IMPROVING STUDENT HEALTH WITH NUTRITION

by

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We accept the Applied Project as conforming to the required standard.

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Abstract

This project investigated how to improve student health using nutritional protocols based on recent research findings. By avoiding foods that trigger inflammatory responses in the microbiome and including foods that provide support for mitochondrial functioning, students are able to achieve improved mental and physical functioning. Based on peer reviewed research, a website was developed to educate parents and educators about the mind-gut connection and to provide a variety of strategies that can be used to help improve student health. The website is https://lmshaw7.wixsite.com/nutritionforkids.

*Keywords:* microbiome, mitochondria, probiotics, nutrition, inflammation
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Chapter One: Introduction

Personal Context

As a special education teacher, I have worked with many students with a wide variety of learning, emotional and physical disorders. It has always struck me that if we address the root cause of their disorders, our educational interventions could be more effective. I believe that the root causes of many childhood disorders are health impairments, particularly brain impairments; however, the research is clearly showing that the state of children’s brains is intimately connected with the state of their gut microbiome (Goyal, 2015; Sampson & Mazmanian, 2015). I have wondered if students had better health, could achieve better academic results, improved behaviour and enjoy equanimous mood levels. The US National Research Council report on Children’s Health (2004) states that “children’s health is determined by the interaction of a multitude of influences, reflecting complex processes” (p.7). One of the most powerful factors influencing children’s health is their nutritional intake and the state of their microbiome (Cubells, Mulle, & Sharp, 2013; De Meij et al., 2016). What possibilities await our students if they had the very best diets and their gastrointestinal tract (GI) was healthy and able to use the nutrients from the wholesome food they ate? In my role as a case manager of students with various exceptionalities, I suspect that their learning and behaviour could be improved if their health was improved first. Basch (2010) states:

No matter how well teachers are prepared to teach, no matter what accountability measures are put in place, no matter what governing structures are established for schools, educational progress will be profoundly limited if students are not motivated and able to learn. Particular health problems play a major role in limiting the motivation and ability to learn of urban minority youth. (p. 595)
A significant influence on health is diet. Gomez-Pinilla (2013) writes that “research over the past 5 years has provided exciting evidence for the influence of dietary factors on specific molecular systems and mechanisms that maintain mental function” (p.726).

My interest in using nutrition to improve learning and behaviour began early in my career. I observed students who initially exhibited extreme behaviour, but after implementation of a strict nutrition program, their behaviour improved significantly. In the early 2000s I met Dr. Michael Lyon, currently a professor at University of British Columbia (UBC), who conducted a study in the Nanaimo area on Attention Deficit Hyperactivity Disorder (ADHD) and nutrition. He inspired me to delve deeper into the area of nutrition and learning. At a conference in March of 2017, I asked him about the latest developments in nutrition and special needs, and he encouraged me to continue my interest in this area as there are many exciting developments in this field currently.

My interest in using nutrition to help children increased even more after I saw children with autism who I worked with at school and some I knew personally, whose symptoms were alleviated due to following a gluten and casein free diet. Using nutrition, diet and food to treat childhood conditions is not new and nor is it free of criticism; however, a review of the research shows that there has been an increase in research in the last ten years on diet, nutrition, and the gut-brain connection. There is an emerging field of peer reviewed research studies showing that indeed, nutrition has a significant impact on student learning and behaviour (Haskell et al., 2008; Mayer, 2016; Vazir et al., 2006). There is, however, a lack of transference of the latest research implications into the educational field on how diet can impact special needs conditions.

My intention when I started my project was to use the latest scientific research on nutrition to lift the “brain fog” that afflicts so many students with cognitive and social-emotional
problems. As my research progressed, however, an over-arching theme emerged, where the research suggests that the things that are good for brain conditions, also help physical conditions as well. It has been a veritable “connect the dots” exercise for my project, but the big picture that has evolved augurs well for the future health of our students and their learning. As I followed the dots for each brain condition, I found they lead to the same common denominator – the gut’s inhabitants. The fault and the solution it seems – lies in our guts.

**Statement of Problem**

In my experience, I have noticed that many children have difficulty being successful when the state of their health is compromised. The province of British Columbia's special education system, uses category D for ‘chronic health’ designations, (British Columbia Ministry of Education, 2016) but the latest research suggests that many students in other special education categories may actually have medical conditions. For instance, although autism has a category of its own, category G, and is generally considered in the educational field as a communication disorder (British Columbia Ministry of Education, 2016; Theoharides, Duraisamy, & Redwood, 2009), it too is a health condition characterized by systemic inflammation of body and brain (Parracho, 2005). Children suffering from anxiety and depression qualify for a behavior designation, category H (British Columbia Ministry of Education, 2016); these children too have inflammation bio-markers distinct from control populations (de Magistris et al., 2010). Both human subjects with autism and mood/cognitive disorders have elevated levels of one of the worst inflammatory agents – liposaccharide – (LPS) (Emmanuele, 2010; Forsyth, 2011). Chronic inflammation can lead to auto-immune conditions where the immune system is overactive and attacks its own tissue (Campbell, 2014). Could students who do not qualify for a designation, but have serious learning problems, have low level but persistent auto-immune conditions?
Olshansky et al. (2005) state that the current generation of children's life expectancy is going to be less than their parents. I have noticed that childhood diseases are increasing at alarming rates, as are the number of children with allergies. The presence of inhalers, epi-pens, emergency medical plans, food bans are common in classrooms now, where it was once rare. Mental and physical ailments seem to be plaguing school children more often than when I began teaching almost two decades ago.

In my experience as a special needs teacher, I see how the increasing rate of autism alone is presenting challenges to our already budget strained schools and social care system. As of 2013, one in 68 American children is on the autism spectrum (Christensen et al., 2016). There are many predictions about future increases in autism but, irrespective of these predictions, the bottom line is this: we need new ways to help support children with autism.

I'm observing that more and more children are sick and tired, and that as a result their compromised health makes it harder for them to engage enthusiastically in the curriculum. What if there are underlying health conditions that interfere with the child’s ability to engage with the curriculum, no matter how well designed and implemented that curriculum might be? All of us have experienced those days when we feel unwell and we know that it is hard to learn new things when our health is suffering. The principle of "health is everything" is recognized by our school and social systems insofar as infectious diseases - we have no cholera, tuberculosis, dysentery, scarlet fever threatening our children. Moreover, advances in medical science and technology have done wonders for children with heart problems, kidney failure, and spinal conditions. But health encompasses more than avoiding colds and flus, more than managing the symptoms of diseases like diabetes and cancer, and health is more than replacing defective body parts with
surgery. By far and away the greatest health challenge facing our children is pervasive auto-immune conditions (Brimberg et al., 2013; Reinehr, 2013).

