

REVIEW ARTICLE

Probiotics and Disease: A Comprehensive Summary—Part 1, Mental and Neurological Health

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Abstract

This article series provides a literature review of the disease-specific probiotic strains studied in published clinical trials in humans and animals. The goal of the series is to provide clinically useful tools. The table designs allow for quick access to supportive data related to disease states and will be helpful as a guide for both researchers and clinicians. This first article (part 1) focuses on mental health and neurological conditions. Future articles in this series will review conditions related to cardiometabolic and fatigue syndromes; ear, nose, throat, respiratory, and infectious diseases; immune and dermatological conditions; cancer, gastrointestinal and

genitourinary; followed by an article focused on food-based probiotic strains and nutritional supplements. This literature review is specific to condition, probiotic, and strain and also lists currently available products and foods in which these probiotics can be found. In part 1, we explore the role of probiotics in balancing mental health and neurological issues. Conditions in mental health include anxiety, depression, attention-deficit/hyperactivity disorder, and autism. Neurological conditions include age-related cognitive decline, hepatic encephalopathy, cerebral ischemia and reperfusion, traumatic brain injury, and multiple sclerosis.

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There is considerable research on the gut microbiome and role of probiotics; however, this research has not been clearly connected with clinical practice. Clinicians recommend probiotics to their patients. Our group undertook a review of current literature to explore which specific probiotics and probiotic strains have been used in clinical studies in humans and animals. To make this clinically valuable, product names of probiotics and fermented foods have been included. Finished products vary between manufacturers and listing brands provide transparency and a useful guide to clinicians when choosing specific probiotic and fermented food products. Exclusions of products meeting our criteria do not mean that these products are not effective—we simply were not aware of them.

Methodology

This literature review originated from a group class project that was part of the requirements for a course in the doctoral program in functional and clinical nutrition at the Maryland University of Integrative Health (Laurel, MD, USA), and the researchers researched as much as they could in the time allotted. The authors discussed the format, a template was created, and work began. Each author researched and wrote sections reviewing probiotics in relation to various health conditions with literature searches conducted in PubMed, Biomed Central, EBSCO Research Premier, PloS One, Cochrane reviews, and topic-specific open-source journals.

The review of specific probiotic products in the professional marketplace and specific probiotics products was done using Internet searches, primarily Shop Google, in addition to topic specific databases to search for specific probiotic species including the strains listed in the research. Novel strains were cross-referenced to determine whether the strain was available only for research purposes. If a probiotic combination was used in the research, formulas that closely matched the combination were included. Formulas that contain all or most of the specific probiotics and strains were also included.

The food survey focused on probiotic strains and species in food lists foods that are commercially produced and commonly available in the refrigerated sections of grocery stores in the United States. Information was

gleaned from commercial Web sites and by visiting grocery stores (primarily in California).

Research Overview: Mental Health/Neurotransmitters/Stress

Probiotics are live bacteria that provide many benefits, including alteration of the enteric nervous system, housed in the gastrointestinal (GI) tract. The brain and the GI system are connected via the vagus nerve and the gut sends far more information to the brain than the brain sends to the gut. Problems in the gut may directly lead to issues such as anxiety, depression, and autism. Whereas probiotics nourish the gut, prebiotics are the carbohydrates that nourish these bacteria, making them equally as important. A variety of research studies provide efficacy for the use of various probiotic strains to combat mood and neurotransmitter disorders.

Ingestion of “psychobiotics” produces psychotropic effects on behavior, the hypothalamic-pituitary-adrenal axis, and neurochemicals in the brain.¹ A study by Liu et al¹ found that mice subjected to early life stress treated with *Lactobacillus plantarum* strain PS128 responded with less anxiety-like behaviors than the control mice while also reducing inflammatory levels. Other studies elucidate the efficacy of *Lactobacillus helveticus* and *Bifidobacterium longum* by decreasing GI discomfort produced by stress.² In infants, researchers found that *Lactobacillus rhamnosus* GG reduces the risk of neuropsychiatric disorder development later in childhood. They further extrapolated that the mechanisms may not be limited to gut microbiota composition.³ Anxiety, depression, autism spectrum

disorder, obsessive compulsive disorder (OCD), and memory abilities were improved in several studies where *Bifidobacterium* and *Lactobacillus* were used. When healthy women were provided with fermented milk for 4 weeks, brain regions that control the central processing of emotion and sensation were affected.⁴ Because these areas play a role in processing emotion and interoceptive information, this study shows that manipulations of the gut microbiota can result in measurable changes in emotional processing in the healthy brain. Addressing more directly the neuroendocrine imbalances in chronic fatigue syndrome are 2 studies that show that supplementation with certain *Lactobacillus* species can reduce symptoms of anxiety as well as increase *Bifidobacterium* levels.^{5,6} Galland⁷ showed that supplementation with *Bacteroides fragilis* also decreased anxiety levels while improving excessive gut permeability.

Several studies have evaluated the effect of probiotics in children with autism. In a study conducted by Russo et al,⁸ researchers found that probiotic supplementation reduced myeloperoxidase levels in individuals with autism. Probiotic therapy was also associated with lower copper levels in these patients.⁸ In another study, researchers evaluated the fecal microbiota of children with autism. The children with autism showed a decrease of the *Bacteroidetes/Firmicutes* ratio and elevation of *Lactobacillus* species. When probiotic therapy was introduced, the microbiome ratios were balanced.⁹ It is becoming more evident that the modulation of the gut microbiota offers a novel approach for the treatment and prevention of mood and anxiety disorders.

Table 1. Mental Health Overview

Mental Health/Neurotransmitters/Stress	Strains	Overview	Professional and Commercial Products	Foods	
Anxiety					
Galland ⁷ (2014)	<i>B fragilis</i>	Associated with decreased anxiety in patients with chronic fatigue syndrome; “Corrects excessive gut permeability; alters gut microbial composition, and ameliorates deficits in communication and stereotypic, anxiety-like, and sensorimotor behaviors in the maternal immune activation model.”	Not available	<i>B fragilis</i> :	None
Messaaoudi et al ² (2011)	<i>B longum</i> R0175, <i>L helveticus</i> R0052	Daily administration of <i>L helveticus</i> R0052 and <i>B longum</i> R0175 reduced psychological distress, anger hostility. <i>L helveticus</i> R0052 and <i>B longum</i> R0175 taken in combination display anxiolytic-like activity in rats and beneficial psychological effects.	<i>B longum</i> R0175, <i>L helveticus</i> R0052: Dr Formulated Probiotics Mood+ (Garden of Life) <i>L helveticus</i>, <i>B longum</i> R0175: Xymogen Probio Defence <i>L helveticus</i>, <i>B longum</i>: Pure Encapsulations (Probiomood) <i>B longum</i>: FLORASSIST Mood (Life Extension)	<i>B longum</i> R0175	None
				<i>L helveticus</i> R0052	None
Rao et al ⁵ (2009)	<i>L casei</i> strain Shirota ¹⁷	Resulted in a significant rise in both <i>Lactobacillus</i> and <i>Bifidobacterium</i> as well as a significant decrease in anxiety symptoms ($P=.01$) in patients with chronic fatigue syndrome.	Not available	<i>L casei</i> strain Shirota:	Yakult USA ¹⁷
Rao et al ⁵ (2009)	<i>L plantarum</i> 299 V	Resulted in significant rise in fecal <i>Bifidobacterium</i> levels. “Bifidobacteria can boost plasma tryptophan levels and alter serotonin and dopamine turnover in areas of the brain associated with depression and anxiety.”	<i>L plantarum</i> V299: Digestive Health Probiotic (Nature Made) Heart Healthy Probiotic Solutions (Dr Sinatra) Arrow Formulas Ideal Bowel Support, 10 Billion Organisms V-Capsules Probiata Digestion Support and Critical Care (Kyolic) Plantadophilus (3 billion CFU) Transformation Enzymes Probiotic Balance (Sundown Naturals) Probiotic GX (Nature's Bounty) Probiotic Supplement (GoodBelly) UltraFlora Intensive Care (Metagenics)	<i>L plantarum</i> 299V	All GoodBelly products (NextFoods ¹⁸)

