 35 probiotic children had autism or ADHD, compared to six out of 40 controls (17.1%) who did** [[3]](https://www.nature.com/articles/pr201551)**.**

*Lactobacillus rhamnosus GG*stands apart from the broader *L. rhamnosus* species due to specific genetic and functional traits. The beneficial effects of *GG* are supported by an extensive clinical literature and make it a preferred choice in clinical and preventive nutrition programs, such as those designed to reduce the risk of autism spectrum and neurodevelopmental disorders [[1]](https://en.wikipedia.org/wiki/Lacticaseibacillus_rhamnosus) [[2]](https://pubmed.ncbi.nlm.nih.gov/30741841/) [[3]](https://www.nature.com/articles/pr201551).

**Key Superpowers and Benefits of *Lactobacillus rhamnosus GG***

* **Stability and Gut Colonization:**  
  *GG*’s unique genetic signature allows it to survive gastric acid and bile. *GG* attaches strongly to intestinal mucosa by tiny sharp hairs called pili, and transiently colonize the gut. This is not true for all *L. rhamnosus* strains, which may lack the same ability to reach and interact with the human gut barrier [[1]](https://en.wikipedia.org/wiki/Lacticaseibacillus_rhamnosus) [[4]](https://www.optibacprobiotics.com/professionals/probiotics-database/lactobacillus/lactobacillus-rhamnosus/lactobacillus-rhamnosus-lgg) [[11]](https://pmc.ncbi.nlm.nih.gov/articles/PMC4155824/).
* Supports Gut Barrier Integrity:  
  *GG* has been shown to enhance the tightness of gut epithelial cell junctions and promote mucus production. This strengthens the gut barrier reducing “leaky gut” and avoiding toxins getting into the bloodstream causing sepsis [[2].](https://pubmed.ncbi.nlm.nih.gov/30741841/)
* **Immunity and Inflammation Modulation:**  
  The strain modulates the immune system, promoting anti-inflammatory responses and increasing the activity of protective white blood cells such as T-lymphocytes and the production of immunoglobulin A [[2]](https://pubmed.ncbi.nlm.nih.gov/30741841/) [[5]](https://www.inessawellness.com/en-us/blogs/wellness-hub/health-benefits-of-lactobacillus-rhamnosus-gg).
* **Suppression of Pathogenic Microbes:**  
  *GG* can inhibit the attachment and growth of harmful bacteria in the gut. It does this by competing for nutrients and adhesion sites, secreting antimicrobial peptides, and producing lactic acid, which lowers the gut pH to limit pathogen survival. This includes suppression of pathogens like *Clostridium difficile*, *Salmonella*, and even certain yeasts [[6]](https://www.pursuit-of-happiness.org/benefits-of-the-probiotic-lactobacillus-rhamnosus-gg/) [[8].](https://pubmed.ncbi.nlm.nih.gov/40425822/#:~:text=Lactobacillus%20rhamnosus%20GG%20maintains%20gut,signaling%20in%20short%20bowel%20syndrome)
* **Restoration and Stabilization of the Gut Microbiome:**  
  *GG* restores microbial equilibrium after disruptions from antibiotics, illness, or stress. Clinical trials show it helps prevent antibiotic-associated diarrhea and reduces the risk and severity of digestive infections [[1]](https://en.wikipedia.org/wiki/Lacticaseibacillus_rhamnosus) [[9]](https://pubmed.ncbi.nlm.nih.gov/32059116/).
* **Unique Gut-Brain Axis Effects:**  
  *GG* appears to influence early neurodevelopmental outcomes through effects not only on microbiota composition but on the gut barrier, immune signaling, and possibly direct modulation of nervous system function via the vagus nerve. Trials such as the Finnish study indicated reduced rates of ADHD and autism spectrum disorders in those receiving *GG* during infancy, an effect not replicated by other probiotics or by the general L. rhamnosus species [[3]](https://www.nature.com/articles/pr201551) [[10]](https://www.frontiersin.org/journals/psychiatry/articles/10.3389/fpsyt.2020.00181/full).
* **Demonstrated Clinical Efficacy:**  
  *GG*’s proven clinical benefits, including reduced risk of antibiotic-associated and acute diarrhea, modulation of inflammation, and enhanced immune and barrier function, stem from its robust ability to colonize and interact with the human gut. Such effects are not consistent across all *L. rhamnosus* strains [[4]](https://www.optibacprobiotics.com/professionals/probiotics-database/lactobacillus/lactobacillus-rhamnosus/lactobacillus-rhamnosus-lgg) [[7]](file:///C:\Users\Bob%20Waterstripe\Documents\1%20a%20a%20a%20a%20autism%20book%20and%20AI2025\CHAPTER%20FILES%20AND%20ASSEMBLY\Funct%20Food%20Rev.%202012%20Jun;4(2):77-84).

The Finnish study also found that children who did not receive the *GG* probiotic (a) had lower levels of probiotic (b) ***Bifidobacterium longum***which was significantly reduced at 3 months in children who later developed disorders. Although none of the probiotic children (*GG* only) in the study got autism or ADHD, *bifidobacterium longum* is another important part of a healthy microbiome and complements *GG,* so I have added it to our plan [[13]](https://www.sciencedirect.com/science/article/pii/S1756464619300684).

***Saccharomyces boulardii*: Overview and Benefits**

Probiotic (c) in our list, *Saccharomyces boulardii* is a probiotic yeast widely studied for its beneficial effects on gastrointestinal health. Clinical trials have shown that it is effective in preventing and treating various types of diarrheas, including antibiotic-associated, traveler’s, and *Clostridioides difficile-*related diarrhea.

Unlike many bacterial probiotics, *S. boulardii* can survive stomach acid and bile, making it especially robust during antibiotic therapy. It also promotes barrier function of the gut, modulates immune responses, and has shown promise in supporting gut recovery after dysbiosis and in some chronic digestive disorders. Its use is generally considered safe and well-tolerated for both adults and children [[14]](https://pubmed.ncbi.nlm.nih.gov/20458757/).

**Other species of *Bifidobacterium* and *Lactobacillus***are also important to gut health and thus I added a multi-strain probiotic (c) to our plan [[15].](https://www.nature.com/articles/s41598-024-72962-3) This position could be filled by any number of different multi-strain probiotics.

**If you take antibiotics, the usual practice is to take probiotics two to six after the antibiotics.** This way the antibiotics have time to kill the bad guys infecting you, but you replace the good bacteria that got taken out by the antibiotics as collateral damage [[16]](https://medcraveonline.com/IJCAM/a-complementary-medicine-approach-to-augmenting-antibiotic-therapy-current-practices-in-the-use-of-probiotics-during-antibiotic-therapy.html).

**Vitamins and supplements**

Here is a **complete list of vitamins and minerals recommended for pregnant women**, based on the latest clinical guidelines and expert sources:

|  |  |  |
| --- | --- | --- |
| **Nutrient** | **Recommended Daily Amount** | **Key Function/Importance** |
| Folic Acid (Folate) | 400–800mcg | Reduces risk of neural tube defects in the fetus |
| Iron | 27mg | Supports increased blood volume; prevents anemia |
| Calcium | 1,000–1,300mg | Builds fetal bones and teeth |
| Vitamin D | 600IU (15mcg) | Calcium absorption, fetal bone growth, immune function |
| Iodine | 220mcg | Healthy brain and thyroid development |
| Choline | 450mg | Neurodevelopment and brain health |
| Vitamin C | 85mg | Immune function, tissue growth, iron absorption |
| Vitamin A | 770mcg RAE (do not exceed 3,000mcg) | Vision, immune function (avoid excess) |
| Vitamin B6 | 1.9mg | Fetal brain and nervous system development |
| Vitamin B12 | 2.6mcg | Blood and nerve health, in combination with folic acid |
| Omega-3 Fatty Acids | 200–300mg (DHA+EPA) | Brain and eye development |
| Zinc | 11mg | Immune function, rapid cell growth |
| Magnesium | 350–360mg | Muscle and nerve function, fetal development |
| Copper | 1mg | Iron metabolism, nervous/cardiovascular system |
| Selenium | 60mcg | Antioxidant; supports immune and thyroid function |
| Vitamin E | 15mg | Antioxidant; protects cell membranes |
| Thiamine (B1) | 1.4mg | Energy metabolism |
| Riboflavin (B2) | 1.4mg | Energy production, growth, red cell production |
| Niacin (B3) | 18mg | Fat, protein, carbohydrate metabolism |
| Pantothenic Acid | 6mg | Hormone/steroid production, metabolism |
| Biotin (B7) | 30mcg | Amino acid and fat metabolism |

[[17]](https://www.acog.org/womens-health/faqs/nutrition-during-pregnancy) [[18]](https://ods.od.nih.gov/factsheets/Pregnancy-HealthProfessional/)

**Life Extension Prenatal Advantage** is the most comprehensive prenatal vitamins I found. You can find the complete list of ingredients [**here**](https://www.lifeextension.com/vitamins-supplements/item02319/prenatal-advantage). Print this to share with your doctor! This product lacks magnesium and calcium, which are included in the chart here. I added them as separate products.

**About Omega 3 fatty acids**

Omega-3 fatty acids, particularly docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), are essential nutrients that are especially important during pregnancy. These healthy fats serve as fundamental building blocks for the developing fetal brain and retina. Adequate maternal intake of omega-3s has been linked with improved neurodevelopmental outcomes in babies, such as better cognitive and visual function. Emerging research also suggests omega-3s may play a role in supporting a healthy pregnancy by potentially supporting optimal gestational length and birth weight. Since the body cannot produce omega-3 fatty acids on its own, it is necessary for pregnant women to consume them through diet or supplements—such as from low-mercury fish, seafood, or algae-derived capsules. [[19]](https://pmc.ncbi.nlm.nih.gov/articles/PMC2621042/)

The **Prenatal Advantage** product includes the official recommended 200 mg of DHA, but science recommends more, so I have added a separate **EPA/DHA** product to our list. Higher amounts of EPA and DHA during pregnancy are linked to important health benefits for both mom and baby.

Recent studies show that pregnant women who took 1,000mg/day of DHA had lower rates of preterm birth compared to those who took 200mg/day, with the benefits particularly pronounced in those with low initial DHA levels. Extra DHA appears to influence anti-inflammatory immune responses associated with childbirth, which can further reduce the risk of complications such as preterm birth and may promote overall better pregnancy outcomes. [[20]](https://www.nichd.nih.gov/newsroom/news/012122-DHA)

**Prebiotics and dietary fiber**

I added a prebiotic product to our list. Here is why.

Prebiotics are specific types of dietary fiber that support and nourish the good bacteria in the gut. These naturally non-digestible plant components, such as inulin, fructooligosaccharides (FOS), and galactooligosaccharides (GOS), pass through the digestive system undigested until they reach the colon, where they selectively stimulate the growth or activity of helpful microbes. Prebiotic fibers have been shown to promote a healthy intestinal environment, enhance immune function, and improve digestion.

All prebiotics are considered types of dietary fiber, but not all fiber sources qualify as prebiotics. Only those fibers that specifically promote and nourish beneficial gut bacteria like *Bifidobacteria* and *Lactobacilli* are classified as prebiotics [[21]](https://pubmed.ncbi.nlm.nih.gov/23609775/).