Learning could be said to follow a simple formula: quality of learning equals quality of health (Goyal, 2015). Parents and teachers alike would benefit from understanding the interplay between the gut and brain and how nutrition interventions can help. An understanding of health from a preventative and holistic model rather than a reactionary and management of symptoms model could help open doors to new ways of supporting special needs children.

When it comes to feeding the bodies and minds of our students, there is more to it than providing enough calories, as calories are not equal (Fasano, 2015; Finegold 2015; Mayer, 2015). In other words, simply providing ‘food’ does not take care of the nutritional needs of our children, and often the wrong food can impact health, behaviour and/or learning problems (McCann, 2007; Pelsser, 2015). From a physical perspective, a child's body and mind is made up of the food and drink they have ingested through a tube called the gastrointestinal (GI) tract. The GI tract is home to what is called the micro-biome, "a community of bacteria, yeasts, and viruses that live in the gut" (O'Bryan, p. 65). The state of the micro-biome has profound implications on the health and learning of all students, especially those with special needs (Gorrindo et al, 2012; Mulle, 2013; Parracho, 2005). Mayer (2016) writes that "perhaps no other system in the body is more sensitive to changes in gut bacteria than the central nervous system and the brain" (p. 47).

The Way Forward

It has been estimated that scientific or medical research findings take as long as 17 years to reach front line practitioners - the doctors, therapists and teachers (O’Bryan, 2015). Smith and Scholey (2014) write that “in recent years, there has been an overwhelming increase in research
dedicated to better understanding how nutritional factors influence cognition and behavior” (p. 58). O’Neil et al. (2014) state that the “importance of the relationship between dietary patterns or quality and mental health early in the life span are emerging as important determining factors in children’s health” (p. 359). We are now seeing the results of research conducted many years ago about the mind-body connection. We often hear discussion about how the mind can impact the body, but what is happening in the body, particularly the gut, can impact the mind (Tillisch, 2013). A more holistic and unified way of looking at children’s health and brain functioning is helping us to have new understandings about possible interventions.

Learning in school requires memory and memory requires attention and attention requires effort and effort requires energy (Picard & McEwen, 2014). Any teacher will tell you it is next to impossible to teach a student who is slouched in a chair, in a state of somnolence. There needs to be a certain level of alertness and arousal in order for a student to engage successfully with the curriculum. Therefore a marker of learning potential can be stated as the amount of energy available to fuel the brain and body cells of the student.

The amount of energy a student has available for learning is dependent on how efficient the energy power plants, the mitochondria, are functioning in each cell of their body. Adenosine triphosphate (ATP) is the currency of human energy produced in the mitochondria, and it is the precursor of all learning activities, because student energy begets learning (Baron, 1996; James, 2009; Rose et al., 2016). Healthy cellular metabolism is critical to learning. Maintaining a healthy microbiome through nutrition are critical aspects to maintaining healthy cellular metabolism in the body and the brain (Filippo, 2010; Goyal et al., 2015; Rose et al., 2016; Turnbaugh, 2006).
It may well be argued that if increasing student learning was as simple as increasing student energy levels, what about students with hyperactivity who display an abundance of energy, yet their very surfeit of energy seems to sabotage their learning? After all, these children rarely remain in their seats and they are certainly skilled at finding their own coping strategies much to the teacher's dismay. The answer is that the so-called `energy' that such students display is not coming from harmonious cellular metabolism, rather it is a para-sympathetic nervous system response employing various stress hormones such as adrenaline, cortisol and norepinephrine (Ranabir & Reetu, 2011). Students with autism, ADHD and related disorders are continually `dining out' as it were, and there are several negative consequences, not least of all, cellular exhaustion. Emerging research suggests the possibility that children with such conditions have unbalanced microbiomes (James, 2009; Lyon, 1999; Mayer, 2016; Parracho, 2005).

Perhaps the biggest challenge facing special education today is not the alarming increases in any one condition such as autism or other childhood auto-immune diseases, not ADHD, not the social-emotional disorders and nor is it learning disorders or under achievement. An epidemic of cellular exhaustion, caused by an impaired microbiome underlies all of these conditions (Hoban et al., 2017). Many of our students are incapable of reaching their potential because they simply do not have the energy to fuel their developing bodies and brains (Gomez-Pinilla, 2008; James, 2009; Mayer, 2016; Oriach, 2017; Parracho, 2005; Rucklidge, 2013).

Our students are living in an increasingly toxic environment (Barrett, 2005; Rudd, 1970; Shelton et al., 2014). There are tens of thousands of chemicals around today that did not exist even a decade ago, that are not tested for safety on children (Barrett, 2005; Goldman & Koduru, 2000). Moreover, there is no safety testing on the synergistic effect of all these chemicals on children's health (Goldman & Koduru, 2000). Barrett (2005) states that “several recent reports
highlight the presence of low-level concentrations of potential reproductive or developmental toxicants, particularly phthalates” (p. 24). In a 2005 study by the Environmental Working Group (EWG), researchers found that 287 industrial chemicals and pollutants were found in the umbilical cord blood of babies. The EWG study said that of these 287 chemicals, "180 cause cancer in humans or animals, 217 are toxic to the brain and nervous system, and 208 cause birth defects or abnormal development in tests" (EWG, 2005). Students born after year 2000 have many factors that are making them sick and tired at the cellular level and the students under the auspices of special education are the most affected. They are the canary in the coalmines (National Research Council, 2004). To help remedy the cellular exhaustion of our most vulnerable students, several things can be done: children need to greatly reduce screen time (Barr, Lauricella, Zack, & Calvert, 2010) and play outside during their leisure time, children need to eat truly wholesome food (Gómez-Pinilla, 2008), children need to be protected from environmental toxicity (Goldman & Koduru, 2000; National Research Council, 2004) and children need to be on their feet and active most of the time in school.

**Rationale and Value of My Project**

The latest research supports the assertion that food really does matter, and that significant improvements in the health and learning of youth can be made by simple and safe dietary interventions. As a result, I have chosen to create a website primarily for parents and caregivers as they provide most of what children eat. The website will also serve as a resource for educators who are interested in nutrition and diet. The website will explain the latest nutritional findings, the gut/brain connection and suggest possible interventions to support a healthy gut microbiome. The research discussed in chapter two suggests that the health of children and especially their brain health is intimately tied with the state of their microbiome. If a student has a systemic
health problem which is affecting their mood and energy levels, the very best educational interventions in the world, delivered by the most dedicated and skilled professionals is going to have negligible improvements. The research reviewed in chapter two suggests that there are certain dietary principles that will help heal children’s microbiome. Having children eat healthy foods may seem like an obvious idea, but there is more to it than following food guide recommendations or trying to eat more fruits and veggies. My website provides a resource that explains the research in a clear style and also provides various strategies for implementing dietary changes.
Chapter Two: Literature Review

Overview

This literature review investigates the field of health and student learning through nutritional interventions. The historical context of how nutrition has been used to support student learning is discussed. Reasons for implementing nutritional interventions and current research on the topic are examined. Finally, missing areas of knowledge in this field are suggested.