Table 1. (continued)

Mental Health/ Neurotransmitters/Stress	Strains	Overview	Professional and Commercial Products	Foods	
Wang et al ¹⁰ (2016); Akkasheh et al ¹¹ (2016); Liu et al ¹ (2016); Liu et al ¹² (2016); Mohammadi et al ¹³ (2015)	<i>B longum</i> , <i>B bifidum</i> , <i>B breve</i> , <i>B infantis</i>	<i>Bifidobacterium</i> and <i>Lactobacillus</i> showed efficacy in improving psychiatric disorder related behaviors including anxiety, depression, autism spectrum disorder, obsessive compulsive disorder, and memory abilities including spatial and nonspatial memory.	<i>B longum</i>, <i>B bifidum</i>, <i>B breve</i>, <i>B infantis</i>, <i>L helveticus</i>, <i>L rhamnosus</i>, <i>L acidophilus</i>, <i>L casei</i>, <i>L plantarum</i> : Dr Formulated Probiotics Mood+ (Garden of Life) Primadophilus Optima (Nature's Way) <i>L helveticus</i>, <i>L rhamnosus</i>, <i>B longum</i> : Xymogen Probio Defense <i>L helveticus</i>, <i>B longum</i> : Pure Encapsulations Probiomood <i>L acidophilus</i>, <i>L rhamnosus</i>; <i>B bifidum</i>/<i>lactis</i>, <i>B longum</i> : FLORASSIST Mood (Life Extension) <i>L helveticus</i>, <i>L rhamnosus</i>, <i>L acidophilus</i>, <i>L casei</i>, <i>L plantarum</i> strain PS128 (plantarum not strain specific) : Jarro-Dophilus EPS 5 & 25 Billion (Jarro Formulas) RAW Probiotics Ultimate Care (Garden of Life) Primadophilus Optima (Nature's Way) PrepTonic Detox (Professional Botanicals)	<i>B longum</i>	None
	<i>L helveticus</i> , <i>L rhamnosus</i> , <i>L acidophilus</i> , <i>L casei</i> , <i>L plantarum</i> strain PS128	Probiotic administration with <i>L casei</i> , <i>L acidophilus</i> , and <i>Bifidobacterium</i> for 8 wk had beneficial effects in Beck Depression Inventory, insulin, homeostasis, high-sensitivity C-reactive protein concentrations, and glutathione concentrations. Chronic ingestion of PS128 could ameliorate anxiety and depression-like behaviors and modulate neurochemicals related to affective disorders. PS128 shows psychotropic properties and has great potential for improving stress-related symptoms. Daily intake of <i>L plantarum</i> strain PS128 could improve anxiety-like behaviors and may be helpful in ameliorating neuropsychiatric disorders.	<i>B longum</i>, <i>B bifidum</i>, <i>B breve</i>, <i>B infantis</i> : Ther-Biotic for Infants, Children's Chewable, Senior, LactoPrime Plus SCD Compliant (Klaire Labs) iFlora Multi Probiotic (Sedona Labs Pro) Broad Spectrum Probiotic (Progressive Labs) Kyo-Dophilus (Wakunaga) Dr Formulated Once Daily Women/Men, Organic Kids, Mood, Once Daily Ultra, Fitbiotic, Urinary Tract, Prostate+ (Garden of Life) Primadophilus for Children & Optima (Nature's Way) Multi Probiotic 40 Billion (Douglas Labs) Proflora (BioBotanical Research) Gastro Complete (NewMark)	<i>B bifidum</i>	Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Green Valley Organics Lactose-free Cow's Milk Kefir (Green Valley Organics ²⁰) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Trader Joe's Cultured Coconut Milk (Trader Joe's ²²)
				<i>B breve</i>	None
				<i>B infantis</i>	None
				<i>L helveticus</i>	Used in the production of various cheeses (Fox et al ²³ [2016])
				<i>L rhamnosus</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ²⁰) KeVita Kombucha Cleansing Probiotic Drink, Masterbrew, and Sparkling Probiotic Drink (KeVita ²⁵) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Trader Joe's Cultured Coconut Milk (Trader Joe's ²²)
				<i>L acidophilus</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Bellwether Farms Sheep's Milk Yogurt (Bellwether Farms ²⁸) Coconut Grove Organic Cultured Coconut Milk (Coconut Grove Yogurt ²⁹) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ²⁰) Kite Hill Almond Milk Yogurt (Kite Hill ³¹) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Redwood Hill Farm Goat Milk Yogurt (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ²³) Stonyfield Organic O'Soy Soy Yogurt (Stonyfield Farm ³³) Trader Joe's Cultured Coconut Milk (Trader Joe's ²²) Wallaby Yogurt Company Organic Greek Whole Milk Plain Yogurt (Wallaby Yogurt Company ³⁴)

Table 1. (continued)

Mental Health/ Neurotransmitters/Stress	Strains	Overview	Professional and Commercial Products	Foods	
				<i>L. casei</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ²⁹) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ³⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ³²) Zukay Live Foods Fruit Kvass (Zukay Lives Foods ³⁵) Zukay Live Foods Veggie Kvass (Zukay Live Foods ³⁶)
				<i>L. plantarum</i> strain PS128	None
Attention-deficit/Hyperactivity Disorder					
Partty et al ³ (2015)	<i>L. rhamnosus</i> GG	Probiotic supplementation (<i>L. rhamnosus</i> GG) early in life may reduce risk of neuropsychiatric disorder development later in childhood.	<i>L. rhamnosus</i> GG: Culturelle Solgar, Advanced 40+ Acidophilus Walgreens Probiotic Advanced Multi-Billion Dophilus (Solgar) Digestive Health Probiotic, Kids Chewables & Packets (Culturelle) UltraFlora Baby (Metagenics)	<i>L. rhamnosus</i> GG	None
Autism					
Wang et al ¹⁴ (2016); Parracho ¹⁵ (2010); Russo ⁸ (2015); Tomova et al ⁹ (2015); Critchfield et al ¹⁶ (2011); Critchfield et al ¹⁶ (2011)	<i>B. longum</i> , <i>B. breve</i> , <i>B. infantis</i> , <i>B. bifidum</i> , <i>B. breve</i> , <i>L. acidophilus</i> , <i>L. helveticus</i> , <i>L. rhamnosus</i> , <i>L. plantarum</i> , <i>L. brevis</i> , <i>L. casei</i> , <i>L. salivarius</i> , <i>L. paracasei</i> , <i>S. thermophilus</i> , <i>Lactobacillus</i> spp, <i>Bifidobacterium</i> spp	<i>B. longum</i> , <i>B. breve</i> , <i>B. infantis</i> , <i>L. helveticus</i> , and <i>L. rhamnosus</i> showed efficacy in improving psychiatric disorder-related behaviors including anxiety, depression, and autism spectrum disorder. Significant behavioral improvement when treated with <i>L. plantarum</i> compared to placebo. <i>S. thermophilus</i> , <i>Bifidobacterium</i> spp, and <i>Lactobacillus</i> spp provide various health benefits including decreased plasma myeloperoxidase upon ingestion and serve to normalize gut flora populations. Probiotic supplementation normalized the <i>Bacteroidetes/Firmicutes</i> ratio, <i>Desulfovibrio</i> spp, and the amount of <i>Bifidobacterium</i> spp in feces of children with autism. <i>B. infantis</i> showed effects on immune, neuroendocrine, and central monoaminergic activity. A probiotic drink containing <i>L. casei</i> has also revealed positive effects on mood and cognition.	<i>B. longum</i>, <i>B. breve</i>, <i>B. infantis</i>, <i>L. helveticus</i>, <i>L. rhamnosus</i>: Dr Formulated Mood+ (Garden of Life) <i>L. plantarum</i> 299v: Digestive Health Probiotic (Nature Made, 10 billion CFU) Heart Healthy Probiotic Solutions (Dr Sinatra) Ideal Bowel Support (Jarow Formulas 10 Billion Organisms V-Capsules) Probiata Digestion Support and Critical Care (Kyolic) Probiotic Supplement (GoodBelly) Plantadophilus (Transformation Enzyme Corp, 3 billion CFU) Probiotic GX (Nature's Bounty) <i>S. thermophilus</i>, <i>Bifidobacterium</i> spp, <i>Lactobacilli</i> spp: Widely available in commercial products <i>L. plantarum</i>, <i>B. longum</i>: Probiotic Balance (Sundown Naturals) Multi-Flora Adult Ultra (UAS Life Sciences) <i>L. rhamnosus</i>, <i>L. acidophilus</i>, <i>L. plantarum</i>, <i>L. salivarius</i>, <i>L. casei</i>, <i>B. bifidum</i>, <i>B. infantis</i>, <i>B. longum</i>, <i>B. breve</i>: Dr Formulated Formulas (Garden of Life) Gastro Complete (NewMark) iFlora Multi-Probiotic Capsule 60 ct (Sedona Labs Pro) Multi-Probiotic 40 Billion (Douglas Labs) Prothera LactoPrime Plus <i>L. rhamnosus</i>, <i>L. casei</i>, <i>L. salivarius</i>, <i>B. infantis</i>, <i>B. bifidum</i>, <i>B. longum</i>, <i>B. breve</i>: Dr Formulated Formulas (Garden of Life) Gastro Complete (NewMark) iFlora Multi-Probiotic Capsule 60 ct (Sedona Labs Pro) Multi-Probiotic 40 Billion (Douglas Labs) Ther-biotic Children's Chewable <i>L. rhamnosus</i>, <i>B. bifidum</i>, <i>L. acidophilus</i>, <i>L. casei</i>, <i>B. longum</i>, <i>B. breve</i>: Dr Formulated Formulas (Garden of Life) Green SuperFood Raw Green SuperFood Raw Reserve Berry 8.5 oz (Amazing Grass) iFlora Multi-Probiotic Capsule 60 ct (Sedona Labs Pro) ImmuProbio One-a-Day (Health Aid America) Multi-Probiotic 40 Billion (Douglas Labs) Primal Defense Ultra (Garden of Life)	<i>B. longum</i>	None
				<i>B. breve</i>	None
				<i>L. acidophilus</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ²⁹) Bellwether Farms Sheep's Milk Yogurt (Bellwether Farms ²⁸) Coconut Grove Organic Cultured Coconut Milk (Coconut Grove Yogurt ²⁹) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ³⁰) Kite Hill Almond Milk Yogurt (Kite Hill ³¹) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Redwood Hill Farm Goat Milk Yogurt (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ³²) Stonyfield Organic O'Soy Soy Yogurt (Stonyfield Farm ³³) Trader Joe's Cultured Coconut Milk (Trader Joe's ³²) Wallaby Yogurt Company Organic Greek Whole Milk Plain Yogurt (Wallaby Yogurt Company ³⁴)

