

Food, Physical, Mental and Emotional Health Are Intertwined

Where the United States Got It All Wrong

By Jennifer DeRensis DeVecchio

The path to greater happiness is surprisingly simple and may not involve any self-help books. The well-being of the body is intricately connected with the well-being of the brain, and the brain is home to the emotions. Maintaining the well-being of the whole-self requires eating the right nutrients and avoiding inflammatory foods; studies show nutritional needs are best met by eating a traditional diet of whole foods.

Nutritional psychiatry is an exciting, emerging field that holds the potential to better brain health. There is a

“diversity of studies being conducted in a new, rapidly emerging field of nutrition and mental health,” write guest editors Julia J. Rucklidge (University of Canterbury) and Bonnie J. Kaplan (University of Calgary)⁸ “Extensive animal data show that dietary manipulation affects brain plasticity and there are now data from humans to suggest the same.” (Bernstein, 2018)

Some examples of the recent growth of interest in this field include:

- 2013: The International Society for Nutritional Psychiatry Research is founded by researcher epidemiologist Dr. Felice Jacka.
- 2016: Dr. Jacka is involved in starting Deakin University’s Food & Mood Centre of Australia. Its focus is “researching and developing nutrition-based strategies for brain disorders” (Bernstein, 2018).
- 2017: The annual American Psychiatric Association conference includes a presentation on supporting the peripheral nervous system with nutrition by Chef David Bouley.

- Onward: Medical schools such as Columbia University's Vagelos College of Physicians and Surgeons are venturing into nutritional psychiatry. Note: A need for greater inclusion of nutrition in medical schools has mentioned by entities such as the Harvard T. H. Chan School of Public Health ("Doctors Need," 2017).

When considering mental health, it is important to remember that the brain is essentially another organ and needs premium fuel for optimal performance.

The brain is an organ with very high metabolic and nutrient demands. On average, the brain consumes 20% of a person's daily caloric intake, approximately 400 calories per day. It is composed of 60% fat, and contains high concentrations of cholesterol and polyunsaturated fatty acids (PUFAs) such as Omega-3s. (Lachance & Ramsey, 2015)

The brain's core houses our emotional center, the limbic system. Neurotransmitters are brain chemicals that carry messages and in combination with hormones cause an emotional response to life events. To maintain the best level of these brain chemicals and hormones, quality food is required.

Eating high-quality foods that contain lots of vitamins, minerals, and antioxidants nourishes the brain and protects it from oxidative stress — the "waste" (free radicals) produced when the body uses oxygen, which can damage cells...

It makes sense. If your brain is deprived of good-quality nutrition, or if free radicals or damaging inflammatory cells are circulating within the brain's enclosed space, further contributing to brain tissue injury, consequences are to be expected." (Selhub, 2015)

Free radicals are unavoidable, but the levels produced by a brain-healthy diet are the levels the brain is equipped to handle (Ede, 2017).

Some specific brain nutrients are:

Vitamin B12, B9 (folate) and zinc reduce homocysteine elevated levels which are linked to both depression and cardiovascular disease. Deficiencies in these important nutrients “can cause symptoms of depression and dementia. Such symptoms include: low mood, fatigue, cognitive decline and irritability” (Lachance & Ramsey, 2015).

Amino acids are needed to produce monoamine neurotransmitters such as serotonin, norepinephrine, and dopamine which are “all important in pathophysiology of mental illness” (Lachance & Ramsey, 2015).

Omega-3 fatty acids are required for neuronal cell membranes. They are also involved in essentials such as “neurotransmission, gene expression and neurogenesis [“the process by which nervous system cells, the neurons, are produced by neural stem cells (NSC)s.” (“Neurogenesis,” n.d.)] and neuronal survival” (Lachance & Ramsey, 2015).

“Decades of research shows the importance of proper nutrition in preventing and treating the ill effects of inflammation and stress, physiological processes that are intimately linked with mental health” (Scientists Explore, 2016).

Not all stress is bad:

Eustress (good stress) and distress (bad stress) both trigger the release of cortisol, the stress hormone. Cortisol initiates an urgent fight-or-flight emotional reaction in the wake of stressful events. When circumstances of eustress cause cortisol levels to rise,

you may feel invigorated, alert, and determined. As the stressor passes, cortisol levels return to normal and your mood adjusts accordingly.

But in times of distress, cortisol levels rise and stay high—even after the distress passes.

This increase in stress hormone can be triggered by the loss of a loved one, illness, sudden unemployment, etc. Feelings of uneasiness, tension, and anxiety accompany a rise in cortisol. (Sprouse, n.d.)

Some studies showing the link between food and mood:

- 2016:

“Almudena Sanchez-Villegas and colleagues examine outcomes associated with a broader Mediterranean lifestyle that includes diet, physical activity, and social activity. Looking at data from 11,800 individuals participating in a university-based longitudinal study, the researchers found that all of these variables independently predicted a lower risk of depression. The article highlights the importance of examining the combined effects of nutritional and other lifestyle factors on mental health outcomes.” (Scientists Explore, 2016)

“The study spanned 4.4 years and showed that those following a Mediterranean Diet were 42% less likely to develop depression” (Lachance & Ramsey, 2015).

Tasnime N. Akbaraly and colleagues

“examine data on diet and depressive symptoms collected from 4,246 adults over a period of 5 years. The researchers found that diets that

rated high on the 'dietary inflammatory index' were associated with increased risk of depressive symptoms, but only among women."

(Scientists Explore, 2016)

Note "The prevalence of major depression is higher in women than in men"

(Albert, 2015).

- 2017:

January: Dr. Jacka contrasts the benefits of a traditional whole foods diet to the beneficial effects of social interaction on depression:

"After 12 weeks, the people who improved their diets showed significantly happier moods than those who received social support. And the people who improved their diets the most improved the most"

(Bernstein, 2018).

December: Nutritional Neuroscience publishes a second larger study done by researchers at the University of South Australia finding that a "boost in mood" lasted 6 months (Bernstein, 2018).

- 2018:

The American Academy of Neurology's annual meeting includes research done at Rush University Medical Center in Chicago suggesting that eating fruits and vegetables may reduce depression in seniors (Bernstein, 2018; Dash, 2018).

There are encouraging signs that nutrition has a beneficial role in treating specific psychiatric struggles beyond depression. For example:

OCD: "There was some success in treating less-established OCD with an amino acid

agent called N-acetyl-cysteine (NAC) in a randomized controlled trial with 44 participants” (Scientists Explore, 2016).