Historical Context

A general understanding of the correlation between nutrition and student health and learning has existed for a long time but it is not an area that has historically received a great deal of research. Gómez-Pinilla (2008) states that “it has long been suspected that the relative abundance of specific nutrients can affect cognitive processes and emotions” (p. 569). Florence, Asbridge and Veugelers (2008) state that “although the effects of nutrition on health and school performance are often cited, few research studies have examined the effect of diet quality on the academic performance of children” (p. 209).

School food programs. Taras (1999) reviewed several nutritional studies and concluded that a “healthy breakfast is an effective measure to improve academic performance and cognitive functioning” (p. 213). Governments around the world have recognized the importance that nutrition has on youngsters by implementing food programs to avoid nutritional deficiencies. In the United States, The National School Lunch Program (NSLP) was started after World War II for the purpose of providing adequate nutrition for children (Frisvold, 2012; Winchell, 2009). In 1966, the largest school breakfast program in the world was started, The School Breakfast Program, to provide food for disadvantaged students across America (Frisvold, 2012; Winchell, 2009). Frisvold (2012) concluded that “food assistance programs and nutrition interventions can
influence cognitive achievement, not just in developing countries, but also in higher income countries, such as the U.S.” (p. 103). Similar government funded school food programs have been implemented in Canada and other developed nations (Fung et al., 2013; Noboko & Miyoshi, 2012).

**Diet and academic performance.** Florence, Asbridge, and Veugelers (2008) studied 5,200 grade five students in Nova Scotia to look at the relationship between diet quality and academic performance. The study analyzed health, nutrition, physical activity, school performance, and socioeconomic factors. The authors used multilevel regression methods to investigate the relationship between diet and academic performance. They used the Diet Quality Index-International (DQI-I) and the Harvard Youth Adolescent Questionnaire (YAQ) to summarize overall dietary intake information. The dietary information was compared to the results of provincial standardized testing scores. They found that “students with decreased overall diet quality were significantly more likely to perform poorly” on assessments (p. 210). This study was different than most studies in that it looked at a wide variety of dietary factors, not just single nutrients or specific foods. This study is significant because it shows that diet does impact academic performance. Similarly, Sorhaindo and Feinstein (2006) reported that nutritional deficiencies “have the potential to impact upon cognitive outcomes in school-aged and adolescent children” (p. 1). Bryan et al. (2004) found that micronutrients may influence executive functioning, ADHD, and dyslexia. Van Stuijvenberg et al. (1999), studied children who were given biscuits that were fortified with iron, iodine and beta-carotene. The study showed an improvement “in cognitive function with the digit span forward task (short-term memory)” (p. 200) which assesses working memory, a sub-test in measuring of intelligence.
Clark (1982) describes her own experiences using nutrition to improve student learning along with practitioners in the field. Clark wrote, "changing children's behaviours by changing their diets may signal a breakthrough in the treatment of learning disorders" (p. 300). Clark discusses her experiences working with children whose "problems of dyslexia are often improved by nutrition," (p. 300) and she goes on to say that:

nutritional therapy used as a means to manage children with behavior disorders or language and learning problems or both has received increased attention in the past 20 years. Since the early 1950s evidence has been accumulating that indicates bio-chemical conditions are the cause of a number of abnormal physical, socio-emotional, language and learning states. (p. 300)

Hoffer (2008), a pioneer in the field of orthomolecular psychiatry, had success treating a variety of mental illnesses, and reported improvements in children with various types of behaviour problems. The Hoffer protocol for treating children removed common allergens like gluten and dairy, and then used high dose vitamin therapy, especially B3 (Hoffer, 2008).

The focus of early nutritional interventions for children was mainly providing high dose vitamin therapy, avoiding high carbohydrate diets, and ensuring adequate amounts of protein (Clark, 1982). Malnutrition occurred not in just poor families, as it was "quite common in families who spare no expense to feed their children" (Powers as cited in Clark, 1982, p. 304). Dr. Power called a high carbohydrates diet the “malnutrition of affluence: a refined carbohydrate overload" (Powers as cited in Clark, 1982 p. 304).

Benton and Roberts (1988) studied the effect of vitamin and mineral supplementation on the intelligence of school children. They studied 90 children, ages 12 and 13, for eight months. The authors used a double blind placebo study to collect and interpret data. The conclusion of
the study was “the supplement group showed a significant increase in non-verbal intelligence” (Benton & Roberts, 1988, p. 142). Another double-blind placebo-controlled study by Akhondzadeh et al., (2004) demonstrated that zinc as a supplementary medication might be beneficial in the treatment of children with attention-deficit hyperactivity disorder. Both of these studies are significant because they show that vitamin and mineral supplementation does have an impact on cognitive performance.

**The microbiome.** In the 1990s research on the effect of dietary changes on autism and ADHD suggested links between the effect of gluten and casein free diets on the gut microbiome, as well as the addition of omega-3 fatty acids into children's diets (Lyons, 1999).

As the understanding of the significance of the micro-biome has gained purchase in the scientific community, scientific research in this area has expanded (Mayer, 2016). Hoban et al. (2017) state that “there is growing evidence for a role of the gut microbiome in shaping behaviour relevant to many psychiatric and neurological disorders” (p. 3). Scientists used to view the human body as a cellular vessel that contains some bacteria, but the latest research is showing a reversal of views: the body is a mass of bacteria sheathed by cells, and that there is ten times more bacteria than human cells (Zhang et al., 2014). The significance of the micro-biome is that it is the interface between the rest of the world and the body. The micro-biome is the border patrol for the body, charged with the duty of keeping out unhealthy and dangerous “invaders”, while letting nutrients and vitamins into the bloodstream (Mayer, 2016). When the micro-biome is chronically inflamed, a condition called dysbiosis develops where permeability in the epithelial lining allows undigested molecules to enter the bloodstream (Tillisch et al., 2013). Once in the blood stream these molecules, especially LPS molecules can cause a cycle of inflammation-auto-immune response (Lee et al., 2008). In addition, inflammation alone in the
gut lining can directly cause inflammation in the brain through an intricate messaging system that exists between the gut and brain (Mayer, 2016). Lathe (2006), states "GI tract inflammation can signal directly to the limbic brain, stimulating local toxic cytokine [which regulates inflammation] production and neuronal damage" (p. 58). Fasano (2012) writes that “the most significant factor related to children's health and the diversity of their microbiome is the food they eat. What they put in their mouths represents the biggest environmental challenge to their genome and their microbiome" (Fasano, 2016, p. 33). Fasano's statement offers hope because parents can experiment with different foods and see what helps their child, although families in poverty have significant challenges purchasing food for special diets (Darmon & Drewnowski, 2015). Hoban et al. (2016) state that “the prefrontal cortex is a key region implicated in a range of neuropsychiatric disorders such as depression, schizophrenia, and autism. In parallel, the role of the gut microbiota in contributing to these disorders is emerging” (p. 470). Larrieu et al. (2014) state that “understanding how malnutrition contributes to depression is building momentum” (p. 8), and Bercik (2011) writes that “the intestinal microbiota influences brain chemistry and behavior independently of the autonomic nervous system, gastrointestinal-specific neurotransmitters, or inflammation. Intestinal dysbiosis might contribute to psychiatric disorders” (p. 602). The research is suggesting a link between the state of the gut, nutritional intake and brain function. Research continues to examine the specific details of what happens in the brain involving the interplay of microbiota and nutrition.