Table 1. (continued)

Mental Health/ Neurotransmitters/Stress	Strains	Overview	Professional and Commercial Products	Foods	
			Probiophage DF & Probiotic Supreme DF (Designs for Health) ProtoDophilus 50 Billion (Protocol For Life Balance) Ther-biotic Complete Prothera	<i>L. helveticus</i>	Used in the production of various cheeses (Fox et al ²³ [2016])
				<i>L. rhamnosus</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt.com ¹⁹) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ²⁰) KeVita Kombucha Cleansing Probiotic Drink (KeVita ²⁵) KeVita Kombucha Masterbrew (KeVita ²⁵) KeVita Kombucha Sparkling Probiotic Drink (KeVita ²⁵) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Trader Joe's Cultured Coconut Milk (Trader Joe's ²²)
				<i>L. plantarum</i>	Farmhouse Culture Sauerkraut (Farmhouse Culture ³⁷) Green Olives (various brands; not refrigerated) (Abriouel ³⁸ [2012]; Doulgeraki et al ³⁹ [2013]) KeVita Kombucha Cleansing Probiotic Drink (KeVita ²⁵) KeVita Kombucha Sparkling Probiotic Drink (KeVita ²⁵) King's Kimchi (King's Asian Gourmet ⁴⁰) PureLiving Pickled Beets and Sauerkraut (Shiloh Farms ⁴¹) Seoul Kimchi (Lucky Foods ⁴²) Wildbrine Kimchi, Kimchi Live Shots, Pickled Ginger, Salsa, and Sauerkraut (Wildbrine ⁴³)
				<i>L. brevis</i>	Farmhouse Culture Sauerkraut (Farmhouse Culture ³⁷) King's Kimchi (King's Asian Gourmet ⁴⁰) PureLiving Pickled Beets and Sauerkraut (Shiloh Farms ⁴¹) Seoul Kimchi (Lucky Foods ⁴²) Wildbrine Kimchi, Kimchi Live Shots, Pickled Ginger, Salsa, and Sauerkraut (Wildbrine ⁴³)
				<i>L. casei</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Dahlicious Cow's Milk Lassi (Dahlicious ²⁸) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ²⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ³²) Zukay Live Foods Fruit Kvass (Zukay Lives Foods ³⁵) Zukay Live Foods Veggie Kvass (Zukay Live Foods ³⁶)
				<i>L. salivarius</i>	None
				<i>L. paracasei</i>	KeVita Kombucha Cleansing Probiotic Drink and Sparkling Probiotic Drink (KeVita ²⁵) Wallaby Yogurt Company Organic Greek Whole Milk Plain Yogurt (Wallaby Yogurt Company ²⁴)

Table 1. (continued)