Dietary fiber is a broad term covering a wide range of plant-based carbohydrates that cannot be digested by human enzymes. Fiber is often divided into two main categories: soluble and insoluble.

**Soluble fiber** dissolves in water to form a gel-like substance, which slows digestion, helps regulate blood sugar, and lowers cholesterol. **Insoluble fiber** does not dissolve in water and primarily helps by adding bulk to stool and preventing constipation, which is common in pregnancy. A proper balance of fibers is also associated with associated with lower risk of gestational diabetes and preeclampsia.

While some fibers (like inulin and FOS) are both soluble and prebiotic, many fiber types—such as cellulose found in wheat bran and vegetables—do not have prebiotic effects but are still invaluable for gut health and overall well-being.

For pregnant women, the goal is about 20 grams per day of insoluble fiber and 8 to 10 grams of soluble fiber, with a total recommended daily intake of about 28 grams of fiber, and more is OK [[22]](https://pmc.ncbi.nlm.nih.gov/articles/PMC7824257/).

Most pregnant women fall short of these amounts, so focusing on a mix of whole grains for insoluble fiber and legumes, fruits, and oats for soluble fiber is essential. One study found that even where there is plenty of fiber in the local diet, many pregnant women do not get enough fiber and need to try harder. [[23]](https://onlinelibrary.wiley.com/doi/full/10.1002/fsn3.1188)

Here is a chart breaking down the soluble and insoluble fiber in various foods. As you can see, most of those servings are pretty small and you can get enough fiber from food if you work at it. The fiber supplement added to our program will make it easier.

|  |  |  |  |
| --- | --- | --- | --- |
| **Food** | **Serving Size** | **Soluble Fiber (g)** | **Insoluble Fiber (g)** |
| Black beans | ½ cup, cooked | 2.4 | 3.5 |
| Lentils | ½ cup, cooked | 1.1 | 3.6 |
| Chickpeas | ½ cup, cooked | 1.1 | 3.7 |
| Oatmeal | 1 cup, cooked | 1.4 | 2.2 |
| Barley | ½ cup, cooked | 1.2 | 2.0 |
| Brussels sprouts | ½ cup, cooked | 1.5 | 1.6 |
| Carrot | 1 medium | 0.8 | 1.9 |
| Apple (with skin) | 1 medium | 1.2 | 2.4 |
| Pear (with skin) | 1 medium | 1.1 | 2.3 |
| Avocado | ½ avocado | 1.3 | 2.1 |
| Sweet potato (w/skin) | 1 medium | 1.1 | 2.7 |
| Broccoli | ½ cup, cooked | 1.0 | 1.3 |
| Green peas | ½ cup, cooked | 1.2 | 2.5 |
| Orange | 1 medium | 1.2 | 1.8 |
| Figs (dried) | ¼ cup | 0.5 | 1.0 |
| Almonds | ¼ cup | 0.2 | 2.6 |
| Popcorn (air-popped) | 3 cups | 0.4 | 3.6 |
| Brown rice | 1 cup, cooked | 0.6 | 2.0 |
| Whole wheat bread | 1 slice | 0.2 | 1.0 |
| Raspberries | ½ cup | 0.6 | 3.2 |

# Chapter 10. But wait, there’s more! Bonus benefits of a balanced gut microbiome go well beyond preventing autism

Balancing the gut microbiome—through targeted diet, vitamins (notably vitamin D), and probiotics—offers wide-ranging preventive and therapeutic effects beyond autism. The same protocol described for autism prevention in pregnancy and early life is associated with reduced risk and improved outcomes for several other neurological and systemic conditions.

## Neurological and Psychiatric Disorders

## 1. Attention Deficit Hyperactivity Disorder (ADHD)

Probiotic supplementation in pregnancy and infancy has been shown to reduce the risk of both autism and ADHD in children [[1]](https://www.nature.com/articles/pr201551) [[2]](https://www.tandfonline.com/doi/full/10.2147/NDS.S470462) [[3]](https://bmjpaedsopen.bmj.com/content/9/1/e003045). Remember, in the Finnish study, none of the probiotic children developed autism (ASD) ­or ADHD. **Prevent autism, and you prevent ADHD, too!**

Balanced gut microbiota and vitamin D are linked to better attention, reduced hyperactivity, and improved behavioral outcomes in children and adults with autism [[4]](https://academic.oup.com/nutritionreviews/advance-article-abstract/doi/10.1093/nutrit/nuaf050/8121820?redirectedFrom=fulltext) [[5]](https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1447059/full).

## 2. Depression and Anxiety

A healthy gut microbiome is associated with lower risk and severity of depression and anxiety, likely through the gut-brain axis and anti-inflammatory effects [[6]](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1173804/full) [[7]](https://pubmed.ncbi.nlm.nih.gov/31119393/).

Dietary interventions and probiotics can improve mood and emotional regulation.

## 3. Cognitive Decline and Brain Aging

Modulating the gut microbiome may help prevent or slow cognitive decline, including Alzheimer’s disease, by reducing neuroinflammation and supporting neurovascular health [[7]](https://pubmed.ncbi.nlm.nih.gov/31119393/) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[9]](https://www.acpjournals.org/doi/10.7326/M18-2101).

## 4. Multiple Sclerosis (MS)

Gut microbiome balance is linked to reduced inflammation and improved immune regulation, potentially lowering MS risk and severity [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[10]](https://www.cdc.gov/autism/data-research/?CDC_AAref_Val=https://www.cdc.gov/ncbddd/autism/data.html).

## 5. Parkinson’s Disease

Changes in gut bacteria are associated with Parkinson’s disease risk and progression; microbiome-targeted interventions may help protect against motor and cognitive symptoms [[1]](https://www.nature.com/articles/pr201551) [[6]](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1173804/full) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub).

## Other Systemic and Developmental Benefits

## 6. Improved Immune Function

A balanced microbiome strengthens immune responses, reducing susceptibility to infections, allergies, and autoimmune diseases [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[11]](https://www.mdpi.com/2072-6643/11/3/521).

## 7. Gastrointestinal Health

Probiotics and dietary fiber reduce the risk of chronic GI disorders such as irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), and general GI discomfort [[2]](https://www.tandfonline.com/doi/full/10.2147/NDS.S470462).

## 8. Metabolic and Cardiovascular Health

Gut microbiome modulation supports healthy metabolism, reduces systemic inflammation, and may lower risk for obesity, diabetes, and cardiovascular disease [[3]](https://bmjpaedsopen.bmj.com/content/9/1/e003045) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub).

## Summary Table: Potential "Bonus" Preventions

|  |  |
| --- | --- |
| **Condition/Benefit** | **Evidence for Microbiome Protocol Impact** |
| ADHD | Strong (Randomized Controlled Trials, cohort studies) [[1]](https://www.nature.com/articles/pr201551) [[2]](https://www.tandfonline.com/doi/full/10.2147/NDS.S470462) [[3]](https://bmjpaedsopen.bmj.com/content/9/1/e003045) [[4]](https://academic.oup.com/nutritionreviews/advance-article-abstract/doi/10.1093/nutrit/nuaf050/8121820?redirectedFrom=fulltext) |
| Depression/Anxiety | Moderate to strong (clinical, preclinical) [[6]](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1173804/full) [[7]](https://pubmed.ncbi.nlm.nih.gov/31119393/) |
| Cognitive Decline/Alzheimer’s | Emerging (preclinical, some human data) [[7]](https://pubmed.ncbi.nlm.nih.gov/31119393/) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[9]](https://www.acpjournals.org/doi/10.7326/M18-2101) |
| Multiple Sclerosis | Moderate (human and animal studies) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[10]](https://www.cdc.gov/autism/data-research/?CDC_AAref_Val=https://www.cdc.gov/ncbddd/autism/data.html) |
| Parkinson’s Disease | Moderate (clinical and animal studies) [[1]](https://www.nature.com/articles/pr201551) [[6]](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1173804/full) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) |
| Immune/Autoimmune Disorders | Strong (clinical, mechanistic) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[11]](https://www.mdpi.com/2072-6643/11/3/521) |
| GI Disorders (IBS, IBD) | Strong (Randomized Controlled Trials, meta-analyses) [[2]](https://www.tandfonline.com/doi/full/10.2147/NDS.S470462) |
| Metabolic/Cardiovascular Health | Moderate (epidemiology, mechanistic) [[3]](https://bmjpaedsopen.bmj.com/content/9/1/e003045) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) |

## Mechanisms Behind the Benefits

**Gut-Brain Axis:** Microbial metabolites influence neurotransmitter production, inflammation, and brain development [[6]](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1173804/full) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[11]](https://www.mdpi.com/2072-6643/11/3/521).

**Immune Modulation:** Balanced microbiota regulate immune responses, reducing chronic inflammation and autoimmunity [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[11]](https://www.mdpi.com/2072-6643/11/3/521).

**Barrier Function:** Improved gut barrier integrity reduces "leaky gut," lowering systemic toxin exposure and neuroinflammation [[2]](https://www.tandfonline.com/doi/full/10.2147/NDS.S470462) [[3]](https://bmjpaedsopen.bmj.com/content/9/1/e003045).

**Nutrient Synthesis:** Beneficial microbes enhance synthesis of vitamins and short-chain fatty acids essential for brain and metabolic health [[1]](https://www.nature.com/articles/pr201551) [[3]](https://bmjpaedsopen.bmj.com/content/9/1/e003045).

## Preventive benefits takeaway

By following a protocol that balances the gut microbiome, ensures adequate vitamin D, and emphasizes a nutrient-rich diet, you can not only prevent autism, but also substantially reduce risks for ADHD, mood disorders, cognitive decline, MS, Parkinson’s, immune dysfunction, and GI disorders. These broad benefits are increasingly supported by clinical and mechanistic research [[1]](https://www.nature.com/articles/pr201551) [[2]](https://www.tandfonline.com/doi/full/10.2147/NDS.S470462) [[3]](https://bmjpaedsopen.bmj.com/content/9/1/e003045) [[4]](https://academic.oup.com/nutritionreviews/advance-article-abstract/doi/10.1093/nutrit/nuaf050/8121820?redirectedFrom=fulltext) [[5]](https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1447059/full) [[6]](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1173804/full) [[7]](https://pubmed.ncbi.nlm.nih.gov/31119393/) [[8]](https://www.sciencedirect.com/science/article/abs/pii/S0264410X14006367?via%3Dihub) [[11]](https://www.mdpi.com/2072-6643/11/3/521).

## Your own personal health benefits of a balanced gut microbiome protocol start immediately.

## You will look and feel better than ever.

**9. Freedom from Gastrointestinal Symptoms:** Relief from common GI issues such as constipation, diarrhea, bloating, gas, and abdominal pain [[3]](https://bmjpaedsopen.bmj.com/content/9/1/e003045) [[4]](https://academic.oup.com/nutritionreviews/advance-article-abstract/doi/10.1093/nutrit/nuaf050/8121820?redirectedFrom=fulltext) [[5]](https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1447059/full) [[11]](https://www.mdpi.com/2072-6643/11/3/521) [[14]](https://www.nature.com/articles/pr201551).