Inflammation in youth, and particularly in their brains, may be the common factor behind a seemingly different array of childhood diseases and conditions like autism, ADHD, learning disorders, anxiety, depression, conduct disorders and even diseases such as cancer and diabetes (Ashwood et al., 2011; Marin & Kipnis, 2013; Rakoff-Nahoum, 2006; Salim et al.,
2012; Sastre, 2006). The inflammation process starts in children's guts with the food that they eat.

Dietary treatment of children with special needs has two main components: eliminating known trigger foods and eating nutrient dense foods (Lyons, 1999). A significant trigger food is sugar and simple carbohydrates that break down into sugar because they feed gut pathogens which in turn damage the gut lining causing leaky gut (Ha, Jayalath, Cozma, et al., 2013; National Institute of Health, 2014; Westover, 2002). Other significant food allergens are gluten and casein (O'Bryan, 2016; Hochwallner et al., 2014). The most important foods to add into a diet are high quality fats and probiotic foods (Mayer, 2016).

Cubells, Mulle, and Sharp's (2013) review of the latest research on the relationship between the gut microbiome and autism, concluded that there was also a need for "further research on the relationships among the gut microbiome, the development and function of the nervous system, and behavior" (p. 339). The authors reported that "GI microbes influence brain function and behavior through several sets of complex pathways" (Cubells et al., p. 338). Unfortunately, ethical issues prevent many experiments of the microbiome and brain function (Cubells et al., 2013). Animal studies using mice suggest that differences in "gut microbiota may influence neuro-behavioral development" (Cubell et al., 2013, p. 340).

Thus far, several important themes have emerged from a review of the literature. Vitamin and omega-3 supplementation is associated with improved cognitive and emotional functioning. Inflammation in the microbiome can cause gut permeability which in turn can cause inflammatory substances to pass into the bloodstream. Once in the bloodstream these inflammatory substances can potentially breach the blood-brain-barrier and impact brain functioning.
An Overview of Dietary Influences

An examination of peer-reviewed journals shows that in the last five years there has been an increase in research into the effects of diet on the gut microbiome and subsequent neurological effects (Hoban et al., 2017). Carabotti, Maselli, Scirocco, and Severi (2015) state that the existence of the gut-brain-axis “in humans, the most compelling evidence of a gastrointestinal microbe-brain interaction arose more than 20 years ago” (p. 203).

The gut microbiome - brain connection is potentially important, as the GI tract can signal directly to the brain (Lathe, 2006). Omega-3 fatty acids are critical in healthy brain functioning during this signalling process (Lyons, 2000). Burgess, Peck, Stevens, and Zhang (2000) analyzed the impact of using omega-3 fatty acids as a dietary intervention for children with a diagnosis of clinical ADHD. The authors used a double-blind, placebo controlled study with 6–12-year old boys. Results showed that “53 subjects with ADHD had significantly lower proportions of key fatty acids ... than did 43 control subjects (Burgess et al., 2000). The significance of the study was that it complemented previous studies using rodents where a deficiency of omega-3 fatty acids was associated with behaviour, sensory and neurological problems (Burgess et al. 2000). The authors concluded that their study supports a “relation between n−3 fatty acid status and behaviour in children that parallels the relation observed in rats ... and monkeys ...” (Burgess et al, p. 123). Similarly, Gomez-Pinella (2013) concluded that the DHA form of omega-3 fats, dietary docosahexenoic acid, “seems crucial for supporting plasma membrane function, interneuronal signaling, and cognition” (p. 726).

The gut-brain axis (GBA) has bidirectional communication ability (Carabotti et al., 2015) and is “a crucial zone of the brain predominantly involved in memory and emotional responses” (Carabotti et al., 2015, p. 204). The microbiome or microbiota can be mapped in humans with
different medical conditions (Mayer, 2016). The importance of human microbes on brain health is summarized by Carabotti et al. (2015): “emerging data support the role of microbiota in influencing anxiety and depressive-like behaviors and, more recently, of dysbiosis in autism. In fact, autistic patients present specific microbiota alterations according to the severity of the disease” (p. 205).

Research suggests that fatty acids, specifically Omega-3 from fish oils are instrumental in brain function of children. Chang, Jingling, Huang, Lu, and Su (2016) concluded that "children with ADHD might require more Essential Fatty Acid intake than normal children to prevent signs of deficiency" (p. 1094). In order to be beneficial fatty acid consumption should be Omega-3 oils found in fish as opposed to omega-6 oils which is found in excess in the refined western diet (Simopoulos, 2016). While Omega-6 oils are needed for health, too high amounts are implicated in causing inflammation (Robertson & Oriach, 2017). Larrieu et al. (2014) concluded that omega-3 oils could be a “potential tool in the prevention of neuropsychiatric disorders associated with HPA axis dysfunction such as depression and anxiety” (para. 1).

Along with increasing omega-3 intake, micro-nutrient therapy has shown promising results. A study using high dose micro-nutrient therapy to treat children ages eight to eleven with stress related disorders resulting from earthquakes, suggested that "treatment with a dietary supplement containing micronutrients reduced children’s post-disaster anxiety to a clinically significant degree" (Sole, Rucklidge, & Blampied, 2014, p. 1123). These findings agree with the results of Lyon's (2000) study where high dose micro-nutrient therapy and other dietary protocols helped improve systems for ADHD symptoms. Ames (2010) has put forth the idea "that some people may inherit an in-born error of metabolism that results in the need for a greater intake of the nutrient(s) not being well metabolized” (Rucklidge & Kaplan, 2013, p. 50).
As a result, a new area of psychiatry is emerging, called nutritional psychiatry, where nutraceutical agents are prescribed instead of pharmaceutical (Jacka, 2017). However, at the core of any treatment protocols must be sound dietary practices which can be summed up:

The more one eats a Western or highly processed diet, the more one is at risk for developing psychiatric symptoms such as depression and anxiety. Conversely, the more one eats a diet rich in fruits and vegetables, high in healthy fats, nuts, and fish, and low in processed food (a Mediterranean-style diet), the more one is protected from developing a mental disorder. (Akbaraly et al., 2009, p. 410)

**A closer look at the microbiome.** As mentioned earlier, the relationship between the brain and gut is bidirectional. The mechanism for this connection is the cranial nerves, the main one being the vagus nerve which connects the many gut neurons to the brain (Carprenter, 2012; Galland, 2014). There are so many neurons in the gut that it is now termed the ‘second brain’. This ‘second brain’ can “act independently from the main brain and control many functions without the brain’s input or help” (Carprenter, 2012).