ADHD: Jane Pei-Chen Chang and colleagues found some correlation between ADHD and EFA (Essential Fatty Acid):

Although children with ADHD showed no difference in essential fatty acid (EFA) intake compared with their non-ADHD peers, they did show signs of EFA deficiency. At the same time, children who had lower EFA intake and symptoms of EFA deficiency were likely to show greater ADHD symptoms. (Scientists Explore, 2016)

Insomnia: An 8-week trial on 14 adults by Joanna Lothian, Neville M. Blampied, and Julia J. Rucklidge shows broad-spectrum micronutrients (i.e., vitamins and minerals) to be:

useful in treating insomnia which is associated with “a variety of mental health problems...Participants reported improvements with insomnia symptoms, mood, stress, and anxiety over the course of the trial. The researchers note several limitations – including the fact that participants were aware of the treatment and the study lacked a control group – that should be addressed in future research. (Scientists Explore, 2016)

Stress: A carbohydrate rich/protein poor diet was found to “increase personal control, probably under the influence of higher levels of brain tryptophan and serotonin” (Markus, 1998) in high-stress people.

Depression can have a myriad of roots. Depression can be “genetic, triggered by a specific event or situation, such as loneliness, or brought on by lifestyle choices” (Bernstein, 2018). Other factors such as such as poverty, poor health and “living in a deprived area” have a “complex relationship” with nutrition (Diet and, 2018). Nonetheless, the relationship between diet and mental health is clear; “people with mental illness have been identified as having poorer diet and other lifestyle behaviors that impact on health, and less understanding of the impact of lifestyle behaviors on health” (Scientists Explore, 2016). Diet in early life also appears important in achieving optimal mental health (Diet and, 2018).

“The global burden of mental illness, both in terms of financial cost and disability, rivals that of all cancers combined” (LaChance & Ramsey, 2015). In that mood disorders and anxiety are associated with inadequate access to “sufficiently nutritious and culturally appropriate food,” (LaChance & Ramsey, 2015) perhaps an investment in education on, accessibility to, and availability of a beneficial nutritious diet would be an example of the human and financial benefits of preventative care. *(Note: With childhood nutrition undoubtedly the most important, an investment in optimal childhood nutrition is a lucrative investment.)*

The 2013 Global Burden of Disease report identified that, in both developing and developed countries, major depressive disorder now ranks as the second highest cause of years of life lost due to disability(YLD). From 1990 to 2013, YLD attributed to mental and substance abuse disorders increased by 45%, depressive disorders by 53.4% and CVDs by 89.2%, constituting a major burden of disease worldwide with tremendous associated personal, psychosocial, and financial impacts. (Scientists Explore, 2016)

There have been efforts to close the 'mortality gap' for people with severe mental health problems, who on average tend to die 10 to 25 years earlier than the general population. A number of factors may contribute to this premature mortality, including dietary and nutritional factors, among other things. (Diet and, 2018)

Poor nutrition is the source of health problems including obesity. The association between obesity and mental health runs both ways.

Results from a 2010 systematic review found two-way associations between depression and obesity, finding that people who were obese had a 55% increased risk of developing depression over time, whereas people experiencing depression had a 58% increased risk of becoming obese. There are a number of demographic variables that could affect the direction and/or strength of the association with mental health including severity of obesity, socioeconomic status and level of education, gender, age and ethnicity. (Diet and, 2018)

The Standard American Diet (SAD) is "strongly correlated with an increased risk of: depression, mild cognitive impairment and ADHD" (Lachance, 2015).

"Based on preliminary epidemiological studies, compared to a healthy diet, the Western pattern diet is positively correlated with an elevated incidence of obesity, death from heart disease, cancer (especially colon cancer), and other "Western pattern diet"-related diseases. It increases the risk of the metabolic syndrome and may have a negative impact on cardio-metabolic health." (Western, n.d.)

So, what is the Standard American Diet or the Western pattern diet? Here are some general SAD patterns:

From 1970 to 2008, the per capita consumption of calories increased by nearly one-quarter in the United States and about 10% of all calories were from high-fructose corn syrup.

Americans consume more than 13% of their daily calories in the form of added sugars. Beverages such as flavored water, soft drinks, and sweetened caffeinated beverages make up 47% of these added sugars. (Western, n.d.)

Diets high in refined sugars are harmful to the brain. In addition to harming the body's regulation of insulin, they promote inflammation and oxidative stress. "Multiple studies have found a correlation between a diet high in refined sugars and impaired brain function — and even a worsening of symptoms of mood disorders, such as depression" (Szalay, 2018).

More general SAD patterns are:

Vegetable consumption is low among Americans, with only 13% of the population consuming the recommended amounts.

Whole grains should consist of over half of total grain consumption, and refined grains should not exceed half of total grain consumption. However, 85.3% of the cereals eaten by Americans are produced with refined grains, where the germ and bran are removed. (Western, n.d.)

The Standard American Diet is remarkably similar to an inflammatory diet which also has been found to increase the risk of developing depression. "An inflammatory diet is high in in sugar, refined grains, diet soft drinks, and saturated and trans fats [red meats, dairy products and foods containing partially hydrogenated oils (Szalay, 2018)], and low in wine, coffee, olive oil, green leafy, and yellow vegetables" (Lachance& Ramsey, 2015). The western diet is also

high in Omega-6, whereas a healthy diet entails a balance between Omega 3 and Omega-6 fatty acids. To restore a balance of fatty acids “cut back on the use of cooking oils and margarines that are high in omega-6 fatty acids, such as corn, safflower and sunflower oil” (Szalay, 2018). Another cause of inflammation is processed meat which “is high in inflammatory compounds like AGEs, and its strong association with colon cancer may partly be due to an inflammatory response” (Spritzler, 2019). *Note: Unproven, but suggested possible herbal remedies that can counter inflammation are Devils Claw, Turmeric, and Willow Bark (Szalay, 2018).*

Beyond cutting back on omega-6 intake, some depressing foods to avoid or limit are:

- ***Refined sugar***

Refined carbs raise blood sugar levels and promote inflammation that may lead to disease...[then] causes our blood glucose levels to plummet, resulting in a sugar hangover that disrupts our mood, depletes our energy, and is linked to sleep disorders. (Borchard, 2018)

- ***Artificial sweeteners***

Aspartame is bad stuff. Especially if you are prone to depression. It blocks the production of the neurotransmitter serotonin and causes mood dips, headaches, and insomnia. The artificial sweeteners NutraSweet or Equal could also be bad news as well. If you really need a soda fix, go for the fully leaded. The refined sugar, while not health food, is better for you than the fake kind. (Splenda appears safe for now). (Borchard, 2018)

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- **Sodium**

“Excess sodium...can disrupt your neurological system, contributing to depression, and can muck up your immune system response, causing fatigue” (Borchard, 2018).