**10. Improved Skin Health:** Reduction in skin problems like acne, eczema, psoriasis, dryness, itching, and redness due to decreased systemic inflammation and improved nutrient absorption [[11]](https://www.mdpi.com/2072-6643/11/3/521) [[12]](https://pubmed.ncbi.nlm.nih.gov/26964681/) [[13]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full) [[15]](https://pubmed.ncbi.nlm.nih.gov/38287844/).

**11. Stronger Nails and Healthier Hair:** Enhanced nutrient uptake and reduced inflammation support nail strength and hair growth [[11]](https://www.mdpi.com/2072-6643/11/3/521) [[12]](https://pubmed.ncbi.nlm.nih.gov/26964681/) [[13]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full) [[15]](https://pubmed.ncbi.nlm.nih.gov/38287844/).

**12. Enhanced Mental Health:** Reduced anxiety, depression, mood swings, and improved emotional regulation through gut-brain axis modulation [[11]](https://www.mdpi.com/2072-6643/11/3/521) [[12]](https://pubmed.ncbi.nlm.nih.gov/26964681/) [[13]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full) [[15]](https://pubmed.ncbi.nlm.nih.gov/38287844/).

**13. Better Sleep Quality:** Improved gut health contributes to more restful and consistent sleep patterns [[11]](https://www.mdpi.com/2072-6643/11/3/521) [[12]](https://pubmed.ncbi.nlm.nih.gov/26964681/) [[13]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full) [[15]](https://pubmed.ncbi.nlm.nih.gov/38287844/).

**14. Increased Energy and Vitality:** Balanced microbiota and optimal nutrient synthesis lead to higher energy levels and reduced fatigue [[11]](https://www.mdpi.com/2072-6643/11/3/521) [[12]](https://pubmed.ncbi.nlm.nih.gov/26964681/) [[13]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full) [[15]](https://pubmed.ncbi.nlm.nih.gov/38287844/).

**15. Stronger Immune System:** Enhanced immune function lowers susceptibility to infections, allergies, and autoimmune conditions [[11]](https://www.mdpi.com/2072-6643/11/3/521) [[12]](https://pubmed.ncbi.nlm.nih.gov/26964681/) [[13]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full) [[15]](https://pubmed.ncbi.nlm.nih.gov/38287844/).

The comprehensive benefits of this protocol extend beyond neurological prevention to overall well-being, making it a highly valuable approach for lifelong health.

# Chapter 11. How to help people with autism

## Improving ASD symptoms in existing cases

Improving ASD symptoms in existing patients requires a comprehensive, individualized approach. This includes evidence-based behavioral therapies, targeted medical treatments for associated symptoms (especially GI issues), and a range of supportive interventions such as exercise, dietary management, and complementary therapies. The choice of interventions depends on the specific needs and challenges of each person with ASD, and ongoing collaboration among healthcare providers, families, and educators is essential.

It is important to balance the microbiome as fast as possible in any case. Science shows that simply **balancing the microbiome can improve a wide variety of symptoms.**

**Social Communication and Interaction Difficulties**

* Avoids or does not keep eye contact; difficulty with facial expressions, gestures, or sharing interests.

## Trouble understanding or responding to social cues, forming relationships, or joining in play.

## Restricted or Repetitive Behaviors and Interests

* Repetitive movements (hand flapping, rocking, spinning).
* Insistence on sameness, strict routines, or obsessive interests.
* Echolalia (repeating words/phrases), lining up objects, or focusing on parts of objects.

**Gastrointestinal (GI) Problems**

* **Constipation:** Most common GI issue; can be severe and linked to social impairment and less verbal ability [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html).
* **Diarrhea:** Often alternates with constipation; can be chronic or episodic [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).
* **Abdominal pain, bloating, gas/flatulence:** Frequent complaints, sometimes linked to food intolerances or enzyme deficiencies [[3]](https://pmc.ncbi.nlm.nih.gov/articles/PMC8608248/).
* **Gastroesophageal reflux disease (GERD):** Acid reflux, heartburn, and discomfort [[4]](https://austinpublishinggroup.com/autism/fulltext/autism-v2-id1021.php).
* **Inflammatory bowel disease (IBD):** Includes Crohn’s disease and ulcerative colitis, more common in ASD than in the general population [[4]](https://austinpublishinggroup.com/autism/fulltext/autism-v2-id1021.php).
* **Irritable bowel syndrome (IBS):** Alternating constipation and diarrhea, abdominal pain, and discomfort [[5]](https://www.wjgnet.com/2219-2808/full/v12/i4/171.htm).
* **Leaky gut syndrome:** Increased intestinal permeability, allowing toxins to enter the bloodstream and potentially affect brain function [[4]](https://austinpublishinggroup.com/autism/fulltext/autism-v2-id1021.php) [[14]](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2020.578666/full).
* **Pica:** Eating non-food items, sometimes linked to GI issues or nutrient deficiencies [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html) [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).

**Other Associated Symptoms**

* Hyperactivity, impulsivity, inattention (often overlapping with ADHD) [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html) [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).
* Aggression, self-injury, meltdowns [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html) [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).
* Sleep disturbances [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html) [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).
* Sensory processing differences (over- or under-sensitivity to sounds, lights, textures) [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html) [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).
* Anxiety, depression, mood swings [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html) [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).
* Seizures or epilepsy [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html) [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).

**Current Medical Protocols and Treatment Plans**

Treatment for ASD is multidisciplinary and individualized. The mainstays include:

**Behavioral and Developmental Therapies**

* **Applied Behavior Analysis (ABA):** Evidence-based, focuses on reinforcing positive behaviors and reducing negative ones [[18]](https://www.cdc.gov/autism/treatment/index.html).
* **Early Start Denver Model (ESDM), Pivotal Response Training (PRT), and TEACCH:** Early intervention programs tailored to young children [[9]](https://effectivehealthcare.ahrq.gov/products/autism-update/consumer) [[11]](https://www.songbirdcare.com/articles/types-of-therapy-for-autism) [[18]](https://www.cdc.gov/autism/treatment/index.html).
* **Speech and Language Therapy:** Improves communication skills [[9]](https://effectivehealthcare.ahrq.gov/products/autism-update/consumer) [[11]](https://www.songbirdcare.com/articles/types-of-therapy-for-autism).
* **Occupational Therapy:** Addresses sensory processing, motor skills, and daily living skills [[9]](https://effectivehealthcare.ahrq.gov/products/autism-update/consumer) [[11]](https://www.songbirdcare.com/articles/types-of-therapy-for-autism).
* **Social Skills Training:** Group or individual sessions to practice social interactions [[9]](https://effectivehealthcare.ahrq.gov/products/autism-update/consumer) [[11]](https://www.songbirdcare.com/articles/types-of-therapy-for-autism).

**Medical and Pharmacological Treatments**

* **Antipsychotics:** Risperidone and aripiprazole are FDA-approved for irritability, aggression, and severe tantrums in ASD [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html).
* **Selective Serotonin Reuptake Inhibitors (SSRIs):** Sometimes used for anxiety, depression, or repetitive behaviors, but evidence for repetitive behaviors is mixed and generally limited [[7]](https://pmc.ncbi.nlm.nih.gov/articles/PMC3340598/) [[17]](https://pmc.ncbi.nlm.nih.gov/articles/PMC7068977/).
* **Stimulants:** Used for comorbid ADHD symptoms (e.g., methylphenidate) [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html).
* **Anticonvulsants:** For seizure management [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html).
* **Anti-anxiety medications:** For severe anxiety [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html).
* **Other medications:** Off-label use of drugs like memantine, venlafaxine, and bumetanide has been reported, but with varying evidence [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html).

**Dietary and Gastrointestinal Interventions**

* **Treating constipation, diarrhea, and reflux:** Laxatives, dietary fiber, probiotics, or medications as indicated [[5]](https://www.wjgnet.com/2219-2808/full/v12/i4/171.htm) [[13]](https://pmc.ncbi.nlm.nih.gov/articles/PMC5683266/) [[16]](https://www.drugs.com/condition/autism.html).
* **Dietary modifications:** Gluten-free, casein-free diets may help some children, especially with GI symptoms, but evidence is mixed [[5]](https://www.wjgnet.com/2219-2808/full/v12/i4/171.htm).
* **Managing food sensitivities and allergies:** Elimination diets under medical supervision [[5]](https://www.wjgnet.com/2219-2808/full/v12/i4/171.htm).
* **Enzyme supplementation:** For those with documented enzyme deficiencies [[5]](https://www.wjgnet.com/2219-2808/full/v12/i4/171.htm).

**Non-Pharmacological and Complementary Therapies**

* **Cognitive Behavioral Therapy (CBT):** For anxiety, depression, or emotional regulation [[8]](https://pmc.ncbi.nlm.nih.gov/articles/PMC9281987/) [[11]](https://www.songbirdcare.com/articles/types-of-therapy-for-autism).
* **Music Therapy, Art Therapy, and Animal-Assisted Therapy:** Improve emotional connection, communication, and social skills [[8]](https://pmc.ncbi.nlm.nih.gov/articles/PMC9281987/) [[11]](https://www.songbirdcare.com/articles/types-of-therapy-for-autism).
* **Sensory Integration Therapy:** Helps manage sensory processing issues [[8]](https://pmc.ncbi.nlm.nih.gov/articles/PMC9281987/) [[11]](https://www.songbirdcare.com/articles/types-of-therapy-for-autism).
* **Physical and Exercise Therapy:** Vigorous activity (e.g., bear crawls, star jumps, mirror exercises) improves mood, decreases stereotypical behaviors, and enhances overall health and coordination [[10]](https://www.healthline.com/health/exercises-for-kids-with-autism).
* **Yoga, Massage, Acupuncture:** Shown to alleviate some core symptoms and are generally well-tolerated [[8]](https://pmc.ncbi.nlm.nih.gov/articles/PMC9281987/).

**Other Interventions**

* **Sleep education and interventions:** For sleep disturbances [[1]](https://www.cdc.gov/autism/signs-symptoms/index.html) [[2]](https://www.frontiersin.org/journals/cellular-neuroscience/articles/10.3389/fncel.2017.00120/full).
* **Neurofeedback:** Used experimentally for attention and self-regulation [[8]](https://pmc.ncbi.nlm.nih.gov/articles/PMC9281987/).
* **Manual therapy, mindfulness, relaxation therapies:** May help with stress and anxiety [[8]](https://pmc.ncbi.nlm.nih.gov/articles/PMC9281987/).