A study out of McMaster University used germ-free mice to show a connection between the gut, brain, and behavior (Neufeld, 2011). Mice missing a microbiome displayed greater risk taking behaviours and had higher levels of stress hormones, while lacking the good brain chemical Brain Derived Neurotrophic Factor (BDNF), compared to mice with a microbiome. In a Japanese study, mice without a microbiome overacted to stress (Sudo, 2004). Conversely in another study where mice were fed probiotics, they had a lowering of the stress hormone corticosterone, than the mice that were not fed the probiotics (Bravo, 2011). Finally, in yet another study (Bercik, 2011) using mice, researchers were able to change the behavior of the mice by manipulating the gut bacteria. Shy mice became bold, and vice-versa. The study
concluded that “the microbiota houses these behaviours” (Bercik, 2011, p. 600). These studies point to the need for more research in this area.

Tillisch (2013) investigated the gut-brain connection with humans. The study analyzed the impact of ingesting a fermented milk product on emotional functioning. The study followed 36 healthy women for four weeks. The women were divided into three groups: 12 women consumed a fermented milk product twice daily, 11 women consumed a non-fermented milk product and 13 women had no intervention. All participants underwent magnetic resonance imaging testing before and after the four week trial to measure responses to emotional faces attention task and resting brain activity. Results of the study showed that the participants in the study who consumed probiotics “displayed greater connectivity between key brain regions and areas of the pre-frontal cortex associated with cognition” (Tillisch, 2013, p. 1395). This study was significant because it was the first study using humans to indicate that the gut-brain connection exists and that there is communication. The study concluded that “this study is the first to demonstrate an effect of fermented food product intake on gut–brain communication in humans. As a proof of concept it has been successful in showing that such communication exists and is modifiable” (Tillisch, 2013, p. 1398).

In addition, Mayer, a research team member, commented on the study that:

The knowledge that signals are sent from the intestine to the brain and that they can be modulated by a dietary change is likely to lead to an expansion of research aimed at finding new strategies to prevent or treat digestive, mental and neurological disorders…Now we know that this has an effect not only on the metabolism but also affects brain function. (UCLA Newsroom, Champeau, 2013, p. 12)
In the gut there is 70 to 80% of the body's immune system, made up of Gut-Associated Lymphatic Tissue (GALT), and it is in constant communication with the brain and the rest of the immune system in the body (Mayer, 2016). In the GALT are the microbes that act as the body’s border patrol – the Homeland Security if you will. If they detect a hostile invader, they message the brain and the rest of the body’s immune system to take action. When the GALT tissue is healthy this process works well, but when it is compromised by having the wrong microbial balance then the wrong messages get sent to brain and body, resulting in an auto-immune response in which the body starts attacking itself (O’Bryan, 2013). Moreover, when the intestinal flora is unbalanced, inflammatory proteins called cytokines pass through the gut lining at ‘tight junctions’ into the bloodstream. Normally, these proteins are not allowed through the tight junctions but when they do pass through they travel around in the blood wreaking havoc in the body, not least of all the brain. O’Bryan claims these cytokines create problems at the body’s ‘weak link’, which for many is the brain, but could be any part or multiple parts of the body. Protein molecules like the lipopolysaccharide (LPS) are one of the worst inflammatory offenders because they quickly provoke inflammatory responses in the body. LPS has an important job to do and is safe when it is stays in the intestinal tract; however, if it gets into the bloodstream through a leaky gut condition, it can cause systemic inflammation, so much so that LPS is the standard molecule used in research if scientists want to create inflammation in a subject (Habaab, 2012; Kahn, 2011). Kahn (2011) showed that when the bodies of lab animals were injected with LPS, they developed learning deficits. Animals injected with LPS had significantly higher levels of amyloid plaques in the hippocampal tissue than did the control animals, and testing showed that in LPS injected animals that “the memory of aversive contexts was less retrievable (Kahn, 2011, p. 38). Animals were able to rapidly clear the LPS from the hippocampus following
exercise, suggesting a possible link between exercise and reducing brain inflammation (Kahn, 2011). Lee et al. (2008) showed that mice injected with LPS developed severe memory problems. Mice injected with LPS had “induced memory impairment determined by passive avoidance and performance on water maze tests” (Lee, 2008, p. 27). Repeated injection of LPS resulted in an accumulation of amyloids in the hippocampus and cerebral cortex of the mice. Damage to the hippocampal formation can cause problems learning new information and with memory (Zilmer, Spiers & Cuthbertson, 2008). Scientists used to think that the blood-brain barrier protected the brain from foreign protein particles getting into the brain (Shilo et al., 2015; Stiles & Jernigan, 2010) but the latest autism and Alzheimer research suggests that LPS does indeed pass into the brain causing brain inflammation (Ashwood et al., 2011; Laterra et al., 1999; Muller et al., 2015; Welling, 2014). LPS in the crossing into the brains of students could potentially cause inflammation in the brain, resulting in possible behavior and learning problems.

There are many types of gut bacteria, but the two main types are the Firmicutes and Bacteroidetes (De Meij et al., 2016; Filippo, 2010). The important point to remember about gut bacteria is the concept of balance. The line between good and bad bacteria is not always clear, as bacteria can perform multiple functions, both positive and harmful, however too many Firmicutes may cause problems in the gut (Abdallah, 2011). Research suggests that “obese people have elevated levels of Firmicutes in their gut flora, compared to lean people, who are dominated by Bacteriodetes” (Abdallah, 2011). Research also suggests that too high levels of Firmicutes can have an epigenetic effect and can “turn on” dormant genes in people: “people in which Firmicutes were dominant, were linked to risk of disease, predominantly to cardiovascular disease and specifically to lipid metabolism, obesity, and the inflammatory response” (Kumar, 2011, p. e02113). Studies comparing the gut microbiota of children in the western world to those
living in Africa have shown dramatic differences in profiles (Filippo, 2010). Children in the West have a gut profile that is heavily dominated by Firmicutes whereas children in rural Africa have gut profiles in which Bacteroidetes are the majority. Obesity and auto-immune problems are high in western children, but very low in children in Africa (DeFilippo, 2010). Similar to the study comparing western children to African children’s gut profiles, are studies of children with autism. Children with autism “exhibit certain patterns in the composition of their gut bacteria that are absent in children without autism” (Parracho, 2005).