Mental Health/ Neurotransmitters/Stress	Strains	Overview	Professional and Commercial Products	Foods	
				<i>S thermophiles</i>	All yogurt containing "Live and Active Cultures" (National Yogurt Association ⁴⁴) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Dannon Activia Products and DanActive (Dannon ^{45,46}) Green Valley Organics Cow's Milk Lactose Free Kefir (Green Valley Organics ³⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶)
				<i>Lactobacillus</i> spp	A variety of fermented dairy and nondairy foods Bubbies Kosher Dill Pickles (Bubbies of San Francisco ⁴⁷) Real Pickles Organic Dill Pickles (Real Pickles ⁴⁸)
				<i>Bifidobacterium</i> spp	A variety of cultured dairy foods and cultured dairy alternatives
Depression					
Wang ¹⁰ (2016); Akkasheh et al ¹¹ (2016); Liu et al ¹ (2016); Liu et al ² (2016); Mohammadi et al ¹³ (2015)	<i>B longum</i> , <i>B bifidum</i> , <i>B breve</i> , <i>B infantis</i> <i>L helveticus</i> , <i>L rhamnosus</i> , <i>L acidophilus</i> , <i>L casei</i> , <i>L plantarum</i> strain PS128	<i>Bifidobacterium</i> and <i>Lactobacillus</i> showed efficacy in improving psychiatric disorder-related behaviors including anxiety, depression, autism spectrum disorder, obsessive compulsive disorder, and memory abilities including spatial and nonspatial memory. Probiotic administration with <i>L casei</i> , <i>L acidophilus</i> , and <i>Bifidobacterium</i> for 8 wk had beneficial effects in Beck Depression Inventory, insulin, homeostasis, high-sensitivity C-reactive protein concentrations, and glutathione concentrations. Chronic ingestion of PS128 could ameliorate anxiety and depression-like behaviors and modulate neurochemicals related to affective disorders. PS128 shows psychotropic properties and has great potential for improving stress-related symptoms. Daily intake of <i>L plantarum</i> strain PS128 could improve anxiety-like behaviors and may be helpful in ameliorating neuropsychiatric disorders. The consumption of probiotic yogurt or multispecies probiotic capsule had beneficial effects on mental health parameters.	<i>B longum</i>, <i>B bifidum</i>, <i>B breve</i>, <i>B infantis</i>, <i>L helveticus</i>, <i>L rhamnosus</i>, <i>L acidophilus</i>, <i>L casei</i>, <i>L plantarum</i>: Dr Formulated Probiotics Mood+ (Garden of Life) <i>B lactis</i> (<i>infantis</i>), <i>B longum</i>, <i>L acidophilus</i>: Probiotic Synergy powder (Designs for Health) <i>B bifidum</i>, <i>B breve</i>, <i>B longum</i>, <i>L rhamnosus</i>, <i>L casei</i>, <i>L acidophilus</i>, <i>S thermophiles</i>: Probiophage DF (Designs for Health) <i>L acidophilus</i>, <i>B lactis</i>, <i>B longum</i>, <i>L plantarum</i>, <i>B bifidum</i>, <i>B infantis</i>, <i>L casei</i>, <i>L salivarius</i>, <i>S thermophiles</i>: Integrative Therapeutics, Spectra Probiotic with Co-Factors <i>L acidophilus</i>, <i>B bifidum</i>, <i>B infantis</i>, <i>Enterococcus faecium</i>: Integrative Therapeutics, Enterogenic Concentrate <i>L helveticus</i>, <i>L rhamnosus</i>, <i>B longum</i>: Probio Defense (Xymogen) NutriVitamin Enzyme Comp w/o Iron (Integrative Therapeutics) Jarro-Dophilus EPS 5 Billion & 25 Billion (Jarro Formulas) RAW Probiotics Ultimate & Colon Care (Garden of Life) Primadophilus Optima (Nature's Way) <i>L helveticus</i>, <i>B longum</i>: FLORASSIST Mood (Life Extension) Pure Encapsulations Probiomood <i>L acidophilus</i>, <i>L rhamnosus</i>; <i>B bifidum</i>/<i>lactis</i>, <i>B longum</i>: Ther-biotic Complete & Senior (Klaire Labs) Multi-Probiotic 40 Billion (Douglas Labs) iFlora Multi-Probiotic Capsule 60 ct (Sedona Labs Pro) Primal Defense Ultra (Garden of Life) Dr Formulated Formulas (Garden of Life) RAW Probiotics Wom 50 & Wiser (Garden of Life) Ultimate FloraMax Total Woman (Advanced Naturals) FloraBoost (OrthoMolecular) Bifido Digest (Protocol for Life Balance) FlorAssist Probiotic (Life Extension)	<i>B longum</i> <i>B bifidum</i>	None Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Green Valley Organics Lactose-free Cow's Milk Kefir (Green Valley Organics ³⁰) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Trader Joe's Cultured Coconut Milk (Trader Joe's ²³)
				<i>B breve</i>	None
				<i>B infantis</i>	None
				<i>L helveticus</i>	Used in the production of various cheeses (Fox et al ²⁴ [2016])
				<i>L rhamnosus</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ³⁰) KeVita Kombucha Cleansing Probiotic Drink, Masterbrew, and Sparkling Probiotic Drink (KeVita ²⁵) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Trader Joe's Cultured Coconut Milk (Trader Joe's ²³)
				<i>L acidophilus</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Bellwether Farms Sheep's Milk Yogurt (Bellwether Farms ²⁸) Coconut Grove Organic Cultured Coconut Milk (Coconut Grove Yogurt ²⁹) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ³⁰) Kite Hill Almond Milk Yogurt (Kite Hill ³¹) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Redwood Hill Farm Goat Milk Yogurt (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷)

Table 1. (continued)

Mental Health/ Neurotransmitters/Stress	Strains	Overview	Professional and Commercial Products	Foods
				Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ³²) Stonyfield Organic O'Soy Soy Yogurt (Stonyfield Farm ³³) Trader Joe's Cultured Coconut Milk (Trader Joe's ³²) Wallaby Yogurt Company Organic Greek Whole Milk Plain Yogurt (Wallaby)
			<i>L. casei</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ³⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ³²) Zukay Live Foods Fruit Kvass (Zukay Lives Foods ²⁶) Zukay Live Foods Veggie Kvass (Zukay Live Foods ²⁶)
			<i>L. plantarum</i> strain PS128	None
			<i>S. thermophiles</i>	All yogurt containing "Live and Active Cultures" (National Yogurt Association ⁴⁴) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Dannon Activia Products and DanActive (Dannon ^{45,46}) Green Valley Organics Cow's Milk Lactose Free Kefir (Green Valley Organics ³⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶)
			<i>Lactobacillus</i> spp	A variety of fermented dairy and nondairy foods Bubbies Kosher Dill Pickles (Bubbies of San Francisco ⁴⁷) Real Pickles Organic Dill Pickles (Real Pickles ⁴⁸)
			<i>Bifidobacterium</i> spp	A variety of cultured dairy foods and cultured dairy alternatives

Neurological Health

Research Overview: Neurological

Research on probiotic supplementation for neurological health is in its early stages. Although some promising studies are cited in the scientific literature, the amount of evidence in support of these interventions is scant. Most of the relationships explored do not have sufficient details to draw broader conclusions about the primary mechanisms and the diversity of probiotic strains and actions suggest that we are only beginning to consider the possible applications. In the case of age-related cognitive decline, Distrutti et al⁴⁹ examined the effect of the combination of *Streptococcus thermophilus*, *Bifidobacterium breve*, *B. longum*, *Bifidobacterium infantis*, *Lactobacillus acidophilus*, *L. plantarum*, *Lactobacillus paracasei*, and *Lactobacillus delbrueckii* sbsp *bulgaricus* in a dose of 12.86

billion bacteria/kg/day upon the rat cerebral cortex. There was evidence to suggest that through an unknown mechanism, these probiotic strains influenced brain genetic expression and modulated neurotransmitters to counter age-related reduction in cognitive function. It is premature to extend these findings to human cognitive function; however, it may be a valuable study for clinicians considering whether they would consider probiotic supplementation as part of their care for supporting cognitive health.

Probiotic use for hepatic encephalopathy has been evaluated by several researchers and Sharma et al⁵⁰ conducted a randomized controlled trial to compare L-ornithine-L-aspartate (18 g/day), rifaximin (1200 mg/day), and the Velmot probiotic combination *L. acidophilus*, *L. rhamnosus*, *L. plantarum*, *L. casei*, *B. longum*, *B. infantis*, *B. breve*,