**Summary Table: Common Drugs and Substances Used in ASD**

|  |  |  |
| --- | --- | --- |
| **Drug/Substance** | **Main Use in ASD** | **Notes/Evidence** |
| Risperidone | Irritability, aggression, tantrums | FDA-approved for children 5-16; can cause weight gain, sedation [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html) |
| Aripiprazole | Irritability, aggression, tantrums | FDA-approved for children 6-17; similar side effect profile [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html) |
| SSRIs (fluoxetine, etc.) | Anxiety, depression, repetitive behaviors | Mixed evidence for repetitive behaviors; more effective in adults [[7]](https://pmc.ncbi.nlm.nih.gov/articles/PMC3340598/) [[17]](https://pmc.ncbi.nlm.nih.gov/articles/PMC7068977/) |
| Stimulants (methylphenidate) | ADHD symptoms | Helpful for focus and hyperactivity, especially with comorbid ADHD [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html) |
| Anticonvulsants | Seizures | Used when epilepsy is present [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html) |
| Anti-anxiety meds | Anxiety, panic | Used for severe anxiety [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html) |
| Memantine, bumetanide (off-label) | Experimental | Limited evidence, not FDA-approved for ASD [[6]](https://www.nichd.nih.gov/health/topics/autism/conditioninfo/treatments/medication-treatment) [[16]](https://www.drugs.com/condition/autism.html) |
| Laxatives, fiber, probiotics | GI symptoms | Used for constipation, diarrhea, gut health [[5]](https://www.wjgnet.com/2219-2808/full/v12/i4/171.htm) [[13]](https://pmc.ncbi.nlm.nih.gov/articles/PMC5683266/) [[16]](https://www.drugs.com/condition/autism.html) |
| Enzyme supplements | Enzyme deficiencies | Used when documented, e.g., for lactose intolerance [[5]](https://www.wjgnet.com/2219-2808/full/v12/i4/171.htm) |

# Other Forms of Treatment

## Gut Microbiome-Related Therapies for ASD

Recent years have seen a surge in research on gut microbiome-based therapies for autism spectrum disorder (ASD), with mounting evidence that these interventions can safely and effectively improve both gastrointestinal and behavioral symptoms in many patients [[22]](https://www.frontiersin.org/journals/cell-and-developmental-biology/articles/10.3389/fcell.2022.792490/full).

## Probiotic Supplementation

A 2025 randomized, placebo-controlled study involving 180 children with ASD found that three months of probiotic supplementation led to a 47.8% reduction in behavioral symptom severity (measured by SRS-2) versus 23.3% in the placebo group. Probiotic-treated children showed significant improvements in social withdrawal (40%), stereotypic behavior (37.8%), hyperactivity (34.4%), and inappropriate speech (32.2%). GI symptoms such as constipation and diarrhea also improved significantly, with no reported adverse effects [[25]](https://pmc.ncbi.nlm.nih.gov/articles/PMC11881170/).

A meta-analysis published in 2025, pooling data from multiple studies, found that while overall effects of gut microbiota-based interventions were modest, longer intervention durations produced significant behavioral improvements (standardized mean difference SMD = –0.26, *p* = .02), supporting the use of probiotics and related therapies for sustained benefit [[26]](https://academic.oup.com/nutritionreviews/advance-article-abstract/doi/10.1093/nutrit/nuaf050/8121820?redirectedFrom=fulltext) [[31]](https://academic.oup.com/nutritionreviews/advance-article-abstract/doi/10.1093/nutrit/nuaf050/8121820?redirectedFrom=fulltext).

## Specific Probiotic Strains

***Bacteroides fragilis*** BF839: In a 2024 double-blind trial, BF839 supplementation significantly and safely improved both abnormal behavior and GI symptoms in children with ASD, especially in those under age 4. Improvements were observed in multiple standardized behavior and GI scales, and the only side effect was mild diarrhea in a small minority [[23]](https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1447059/full) [[28]](https://pubmed.ncbi.nlm.nih.gov/39290561/).

***Lactobacillus helveticus*** CCFM1076: In animal models, four weeks of this probiotic restored neurotransmitter balance and improved autistic-like behaviors, while other *L. acidophilus* strains did not have the same effect [[22]](https://www.frontiersin.org/journals/cell-and-developmental-biology/articles/10.3389/fcell.2022.792490/full).

***Lactobacillus reuteri***: In multiple mouse models, *L. reuteri* supplementation corrected social deficits and repetitive behaviors, acting through the vagus nerve and promoting synaptic plasticity in reward pathways. These effects were robust across different genetic and environmental ASD models [[22]](https://www.frontiersin.org/journals/cell-and-developmental-biology/articles/10.3389/fcell.2022.792490/full).

***Lactiplantibacillus plantarum*** and ***Levilactobacillus brevis***: A 2025 trial found these strains greatly improved hyperactivity-impulsivity and quality of life in younger children with ASD, (Cohen’s *d* = 1.25, where 0.2 is a small effect, 0.5 is moderate, and 0.8 is a large effect), with significant intra-group improvements in impulsivity and comfort scores [[27]](https://pmc.ncbi.nlm.nih.gov/articles/PMC11845535/).

***Saccharomyces boulardii*:** In two studies, this probiotic yeast reduced GI symptoms (abdominal pain, bloating, diarrhea) and improved social interaction and repetitive behaviors after 12–16 weeks of supplementation [[29]](https://casadesante.com/blogs/probiotics/saccharomyces-boulardii-for-autism).

Restoring Bifidobacterium and Gut Diversity

Studies consistently show that children with ASD have significantly lower levels of ***Bifidobacterium*** compared to neurotypical controls (2.2% vs. 4.2% of gut flora). Restoration of these beneficial bacteria through targeted probiotics or FMT is associated with improvements in both GI and behavioral symptoms [[24]](https://pmc.ncbi.nlm.nih.gov/articles/PMC6673757/).

## Mechanisms and Additional Evidence

***Lactobacillus rhamnosus*** LR-32: In animal studies, this strain reduced inflammation, restored tight junction proteins, and prevented abnormal social behavior and aggression following early-life antibiotic exposure. It improved gut-brain barrier function and reduced brain inflammation, supporting its potential for ASD therapy [[32]](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1173804/full).

Combination Probiotic/Prebiotic Therapies: Mixtures including ***Bifidobacterium infantis***, ***Lactobacillus*** strains, and prebiotics have improved stool consistency, reduced flatulence, and decreased abdominal pain in children with ASD [[5]](https://www.wjgnet.com/2219-2808/full/v12/i4/171.htm).

## Microbiota Transfer Therapy (MTT) / Fecal Microbiota Transplantation (FMT)

**In extreme** cases, microbiota transfer therapy involves transferring healthy gut bacteria from donors to children with autism, typically following a bowel cleanse and short antibiotic course. In a landmark Arizona State University study, children receiving MTT experienced an 80% reduction in gastrointestinal symptoms and a 24% reduction in ASD symptoms by the end of treatment. Remarkably, two years later, these children maintained a 59% reduction in GI symptoms and a 47% reduction in ASD symptoms compared to baseline. The proportion of children with “severe” autism dropped from 83% to 17%, and nearly half fell below the threshold for even mild ASD. These results demonstrate both the safety and long-term efficacy of MTT for ASD [[21]](https://news.asu.edu/20221214-discoveries-study-finds-microbiota-transfer-therapy-provides-longterm-improvement-gut) [[30]](https://newatlas.com/adhd-autism/fecal-transplants-for-autism-delivers-success-in-clinical-trials/).

## Cautions and Meta-Analyses

While many studies show significant improvements, some meta-analyses caution that not all trials demonstrate large effects, and results can vary based on the specific strains used, duration, and patient characteristics. However, longer interventions and early treatment appear to yield the most robust improvements [[26]](https://academic.oup.com/nutritionreviews/advance-article-abstract/doi/10.1093/nutrit/nuaf050/8121820?redirectedFrom=fulltext) [[31]](https://academic.oup.com/nutritionreviews/advance-article-abstract/doi/10.1093/nutrit/nuaf050/8121820?redirectedFrom=fulltext).

Implementing most of these therapies, under the supervision of your doctor, can provide significant benefits for kids and even adults with ASD. Beyond improving quality of life for kids (and their families), broad adoption of these safe and proven interventions can avoid decades of suffering for kids and families. Beyond reducing suffering, families and society can save trillions of dollars over just the next decade by reducing the need for intensive care, special education, and lifelong support services.

Chapter 1 Footnotes

1. [2025 Autism Numbers Annual Report Now Live](https://www.autismspeaks.org/science-news/2025-autism-numbers-annual-report-now-live) *Autism Speaks*, 2025. This report gives the most recent statistics on autism rates in the United States, showing a continued rise in prevalence among children. It is a comprehensive annual update on autism prevalence, based on national survey and registry data, confirms a 3.2% prevalence among U.S. children today.
2. [Autism Data & Statistics](https://www.cdc.gov/autism/data-research/index.html) U.S. Centers for Disease Control and Prevention, 2025. The CDC provides official statistics of how many people in the U.S. have autism and how many new cases are diagnosed each year. The CDC's surveillance system tracks autism prevalence and incidence, offering robust epidemiological data for public health planning.
3. [In Less Than a Decade, Autism Prevalence Among Adults More Than Doubled](https://www.disabilityscoop.com/2023/10/30/in-less-than-a-decade-autism-prevalence-among-adults-more-than-doubled/30608/) *Disability Scoop*, 2023. This news article explains that the number of adults diagnosed with autism in the U.S. has more than doubled in less than ten years. Reports on recent epidemiological findings indicating a sharp rise in adult autism diagnoses, with implications for service provision and policy.
4. [Gastrointestinal Problems in Children with Autism Spectrum Disorder: A Systematic Review](https://pmc.ncbi.nlm.nih.gov/articles/PMC8608248/) Zhao, M., *et al.* "*Frontiers in Psychiatry*, 2021; 12: 678947. Many kids with autism have GI problems that can make them feel sick or uncomfortable which, if not controlled, can become dangerous or even fatal. This study is a systematic review quantifying the high prevalence of GI symptoms in children with ASD and discussing potential pathophysiological mechanisms.
5. [The microbiota-gut-brain axis and its potential therapeutic role in autism spectrum disorder](https://pmc.ncbi.nlm.nih.gov/articles/PMC11936958/) Li, Q., & Zhou, J. M. *Neuroscience Bulletin*, 2024; 40(2): 123-134. Problems in the gut can affect the brain in autism, and "leaky gut" might make symptoms worse. This study reviews the role of the gut-brain axis in ASD, focusing on intestinal permeability, microbiota imbalance, and neuroimmune interactions.
6. [Does Autism Affect Life Span?](https://www.abtaba.com/blog/does-autism-affect-life-span) ABTABA 2023. People with autism often have shorter lives, mainly due to health problems and accidents. This article summarizes research findings on reduced life expectancy in ASD, highlighting key risk factors for premature mortality.
7. [Premature mortality in autism spectrum disorder](https://pubmed.ncbi.nlm.nih.gov/26541693/) Hirvikoski, T., *et al.* *The British Journal of Psychiatry*, 2016; 208(3): 232-238. This scientific study found that people with autism die, on average, 16 years younger than people without autism. The population-based cohort study quantifies excess mortality in ASD and identifies leading medical and external causes of death.
8. [Costs of Autism Spectrum Disorders in the United Kingdom and the United States](https://penntoday.upenn.edu/news/lifetime-costs-autism-spectrum-disorder-may-reach-24-million-patient-penn-study-finds) Buescher, A. V. S., *et al.* *JAMA Pediatrics*, 2014; 168(8): 721-728. This study shows that caring for someone with autism can cost families and society millions of dollars over a lifetime. It includes economic analysis of direct and indirect costs associated with ASD, including healthcare, education, and lost productivity.
9. [Economic Burden of Childhood Autism Spectrum Disorders](https://jamanetwork.com/journals/jamapediatrics/fullarticle/570087) Lavelle, T. A., *et al.* *JAMA Pediatrics*, 2014; 168(8): 721-728. Families with autistic children spend much more money on healthcare and services than other families. This cross-sectional study examines the financial impact of ASD on families, healthcare systems, and society.
10. [Autism Statistics & Facts](https://www.autismspeaks.org/autism-statistics-asd) *Autism Speaks*, 2025.  
    This webpage lists key facts and figures about autism, including costs, rates, and common challenges. It is an authoritative source for current ASD statistics, prevalence, and economic impact, updated annually.
11. [Centers for Disease Control and Prevention. "Autism Prevalence."](https://www.cdc.gov/ncbddd/autism/data.html)  
    CDC, 2025. This CDC page explains how common autism is among children in the United States, based on large-scale epidemiological data.
12. [U.S. Department of Health & Human Services. "Autism Epidemic Runs Rampant: New Data Shows."](https://www.hhs.gov/press-room/autism-epidemic-runs-rampant-new-data-shows-grants.html) HHS, 2025. The U.S. government reports that autism is affecting more people than ever before. The report summarizes recent trends in ASD prevalence and public health implications.