**Factors affecting the microbiome.** There are many factors causing the microbiome to be compromised and distressed, leading to a variety of health and learning problems. The main problems are: improper colonization of the GI tract at birth, anti-biotic use (especially with infants), sugar consumption, gluten consumption and lack of pre-biotic and probiotic food (Abrahamsson et al., 2014; Brown et al., 2012; Cryan & Dinan, 2012; Fasano, 2012,).

**Improper colonization of the GI tract at birth.** The microbiome is established during the birth process when the baby is exposed to the microbes in the birthing passage (Makino, 2013). There is evidence that it may even start in utero through the mother passing microbes through the placenta (Aagaard, 2014). How the baby is delivered is critical to establishing the ‘right’ kind and proportion of microbes in the newborn. Makino (2013) concluded that “our data suggest that the mother's intestine is an important source for the vaginal delivered infant's intestinal microbiota” (para.4). Vaginally delivered babies are exposed to the necessary microbes, whereas c-section babies miss out on the mother’s microbes; instead the new-born is colonized by the microbes from the doctor and nurses hands and the delivery room (Dominquez-Bello, 2010). The baby is born missing out on the microbial instructions they need and at the same time they are given the wrong set of instructions.
Azad (2013) reports that c-sections cause “the disruption of the infant’s gut microbiota and is linked to many inflammatory and immune problems” (p. 385). Furthermore, Azad (2013) writes that “children born by caesarean delivery or fed formula may be at increased risk of a variety of conditions later in life; both processes alter the gut microbiota in healthy infants, which could be the mechanism for the increased risk” (p. 387). Since the mid 1990’s there has been a big jump in the rate of c-sections (Witt et al., 2015) and it is predicted that by 2020 as much as half of deliveries will be by c-section (Blaser, 2014). In addition, it is standard practice for all mothers in the USA to be given anti-biotics before having a c-section as a preventative measure, so again the new-born’s microbiome is further compromised (Blaser, 2014).

**Anti-biotic use.** Anti-biotic use harms the microbiome because they kill both pathogenic bacteria and positive bacteria (Francino, 2015). Many research studies have highlighted the effect of the damage on the microbiome and the rise in anti-biotic resistance (Costelloe, 2010). Substances called bio-films develop around harmful bacteria, effectively protecting them against anti-biotic medicine treatment. When these pathogenic bacteria are protected by this bio-armour, they can then proliferate in the intestines causing inflammation in the gut lining, eventually causing leaky gut (Langdon, 2016).

**Probiotics.** The use of probiotics has received more attention in recent years and now some doctors are prescribing a probiotic in conjunction with anti-biotics (Harish & Varghese, 2006). Harish and Varghese comment that:

The Western diet has dramatically decreased numbers of fermented foods, exposing the host to as few as one millionth of the probiotic organisms to which human ancestors were exposed. It may not be a coincidence that the increase in inflammatory conditions,
allergic conditions, obesity, heart disease and cancers has paralleled the decreased content of probiotics in the Western diet. (p. 3)

An example of a probiotic improving health is *Akkermansia muncinphila* which has been shown to help avoid obesity, diabetes and heart disease, as well as improving insulin resistance (Doa, Everad & Aron-Wisnewsky, 2016). Bravo (2011) found that the probiotic *Lactobacillus rhamnosus* had a positive effect on neurotransmitters. Probiotics that ferment soluble fiber in the gut help protect against inflammation by preventing inflammation in the gut in the first place and therefore preventing inflammation being signaled to the brain, which in turn signals other areas in the body. Probiotics have been shown to prevent and interrupt this inflammatory response (Hemarajata & Versalovic, 2013). Fermented foods have been found to improve social anxiety in young adults (Hillmire et al., 2015). Steenbergen and Sellaro (2015) found that subjects that took a multi-strain probiotic for at least four weeks reported a lessening of worrying about something distressful happening.

**Sugar consumption.** Sugar is a significant fuel for the harmful bacteria in the intestinal tract (Kruis et al, 1991). High fructose corn syrup (HFCS), a type of sugar that is being used more and more in processed foods, has been implicated as being particularly harmful. Fructose is metabolized differently than other sugars and is linked with obesity (Kavanagh, 2013). Kavanagh (2013) reported that HFCS causes bacteria to exit the intestines and cause liver damage, stating that “something about high fructose corn syrup levels was causing the intestines to be less protective than normal, and consequently allowing bacteria to leak out a 30 percent higher rate” (p. 350). Fructose also damages mitochondria in skeletal tissue (Jaiswal et al., 2015). Elevated glucose levels harming the brain is called the Crabtree Effect after the researcher who discovered in 1927. High glucose levels can harm the brain by causing spikes and sudden crashes in brain
signaling chemicals which results in the brain’s mitochondria producing less ATP (De Deken, 1966). Elevated glucose levels have been shown to be related with Alzheimer’s disease (Crane et al., 2013). Elevated glucose levels lead to insulin resistance in the body. As a result excess insulin goes into the brain affecting neuron function (Crane et al., 2013). Argawal and Gomez-Pinalla (2012) found that rats fed a high sugar diet showed cognitive decline compared to rats that were not fed the high sugar diet. Ingestion of sugar also has been shown to decrease the responsiveness of the immune system’s ‘first responders’, the neutrophils (Sanchez et al., 1973).

Although sugar is an important fuel for the brain, too much sugar can have undesirable consequences in the microbiome, immune system and brain inflammation. While some studies point to the positive role of glucose as an important fuel for the brain (Meikle, Riby & Stollery, 2004), it is important to take a cautionary view of the impact of sugar on the brain in a wider context. The brain, specifically the pre-frontal cortex, is the largest energy consumer in the body next to ovary cells and it gets it energy from three sources: glucose or fat and to a lesser extent protein (Mergenthaler, Lindauer, Dienel, & Meisel, 2013). The long held belief that the brain’s mitochondria can only run on glucose is changing with research showing the positive effects of dietary ketosis on brain function; however, achieving and maintaining dietary ketosis is challenging for most adults and especially children (Westman, Yancy, Mavropoulos, Marquart & McDuffie, 2008). A sugar laden diet on the other hand, while easier to adhere to, has negative consequences on brain mitochondria in the long run. While sugar can give a temporary boost in brain energy, if too much sugar is consumed, the brain mitochondria become dependent on glucose as the only source of fuel and will have a hard time using fat as a brain fuel. A high sugar diet causes the brain mitochondria to burn through the glucose quickly resulting in blood sugar crashes (Westman et al., 2008). Children’s brains need healthy carbohydrates, not high-
glycemic carbohydrates like refined sugar—and other foods that convert to sugar quickly in their bodies including potatoes, bread, and cereal. Children’s brains need a glucose to function but the level of glucose is probably much lower than previously thought and should come from foods that slowly release sugar in order to prevent blood sugar and insulin spikes and crashes as well keep serotonin levels even (Westman et al., 2008). Overall, the research is telling us that it is important for the brain mitochondria to be fueled by healthy fats and not exclusively sugar.