Table 2. Neurological Health Overview

Neurological	Strains	Overview	Professional and Commercial Products	Foods
Age-related Cognitive Decline				
Distrutti et al ⁴⁹ (2014) (animal model)	Combination of: <i>S thermophilus</i> DSM24731, <i>B breve</i> DSM24732, <i>B longum</i> DSM24736, <i>B infantis</i> DSM24737, <i>L acidophilus</i> DSM24735, <i>L plantarum</i> DSM24730, <i>L paracasei</i> DSM24733, <i>L delbrueckii</i> subsp <i>bulgaricus</i> DSM24734	Treatment group showed modulated age-related shifts in inflammation-linked genes <i>PLA2G3</i> , <i>Nid2</i> , and <i>Alox15</i> ; reduces impairments in long-term potentiation.	<i>B longum</i> , <i>B infantis</i> , <i>B breve</i> , <i>L acidophilus</i> , <i>L casei</i> , <i>L delbrueckii</i> subsp, <i>bulgaricus</i> , <i>L plantarum</i> , <i>S salivarius</i> subsp <i>thermophiles</i> : VSL#3 (Sigma Tau Pharmaceuticals) <i>S boulardii</i> , <i>S thermophilus</i> , <i>L fermentum</i> , <i>L acidophilus</i> , <i>L brevis</i> , <i>L bulgaricus</i> , <i>L casei</i> , <i>L helveticus</i> , <i>L paracasei</i> , <i>L plantarum</i> , <i>L rhamnosus</i> , <i>L salivarius</i> , <i>L lactis</i> , <i>Bacillus coagulans</i> , <i>B bifidum</i> , <i>B breve</i> , <i>B infantis</i> , <i>B lactis</i> , <i>B longum</i> , <i>P acidilacti</i> : Nexabiotic (Bioprospers Labs) <i>S boulardii</i> DDS-1, <i>L acidophilus</i> , <i>Bacillus coagulans</i> : Strengtia (Apex Energetics)	None
Hepatic Encephalopathy				
Sharma et al ⁵⁰ (2014) (randomized, controlled trial)	Combination of: <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>L plantarum</i> , <i>L casei</i> , <i>B longum</i> , <i>B infantis</i> , <i>B breve</i> , <i>S boulardii</i> , <i>S thermophilus</i>	Reduced blood ammonia.	Combination of: <i>L acidophilus</i> , <i>L rhamnosus</i> , <i>L plantarum</i> , <i>L casei</i> , <i>B longum</i> , <i>B infantis</i> , <i>B breve</i> , <i>S thermophiles</i> (missing <i>S boulardii</i>): iFlora Multi Probiotic (Sedona Labs Pro) Multi Probiotic 40 Billion Pwdr (Douglas Labs) Gastro Complete (NewMark) <i>S boulardii</i> , DDS-1, <i>L acidophilus</i> , <i>B coagulans</i> : Strengtia (Apex Energetics) <i>L casei</i> , <i>B breve</i> , <i>L plantarum</i> : Sibiotica (Apex Energetics)	<div> <i>L acidophilus</i> <p>Almond Dream Non-dairy Yogurt (Dream²⁴) Amande Cultured Almond Milk (Amande Yogurt¹⁹) Bellwether Farms Sheep's Milk Yogurt (Bellwether Farms²⁹) Coconut Grove Organic Cultured Coconut Milk (Coconut Grove Yogurt²⁹) Dahlicious Cow's Milk Lassi (Dahlicious³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics²⁹) Kite Hill Almond Milk Yogurt (Kite Hill³¹) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery²⁶) Redwood Hill Farm Goat Milk Yogurt (Redwood Hill Farm and Creamery²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurt (Springfield Creamery²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Kefir (Springfield Creamery²⁷) Stonyfield Organic O'Soy Soy Yogurt (Stonyfield Farm³³) Trader Joe's Cultured Coconut Milk (Trader Joe's²²) Wallaby Yogurt Company Organic Greek Whole Milk Plain Yogurt (Wallaby Yogurt Company³⁴)</p> </div> <div> <i>L rhamnosus</i> <p>Almond Dream Non-dairy Yogurt (Dream²⁴) Amande Cultured Almond Milk (Amande Yogurt¹⁹) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics²⁹) KeVita Kombucha Cleansing Probiotic Drink, Masterbrew, and Sparkling Probiotic Drink (KeVita²⁵) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery²⁷) Trader Joe's Cultured Coconut Milk (Trader Joe's²²)</p> </div> <div> <i>L plantarum</i> <p>Farmhouse Culture Sauerkraut (Farmhouse Culture³⁷) Green Olives (various brands; not refrigerated) (Abriouel³⁸ [2012]; Doulgeraki et al³⁹ [2013]) KeVita Kombucha Cleansing Probiotic Drink (KeVita²⁵) KeVita Kombucha Sparkling Probiotic Drink (KeVita²⁵) King's Kimchi (King's Asian Gourmet⁴⁰) PureLiving Pickled Beets and Sauerkraut (Shiloh Farms⁴¹) Seoul Kimchi (Lucky Foods⁴²) Wildbrine Kimchi, Kimchi Live Shots, Pickled Ginger, Salsa, and Sauerkraut (Wildbrine⁴³)</p> </div>

Table 2. (continued)

Neurological	Strains	Overview	Professional and Commercial Products	Foods	
				<i>L. casei</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ²⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ²²) Zukay Live Foods Fruit Kvass (Zukay Lives Foods ³⁵) Zukay Live Foods Veggie Kvass (Zukay Live Foods ³⁶)
				<i>B. longum</i>	None
				<i>B. infantis</i>	None
				<i>B. breve</i>	None
				<i>S. boulardii</i>	GT's Kombucha Classic Kombucha, Classic Synergy, Enlightened Kombucha, Enlightened Synergy (Millennium Products ³⁸)
				<i>S. thermophiles</i>	All yogurt containing "Live and Active Cultures" (National Yogurt Association ⁴⁴) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Dannon Activia Products and DanActive (Dannon ^{45,46}) Green Valley Organics Cow's Milk Lactose Free Kefir (Green Valley Organics ²⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶)
Luo et al ³¹ (2014) (animal model)	<i>L. helveticus</i> NS8	Reduced inflammation and improved cognitive function.	Not available	<i>L. helveticus</i> NS8	None
Cerebral Ischemia/Reperfusion					
Sun et al ³² (2016) (animal model)	<i>C. butyricum</i>	Pretreatment reduced neurological impairment, perhaps through reducing reactive oxygen species, decreasing butyrate in the brain, and/or inhibiting apoptosis.	<i>C. butyricum</i>: AOR Probiotic-3 Miyarisan MIYARISAN 630 Tablets	<i>C. butyricum</i>	None
Traumatic Brain Injury					
Tan et al ³³ (2011) (randomized, controlled trial)	Combination of: <i>B. longum</i> , <i>L. bulgaricus</i> , <i>S. thermophilus</i>	Balanced T _H 1/T _H 2, decreased rate of infection, antibiotic use, and length of stay in intensive care unit.	Combination of: <i>B. longum</i>, <i>L. bulgaricus</i>, <i>S. thermophiles</i>: Nexabiotic (Bioprosper Labs) Propolis Plus (Essential Formulas) Mega Flora Plus (Mega Food) Adult Probiotic (Probacla) Ther-Biotic Complete (Klaire Labs) Multi Probiotic 40 Billion (Douglas Labs) Flora 50-14 Clinical Strength, 200-14: 7-day Intensive, 5-14 Complete Care (Innate Response) Dr Ohhira's Probiotics Prof/Plus (Essential Formulas) ProGreens Powder (Nutricology) iFlora Multi-Probiotic Powder 60 ct (Sedona Labs Pro) <i>B. longum</i>, <i>B. infantis</i>, <i>B. breve</i>, <i>L. acidophilus</i>, <i>L. casei</i>, <i>L. delbrueckii</i> sbsp <i>bulgaricus</i>, <i>L. plantarum</i>, <i>S. salivarius</i> subsp <i>thermophiles</i>: VSL#3 (Sigma Tau Pharmaceuticals) <i>L. acidophilus</i> HA-122, <i>L. rhamnosus</i> HA-111, <i>L. rhamnosus</i> HA-114, <i>L. plantarum</i> HA-119, <i>B. bifidum</i> HA-132, <i>L. casei</i> HA-108, <i>B. longum</i> HA-135, <i>L. salivarius</i> HA-118L: Super 8 Hi-Potency (Udo's Choice) <i>B. lactis</i> HN019, <i>L. acidophilus</i> La-14, <i>L. plantarum</i> Lp-115, <i>B. longum</i> BI-05: Probiomax DF (Xymogen; 250 DF)	<i>B. longum</i>	None
				<i>L. bulgaricus</i>	All yogurt containing "Live and Active Cultures" (National Yogurt Association ⁴⁴) Dannon Activia Products and DanActive (Dannon ^{45,46}) Green Valley Organics Cow's Milk Lactose Free Kefir (Green Valley Organics ²⁰)
				<i>S. thermophiles</i>	All yogurt containing "Live and Active Cultures" (National Yogurt Association ⁴⁴) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Dannon Activia Products and DanActive (Dannon ^{45,46}) Green Valley Organics Cow's Milk Lactose Free Kefir (Green Valley Organics ²⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶)
Falcão de Arruda & de Aguiar-Nascimento ³⁴ (2004) (randomized, controlled trial)	<i>L. johnsonii</i>	Combined with 30 g of glutamine was associated with reduced infection and shorter time in intensive care unit.	<i>L. johnsonii</i>: Not available	<i>L. johnsonii</i>	None

Table 2. (continued)