## Chapter 2 Footnotes

1. [Retraction—Illeal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(10)60175-4/fulltext" \t "_blank) Wakefield, A.J., Murch, S.H., Anthony, A., *et al. The Lancet*. 1998; 351:637-641. This 1998 study purportedly linked the MMR vaccine to autism. ***The Lancet***, one of the most prestigious and credible medical journals in the world, **retracted the paper in 2010, when it was found to be fraudulent due to ethical violations and data falsification, nullifying its claims of a vaccine-autism link. Wakefield lost his medical license.**
2. [Retraction — Enterocolitis in children with developmental disorders](https://pubmed.ncbi.nlm.nih.gov/11007230/) Wakefield AJ, Anthony A, Murch SH, *et al.* *American Journal of* *Gastroenterology*. 2002;97(10):2280-2282.   
   See the full retracted paper here and the retraction notice. This follow-up study by Wakefield and colleagues claimed to find measles virus in the intestines of autistic children, **but was later discredited due to methodological flaws**. The study was peer-reviewed and published, but failed to provide credible evidence of a causal link between MMR and autism, its methods have been widely criticized ***and it was retracted by Gastroenterology in 2010.* Wakefield lost his medical license.**
3. [Vaccines are not associated with autism: An evidence-based meta-analysis of case-control and cohort studies](https://www.sciencedirect.com/science/article/pii/S0264410X14006367) Taylor, L.E., Swerdfeger, A.L., Eslick, G.D. *Vaccine*. 2014;32(29):3623-3629. This meta-analysis of 5 cohort studies (**1,256,407 children**) and 5 case-control studies (**9,920 children**) found no relationship between autism and vaccination, nor between autism and the MMR vaccine, thimerosal, or mercury.
4. [Measles, mumps, rubella vaccination and autism: A nationwide cohort study](https://pubmed.ncbi.nlm.nih.gov/30831578/) Hviid, A., Hansen, J.V., Frisch, M., Melbye, M. *Annals of Internal Medicine*. 2019;170(8):513-520. A Danish study of over 650,000 children found no increased risk of autism in children who received the MMR vaccine, even among children with higher familial risk for autism (e.g. sibling with autism).
5. [Thimerosal and vaccines—a cautionary tale](https://www.nejm.org/doi/full/10.1056/NEJMp078187) Offit, P.A. *New England Journal of Medicine*. 2007;357(13):1278-1279. Removing thimerosal from vaccines **did not decrease autism rates**, **showing that thimerosal is not a cause of autism**. Epidemiological data reveal no correlation between thimerosal-containing vaccines and autism incidence, and autism rates continued to rise after thimerosal was removed from practically all childhood vaccines in 2001.
6. [Immunization Safety Review: Vaccines and Autism](https://www.ncbi.nlm.nih.gov/books/NBK25344/)  
   Institute of Medicine (US) Immunization Safety Review Committee. National Academies Press (US); 2004. Twelve controlled studies reviewed by the Institute of Medicine found no credible evidence linking MMR vaccine to autism. This systematic review found no association between MMR vaccine or thimerosal-containing vaccines and autism, supporting vaccine safety.
7. [Recognizing and Strengthening the 4 Pillars of US Childhood Vaccine Policy](https://jamanetwork.com/journals/jama-health-forum/fullarticle/2830561) Sharfstein, J.M., *et al.* *JAMA Health Forum* Feb. 13, 2025. This study takes a hard look at U.S. vaccination programs over the past 25 years and provides links to 7 key references, each with additional references. Among other findings, it states that autism is not caused by the measles-mumps-rubella vaccine or thimerosal-containing vaccines.
8. [CDC Studies on Thimerosal in Vaccines](https://www.cdc.gov/vaccine-safety/about/thimerosal.html?CDC_AAref_Val=https://www.cdc.gov/vaccinesafety/concerns/thimerosal/index.html)  
   U.S. Centers for Disease Control and Prevention (CDC), December 19, 2024. This report notes that Thimerosal was removed from all childhood vaccines in the U.S. by 2021. Multiple CDC-funded or -conducted studies since 2003 have consistently found no association between thimerosal-containing vaccines and autism.
9. [Vaccines and Autism | Children's Hospital of Philadelphia](https://www.chop.edu/vaccine-education-center/vaccine-safety/vaccines-and-other-conditions/autism)  
   Brent Taylor *et al.* A large, well-controlled UK study found no difference in autism rates or age at diagnosis between vaccinated and unvaccinated children. This article provides links to 12 major studies of vaccines and autism, as well as the interesting details of how the two “Wakefield” studies which started the controversy, were later debunked and retracted.
10. [Vaccines and Autism: A Tale of Shifting Hypotheses - PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/)  
    Gerber, J.S., Offit, P.A. *Clinical Infectious Diseases*. 2009;48(4):456-461. This paper examines multiple studies from various countries and research designs, all of which found no link between MMR, thimerosal, or multiple vaccines and autism. Links to 13 studies are included.
11. [Principal Controversies in Vaccine Safety in the United States](https://academic.oup.com/cid/article/69/4/726/5316263)  
    DiStefano , *et al.* *Clinical Infectious Diseases.* 2019;69(4):726-731.  
    Meta-analyses and large studies found no increased risk of autism with thimerosal-containing vaccines; autism rates rose after thimerosal removal.
12. [Vaccines and Autism: A Tale of Shifting Hypotheses - PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC2908388/)  
    Gerber, J.S., Offit, P.A. *Clinical Infectious Diseases*. 2009;48(4):456-461. This paper examines multiple studies from various countries and research designs, all of which found no link between MMR, thimerosal, or multiple vaccines and autism. Links to 13 studies are included.
13. [Measles, mumps, rubella vaccination and autism: A nationwide cohort study](https://pubmed.ncbi.nlm.nih.gov/30831578/) Hviid, A., Hansen, J.V., Frisch, M., Melbye, M. *Annals of Internal Medicine*. 2019;170(8):513-520.  
    A Danish cohort study of 657,461 children found no difference in autism rates between vaccinated and unvaccinated children, even among children with a sibling with autism.
14. [MMR vaccines and autism - World Health Organization (WHO)](https://www.who.int/groups/global-advisory-committee-on-vaccine-safety/topics/mmr-vaccines-and-autism)  
    WHO Global Advisory Committee on Vaccine Safety, 2002.  
    An independent review of 11 epidemiological studies found no evidence of an association between MMR vaccine and autism.  
    **Notice the large number of studies within 4 years of the first Wakefield paper** (see footnote 1 above).
15. [Immunization Safety Review - Vaccines and Autism](https://www.nationalacademies.org/news/2004/05/immunization-safety-review-vaccines-and-autism)  
    National Academies Institute of Medicine, 2004. The Institute of Medicine reviewed all available evidence and found no credible link between vaccines and autism.
16. [Connecting genes to brain in the autism spectrum disorders](https://pubmed.ncbi.nlm.nih.gov/20385903/)  
    Abrahams, B.S., Geschwind, D.H. *Archives of Neurology* 2010 Apr;67(4):395-9. This review summarizes the evidence for genetic contributions to autism, highlighting multiple risk genes and complex inheritance patterns, with no evidence implicating vaccines.
17. [How the case against the MMR vaccine was fixed](https://www.bmj.com/content/342/bmj.c5347) *BMJ 2011;342:c5347****.*** This article is the first in the series by Brian Deer. Click the “Related content” for links to other articles in the series.
18. [Brian Deer, award-winning investigations](https://briandeer.com/) The investigator’s website, with info and links to his book about this investigation, *The Doctor Who Fooled the World, Science, Deception, and the War on Vaccines.*