- **Alcohol**

“Alcohol is a [central nervous system] depressant. ... Your central nervous system is responsible for taking in information through the senses, controlling motor function, as well as thinking, understanding, and reasoning. It also controls emotion. Alcohol slows all this down, exacerbating symptoms associated with depression.” (Borchard, 2018) Heavy alcohol consumption may increase inflammation and lead to a "leaky gut" that drives inflammation throughout your body” (Spritzler, 2019).

A “whole” or traditional diet, such as the Mediterranean Diet “will provide the nutrition our brain needs, regulate our inflammatory response and support the good bacteria in our gut,” says Dr. Mosconi, author of *“Brain Food: The Surprising Science of Eating for Cognitive Power”* (Bernstein, 2018). It is based on the traditional cooking styles of the countries along the Mediterranean Sea. The diet is rich in fish, olive oil, legumes and whole grains.

Juxtaposing the body’s emotional response to a traditional diet and its response to the Standard American Diet:

The risk of depression is 25% to 35% lower in those who eat a traditional diet. Scientists account for this difference because these traditional diets tend to be high in vegetables, fruits, unprocessed grains, and fish and seafood, and to contain only modest amounts of lean meats and dairy. They are also void of processed and refined foods and sugars, which are staples of the “Western” dietary pattern. In addition, many of these

unprocessed foods are fermented, and therefore act as natural probiotics.” (Selhub, 2015)

Brain derived neurotrophic factor or BDNF may explain some of the benefit of a more whole food approach to eating. BDNF is “an important neurochemical involved in crucial functions such as neuroplasticity, neuronal survival, and growth and differentiation of new neurons and synapses” (Lachance & Ramsey, 2015). Low levels of BDNF are associated with “major depressive disorder, PTSD, Schizophrenia, and Alzheimer’s dementia” and have “been implicated in the mechanism of action of anti-depressant medications. The Mediterranean Diet has been shown to raise the levels of BDNF” (Lachance & Ramsey, 2015).

A Mediterranean Diet Study shows that “dietary changes are possible and supplemented with fish oil can improve mental health in people with depression” (Parletta et al., 2017). Food baskets and cooking classes were provided to facilitate the diet change. The results are lengthy but interesting:

Higher Mediterranean diet scores were significantly associated with lower depression, anxiety, negative affect and better coping and overall QoL. Higher vegetable consumption was associated with less stress and more positive emotions and happiness while higher fruit consumption was associated with less anxiety and more positive emotions and relationships. Higher intake of nuts was associated with reduced depression, anxiety and stress, and better mental health, self-worth and overall QoL. More legumes were associated with reduced anxiety, stress, negative emotions, and greater coping, psychosocial and overall QoL scores.

Greater diversity of vegetables was associated with reduced depression, anxiety and negative emotions, and higher positive emotions, and along with greater diversity of fruits also with higher independent living, mental health, happiness, relationships, psychosocial and overall QoL. Reduced intake of takeaway food was associated with better pain and overall physical health QoL scores and reduced intake of unhealthy snacks was associated with improved mental health, coping and psychosocial QoL scores. Increased omega-3 PUFA eicosapentaenoic acid (EPA) was significantly associated with reduced anxiety and stress at 3 months and 6 months, and also with improved independent living, senses and physical health at 6 months. Increased omega-3 PUFA docosahexaenoic acid (DHA) was associated with reduced stress and negative emotions at 6 months. Decreased omega-6 PUFA arachidonic acid (AA) was associated with decreased stress and increased AQoL mental health, psychosocial and overall QoL at both 3 and 6 months as well as lower coping AQoL scores at 6 months. A reduced ratio of AA to EPA was associated with better pain, senses and physical health QoL scores at 6 months.

Both groups reported significantly improved mental health outcomes across all measures over 3 months which were also sustained at 6 months. The MedDiet group reported significantly greater improvements in depression and overall mental health-related QoL compared to the social group. Improvements in a range of mental health outcomes were significantly correlated with improvements in diet over 3 months, most notably for greater diversity of vegetables and fruit and intake of legumes but also

including higher Mediterranean diet score, vegetables, fruit and nuts and reduced consumption of unhealthy snacks, takeaway food, and meat.

Changing established dietary behaviours is challenging, and this is attributed to factors such as an obesogenic environment and the addictive nature of high-fat high-sugar foods. However, there is evidence that neural reward thresholds can be changed in favour of preferring healthy over unhealthy food. A Mediterranean diet not only has demonstrated health benefits but is also a highly palatable diet and thus more likely to become a sustainable part of a healthy lifestyle.” with behavioural economics and ‘nudging’ principles, i.e. using the path of least resistance, setting desirable defaults, making healthy food more available. Along with education, goalsetting, and menu ideas, continued exposure to and familiarity with healthy foods such as vegetables can increase liking and preference for that food. Furthermore, learning basic cooking skills and hands-on learning of healthy recipes is empowering and has previously been associated with healthier food choices. (Parletta et al., 2017)

In addition to being high in omega-6 fatty acids, the Western Diet is quite low in omega-3s, a phenomenon that has occurred with the shift towards industrialized and processed food. Omega-6 fatty acids are the primary fatty acid in many vegetable oils, such as corn oil and soy oil, often the cooking fats of choice in packaged and restaurant food. Long chained omega-3 fatty acids are found in fish, seafood, and grass-fed beef. Typically, these are not foods that come to mind as staples of the standard American diet. Grass fed beef omega-3 content varies greatly, but generally contains 100mg of long-chained omega-3 fatty acids per 100g serving, much

less than an equivalent serving of fatty fish. This highlights the importance of educating patients about meat quality and alternatives, such as grass-fed beef, which is generally more nutrient dense than conventionally-raised beef. (Parletta et al., 2017)

The best omega-3s resources are:

- **Fish and seafood** are nutrient dense foods.
- **Greens** (like kale, beans, and legumes) are excellent sources of folate in addition to omega-3s.
- **Fiber and B-vitamins** are other excellent sources of folate and omega-3s.