Neurological	Strains	Overview	Professional and Commercial Products	Foods	
Multiple Sclerosis					
Kwon et al ⁵⁵ (2013) (animal model)	Combination of: <i>L. casei</i> , <i>L. acidophilus</i> , <i>L. reuteri</i> , <i>B. bifidum</i> , <i>S. thermophilus</i>	Significantly reduced incidence of developing experimental autoimmune encephalomyelitis with pretreatment (for 3 wk) and decreased clinical symptoms.	Combination of: <i>L. L. acidophilus</i> , <i>L. reuteri</i> , <i>B. bifidum</i> , <i>S. thermophiles</i> : Flora 50-14 Clinical Strength, 200-14: 7-day Intensive, 5-14 Complete Care (Innate Response) IRT5 probiotic powder Mega Flora Plus, Mega Food Probiotic Synergy & Supreme (Designs for Health) RAW Probiotics Women & Mom 50 & Wiser (Garden of Life) NDF, NDF-Plus, & Cytoflora (BioRay)	<i>L. casei</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ²⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ³⁴) Zukay Live Foods Fruit Kvass (Zukay Lives Foods ³⁵) Zukay Live Foods Veggie Kvass (Zukay Live Foods ³⁶)
				<i>L. acidophilus</i>	Almond Dream Non-dairy Yogurt (Dream ²⁴) Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Bellwether Farms Sheep's Milk Yogurt (Bellwether Farms ²⁹) Coconut Grove Organic Cultured Coconut Milk (Coconut Grove Yogurt ²⁹) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Green Valley Organics Lactose-Free Cow's Milk Kefir (Green Valley Organics ²¹) Kite Hill Almond Milk Yogurt (Kite Hill ³¹) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamery ²⁶) Redwood Hill Farm Goat Milk Yogurt (Redwood Hill Farm and Creamery ²⁶) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²¹) Springfield Creamery Nancy's Organic Cultured Soy (Springfield Creamery ²⁷) Springfield Creamery Nancy's Organic Lowfat Plain Cow's Milk Kefir (Springfield Creamery ³²) Stonyfield Organic O'Soy Soy Yogurt (Stonyfield Farm ³³) Trader Joe's Cultured Coconut Milk (Trader Joe's ²²) Wallaby Yogurt Company Organic Greek Whole Milk Plain Yogurt (Wallaby Yogurt Company ³⁴)
				<i>L. reuteri</i>	No specific brands or products identified. Traditionally used in sourdough bread, and fermented milk production (De Vuyst & Neysens ⁵⁹ [2005]; Tamime ⁶⁰ [2002])
				<i>B. bifidum</i>	Amande Cultured Almond Milk (Amande Yogurt ¹⁹) Green Valley Organics Lactose-free Cow's Milk Kefir (Green Valley Organics ²⁰) Springfield Creamery Nancy's Organic Cow's Milk Yogurts (Springfield Creamery ²⁷) Trader Joe's Cultured Coconut Milk (Trader Joe's ²²)
				<i>S. thermophiles</i>	All yogurt containing "Live and Active Cultures" (National Yogurt Association ⁴⁴) Dahlicious Cow's Milk Lassi (Dahlicious ³⁰) Dannon Activia Products and DanActive (Dannon ^{45,46}) Green Valley Organics Cow's Milk Lactose Free Kefir (Green Valley Organics ²⁰) Redwood Hill Farm Goat Milk Kefir (Redwood Hill Farm and Creamert ²⁶)
Rosche et al ⁵⁶ (2013)	<i>T suis</i> ova	Pilot study: Administration in the course of 6 mo, every 2 wk, was associated with decrease in brain-derived neurotrophic factor.	Produced for research purpose (not commercially available)	None	

Table 3. Summary of Brands of Nutritional Supplements by Health Concern

Health Concern	Professional and Commercial Products	Strains
Attention-deficit/hyperactivity disorder	Advanced Multi-Billion Dophilus (Solgar); Advanced 40+ Acidophilus (Culturelle); Lactobacillus GG (Walgreens); Probiotic <i>Lactobacillus GG</i>	<i>L rhamnosus GG</i>
Age-related cognitive decline	Nexabiotic (Bioprosper Labs)	<i>S boulardii</i> , <i>S thermophilus</i> , <i>L fermentum</i> , <i>L acidophilus</i> , <i>L brevis</i> , <i>L bulgaricus</i> , <i>L casei</i> , <i>L helveticus</i> , <i>L paracasei</i> , <i>L plantarum</i> , <i>L rhamnosus</i> , <i>L salivarius</i> , <i>L lactis</i> , <i>B coagulans</i> , <i>B bifidum</i> , <i>B breve</i> , <i>B infantis</i> , <i>B lactis</i> , <i>B longum</i> , <i>P acidilacti</i>
Age-related cognitive decline	VSL#3 (Sigma Tau Pharmaceuticals)	<i>B longum</i> , <i>B infantis</i> , <i>B breve</i> , <i>L acidophilus</i> , <i>L casei</i> , <i>L delbrueckii</i> subsp <i>bulgaricus</i> , <i>L plantarum</i> , <i>S salivarius</i> subsp <i>thermophiles</i>
Autism	Digestive Health Probiotic (Nature Made); Heart Healthy Probiotic Solutions (Dr Sinatra); Jarrow Formulas Ideal Bowel Support (10 billion CFU per capsule); Plantadophilus (Transformation Enzymes, 3 billion CFU per capsule); Probiata Digestion Support and Critical Care (Kyolic); and many more	<i>L plantarum</i>
Autism	Probiotic Balance (Sundown Naturals)	<i>L plantarum</i> , <i>B longum</i>
Autism	Prothera LactoPrime Plus	<i>L rhamnosus</i> , <i>L acidophilus</i> , <i>L plantarum</i> , <i>L salivarius</i> , <i>L casei</i> , <i>B bifidum</i> , <i>B infantis</i> , <i>B longum</i> , <i>B breve</i>
Autism	Ther-biotic Children's Chewable	<i>L rhamnosus</i> , <i>L casei</i> , <i>L salivarius</i> , <i>B infantis</i> , <i>B bifidum</i> , <i>B longum</i> , <i>B breve</i>
Autism	Ther-biotic Complete (Prothera)	<i>L rhamnosus</i> , <i>B bifidum</i> , <i>L acidophilus</i> , <i>L casei</i> , <i>B longum</i> , <i>B breve</i>
Autism	Widely available	<i>L acidophilus</i>
Cerebral ischemia/reperfusion	AOR Probiotic-3	<i>C butyricum</i>
Cerebral ischemia/reperfusion	Miyarisan MIYARISAN 630 Tablets	<i>C butyricum</i>
Depression	Dr Formulated Probiotics Mood+ (Garden of Life)	<i>B longum</i> , <i>B bifidum</i> , <i>B breve</i> , <i>B infantis</i> , <i>L helveticus</i> , <i>L rhamnosus</i> , <i>L acidophilus</i> , <i>L casei</i> , <i>L plantarum</i> + ashwaganda and food extracts
	FLORASSIST Mood (Life Extension)	<i>L acidophilus</i> , <i>L rhamnosus</i> , <i>B bifidum/lactis</i> , <i>B longum</i>
	Pure Encapsulations (Probiomood)	<i>L helveticus</i> , <i>B longum</i>
	Xymogen Probio Defense	<i>L helveticus</i> Roselle-52, <i>L rhamnosus</i> Roselle-11, <i>B longum</i> Roselle-175
Multiple sclerosis	Flora 50-14 and Flora 20-14 (Innate Response)	<i>L casei</i> , <i>L acidophilus</i> , <i>L reuteri</i> , <i>B bifidum</i> , <i>S thermophiles</i> combined
Multiple sclerosis	IRT5 probiotic powder	<i>L casei</i> , <i>L acidophilus</i> , <i>L reuteri</i> , <i>B bifidum</i> , <i>S thermophiles</i> combined
	Mega Flora Plus (Mega Food)	
Traumatic brain injury	Adult Probiotic (Probiolac) Mega Flora Plus (Mega Food) Nexabiotic (Bioprosper Labs)	<i>B longum</i> , <i>L bulgaricus</i> , <i>S thermophiles</i> combined
Traumatic brain injury	Not available	<i>L johnsonii</i>
Traumatic brain injury	Propolis Plus (Essential Formulas) Super 8 Hi-Potency VSL#3 (Sigma Tau Pharmaceuticals)	<i>B longum</i> , <i>L bulgaricus</i> , <i>S thermophiles</i> combined

Saccharomyces boulardii, and *Streptococcus thermophiles* (10 billion CFU/day) for the treatment of minimal hepatic encephalopathy. They found that those in the probiotic group showed improved function on the neurophysiologic assessment and it was significantly better than placebo. *L helveticus* was the strain used by Luo et al⁵¹ in their animal model of hepatic encephalopathy and they found decreased inflammation and improved cognitive function.