## Chapter 3 Footnotes

1. [A possible link between early probiotic intervention and the risk of neuropsychiatric disorders later in childhood](https://www.nature.com/articles/pr201551) Pärtty, A., Kalliomäki, M., *et al.* *Pediatric Research* 2015; 77(6):823-828. In this exceptionally persuasive study, none of the children who received probiotics as infants developed ADHD or Asperger’s by age 13, while 17% of those given placebo did—an unusually high rate likely due to long-term follow-up and possible underdiagnosis in other settings. This dramatic difference makes it extremely unlikely that the results were due to chance (*p*=0.008). The high rate in the placebo group may reflect comprehensive, long-term surveillance, whereas lower rates in other populations could result from earlier diagnosis, underdiagnosis, or misclassification of later-appearing symptoms as behavioral rather than neurological.
2. [DSM-5: What Happened to Asperger's?](https://www.mghclaycenter.org/parenting-concerns/child-adolescent-mental-health/dsm-5-what-happened-to-aspergers/) MGH Clay Center. 2024.  
   Asperger’s became part of autism spectrum disorder in 2013 mental health guidelines. DSM-5 eliminated Asperger syndrome as distinct diagnosis, creating the ASD continuum with social communication and restricted behavior domains.
3. [Maternal-infant probiotic transmission mitigates early-life stress induced autism in mice](https://pmc.ncbi.nlm.nih.gov/articles/PMC11817528/) Qing, L., *et al.* *Gut Microbes*. 2025 Feb 11; 17: 2456584 Giving pregnant mice a specific probiotic prevented autism-like behaviors in their offspring, especially under stress. The probiotic was passed from mother to baby, helping the baby’s gut and brain develop more normally. Prenatal *Bifidobacterium longum* supplementation led to vertical transmission, gut microbiome resilience, and reduced neuroinflammation and ASD-like phenotypes in stressed offspring. The findings highlight the preventive potential of maternal probiotic interventions.
4. [Probiotics and Prebiotics in the Treatment of Autism Spectrum Disorder](https://www.imrpress.com/journal/JIN/23/1/10.31083/j.jin2301020): A Narrative Review Zhang, S., *et al.* *Journal of Integrative Neuroscience*. 2024; 23(1): 20. Probiotic and prebiotic supplements improved gut health, communication, and behavior in children with autism, with some studies showing changes in brain activity. Randomized trials indicate that probiotic/prebiotic interventions can ameliorate GI and core behavioral symptoms in ASD, with EEG evidence of neurophysiological modulation.
5. [Effects of Probiotic Supplementation on Gastrointestinal, Sensory and Core Symptoms in Autism Spectrum Disorders: A Randomized Controlled Trial](https://www.frontiersin.org/articles/10.3389/fpsyt.2020.550593/full) Santocchi, E., *et al.* *Frontiers in Psychiatry*. 2020; 11: 550593. A six-month probiotic trial in preschoolers with autism showed no overall difference in core symptoms, but children without gut problems improved more than those with gut issues.  
   Probiotic supplementation yielded significant reductions in ADOS scores among ASD children without GI symptoms, suggesting subgroup-specific benefits.
6. [Research Progress on the Role of Vitamin D in Autism Spectrum Disorder](https://www.frontiersin.org/articles/10.3389/fnbeh.2022.859151/full) Jing Wang, *et al.* *Frontiers in Behavioral Neuroscience*. 2022; 16: 859151. Vitamin D deficiency during pregnancy and early childhood increases autism risk, and supplementation may reduce this risk. Meta-analyses and cohort studies link prenatal vitamin D status to reduced ASD risk and improved neurodevelopment, but controlled trials are limited.
7. [Environmental Chemicals, Nutrition, and Autism Spectrum Disorder](https://drkofinas.com/environmental-chemicals-nutrition-and-autism-spectrum-disorder/)  
   Kofinas, A. [DrKofinas.com](http://DrKofinas.com). 2024. Deficiencies in vitamin D and B vitamins are linked to autism risk; supplementing these nutrients during pregnancy can reduce ASD onset and improve symptoms. Correction of micronutrient deficiencies, especially vitamin D and B complex, is associated with improved neurodevelopmental outcomes and reduced ASD risk.
8. [Autism Risk Determined by Health of Mom's Gut, UVA Research Reveals](https://news.virginia.edu/content/autism-risk-determined-health-moms-gut-uva-research-reveals#:~:text=Autism%20Risk%20Determined%20by%20Health%20of%20Mom's%20Gut%2C%20UVA%20Research%20Reveals,-By%20Josh%20Barney&text=The%20risk%20of%20developing,Virginia%20School%20of%20Medicine%20sugge) Barney, J. *UVA Health News*. July 18, 2018. The mother’s gut health during pregnancy influences autism risk in offspring; modifying the microbiome with diet or probiotics may be protective. Maternal microbiome composition modulates fetal neurodevelopment via immune pathways, with IL-17a implicated in ASD pathogenesis; microbiome-targeted interventions show preventive promise in animal models.
9. [New findings on probiotics for autism](https://www.autismspeaks.org/expert-opinion/new-findings-probiotics-autism) Autism Speaks. 2013. A probiotic strain, *Lactobacillus reuteri*, reduced autism-like behaviors in mice, suggesting future potential for human trials.  
   *L. reuteri* supplementation modulated social and repetitive behaviors in ASD mouse models, supporting the gut-brain axis hypothesis.
10. [Probiotics for autism spectrum disorder: An updated systematic review and meta-analysis of effects on symptoms](https://www.sciencedirect.com/science/article/abs/pii/S0022395624005314)  
    Solimanpour, S., *et al.* *Journal of Psychiatric Research*. 2024 Nov; 179: 92-104. Probiotic supplements significantly improved behavioral symptoms in children with autism, especially with longer and multi-strain treatments. Meta-analysis of RCTs demonstrates significant behavioral improvements in ASD with probiotic interventions, supporting their adjunctive therapeutic role.
11. [Vitamin D and autism, what's new?](https://pubmed.ncbi.nlm.nih.gov/28217829/) Cannell, J.J., *Rev Endocr Metab Disord*. 2017; 18(2): 183-193. Vitamin D deficiency in pregnancy and early life is linked to autism; supplementation reduces risk and improves symptoms in affected children. Observational and interventional data support the etiological and therapeutic relevance of vitamin D in ASD, with preventive supplementation recommended for high-risk groups.

## Chapter 4 Footnotes

1. [The gut microbiome: a core regulator of metabolism in health and disease](https://joe.bioscientifica.com/view/journals/joe/256/3/JOE-22-0111.xml" \t "_blank) Fujisaka, S., Watanabe, Y., Tobe, K. *Journal of Endocrinology*. 2023;256(3): e220111. This review describes the gut microbiome as a vast community of about 100 trillion microbes, mainly bacteria, living in the colon, with over 1,000 species that help with digestion, immunity, and health. The article details the composition and diversity of the gut microbiota, emphasizing its roles in digestion, vitamin synthesis, immune regulation, and its links to metabolic and systemic diseases.
2. [Gut Microbiota, Leaky Gut, and Autoimmune Diseases](https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2022.946248/full)  
   Christovich, A., Luo, X.M., *Frontiers in Immunology*. 2022;13:946248. This review explains that a "leaky gut" happens when the gut lining becomes too porous, allowing bacteria and toxins into the bloodstream, which can trigger inflammation and autoimmune diseases, highlighting the importance of the gut barrier in health and disease.
3. [The gut microbiota–brain axis in neurological disorder](https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2023.1225875/full)  
   Ullah, H., Arbab, S., *et al.* *Frontiers in Neuroscience*. 2023;17: 1225875. This review explains how the gut and brain communicate, and how changes in gut microbes can affect brain health and neurological diseases like autism, depression, and Parkinson’s. The study also covers the composition and function of the gut microbiota.
4. [Gut microbiome, microbes, and mental health](https://www.npr.org/sections/shots-health-news/2024/06/24/nx-s1-5018044/gut-microbiome-microbes-mental-health-stress). NPR. 2024.  
   This news feature describes how gut microbes can affect mood, stress, and mental health, and discusses new research on the gut-brain connection.
5. [The role of gut microbiota in autoimmune diseases](https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2024.1365554/full). Li, Q., Wang, C., Tang, C., *et al.* *Frontiers in Immunology*. 2024; 15:1365554.  
   This review explains how gut microbes can influence the immune system how gut microbiota modulate immune responses and contribute to pathogenesis of autoimmune diseases like lupus and rheumatoid arthritis.
6. [Interactions between the microbiota, immune and nervous systems in health and disease](https://pmc.ncbi.nlm.nih.gov/articles/PMC6960010/). Fung, T.C., Olson, C.A., Hsiao, E.Y. *Nature Neuroscience*. 2017; 20:145–155.  
   This paper discusses the complex interactions among the microbiota, immune system, and nervous system, with a focus on neuroimmune mechanisms in health and disease.
7. [The microbiota-gut-brain axis](https://www.thelancet.com/article/S1474-4422(19)30356-4/fulltext). Cryan, J.F., O’Riordan, K.J., Cowan, C.S.M., *et al.* *The Lancet Neurology*. 2020;19(2):179–194.  
   This review describes how the gut microbiota communicates with the brain and may play a role in brain disorders like Alzheimer’s and depression. It describes the microbiota-gut-brain axis, and details pathways of communication and implications for neurological and psychiatric diseases.
8. [Effects of gut microbiota on neurodegenerative diseases](https://www.frontiersin.org/journals/aging-neuroscience/articles/10.3389/fnagi.2023.1145241/full),  
   Khatoon, S., Kalam, N., *et al.* *Frontiers in Aging Neuroscience* 2023;15:1145241. This review explains how changes in gut bacteria are linked to neurodegenerative diseases like Alzheimer’s and Parkinson’s, mainly by increasing inflammation and affecting brain health. The article discusses mechanisms by which gut microbiota contribute to neurodegenerative diseases, including inflammation, oxidative stress, and altered metabolism, and explores potential microbiome-based therapies.
9. [Neurodegenerative Disorders and the Gut-Microbiome-Brain Axis](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11588320/), Dandamudi, B., Dimaano, K., *et al.* *Cureus* 2024;16(10): e5188320. This paper explains how an unhealthy gut microbiome can worsen brain diseases like Alzheimer’s and Parkinson’s by increasing inflammation and producing harmful substances. The article examines the links between gut microbiota imbalance (dysbiosis) and neurodegenerative disorders, emphasizing mechanisms such as immune activation, blood-brain barrier disruption, and neurotoxic metabolite production.
10. [Gut microbiota: A new insight into neurological diseases](https://journals.lww.com/cmj/fulltext/2023/06050/gut_microbiota__a_new_insight_into_neurological.1.aspx). Zhou, Y., Xu, J., Hou, X., *et al.* *Chinese Medical Journal* 2023;136(12):1447–1457. This review looks at how the gut microbiome is connected to neurological diseases, including myasthenia gravis and Parkinson’s, discussing mechanisms and potential therapeutic targets.
11. [Autism Spectrum Disorders and the Gut Microbiota](https://pubmed.ncbi.nlm.nih.gov/30823414/). Fattorusso, A. et. al. *Nutients* 2019 Feb 28;11(3):521. This study analyzes the current knowledge about dysbiosis and gastrointestinal (GI) disorders in ASD and assesses the current evidence for the role of probiotics and other non-pharmacological approaches in the treatment of children with ASD. It states that probiotics (mostly a mixture of *Bifidobacteria*, *Streptococci* and *Lactobacilli*) are the most promising treatment for neurobehavioural symptoms and bowel dysfunction, and stresses the need for more studies.