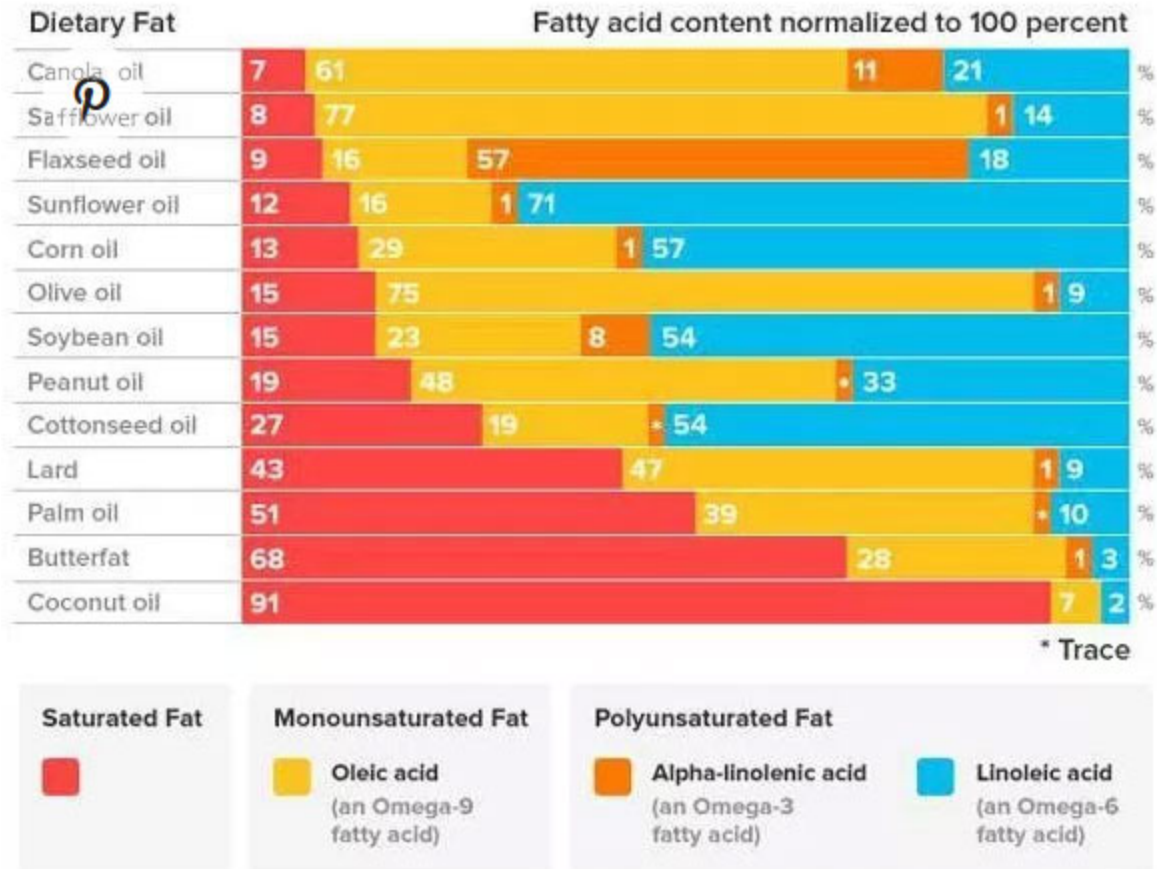
Omega-3s are anti-oxidants and are anti-inflammatory (Lachance & Ramsey, 2015) and are involved in essential brain chemical transmission.

“Thanks to its anti-inflammatory properties and effects on dopamine and serotonin transmission, omega-3 has a role in brain development and functioning, with deficiencies linked to mental health problems, says Mary A. Fristad, PhD, of the Ohio State University Wexner Medical Center.” (Clay, 2017)

Omega-3s may treat a variety of issues including ADHA, major depressive order, bipolar depression and PTSD. An elevated level of omega-6 as compared to omega-3 is associated with major depressive disorder and ADHD. It is suggested that supplementing with omega-3 may be an effective remedy. (Lachance & Ramsey, 2015) Dr. Dariush Mozaffarian, an assistant professor of medicine at Harvard-affiliated Brigham and Women's Hospital, believes that Omega-6 fatty acids are also beneficial, specifically for the heart and circulation, (No Need , 2019) and that balance is key. *Note: Healthline reports an additional unpleasant fact, “most*

people store immense amounts of omega-6 fatty acids in their body fat, and it can take a while to get rid of them” (Gunnars, 2018).

The reason behind the need to balance omega-6 and omega-3 fatty acids may lie in the fact that the same enzymes are required “to convert both short chain omega-3 and omega-6 fatty acids to their long chain biologically active versions” (Lachance & Ramsey, 2015). An excessive amount of Omega-6 fatty acid “can contribute to a pro-inflammatory state, given the inflammatory properties of eicosanoids produced by AA [Omega -3] and anti-inflammatory properties of eicosanoids produced by EPA [omega-6]” (Parletta, 2017). A route to omega balance is not to “regularly consume” oils that are high in Omega-6. “The technology to process these oils didn’t exist until about 100 years ago, and people have not had time to genetically adapt to the high amounts of omega-6” (Gunnars, 2018).



Source: POS Pilot Plant Corporation

(Gunnars, 2018)

“One study also looked at common vegetable oils on food shelves in the U.S. market and discovered that they contain between 0.56 to 4.2% trans fats, which are highly toxic” (Gunnars, 2019).

Specific vitamins that support mental well-being are:

Vitamin B6:

“B6 is needed every day to produce serotonin, the neurotransmitter that is the primary regulator of mood and sleep and maybe even eating the right amount of food. Too little serotonin is associated with depression.”

“Sources: Pistachios. Garlic. Salmon and tuna. Chicken. Spinach. Cabbage. Bananas. Sweet potatoes. Avocados. Whole grains” (Bernstein, 2018).

DHA: DHA is the main omega-3 fat in the brain. “It promotes production of brain-derived neurotrophic factor (BDNF), a hormone that protects neurons and promotes the birth of new brain cells” (Bernstein, 2018).

Sources: Wild salmon. Oysters. Anchovies. Mackerel. Mussels (Bernstein, 2018).

Prebiotics: “Foods that the good microbes in our gut need to stay alive” (Bernstein, 2018).

Sources: Onions. Asparagus. Artichokes. Garlic. Bananas. Oats (Bernstein, 2018).

Probiotics: “Live bacteria and yeasts that replenish the good bacteria in our microbiome” (Bernstein, 2018).

Sources: Yogurt. Sauerkraut. Kefir. Kimchi or other fermented vegetables, such as turnips, cucumbers or carrots (Bernstein, 2018).

5 FOODS LINKED TO BETTER BRAINPOWER

GREEN VEGGIES



1. Leafy greens such as kale, spinach, collards, and broccoli are rich in brain-healthy nutrients like vitamin K, lutein, folate, and beta carotene. Research suggests these plant-based foods may help slow cognitive decline.