**Gluten consumption.** Along with sugar, gluten can be one of the top disruptors of the microbiome. Gluten is the one of the most studied food substances (O’Bryan, 2015) and it has been shown to have a detrimental effect even on non-celiacs (O’Bryan, 2015; Fasano et al., 2015). When gluten is consumed it triggers the body to release a protein called zonulin, which controls the space between the cells that line the gut (Fasano, 2011). An over-release of zonulin causes the gut lining cells to move too far apart allowing pathogens into the bloodstream which in turn causes inflammation (Fasano, 2011). Gluten also reduces blood flow to the brain and interferes with the hormones that are needed to keep brain mitochondria healthy (Sategna-Guidetti et al., 1998). Mass, Kubera, and Leunis (2008) found that gluten provoked leaky gut conditions which resulted in pro-inflammatory cytokines and lipopolysacharide crossing the blood-brain barrier contributing to depression. According to Hadjivassiliou, Grünewald and Davies-Jones (2002) “gluten sensitivity can be primarily, and at times, exclusively, a neurological disease”. Many studies have underscored a strong correlation between severe mental illness, such as schizophrenia and bi-polar disorder (Cascella, Gerner, Fieldstone, Sawa, & Schretlen, 2011; Dohan, 1966; Kalaydjian, Eaton, Cascella & Fasano, 2006; Vlissides, Venulet, & Jenner, 1986).
Using nutritional interventions to help improve children's health and brain functioning dates back many decades (Clark, 1982), however, in the last decade more and more research is being conducted in this area with promising results. The studies reviewed in this literature review suggest that the subject of nutritional intervention on the gut and the brain is an exciting area and much work is still to be done. Many studies have used germ-free rodents in experimental laboratory environments. The next step is for the knowledge gained in the laboratory to be extended to more studies on human subjects.

**The link between nutrition and brain function.** There is an increasing body of literature that suggests a connection between improved nutrition and optimal brain function and overall health. Nutrients provide building blocks that play a critical role in neurotransmitter function and hormone metabolism in the brain (Bhatnagar & Taneja, 2001; De Souza et al., 2011; Lozoff & Georgieff, 2006; Zeisel, 2009; Zimmermann, 2011), however, the body of research reviewed in this literature review suggests that a healthy microbiome is critical for nutrients to be used by the brain. Problems in gut microbiota development disrupt brain metabolism and “interfere with the formation and function of specific neural circuits, and may affect synaptic development or myelination” (Goyal, 2015, p. 14108). Furthermore, Goyal et al. (2015) state that,

> normal development of the gut microbiota is required to support the metabolic activities of the brain during and after critical windows of neurodevelopment. A corollary is that the metabolic output of the gut microbiota might include compounds that directly influence brain development and physiology. (p. 14107)

The research literature also shows that neurotransmitters are produced by the gut microbiota (Reigstad, 2015). Poor nutrition is linked with “impaired cognitive abilities that are
often not evident until the second or third decade, including effects on behaviors, such as self-control” (Moffit et al., 2011, p. 2695).

**Conclusion**

Goyal et al. (2015) state that “new knowledge gleaned from studying the development of our gut microbial communities can be leveraged to build healthy brains and minds through better nutrition” (Goyal et al., 2015, p. 14109). Jacka (2017) states that “new studies focused on understanding the biological pathways that mediate the observed relationships between diet, nutrition and mental health are pointing to the immune system, oxidative biology, brain plasticity and the microbiome-gut-brain axis as key targets for nutritional interventions” (p. 25). The importance of this emerging area is that having an “understanding how feeding our gut satisfies the needs of our developing brain should help determine, and hopefully ultimately facilitate, our continued evolution as a species” (Goyal et al., 2015, p. 14112). Finally, Dauncey (2009) states that “advances in understanding [of] the critical role of nutrition in brain health will help to fulfil the potential of nutrition to optimize brain function” (p. 408). This literature review has covered the important research in the field and points to exciting possibilities in improving student health.
Chapter Three: Overview of Project

My product is a website for parents and caregivers and teachers of children with special needs based on current research. This website provides a comprehensive explanation of the centrality of the microbiome in all aspects of children’s health, behaviour and learning. During the research process for the literature review of using nutrition to improve student health, there emerged a set of nutraceutical and psychobiotic interventions (Jacka, 2017) that are supported by current research as being effective for helping children. For the project product, I built a website about these evidence-based interventions.

I chose a website for my project because online resources have the potential to allow the greatest amount of people quick access to information. Being digital creations, websites avoid the monetary and environmental cost of other products like handbooks. Websites have become easier to make in recent years and they can be updated when necessary providing the latest information. Although, web based resources allow access to a large quantity of information on a subject, the quality of the information may be uneven and the authority of the authors may be unknown. A potential downside to websites is the digital divide where some parents may not have access to the internet (Howard, Busch & Sheets, 2010). However, in the inner city school that I work at, 100% of the parents have internet access. For individuals with disabilities, web-based resources now have the advantage over traditional text in that there are text to speech capabilities more widely available.

The central idea underlying this project and the website is that student health can be improved through holistic, dietary interventions. Although the intent of the website is to build parents’ capacity to implement dietary protocols to help their child, it is important to recognize that a controlling approach may provoke resistance in a child when endeavoring to make positive
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changes to their lifestyle. Brown and Ogden (2004) found that “a positive parental role model may be a better method for improving a child’s diet than attempts at dietary control (p. 261).

Good health is imperative to students feeling their best and having the energy to learn and perform to their potential. The core understanding is that students’ health begins with a healthy and balanced microbiome. There is a bi-directional relationship between the gut and the brain and that the constant communication between these two organs has a profound effect on mood and mental functioning. If the microbiome is compromised then intestinal permeability allows pro-inflammatory molecules to enter the blood stream and ultimately cross the blood-brain barrier, causing brain inflammation and a host of problems. To heal the brain, the gut needs to be healed first. There are a variety of healing diets that parents can follow for their children, but the basic protocols involved are the same: remove toxins and allergens and provide food and supplements that heal the gut and provide the best fuel for the mitochondria.