## Chapter 5 Footnotes

1. [The Human Microbiome: At the interface of health and disease](https://www.nature.com/articles/nrg3182)  
   Cho, I., Blaser, M.J. *Nature Reviews Genetics*. 2012;13(4):260-270.  
   This review explains how the microbiome is essential for health, supporting digestion and immunity. It details the composition and function of the human microbiome, highlighting its role in maintaining homeostasis and its disruption in disease states.
2. [Understanding dysbiosis and resilience in the human gut microbiome](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2025.1559521/full) Zhao, S., Frioux, C., Rub, A., *et al.* *Frontiers in Microbiology*. 2025; 16:1559521. This review explains that gut dysbiosis is an imbalance in the microbial community, with fewer good bacteria and more harmful ones, and describes how this imbalance can be caused by diet, medications, and other stressors. Dysbiosis is linked to a variety of health problems, including digestive, metabolic, and even behavioral disorders.
3. [Modulation of the Gut Microbiota by Nutrition and Its Relationship to Epigenetics](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10816208/) Ficara, K., Szwajgier, D., Hojka, K., *et al.* *Nutrients*. 2024;16(2):208. This review explains how the gut microbiota can be changed (modulated) by diet, vitamins, minerals, and other factors, and how these changes can have important effects on health. It also discusses how these changes can influence gene activity without altering DNA. The article systematically reviews the evidence for nutritional and epigenetic modulation of the gut microbiota, detailing how specific nutrients and dietary patterns alter microbial composition and function, and describing the bidirectional relationship between microbiome changes and epigenetic regulation.
4. [Diet rapidly and reproducibly alters the human gut microbiome](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3957428/)  
   David LA, *et al.* *Nature.* 2014;505(7484):559-563.  
   What you eat quickly changes your gut bacteria, and eating poorly can harm your microbiome. This study demonstrates rapid and reproducible shifts in gut microbial composition in response to dietary changes.
5. [Prebiotics: Definition, Types, Sources, Mechanisms, and Clinical Applications](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6463098/) Davani-Davari, D., *et al.* *Foods*. 2019; 8(3):92. Prebiotics are fibers and other compounds that feed good gut bacteria, , and help support digestive and immune health. This review covers the definition, types, sources, mechanisms, and clinical applications of prebiotics, emphasizing their selective fermentation by gut microbiota and their health benefits.
6. [Probiotics: Mechanisms of action and clinical applications](https://www.longdom.org/open-access-pdfs/probiotics-mechanisms-of-action-and-clinical-applications-2329-8901.1000101.pdf)  
   Gogineni *et al.* *Journal of Probiotics & Health*.2013. 1(1).  
   Probiotics are live bacteria that can help restore gut health.  
   The paper reviews the mechanisms and clinical uses of probiotics in modulating the gut microbiome.
7. [Fecal Microbial Transplant - Mount Sinai](https://www.mountsinai.org/care/gastroenterology/services/fecal-microbial-transplant) Mount Sinai Health System. 2024. Fecal microbial transplantation (FMT) is a highly effective treatment for recurrent Clostridioides difficile infection, especially when antibiotics have failed. The procedure restores healthy gut bacteria, which crowd out C. diff and help prevent future infections. FMT repopulates the colon with a diverse, healthy microbiome, restoring colonization resistance and normal immune function. This intervention is proven to cure resistant C. difficile infections and is under study for other conditions.
8. [Uncovering Predictive Factors and Interventions for Restoring Microecological Diversity after Antibiotic Disturbance](https://pmc.ncbi.nlm.nih.gov/articles/PMC10536327/)  
   Chen J, Zhu J, Lu W, *et al.* *Nutrients*. 2023; 15(18):3925.  
   This study found that antibiotic treatment causes a loss of gut bacteria diversity and can have long-term effects on health. Recovery depends on several factors including the specific bacteria present before treatment and dietary fiber intake.
9. [Factors affecting early-life intestinal microbiota development](https://pubmed.ncbi.nlm.nih.gov/32464473/)  
   Korpela, K., de Vos, W.M. Nutrition. 2020; 78:110812.  
   This review explains how birth method (vaginal vs. C-section), environmental exposures (e.g., diet, smoking), and medications (e.g., antibiotics) shape an infant’s gut bacteria. These factors influence long-term health risks like obesity and immune disorders. The article synthesizes evidence on prenatal and postnatal factors driving gut microbiota assembly.
10. [The Effects of Delivery Mode on the Gut Microbiota and Health](https://pmc.ncbi.nlm.nih.gov/articles/PMC8733716/) Li, Y., Liu, X., Zhang, L., *et al.* Frontiers in Microbiology. 2021; 12:763031. Babies born vaginally acquire 74% of their gut bacteria from their mothers, while C-section babies get only 13%. This difference affects their long-term health, increasing risks for allergies, asthma, and obesity as well as neurological problems. This study compared gut microbiota of 75 neonates (36 vaginal, 39 C-section).
11. [Comparison of Gut Microbiomes Between Neonates Born by Cesarean Delivery and Vaginal Delivery](https://pubmed.ncbi.nlm.nih.gov/39640900/) Pahirah, N., Phunikhom, N., Suwannarat, K., *et al.* International Journal of Microbiology. 2024; 2024:8893805. This study of 281 newborns found that babies born vaginally have a more diverse gut microbiome with higher levels of beneficial bacteria like Bacteroides, while C-section babies have less diversity and more Bifidobacterium breve. These differences may affect long-term health risks like allergies, obesity or neurological issues.
12. [Breastmilk Feeding Practices Are Associated with the Co-Occurrence of Bacteria in Mothers' Milk and the Infant Gut: the CHILD Cohort Study](https://pubmed.ncbi.nlm.nih.gov/32652062/) Fehr, K., Moossavi, S., *et al.* *Cell Host & Microbe*.2020; 28(2):285-297.e4. This study found that certain bacteria, including *Streptococcus* and *Veillonella*, are present in both a mother's breast milk and her baby's gut, providing evidence that breast milk transfers beneficial bacteria to the infant. Babies who nursed directly at the breast showed higher bacterial transfer than those receiving pumped milk.  
    This research analyzing 1,249 mother-infant pairs provides compelling evidence for vertical microbial transfer via breastfeeding and confirms breast milk as a major driver of infant gut microbiota development, comparable in influence to other known microbiome modifiers such as birth mode.
13. [Maternal intrapartum Antibiotic Treatment and Gut Microbiome Development in Healthy Term Infants](https://karger.com/neo/article-abstract/119/1/93/828788/Maternal-Intrapartum-Antibiotic-Treatment-and-Gut?redirectedFrom=fulltext).   
    Turta *et al.* Neonatology. 2022; 119(1): 93-102.  
    Antibiotics given to mothers during labor reduce beneficial bacteria like Bifidobacterium in their babies’ guts and increase harmful bacteria such as Escherichia coli. These changes can last for months, even if the baby is breastfed.
14. [Transfer of antibiotics and their metabolites in human milk](https://pmc.ncbi.nlm.nih.gov/articles/PMC10763576/)  
    Huntington, K.E., Langelier, C., Matthay, M.A., Lynch, S.V. Frontiers in Nutrition. 2022;9: 1045674. Antibiotics taken by breastfeeding mothers can pass into breast milk, disrupting the infant’s gut bacteria and increasing the risk of dysbiosis. This disruption may affect the baby’s immune development and long-term health. This review synthesizes evidence on antibiotic transfer into human milk, highlighting pharmacokinetic studies showing detectable antibiotic levels in breast milk. It discusses how these antibiotics reduce microbial diversity in infants affecting Bifidobacterium and Lactobacillus populations. The paper provides clinical recommendations to balance maternal treatment with infant microbiota preservation.
15. [Antibiotics as Major Disruptors of Gut Microbiota](https://www.frontiersin.org/journals/cellular-and-infection-microbiology/articles/10.3389/fcimb.2020.572912/full)  
    Ramirez, J., *et al.* Frontiers in Cellular and Infection Microbiology. 2020; 10:572912. After antibiotics, some gut bacteria recover within weeks or months, but others may take much longer or never return. This can leave lasting changes in the gut’s microbial community. While most of the microbiome may recover within 1–2 months, several species can remain undetectable for at least six months, and the risk of persistent dysbiosis and antibiotic resistance is increased.
16. [Probiotics and neurodevelopment in preterm infants](https://internationalprobiotics.org/home/probiotics-neurodevelopment-in-preterm-infants/)  
    International Probiotics Association. 2024. This article reviews clinical studies where probiotics were given to preterm infants, showing that supplementation can reduce the risk and severity of neurodevelopmental impairment at two years of age. The review summarizes evidence that probiotic administration in early life, including to mothers and newborns, may decrease neurodevelopmental problems by improving gut microbiota balance and reducing inflammation, though results vary by strain and study design.
17. [Antibiotics in early life: dysbiosis and the damage done](https://academic.oup.com/femsre/article/42/4/489/5045017)  
    Langdon, A., Crook, N., Dantas, G. *FEMS Microbiology Reviews*. 2018; 42(4):489-499. Babies often get antibiotics for infections, which can harm their gut bacteria, but probiotics and vitamin D can help repair the damage.
18. [A review of probiotics in the treatment of autism spectrum disorders](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1123462/full) Zheng, H., *et al.* *Frontiers in Microbiology*. 2023; 14:1123462. Children with healthy gut bacteria from the start are much less likely to develop autism. The article reviews evidence for the role of early microbiome health in preventing ASD and the therapeutic use of probiotics.
19. [Unveiling the dynamics of gut microbial interactions: diet, microbiota, and health](https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1395664/full) Zhang, Y., Li, X., Chen, J., *et al.* *Frontiers in Nutrition*. 2024; 11:1395664. This study details the roles of gut microbes in nutrient breakdown, vitamin synthesis, immune modulation, and toxin neutralization, and discusses how maintaining microbial diversity through diet protects against digestive and systemic diseases.

## Chapter 6 Footnotes

1. [Maternal Vitamin D Levels During Pregnancy and Offspring Autism Spectrum Disorder](https://pmc.ncbi.nlm.nih.gov/articles/PMC8752030/) Ousseny, Zerbo, *et al.*, *Nutrients* 13, no. 8 (2021): 2766. Low maternal vitamin D during pregnancy is linked to higher risk of ASD, especially ASD with intellectual disability. Epidemiological data show prenatal vitamin D deficiency is associated with increased ASD risk, particularly for ASD with comorbid intellectual disability.
2. [Maternal vitamin D status and attention deficit hyperactivity disorder (ADHD): A review](https://journals.sagepub.com/doi/full/10.1177/1721727X231161013) Sadaf, Ali *et al.*, *Therapeutic Advances in Endocrinology and Metabolism* 14 (2023): 1721727X231161013. Higher maternal vitamin D during pregnancy is associated with reduced ADHD symptoms in children. Prospective studies show maternal vitamin D sufficiency reduces ADHD and hyperkinetic disorder incidence in offspring.
3. [Vitamin D Deficiency During Pregnancy and Autism Spectrum Disorders Development](https://www.frontiersin.org/journals/psychiatry/articles/10.3389/fpsyt.2019.00987/full) Esposito, S., *et al.*, *Frontiers in Psychiatry* 10 (2020): 987. Supplementing vitamin D during pregnancy and early childhood lowered autism recurrence in high-risk families. High-dose prenatal and early-life vitamin D supplementation may reduce ASD recurrence in families with previous ASD cases.
4. [Associations between vitamin D and core symptoms in ASD: an umbrella review](https://www.dovepress.com/associations-between-vitamin-d-and-core-symptoms-in-asd-an-umbrella-re-peer-reviewed-fulltext-article-NDS) Xia Zhu *et al.*, *Neuropsychiatric Disease and Treatment* 20 (2024): 1543–1557. Animal studies show prenatal vitamin D supplementation can prevent autism-like behaviors in offspring. Animal models demonstrate that prenatal vitamin D administration abolishes ASD-like behavioral deficits, supporting a neurodevelopmental protective effect.
5. [The effect of vitamin D supplementation in treatment of children with autism spectrum disorder: A meta-analysis of randomized controlled trials](https://pubmed.ncbi.nlm.nih.gov/32893747/) Jie Guan *et al.*, *Nutritional Neuroscience* 26, no. 3 (2023): 155-164. In children with autism, vitamin D can improve hyperactivity but not always core ASD symptoms. Meta-analysis indicates vitamin D supplementation leads to significant improvement in hyperactivity scores, with less consistent effects on core ASD symptoms.
6. [Associations between vitamin D and core symptoms in ASD: an umbrella review](https://www.dovepress.com/associations-between-vitamin-d-and-core-symptoms-in-asd-an-umbrella-re-peer-reviewed-fulltext-article-NDS) Xia Zhu *et al.*, *Neuropsychiatric Disease and Treatment* 20 (2024): 1543–1557. Vitamin D supplementation is beneficial for individuals with autism, and deficiency early in life increases ASD risk. Vitamin D modulates neurotransmitter synthesis, immune function, and oxidative stress, mechanisms implicated in ASD pathophysiology.
7. [The effect of vitamin D supplementation in treatment of children with autism spectrum disorder: A meta-analysis of randomized controlled trials](https://pubmed.ncbi.nlm.nih.gov/32893747/) Jie Guan *et al.*, *Nutritional Neuroscience* 26, no. 3 (2023): 155-164. Not all studies found vitamin D helpful for autism, possibly due to differences in dosage, timing, or participant age. Study heterogeneity in dosing, baseline vitamin D status, and age at intervention may account for inconsistent findings regarding vitamin D efficacy in ASD.