FATTY FISH



2. Fatty fish are abundant sources of omega-3 fatty acids, healthy unsaturated fats that have been linked to lower blood levels of beta-amyloid — the protein that forms damaging clumps in the brains of people with Alzheimer's disease.

BERRIES



3. Flavonoids, the natural plant pigments that give berries their brilliant hues, also help improve memory, research shows.

TEA + COFFEE



4. Coffee and tea might offer more than just a short-term concentration boost. In a recent study, participants with higher caffeine consumption scored better on tests of mental function.

WALNUTS



5. Nuts are excellent sources of protein and healthy fats, and walnuts in particular might also improve memory, according to a study.

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Additional tips on achieving peak physical and mental performance are:

- Try to eat **fish** at least twice a week, but choose varieties that are low in mercury, such as **salmon, cod, canned light tuna, and pollack**...an **omega-3 supplement**, or choose terrestrial omega-3 sources such as **flaxseeds, avocados, and walnuts**.
- **Caffeine** might also help solidify new memories, according to other research. Investigators at Johns Hopkins University asked participants to study a series of images and then take either a placebo or a 200-milligram caffeine tablet. More members of the caffeine group were able to correctly identify the images on the following day.
- A 2015 study from UCLA linked higher walnut consumption to improved cognitive test scores. **Walnuts** are high in a type of omega-3 fatty acid called alpha-linolenic acid (ALA), which helps lower blood pressure and protects arteries. That's good for both the heart and brain. (Foods Linked, n.d.)
- **Nuts**, in general, have a number of health benefits (Spritzler, 2019).
- “High-protein foods like **turkey, eggs, and cheese** contain the amino acid “tryptophan which is a precursor to the neurotransmitter serotonin” (Sprouse, n.d.). *Note: In deciding protein quantities, keep in mind the study suggesting that a high carbohydrate/protein poor diet (Markus, 1998) appears useful in helping control high-stress levels.*

The brain chemical serotonin is important as ““master mood regulator”

and works with receptors in the brain to elevate mood, sharpen memory, and promote healthy sleep and eating habits.

- Serotonin is produced in the brain and all along the digestive tract.

- Serotonin works to regulate your mood. It functions in the body to elicit feelings of happiness and well-being. The master mood regulator facilitates communication between neurons and controls the intensity of signals.
- Low availability of serotonin may cause feelings of sadness, lethargy, and sleepiness. When plenty of serotonin is available to the brain, you feel alert and content.
- There is evidence to suggest a relationship between serotonin and appetite. Healthy levels of serotonin may help your body recognize when it is full and prevent overeating. Serotonin can also minimize cravings for sweet and starchy foods. (Sprouse, n.d.)

The microbiome is another link between diet and mental health and a growing area of research. Fermented foods, a part of the human diet since the Paleolithic age, are a good source of these probiotic microorganisms. Prebiotics are non-digestible fiber which “stimulates the growth and activity of these beneficial microorganisms” (Lachance & Ramsey, 2015). These good bacteria

make molecules that can alter the production of serotonin, a neurotransmitter found in the brain, says Lisa Mosconi, a neuroscientist, nutritionist and associate director of the Alzheimer’s Prevention Clinic at Weill Cornell Medical College in New York. The good and bad bacteria in our gut have complex ways to communicate with our brain and change our mood, she says. We need to maximize the good bacteria and minimize the bad. (Bernstein, 2018)

Since about 95% of your serotonin is produced in your gastrointestinal tract, and your gastrointestinal tract is lined with a hundred million nerve cells, or neurons, it makes sense that the inner workings of your digestive system don’t just help you digest food,

but also guide your emotions. What's more, the function of these neurons — and the production of neurotransmitters like serotonin — is highly influenced by the billions of “good” bacteria that make up your intestinal microbiome. These bacteria play an essential role in your health. They protect the lining of your intestines and ensure they provide a strong barrier against toxins and “bad” bacteria; they limit inflammation; they improve how well you absorb nutrients from your food; and they activate neural pathways that travel directly between the gut and the brain. (Selhub, 2015)

Biodome damage appears linked to glyphosate; GMO foods are often modified so that the pesticide glyphosate, which kills all plants except the new ‘superweeds’ (Superweeds, 2014), can be used. A 2013 study concludes that:

Celiac disease is associated with imbalances in gut bacteria that can be fully explained by the known effects of glyphosate on gut bacteria.

Ingested food and our gut microbes to provide [these] essential nutrients. Glyphosate, patented as an antimicrobial (Monsanto Technology LLC, 2010), has been shown to disrupt gut bacteria in animals, preferentially killing beneficial forms and causing an overgrowth of pathogens. Two other properties of glyphosate also negatively impact human health – chelation of minerals such as iron and cobalt, and interference with cytochrome P450 (CYP) enzymes. (Samsell & Seneff, 2013)

Glyphosates have also been linked to cancer (Dixon, 2019).

Beyond a link to glyphosate, understanding some of the science behind GMOs is essential in making an informed decision as to whether these new age foods have a place in our

modern version of the recommended traditional diet. In addition to being bred for herbicide resistance, the GMO plants themselves sometimes produce toxins that are harmful to pests.

In the case of Bt corn, the donor organism is a naturally occurring soil bacterium, *Bacillus thuringiensis*, and the gene of interest produces a protein that kills Lepidoptera larvae, in particular, European corn borer. This protein is called the Bt delta endotoxin.

(Bessin, n.d.)

Genetic science is not an exact science which begins to suggest that the weight of testing all possible variations and outcomes, especially in terms of long-term effects on an animal with a lifespan as long as that of a human, is significant:

Two factors, the event and the promoter, control where delta endotoxins are produced in the plant and in what amounts. Different seed companies use different events and promoters, so their hybrids will be different in what plant tissues produce delta endotoxins.

The insertion event is the physical act of putting the Bt gene into the corn plant's genetic material. This is when the physical location of the Bt gene is determined (which chromosome, what part of the chromosome, etc). Gene location affects where in the plant delta endotoxins are produced and how much delta endotoxin is produced.

Currently we do not have the technology to control the bt gene location, so each event results in plants that differ in where and in how much delta endotoxin is produced.

(Peairs, 2014)

GMOs remain controversial. There are many articles expressing serious concerns about the effects of GMOS. For example, Oprah Magazine reads:

What impact do GM foods have on our health? The answer is, no one really knows. GM foods have been on the market only since 1994, and research on their long-term effects on humans is scarce. To date most of the studies have been done on animals; worryingly, though, some of those studies link GM foods to altered metabolism, inflammation, kidney and liver malfunction, and reduced fertility. In one experiment, multiple generations of hamsters were fed a diet of GM soy; by the third generation, they were losing the ability to produce offspring, producing about half as many pups as the non-GM soy group. (Mount, n.d.)