The ‘About’ tab explains that this website is a project for a Masters in Special Education and gives a description of who I am. I believe this section is important not just because people are naturally curious about other people, but for providing an understanding of my experiences and my motivations for making this website. I have been a teacher for two decades now and a full time special needs teacher for 13 years. I have taught gardening courses for youth and adults with special needs and I have run an organic vegetable farm for many years. I have had personal experiences where I have seen nutritional protocols significantly improve the health of children with special needs.

The ‘Knowledge’ tab is the main part of the website with a substantial amount of content. Each topic under knowledge has a ‘blog’ style article explaining the topic. The website is designed on three principles: knowledge, attitude and action. Much of the information about
leveraging the microbiome and mitochondria to improve children’s health is based on relatively new research findings and involves a fair bit of science content that needs to be put in an easy to read format. The intent of my website is to provide the necessary information about nutrition so that parents/care-givers will understand the importance of eating certain foods and why it is vital to avoid certain trigger foods. When people can grasp the ‘why’ behind a new idea it can lead to them developing a positive attitude about their capacity to take action. When people decide that something is worth doing then they will be more motivated to take action. They will also be likely to continue when they run into challenges.

The big understanding that readers of the website will gain that will inspire them to take effective and sustained action, is that while food is an energy source for children, it is so much more. Food is more than a calorie source and quality of food matters. What children eat determines to a large extent the state of their microbiome and the state of their microbiome determines to a large degree the state of their brains and the state of their brains has a profound impact on how children function and on their self-concept. What children eat determines whether they will develop a leaky gut condition where inflammatory molecules get into the bloodstream and cross the blood brain barrier causing brain inflammation.

Other sections on the website that provide useful information are as follows. The ‘Videos’ section has short and engaging YouTube videos by experts in the field. There are many excellent videos online that parents, caregivers and teachers will find enjoyable and interesting to watch. The ‘Recipes’ section has an assortment of main meals, snacks, drinks and smoothies, and desserts that support a healthy gut and mind, while being kid-approved for taste. An important part of using nutritional protocols with children is getting them to buy into the new food regime. For many parents this is one of the most challenging aspects of making food changes and is the
'deal breaker’ when it comes to them continuing their efforts or giving up. There is a section on how to make dietary changes and tips for how to deal with picky eaters. Once parents and caregivers have gained the requisite nutritional knowledge and they have made the decision to take action, they need to decide which diet is appropriate for their child. They have to decide if they are going to remove certain top allergens. Will they remove gluten, or dairy, or both? Do they remove all grains or will they use some pseudo-grains like quinoa? These are just some of the questions that have to be answered before embarking on a healing protocol for a child; therefore there is a section on the website that gives an overview of each of the main healing diet options. Understanding the concept of bio-individuality is important for anyone trying to use nutrition to heal children, because it can be the answer when trouble shooting. Bio-individuality means that because children have unique biochemistry, they may react to certain foods that are normally considered very healthy. For example, a small minority of children react to the chemical compounds called salicylates and oxalates that are found in certain fruits and vegetables.

The ‘Supplements’ section discusses the role of the most important supplements and brands. The ‘Resources’ section has links to books, products, authors, institutions and foundations that support youth using nutrition.
Chapter Four: Conclusions and Recommendations

The research shows that eating the right food is critical for a child’s brain and body to function well. Eating the right food reduces inflammation in the gut and the brain. A child can be considered a ‘food’ body because food combined with oxygen and water, literally are the building blocks for their brain and body. If we use the analogy of a child’s brain being a computer then it essential that that computer receive the correct information. Food is the raw material that a child uses to make their brain messenger chemicals, their neurotransmitters and receptors on which the signals in their brain are sent from and land on. Without the proper food, a child’s body cannot detoxify and excrete toxins from their body. Simply put, if a child does not eat the right food and they eat too much of the wrong food, then their brains do not work properly. They become sluggish, angry, foggy, anxious, unfocused, tired, and depressed.

The aforementioned states can be avoided in children by several recommendations for improving student health with nutrition. First, there needs to be more education about the topic of nutrition for parents, caregivers and educators where they learn about the importance of the mind-gut connection and ways nutritional interventions have the potential to significantly improve a child’s health. Ten years ago there was little discussion in the public domain about the impact of the microbiome and mitochondrial functioning on children’s brain health. This is now changing and there are popular books being published and discussions in the media on the subject. It was encouraging that at a recent professional development day that I attended that a presenter talked about using probiotics to help combat anxiety and depression in students. This is an example of research findings getting put into practice and hopefully we will see more of this in the future.
There needs to be a cultural shift in attitude about our ideas about responsibility for our own health and the health of our children. The neurological fatalism that has underpinned much of our society’s beliefs and practices is starting to give way to the enhancing views of neuroplasticity and epi-genetics, where dietary and lifestyle changes can make major improvements in children’s lives. If we believe that we cannot change a child’s brain then we have little motivation to try new things. If we keep waiting for science to come up with the next wonder pill then we won’t put our energy into developing non-proprietary solutions through lifestyle changes. The concept of epi-genetics tells us that we have a lot more control over our genetic expression than we formerly believed and that environment, food and lifestyle really do matter. After updating our nutrition knowledge and tweaking our attitudes, we need to take action with children by implementing a nutritional protocol. The product part of my applied project, my website, deals with all three of these recommendations: knowledge, attitude and how to take action.

Finally, there needs to be continued research on the microbiome and how it affects the health of students. Much of the research on the microbiome, especially on the effectiveness of probiotics, has used animal subjects. It would be useful to have studies on the effectiveness of probiotics on human subjects.

The process of conducting the literature review in chapter two, taught me several things. I learned the importance of basing my claims on solid research and having the openness and flexibility of mind to change my opinions if necessary. The whole process has taught me a few things about my attachment to my opinions and what I consider to be truth. Over the course of working on this project I have realized that there is a lot of outdated and just plain wrong information on nutrition out there. The thing is though, I believed many of those things, but now
I believe new things and in the future I’m going to find the things I believe now, to be wrong. On the face of it, this state of perpetual wrongness seems depressing but it is liberating in a way. Instead of trying to be right, I will spend my energy trying to figure out how I’m wrong.

Secondly, I learned to write in an academic style that promotes discussion of possible implications of research findings. The process of building the website taught me new computer skills and how to write in style that explains complex material in a clear and succinct style. Finally, the project taught me how to stay organized and motivated on a large, creative endeavor. I learned that working shorter hours is more efficient and enjoyable than trying to slog it out in marathon sessions. Most importantly I learned that I could not wait to be in the right mood to work on the project. If I just started doing some small task, however insignificant, I would soon gain purchase and creativity would follow.
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Appendix A

Name of website: Nutrition for Kids

https://lmshaw7.wixsite.com/nutritionforkids