For cerebral ischemia/perfusion, Sun et al⁵² used an animal model to explore protective effects of *Clostridium butyricum* (1 billion CFU/day). Those animals that were pretreated with *C butyricum* had significantly less injury than the untreated controls. The authors hypothesized that reduced reactive oxygen species in the brain and inhibited apoptosis were contributing to their improved outcomes. Further research on the effects of *C butyricum*

in vivo would provide valuable data on its clinical usefulness.

With traumatic brain injuries (TBIs), probiotics have been evaluated in a couple of controlled trials giving greater support for their efficacy. Tan et al⁵³ focused on patients in an intensive care unit (ICU) who had both TBI and were at increased risk for ventilator-associated pneumonia. They used a combination of *B longum*, *L bulgaricus*, and *S thermophiles* (1 billion CFU/day) and found a significant reduction in the length of stay in the ICU. Tan et al⁵³ also postulated that probiotic use could result in reduced risk of infection. Each of these outcomes was supported by earlier research from Falcão de Arruda and de Aguilar-Nascimento,⁵⁴ who researched *Lactobacillus johnsonii* with 30 g of glutamine patients with TBIs in the ICU.

Probiotic therapies for multiple sclerosis (MS) consist of 2 primary research paths. One is what may be considered traditional probiotic therapy using a combination of *L. casei*, *L. acidophilus*, *L. reuteri*, *B. bifidum*, and *S. thermophiles* (5×10^8 CFU) in an animal model of experimental autoimmune encephalomyelitis (EAE).⁵⁵ The authors⁵⁵ found that pretreatment with the probiotic blend for 3 weeks significantly decreased the development of EAE and reduced the clinical symptoms in those subjects that did develop it. Another research strategy involves helminth therapy for the reduction of MS symptoms, specifically *Trichuris suis* ova.^{56,57} Fleming et al⁵⁷ established that 2500 ova every 2 weeks did not result in an increase in clinical presentation in MS, whereas Rosche et al⁵⁵ found that placing their patients on the same protocol in the course of 6 months was associated with a significant reduction in brain-derived neurotrophic factor. As with the other uses of probiotic therapy for neurological health, there are not enough data to formulate clear protocols for predictable outcomes. One consistent finding across these diverse applications is very few reports of adverse effects other than occasional GI distress.

Nutritional Supplements Overview

Professional and commercial dietary supplements containing probiotics are widely available.⁶¹ In 2002, it was estimated that more than 100 companies in the United States market probiotic supplements and nearly 2 million adults use them.⁶² Using probiotics for general health versus targeting a specific health concern is more complex, as the properties of probiotic species are strain specific.⁶³ Unfortunately, there is a lack of consistency naming therapeutic strains in research and strains are often not listed on supplement labels. This makes it difficult to know whether the product matches the product used in the research and is a limitation of these tables.

The Joint Food and Agriculture Organization of the United Nations/World Health Organization Expert Consultation on Evaluation of Health and Nutritional Properties of Probiotics developed guidelines for evaluating probiotics in food.⁶⁴ A combination of phenotypic and genotypic tests must be performed to determine the strain; however, regulations on species identification are not in place and supplement companies are not required to list this information on labels. During this review, it was identified that 30 species were specifically isolated for research purposes and were unavailable and another 56 strains were not commercially available. Because of the wide variety of formulations on the market, lack of knowledge, and poor labeling, it is difficult to for practitioners and consumers to determine which brand contains specific strains researched to address a particular health concern.

Table 3 is designed to be a resource to see what is available at-a-glance. The brands were chosen by searching the probiotic strain and/ strain-species in Google, a number of supplement companies, Probiotics Advisor,⁶⁵ and the

Clinical Guide to Probiotic Products.⁶⁶ Based on the results and to determine what was commercially available, the search was refined using Google Shopping. In some instances, the supplement company was called to determine whether the formula contained a particular species.

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References

1. Liu YW, Liu WH, Wu CC, et al. Psychotropic effects of *Lactobacillus plantarum* PS128 in early life-stressed and naive adult mice. *Brain Res*. January 2016;1631:1-12.
2. Messaoudi M, Lalonde R, Violle N, et al. Assessment of psychotropic-like properties of a probiotic formulation (*Lactobacillus helveticus* R0052 and *Bifidobacterium longum* R0175) in rats and human subjects. *Br J Nutr*. 2011;105(5):755-764.
3. Partty A, Kalliomaki M, Wacklin P, Salminen S, Isolauri E. A possible link between early probiotic intervention and the risk of neuropsychiatric disorders later in childhood: A randomized trial. *Pediatr Res*. 2015;77(6):823-828.
4. Tillisch K, Labus J, Kilpatrick L, et al. Consumption of fermented milk product with probiotic modulates brain activity. *Gastroenterology*. 2013;144(7):1394-1401.
5. Rao AV, Bested AC, Beaulne TM, et al. A randomized, double-blind, placebo-controlled pilot study of a probiotic in emotional symptoms of chronic fatigue syndrome. *Gut Pathogen*. 2009;1:6.
6. O'Sullivan E, Barrett E, Grenham S, et al. BDNF expression in the hippocampus of maternally separated rats: Does *Bifidobacterium breve* 6330 alter BDNF levels? *Benef Microbes*. 2011;2(3):199-207.
7. Galland L. The gut microbiome and the brain. *J Med Food*. 2014;17(12):1261-1272.
8. Russo AJ. Decreased plasma myeloperoxidase associated with probiotic therapy in autistic children. *Clin Med Insights Pediatr*. 2015;9:13-17.
9. Tomova A, Husarova V, Lakatosova S, et al. Gastrointestinal microbiota in children with autism in Slovakia. *Physiol Behav*. 2015;138:179-187.
10. Wang H, Lee IS, Braun C, Enck P. Effect of probiotics on central nervous system functions in animals and humans: A systematic review. *J Neurogastroenterol Motil*. July 2016. doi:10.5056/jnm16018. [E-pub ahead of print]
11. Akkasheh G, Kashani-Poor Z, Tajabadi-Ebrahimi, et al. Clinical and metabolic response to probiotic administration in patients with major depressive disorder: A randomized, double-blind, placebo-controlled trial. *Nutrition*. 2016;32(3):315-320.
12. Liu, WH, Chuang HL, Huang YT, et al. Alteration of behavior and monoamine levels attributable to *Lactobacillus plantarum* PS128 in germ-free mice. *Behav Brain Res*. 2016;298(Pt B):202-209.
13. Mohammadi AA, Jazayeri S, Khosravi-Darani K, et al. The effects of probiotics on mental health and hypothalamic-pituitary-adrenal axis: A randomized, double-blind, placebo-controlled trial in petrochemical workers. *Nutr Neurosci*. April 2015. doi:10.1179/1476830515Y.0000000023. [E-pub ahead of print]
14. Wang H, Lee IS, Braun C, Enck P. Effect of probiotics on central nervous system functions in animals and humans: A systematic review. *J Neurogastroenterol Motil*. July 2016. doi:10.5056/jnm16018. [Epub ahead of print]
15. Parracho HMRT, Gibson GR, Knott F, et al. A double blind, placebo-controlled, crossover designed probiotic feeding study in children diagnosed with autism spectrum disorders. *Internat J Probiotics Prebiotics*. 2010;5(2):69-74.
16. Critchfield JW, van Hemert S, Ash M, Mulder L, Ashwood, P. The potential role of probiotics in the management of childhood autism spectrum disorders. *Gastroenterol Res Pract*. 2011;2011:161358.
17. Yakult USA. Yakult products. <http://www.yakultusa.com/products/>. Accessed October 3, 2016.
18. NextFoods. GoodBelly cure your curiosity. <http://goodbelly.com/faq/>. Accessed October 3, 2016.
19. Amande Yogurt. Amande cultured almond milk: Cultures. <http://www.amandeyogurt.com/cultures.html>. Accessed October 3, 2016.
20. Green Valley Organics. Lactose-free plain kefir. <http://greenvalleylactosefree.com/product/lactose-free-plain-kefir>. Accessed October 3, 2016.
21. Springfield Creamery. Nancy's organic yogurts. <http://www.nancysyogurt.com/index.php/products/yogurts>. Accessed October 3, 2016.
22. Trader Joe's. Cultured coconut milk: Vanilla (food label ingredients list). Santa Rosa, CA: Trader Joe's.
23. Fox PF, Guinee TP, Cogan TM, McSweeney PLH. *Fundamentals of Cheese Science*. 2nd ed. New York, NY: Springer; 2016.