Yet accepted publications such *The New York Times* (Brody, 2018.) accept GMOs as safe. “‘The status quo is innocent until proven guilty,’ says Ashley Koff, a registered dietitian who studies GM foods, ‘as it was for trans fats, DDT, and countless other harmful chemicals (Mount, n.d.).’”

In 2017, the United States Government decided to launch a propaganda campaign in support of GMOs (Dewey, 2017). With the media government-driven to quell public fear of GMOs, and with potential ties existing between the government and big businesses, assessing the impacts of GMOs on health and thus mood requires digging deeper than the media for the facts. Where are scientists in terms of their evaluation of the GMO experiment? If anything, the National Academies of Sciences might be thought to lean in favor of policies supported by the government, as it receives the bulk of its funding from the federal government and has been shown to have connections to big business (National, 2020). In the report, “Human Health Effects of Genetically Engineered Crops,” the National Academies of Sciences reviews the testing that has been done thus far to determine the safety of GMOs. (Human Health, 2016)

Although the report, as expected from a source tied to the U.S. government which appears committed to GMOs despite any public hesitation, does attempt to keep GMOs in a favorable light the information itself is somewhat surprising given the widespread infiltration of GMOs into the American food supply. The scientists declare a need for further and more extensive testing in which acceptable ranges of “normal” should be “predefined” and explained (Human Health, 2016). A fairly substantial list of concerns raised by the scientists regarding the testing done on GMOs can be found at the end. A couple of the concerns mentioned were: the biological allowance of 10-30% difference in test animals vs control animals, and a concern about both introducing new allergens, which as unknowns would be extremely difficult to study, into the human population as well as increasing concentrations of allergens in other places (Human Health Effects, 2016).

Note: Another concern might be the assertion that an increased cancer risk in laboratory animals does not lead to a similar risk in humans. One might consider the fact that although a human being may be larger in many cases and thus less-susceptible to immediate harm, the human lifespan is much longer than that of the test subjects therefore giving problems a longer time in which to develop.

The report reads:

Recommendation: In cases in which testing produces equivocal results or tests are found to lack rigor, follow-up experimentation with trusted research protocols, personnel, and publication outlets is needed to decrease uncertainty and increase the legitimacy of regulatory decisions. (Human Health Effects, 2016)

(Note: The scientists recommended that consumer uncertainty be decreased by the facts produced by further testing – not via a media campaign.) The report continues: “stakeholders have criticized the testing used by U.S. and other national regulatory agencies for lacking rigor (for example, Hillbeck, et al., 2015)” (Human Health Effects, 2016).

There are studies tying GMOs to health issues:

Epidemiological studies demonstrate a closely matched rise in the incidence of more than thirty human diseases with the increased utilization of glyphosate, the active ingredient in Monsanto's RoundUp, and the increased consumption of foreign proteins created by genetically modified plants. More than 140 studies have supported the deleterious effects of glyphosate upon the biome, while studies demonstrating positive effects upon humans consuming GMOs have been widely questioned due to researchers' ties to biotech affiliates. The use of glyphosate in genetically modified agricultural environments may be the leading cause of adverse health in humans, causing imbalances of the gut bacteria and promoting gastrointestinal diseases including inflammatory bowel disease, chronic diarrhea, colitis and Crohn's disease, as well as cardiovascular diseases, depletion of micronutrients, Alzheimer's, autism, sulphur/sulphate deficiency, depression, Parkinson's Disease, hepatic dysregulation, birth defects, reproductive disorders, aggression, obesity, Vitamin D deficiency, aging, cell signaling disorders, and aberrant protein formation.” (D’Brant, 2014)

Another question raised is whether breeding for certain traits, such as herbicide resistance or anti-browning, is at the expense of nutrients. (Porterfield, 2015) In the case of GMO apples,

which are modified only to increase cosmetic consumer appeal, a polyphenol called polyphenol oxidase is silenced.

Apples turn brown when they are sliced, and the slice is exposed to air. The discoloration is due to a polyphenol called polyphenol oxidase.... Back in 2000, Cornell University performed a study in which they discovered that polyphenols and flavonoids are responsible for many of the health benefits associated with apples. In fact, the lead on the study. Rui Hai Liu, said,

Scientists are interested in isolating single compounds — such as vitamin C, vitamin E and beta carotene — to see if they exhibit anti-oxidant or anti-cancer benefits. It turns out that none of those works alone to reduce cancer. It's the combination of flavonoids and polyphenols doing the work. (Luther, 2017)

GMOs are a science experiment with as yet inconclusive results. Consumers will have to decide for themselves using the information available as to whether to include GMOs in a diet geared to optimal physical, mental and emotional health.

Notes: Perhaps GMO induced health effects will vary by the genes modified and the species used for the modification making the weight of testing expense fairly substantial. Any experimentation done on humans certainly should be consensual. The difference between glyphosate driven genetic modification and other forms of genetic modification is a necessary area of exploration if efforts to expand GMO use is continued. Monsanto bred GMOs to be immune to the effects of the poison it is selling.

In conclusion, with the brain being both an organ and responsible for emotions, happiness is correlated with satisfying physical needs.

“When we think of cardiac health, we think of strengthening an organ, the heart,” says Drew Ramsey, a psychiatrist in New York, assistant clinical professor of psychiatry at Columbia and author of “Eat Complete.” “We need to start thinking of strengthening another organ, the brain, when we think of mental health.” (The Key, 2018)

The “basic building blocks of the brain: monoamine neurotransmitters, myelin, and neuronal membranes” (Lachance & Ramsey, 2015) are provided by diet. The ratio of omega-6 to omega-3 dietary intake influences BDNF expression and systemic inflammation both of which are linked to depression. Add a healthy food related biodome to the recipe for happy health. Rather than focus on individual nutritional requirements, a whole diet approach is best.

A range of essential nutrients are required for healthy brain function and they also work synergistically; therefore improving the whole diet is likely to have far greater benefit for mental health than any single nutrient alone.” (Parletta, 2017)

Loretta Go, a 60-year-old mortgage consultant in Ballwin, Mo., suffered from seemingly incurable depression for decades before finding the cure in a healthy diet. Ms. Go’s depression has never come back. “This works so well,” she says. “How come nobody else talks about this?” (Bernstein, 2018.). Dr. Ramsey points out that the only side effect to using a healthy diet to improve mood is good health (The Key, 2018).