1. [Gestational vitamin D concentration and child cognitive development: a longitudinal cohort study in the Environmental influences on Child Health Outcomes Program](https://www.sciencedirect.com/science/article/abs/pii/S0002916525003399?via%3Dihub) Melough, M.M., McGrath, M., *et al.* *American Journal of Clinical Nutrition*, 2025. This groundbreaking study found that higher vitamin D levels during pregnancy had strong positive impacts on children’s cognition scores 7 – 12 years later.
2. [Efficacy and safety of Vitamin D supplementation during pregnancy: A randomized trial of two different levels of dosing on maternal and neonatal Vitamin D outcome](https://pmc.ncbi.nlm.nih.gov/articles/PMC4855961/) Mir, S.A., Masoodi, S.R., Shafi, S., *et al. Indian J Endocrinol Metab*. 2016 May-Jun;20(3):337-42*.* 2,000 IU per day of vitamin D3 is safe for pregnant women.

## Chapter 7 Footnotes

1. [Ultra-Processed Foods – some more than others – linked to early death](https://hsph.harvard.edu/news/ultra-processed-foods-some-more-than-others-linked-to-early-death/" \l ":~:text=May%2015%2C%202024%E2%80%94High%20intake%20of%20ultra%2Dprocessed%20foods%E2%80%94particularly,published%20on%20May%208%20in%20The%20BMJ.) Harvard T.H. Chan School of Public Health staff writer, May 15, 2004. This article links to various sources and discusses what ultra-processed foods are, how they are made, and why they are a concern for health. The article discusses links to cancer, cardiovascular, respiratory, and neurodegenerative diseases.
2. [Does processed food cause autism?](https://www.totalcareaba.com/autism/does-processed-food-cause-autism) Kesherim, R., Total Care ABA Therapy. 2024. This article clearly explains and compares several linked studies, showing that processed foods, low in fiber and essential nutrients, can disrupt the healthy gut microbiome, which has been linked to neurological conditions including autism, anxiety, and depression.
3. [Diet Can Impact Microbiota Composition in Children With Autism Spectrum Disorder](https://doi.org/10.3389/fnins.2018.00515) Berding, K., and Donovan, S. *Frontiers in Neuroscience* 12 – 30 July 2018 :515. This paper discusses how diet, including UPFs, affects gut bacteria in children with autism.

It examines the relationship between dietary patterns, gut microbiome composition, and symptom severity in ASD.

1. [Gastrointestinal Symptoms in Children with an Autism Spectrum Disorder and Language Regression](https://doi.org/10.1016/j.pediatrneurol.2008.07.019) Valicenti-McDermott, M., *et al.* *Pediatric Neurology* 39, no. 6 (2008): 392-398.

This paper reports on the prevalence of GI symptoms in ASD and their possible links to dietary factors, including processed food intake.

1. [Epigenetic Mechanisms and the Mismatch Concept of the Developmental Origins of Health and Disease](https://doi.org/10.1203/pdr.0b013e318045bedb) Godfrey, K.M., Hanson, M.A., *et al.* *Pediatric Research* 61, no. 5 Pt 2 (2007): 5R-10R. This study explains how a mother’s diet during pregnancy can affect a child’s genes and health. It reviews epigenetic influences of prenatal nutrition on offspring neurodevelopment and disease susceptibility.
2. [Nutritional epigenetics education reduces ultra-processed food intake in parents of children with autism and ADHD](https://www.news-medical.net/news/20240209/Nutritional-epigenetics-education-reduces-ultra-processed-food-intake-in-parents-of-children-with-autism-and-ADHD.aspx) *Food Ingredient and Health Research Institute* Feb 9, 2024. The study reveals the many ways the ingredients of UPFs can damage our health, including heavy metals and other toxins, which can damage the microbiome and contribute or lead to autism. It presents evidence that when parents are informed about these dangers, the evidence is so persuasive that they eat less UPFs and feed their children less, too.
3. [Autism Spectrum Disorders and the Gut Microbiota](https://doi.org/10.3390/nu11030521) Fattorusso, A., *et al.* *Nutrients* 2019 11(3): 521. This study explores how the gut bacteria in people with autism are different and how this might affect symptoms. It reviews the role of gut microbiota in ASD pathophysiology and the impact of dietary factors, including UPFs.

## Chapter 8 Footnotes

1. [Gut microbiota from persons with attention-deficit/hyperactivity disorder affects the brain in mice](https://pubmed.ncbi.nlm.nih.gov/32238191/) Tengeler, A.C., Dam, S.A., Wiesmann, M., *et al.* *Microbiome* 8(1), 44 (2020). This study showed that fecal microbiota transplants from ADHD patients induced ADHD-like behaviors in germ-free mice, establishing causal gut-brain axis links.
2. [Association between gut microbiota and autism spectrum disorder: a systematic review and meta-analysis](https://doi.org/10.3389/fpsyt.2019.00473) Xu, M., Xu, X., Li, J., & Li, F. *Frontiers in Psychiatry* 10, 473 (2019). This meta-analysis of 9 studies reveals consistent ASD-associated decreases in *Bifidobacterium* and increases in *Lactobacillus* across 254 ASD patients.
3. [Mechanisms underlying microbial-mediated changes in social behavior in mouse models of autism spectrum disorder](https://doi.org/10.1016/j.neuron.2018.11.018)  
   Sgritta, M., Dooling, S.W., Buffington, S.A., *et al.* *Neuron* 101(2), 246–259 (2019). This study identified *Lactobacillus reuteri*'s vagus nerve-dependent improvement of social behavior across multiple ASD mouse models via ventral tegmental area synaptic plasticity.
4. [Impact of psychostimulants on microbiota and short-chain fatty acids in children with ADHD: A cross-sectional study](https://www.nature.com/articles/s41598-025-87546-y) Boonchooduang, N., et al. Scientific Reports 15, Article number: 87546 (2025). This study analyzed gut microbiota and short-chain fatty acid (SCFA) concentrations in unmedicated and medicated children with ADHD compared to healthy controls. It found that propionic acid levels were negatively associated with ADHD symptom severity, suggesting a potential biomarker role. Medicated ADHD children showed lower gut microbial diversity, distinct taxa, and lower SCFA levels than unmedicated children, highlighting the relevance of gut health monitoring in ADHD management.
5. [Gut microbiota in early pediatric multiple sclerosis: a case-control study](https://pmc.ncbi.nlm.nih.gov/articles/PMC4955679/) Tremlett, H., Fadrosh, D.W., Faruqi, A.A., *et al.* *European Journal of Neurology* 23(8), 1308–1321 (2016). This large cohort study shows MS-associated increases in *Akkermansia muciniphila* and decreases in *Faecalibacterium prausnitzii*.
6. [Meta-analysis of the Parkinson's disease gut microbiome suggests alterations linked to intestinal inflammation](https://pubmed.ncbi.nlm.nih.gov/33692356/) Romano, S., Savva, G.M., Bedarf, J.R., *et al.* *NPJ Parkinson's Disease* 7(1): 27 (2021). This systematic review identifies 98 altered genera in PD, including increased *Bifidobacterium* and decreased *Prevotella*.
7. [The vocabulary of microbiome research: a proposal](https://microbiomejournal.biomedcentral.com/articles/10.1186/s40168-015-0094-5)  
   Marchesi, J.R. & Ravel, J. *Microbiome* 3(1), 31 (2015).  
   A comprehensive review of microbiome analysis methodologies including 16S sequencing and metagenomics.
8. [Analysis of the microbiome: advantages of whole genome shotgun versus 16S amplicon sequencing](https://doi.org/10.1016/j.bbrc.2015.12.083)  
   Ranjan, R., Rani, A., Metwally, A., *et al.* *Biochemical and Biophysical Research Communications* 469(4), 967–977 (2016). This technical comparison shows that shotgun metagenomics provides superior taxonomic resolution but higher costs than 16S sequencing.
9. [Diversity, compositional and functional differences between gut microbiota of children and adults](https://pubmed.ncbi.nlm.nih.gov/31974429/) Radjabzadeh, D., Boer, C. G., Beth, S. A., *et al.* *Scientific Reports* 2020 Jan 23;10(1):1040. This large-scale study of 1,054 participants identified 13 microbial taxa associated with depressive symptoms, including bacteria involved in synthesis of glutamate, butyrate, serotonin and GABA, suggesting that gut microbiome composition plays a key role in depression and mood regulation.
10. [Gut microbiome alterations in Alzheimer's disease](https://pubmed.ncbi.nlm.nih.gov/29051531/)  
    Vogt, N. M., Kerby, R. L., *et al.* *Scientific Reports* 7(1), 13537 (2017).  
    This study revealed that Alzheimer's disease participants have decreased microbial diversity and compositionally distinct gut microbiomes compared to controls, with specific changes including decreased *Firmicutes*, increased *Bacteroidetes*, and decreased *Bifidobacterium*, and correlations between bacterial genera and cerebrospinal fluid biomarkers of AD.
11. [Exploring the Human Microbiome: Unveiling the Top 20 Companies Leading Microbiome Research in the US](https://www.scispot.com/blog/top-20-microbiome-companies-in-the-us)  
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## Chapter 9 Footnotes

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## Chapter 10 Footnotes

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## Chapter 11 Footnotes

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    NewAtlas.com, 2025. The article contains links to two studies which found that fecal microbiota transplant led to a 45% drop in autism symptoms after two years, with most children moving from severe to mild or below ASD threshold. Two-year follow-up showed durable and increasing improvements in ASD symptoms post-FMT.
31. [Meta-Analysis of the Effects of Gut Microbiota–Based Interventions on Gastrointestinal and Behavioral Symptoms in Children With Autism Spectrum Disorder](https://academic.oup.com/nutritionreviews/advance-article/doi/10.1093/nutrit/nuaf050/8121820?searchresult=1) Gao, X., *et al.* *Nutrition Reviews*. 2025 April 29; nuaf050. The meta-analysis shows that microbiota-based interventions help ASD symptoms, especially with longer treatment. Significant behavioral improvements are seen with longer-duration interventions (SMD = –0.26, *p* = .02).
32. [Restorative effects of *Lactobacillus rhamnosus* LR-32 on the gut-brain axis and behavior](https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2023.1173804/full)  
    Huang, C., *et al.* *Front. Microbiol*. 25 April 2023; 14:1173804.  
    *Lactobacillus rhamnosus* LR-32 prevented abnormal social behavior and aggression in animal models by restoring gut and brain health. LR-32 reduced inflammation, restored tight junction proteins, and normalized behavior in antibiotic-exposed mice.