24. Dream. Almond dream non-dairy yogurt, coconut. <http://www.dreamplantbased.com/product/almond-dream-almond-non-dairy-yogurt-coconut/>. Accessed October 3, 2016.
25. KeVita.com. Products. <http://kevitacomm.com/products/>. Accessed October 3, 2016.
26. Redwood Hill Farm & Creamery. Traditional plain kefir, 32 oz. <http://www.redwoodhill.com/goat-kefir/plain/>. Accessed October 3, 2016.
27. Springfield Creamery. Nancy's organic plain cultured soy unsweetened. <http://www.nancysyogurt.com/index.php/products/soy/177-unsweet-soy-nutritional-info>. Accessed October 3, 2016.
28. Bellwether Farms. Sheep's milk yogurt. <http://www.bellwetherfarms.com/sheeps-milk-yogurt/>. Accessed October 3, 2016.
29. Coconut Grove Yogurt. Plain coconut milk yogurt. <http://www.coconutgroveyogurt.com/products/plain/>. Accessed October 3, 2016.
30. Dahlicious. Dahlicious lassi. <http://dahlicious.com/#flavors>. Accessed October 3, 2016.
31. Kite Hill. Yogurts. <http://www.kite-hill.com/our-foods/yogurts/>. Accessed October 3, 2016.
32. Springfield Creamery. Nancy's organic lowfat plain kefir. <http://www.nancysyogurt.com/index.php/products/kefir/104-plain-kefir-nutritional-info>. Accessed October 3, 2016.
33. Stonyfield Farm, Inc. O'soy vanilla. <http://www.stonyfield.com/products/yogurt/osoy/vanilla>. Accessed October 3, 2016.
34. Wallaby Yogurt Company. Our products. <http://www.wallabyyogurt.com/our-products>. Accessed October 3, 2016.
35. Zukay Live Foods, LLC. Fruit kvass. <http://zukay.com/products/fruit-kvass/>. Accessed October 3, 2016.
36. Zukay Live Foods, LLC. Veggie kvass. <http://zukay.com/products/veggie-kvass/>. Accessed October 3, 2016.
37. Farmhouse Culture. Welcome to farmhouse culture. <http://farmhouseculture.com/>. Accessed October 3, 2016.
38. Abriouel H, Benomar N, Cobo A, et al. Characterization of lactic acid bacteria from naturally-fermented Manzanilla Aloreña green table olives. *Food Microbiol.* 2012;32(2):308-316.
39. Doulgeraki AI, Pramateftaki P, Argyri AA, et al. Molecular characterization of lactic acid bacteria isolated from industrially fermented Greek table olives. *LWT: Food Sci Tech.* 2013;50(1):353-356.
40. King's Asian Gourmet. Homepage. <http://www.kingsasian.com/index.html>. Accessed October 3, 2016.
41. Shiloh Farms. PureLiving. <http://www.shilohfarms.com/pureliving/>. Accessed October 3, 2016.
42. Lucky Foods, LLC. Raw & healthy Seoul kimchi. <http://www.luckyfood.com/products/seoul-kim-chi.html>. Accessed October 3, 2016.
43. Wildbrine. Products. <http://www.wildbrine.com/products/>. Accessed October 3, 2016.
44. Yogurt Association (2016) LAC Seal Companies (live organisms). <http://aboutyogurt.com/index.asp?bid=54>. Accessed October 3, 2016.
45. Dannon, Inc. DanActive. <http://www.dannon.com/danactive/>. Accessed October 3, 2016.
46. Dannon, Inc. Beyond bifidus. <http://www.activia.us.com/behind-bifidus#t5Gq3RhYxIM22j2.97>. Accessed October 3, 2016.
47. Bubbies of San Francisco, Inc. Pantry. <http://bubbies.com/pantry>. Accessed October 3, 2016.
48. Real Pickles. Homepage. <http://http://www.realpickles.com/>. Accessed October 3, 2016.
49. Distrutti E, O'Reilly JA, McDonald et al. Modulation of intestinal microbiota by the probiotic VSL#3 resets brain gene expression and ameliorates the age-related deficit in LTP. *PLoS ONE.* 2014;9(9):e106503.
50. Sharma K, Pant S, Misra S, et al. Effect of rifaximin, probiotics, and l-ornithine l-aspartate on minimal hepatic encephalopathy: A randomized controlled trial. *Saudi J Gastroenterol: Off J Saudi Gastroenterol Assoc.* 2014;20(4):225-232.
51. Luo J, Wang T, Liang S, Hu X, Li W, Jin F. Ingestion of *Lactobacillus* strain reduces anxiety and improves cognitive function in the hyperammonemia rat. *Sci China Life Sci.* 2014;57(3):327-335.
52. Sun J, Ling Z, Wang F, et al. *Clostridium butyricum* pretreatment attenuates cerebral ischemia/reperfusion injury in mice via anti-oxidation and anti-apoptosis. *Neuroscience Letters.* 2016;613:30-35.
53. Tan M, Zhu JC, Du J, Zhang LM, Yin HH. Effects of probiotics on serum levels of Th1/Th2 cytokine and clinical outcomes in severe traumatic brain-injured patients: A prospective randomized pilot study. *Critical Care.* 2011;15(6): R290.
54. Falcão de Arruda, IS, de Aguiar-Nascimento, JE. Benefits of early enteral nutrition with glutamine and probiotics in brain injury patients. *Clinical Sci.* 2004;106(3):287-292.
55. Kwon HK, Kim GC, Kim Y, et al. Amelioration of experimental autoimmune encephalomyelitis by probiotic mixture is mediated by a shift in T helper cell immune response. *Clinical Immunology.* 2013;146(3):217-227.
56. Rosche B, Werner J, Benzel FJ, Harms L, Danker-Hopfe H, Hellweg R. Serum levels of brain-derived neurotrophic factor (BDNF) in multiple sclerosis patients with *Trichuris suis* ova therapy. *Parasite.* 2013;20:55.
57. Fleming JO, Isaak A, Lee JE, et al. Probiotic helminth administration in relapsing-remitting multiple sclerosis: A phase 1 study. *Mult Scler.* 2011;17(6):743-754.
58. Millennium Products, Inc. GT's Kombucha: Products. <http://synergydrinks.com/index.php/products/enlightened-kombucha>. Accessed October 3, 2016.
59. De Vuyst L, Neysens P. The sourdough microflora: Biodiversity and metabolic interactions. *Trends Food Sci Tech.* 2005;16(1):43-56.
60. Tamime AY. Fermented milks: A historical food with modern application: A review. *Euro J Clin Nutr.* 2002;56:S2-S15.
61. Sanders ME. Probiotics: Definition, sources, selection, and uses. *Clin Infect Dis.* 2008;46(Suppl 2):S58-S61.
62. Sanders ME. Probiotics, strains matter. *Funct Food Nutraceuticals Mag.* 2007;48:36-41.
63. Boyle RJ, Robins-Browne, RM, Tang ML. Probiotic use in clinical practice: What are the risks? *Am J Clin Nutr.* 2006;83(6):1256-1264.
64. Venugopalan V, Shriner KA, Wong-Beringer A. Regulatory oversight and safety of probiotic use. *Emerg Infect Dis.* 2010; Nov;16(11):1661-5.
65. Hawrelak JA. What are Probiotics? Probiotic advisor Web site. <https://www.probioticadvisor.com/probiotics-essentials-1/what-are-probiotics/>. Accessed October 3, 2016.
66. Skokovic-Sunjic D. Clinical guide to probiotic products: Available in the United States, 2016 Edition. Indications, dosage, forms, and clinical evidence to date. US Probiotics Guide Web site. <http://www.probioticsguide.com>. Accessed October 3, 2016.