A person’s best self saunters forth with a whole life approach. Remember the study by Almudena Sanchez-Villegas and colleagues which “highlights the importance of examining the combined effects of nutritional and other lifestyle factors on mental health outcomes” (Scientists Explore, 2016). Other mood lifters include:

- *Loved ones and social contact:*

Known as the “love hormone,” oxytocin is a powerful player in your mood. Oxytocin is produced in the brain by the hypothalamus. ...another portion of the brain that works in the limbic system. Hormone regulation takes place in the hypothalamus” (Sprouse, n.d.). This hormone is released in the presence of loved ones, and through social contact.

- *Humor*

“Humor can help alleviate discomfort by sending a surge of endorphins (hormones that act as natural pain killers) into your blood stream. As a result, your mood improves” (Sprouse, n.d.).

- *Exercise*

Exercise increases serotonin levels. (Sprouse, n.d.)

References

Albert, P. R., (2015). Why Is Depression More Prevalent in Women?, *Journal of psychiatry & Neuroscience*, 40(4), 219-221.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4478054/>

Dr. Albert discusses possible reasons for the higher rate of depression in females. The article was of interest to the relationship between food and mental health because of the research by Tasnime N. Akbaraly and colleagues which “found that diets that rated high on the ‘dietary inflammatory index’ were associated with increased risk of depressive symptoms, but only among women.” (Scientists Explore, 2016) This suggested differences in depression between men and women. Albert confirms a difference reporting that in general women are more prone to depression. With this insight in mind, it is not surprising that women were more affected by the inflammatory diet in this study, as they appear to be more vulnerable at this point in time. “*The Journal of Psychiatry & Neuroscience* is the highest-ranking free access journal in the psychiatry and neuroscience categories monitored by the Institute for Scientific Information” according to *Scimago Journal & Country Rank*.

<https://www.scimagojr.com/journalsearch.php?q=16816&tip=sid&clean=0>

Bernstein, (2018, April 2). The Food That Helps Battle Depression, *The Wall Street Journal*.

<https://www.wsj.com/articles/the-food-that-helps-battle-depression-1522678367>

Bernstein reviews studies that show a link between depression and nutrition including research by epidemiologist Dr. Jacka of Australia’s Deakin University, a second larger Australian study published in *Nutritional Neuroscience*, and research from Rush

University Medical Center. Bernstein recounts the experience of Ms. Go who struggled with apparently incurable depression, but found relief once she changed her diet.

Events that announce the rise of nutritional psychiatry as a field are mentioned. Dr.

Drew Ramsey reminds us that the brain is an organ. The benefits of a Mediterranean style diet are mentioned as well as specific ways to fill the nutrient needs of the mind.

The information is a good overview of the relationship between food and mood. “*The*

Wall Street Journal is rated to be “generally trustworthy for information.” by *Media*

Bias/ Fact Check. <https://mediabiasfactcheck.com/wall-street-journal/> “Ms. Bernstein

received a bachelor’s degree in journalism and English from Indiana University and a

master’s degree in journalism with honors from Columbia University. In June, 2008, she

completed a Knight Science Journalism Fellowship at MIT, which focused on brain

science.”

Bessin, R., (n.d.). Bt Corn: What it is and How It Works. *University of Kentucky*.

<https://entomology.ca.uky.edu/ef130>

In this article, Bessin explains some of the science behind GMO corn. The article was

used only to help define GMOs. The University of Kentucky is well-known for excellence

in entomology. [https://watermark.silverchair.com/ae59-](https://watermark.silverchair.com/ae59-0038.pdf?token=AQECAHi208BE49Ooan9kKhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAIawggJMBgkqhkiG9w0BBwaggl9MIICOQIBADCCAjIGCSqGSib3DQEHATAeBglghkgBZQMEAS4wEQQMyLK4B_csxt63SpQHAgEQglICA96-up_ecK9CpgEVuNQukoWrdAmIxA3GWZhF5GqNKGo1jHLjbepxvclpYYkg4Tqmy4xAPDX504QEEC4AoShWbr6o9oEVErbRY900-JDuWBicATXi8_99IODvMZJytuLnjxhXGZ7eIEqcM3R1-)

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[4wEQQMyLK4B_csxt63SpQHAgEQglICA96-](https://watermark.silverchair.com/ae59-0038.pdf?token=AQECAHi208BE49Ooan9kKhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAIawggJMBgkqhkiG9w0BBwaggl9MIICOQIBADCCAjIGCSqGSib3DQEHATAeBglghkgBZQMEAS4wEQQMyLK4B_csxt63SpQHAgEQglICA96-up_ecK9CpgEVuNQukoWrdAmIxA3GWZhF5GqNKGo1jHLjbepxvclpYYkg4Tqmy4xAPDX504QEEC4AoShWbr6o9oEVErbRY900-JDuWBicATXi8_99IODvMZJytuLnjxhXGZ7eIEqcM3R1-)

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[4QEEC4AoShWbr6o9oEVErbRY900-JDuWBicATXi8_99IODvMZJytuLnjxhXGZ7eIEqcM3R1-](https://watermark.silverchair.com/ae59-0038.pdf?token=AQECAHi208BE49Ooan9kKhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAAIawggJMBgkqhkiG9w0BBwaggl9MIICOQIBADCCAjIGCSqGSib3DQEHATAeBglghkgBZQMEAS4wEQQMyLK4B_csxt63SpQHAgEQglICA96-up_ecK9CpgEVuNQukoWrdAmIxA3GWZhF5GqNKGo1jHLjbepxvclpYYkg4Tqmy4xAPDX504QEEC4AoShWbr6o9oEVErbRY900-JDuWBicATXi8_99IODvMZJytuLnjxhXGZ7eIEqcM3R1-)

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QE5U_LjKP1L3QZK0edRRwLHbFbi7Q-

dOyHB8X2fcy3CtXz6jRs7OzaQpedB20P0DyQaBdIs94IFtzCsCMkES9KKZLPIYFkEMCV-

MuRsPo6ndoV6u4jtO8qma9fsj9g7gu2bkqZlhdFa2svLhnhvxYVHBxGpREVoW48Rf8IsmJSv

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B0anfxRwJGpp3YMibOjquh5mtA_5bhZLaRCOhHiA4bjaNPH4g3CAkB7rV39kroznNi0w0M

xA9b7Jw

Borchard, T. (2018). 7 Foods That May Contribute to Your Depression, *Psych Central*.

<https://psychcentral.com/blog/7-foods-that-may-contribute-to-your-depression/>

Borchard, associate editor at Psych Central, addresses links between certain foods and depression. Foods that she pinpoints as contributing to depression include sugar, artificial sweeteners, processed food, excessive sodium, hydrogenated fats and alcohol.

The article was reviewed by a scientific advisory board. The material is relevant to a relationship between food and mood. Psych Central is rated high for scientific factual reporting. <https://mediabiasfactcheck.com/psych-central/>

Brody, J. E., (2018, April 24). Are G.M.O Foods Safe?, *The New York Times*.

<https://www.nytimes.com/2018/04/23/well/eat/are-gmo-foods-safe.html>

Just a sample of some of the reassuring mainstream media coverage of GMOs. *The New York Times* is considered reliable by *Media Bias/ Fact Check*.

<https://mediabiasfactcheck.com/new-york-times/>

Clay, R., (2017). The Link Between Food and Mental Health, *American Psychological Association*, 48(8), p. 26.

<https://www.apa.org/monitor/2017/09/food-mental-health>

Clay's article is another examination of the relationship between food and mental health. She reviews studies linking increased nutrition and omega-3 oils to better mental health; she mentions specific studies which have found nutrition helpful with depression and with ADHD. Omega-3 fatty acids appear beneficial in treating depression in children. The American Psychological Association is ranked very high in properly sourced science fact reporting by *Media Bias/ Fact Check*.

<https://mediabiasfactcheck.com/american-psychological-association-apa/>

D'Brant, J., (2014). GMOs, Gut Flora, the Shikimate Pathway and Cytochrome Dysregulation.

[Abstract]. *Nutritional Perspectives: Journal of the Council on Nutrition*, 37(1), 5-12.

<https://web.b.ebscohost.com/abstract?direct=true&profile=ehost&scope=site&authType=crawler&jrnl=01603922&AN=94360210&h=4PCYGUxO52bGE2ivsZ2gu4LxLgOF%2bwYVdAiUYUS9pnuQ5EtUEnsPaHyMqEDF1rtnYJZrr12r831QWVRkz8NW7Q%3d%3d&crl=c&resultNs=AdminWebAuth&resultLocal=ErrCrINotAuth&crlhashurl=login.aspx%3fdirect%3dtrue%26profile%3dehost%26scope%3dsite%26authType%3dcrawler%26jrnl%3d01603922%26AN%3d94360210>

Only the abstract of this study is available without membership, but the information contained in the abstract is relevant to a discussion of GMOs and also reveals ongoing testing of GMOs, supporting a conclusion that the results of the GMO experiment are not yet final. Making an educated decision as to inclusion of GMOs in a healthy diet, requires reviewing the scientific facts including new studies that review possible health repercussions of the GMOs. The *Journal of the Council of Nutrition* is published by the American Chiropractic Association Council on Nutrition.

<https://www.acatoday.org/About> ACA is “the largest professional chiropractic organization in the United States” “with the purpose of staying on the cutting edge of new research, breakthroughs and developments in the industry.”

http://www.chiroindex.org/journals.php?search_page=journals&action=view&journalId=1087

The council holds the “[Leading Chiropractic Symposium on Nutrition Research & Preventive Medicine](#)” The abstract is hosted by EBSCO Information Services which is said to “only contain[s] articles from credible and venerable sources,”

<https://www.nar.realtor/what-is-ebSCO> by the one segment of its users who rated EBSCO. EBSCO Information Services is the worldwide leader in providing access to research through libraries. <https://www.ebscoind.com/businesses/ebSCO-information-services/>

DASH-Style diet Associated with Reduced Depression. (2018, February 26), *Rush University*.

<https://www.rush.edu/news/press-releases/dash-style-diet-associated-reduced-risk-depression>

The article details the study mentioned by LaChance & Ramsey (2015) associating reduced depression in seniors with increased produce intake. Rush University Medical Center is one of the top academic medical centers.

Dewey, (2017, May 3). The government is going to counter 'misinformation' about GMO foods, *The Washington Post*.

<https://www.washingtonpost.com/news/wonk/wp/2017/05/03/the-government-is-going-to-try-to-convince-you-to-like-gmo-foods/>

This article is important to consider in deciding how much weight to give information distributed by the mainstream media. If the media is government driven to allay consumer concern about GMOs, it seems necessary to examine the scientific facts rather than the headlines. The Washington Post is considered factually high by *Media Bias/ Fact Check*. <https://mediabiasfactcheck.com/washington-post/>

Diet and Mental Health, (2018), *Mental Health Foundation*.

<https://www.mentalhealth.org.uk/a-to-z/d/diet-and-mental-health>

The relationship between diet and mental health is examined; eating fruits and vegetables as well as the Mediterranean diet are mentioned as linked to better mental health - as is good nutrition early in life. The content also goes into the complex relationship between nutrition and inequalities. The Mental Health Foundation is a well-known charitable organization in England

https://yougov.co.uk/topics/politics/explore/not-for-profit/Mental_Health_Foundation

which at least claims to include some of the leading experts in the field;

<https://www.mentalhealth.org.uk/about-us>

the article contains a number of references including the study by Parletta et al. (2017). Dixon, E., (2019). Common weed killer glyphosate increases cancer risk by 41%, study says, *CNN Health*. <https://www.cnn.com/2019/02/14/health/us-glyphosate-cancer-study-scli-intl/index.html>

“Focusing on data relating to people with the ‘highest exposure’ to the herbicide, researchers concluded that a ‘compelling link’ exists between glyphosate exposure and a greater risk of developing non-Hodgkin lymphoma...’The [report] highlights the need for new, well-designed and robust studies at appropriate exposure levels,’ [Francis]Martin[, a biosciences professor at the University of Central Lancashire,] said, adding, ‘The number of robust studies in the literature examining this question is pathetically small.’...He called the debate over the safety of glyphosate ‘important,’ explaining that ‘glyphosate is used as a general-purpose herbicide so there will be exposure in the general population.’”

The article is relevant in helping to decide if GMOs, which are generally linked to glyphosate at present, are a viable source of nutrition for prime physical, mental and emotional health. “News reporting on the [CNN] website tends to be properly sourced with minimal failed fact checks,” reports *Media Bias/Fact Check*.

<https://mediabiasfactcheck.com/cnn/>

Doctors Need More Nutrition Education, (2017). *Harvard T. H. Chan School of Public Health*.

<https://www.hsph.harvard.edu/news/hsph-in-the-news/doctors-nutrition-education/>

“Today, most medical schools in the United States teach less than 25 hours of nutrition over four years. The fact that less than 20 percent of medical schools have a single

required course in nutrition, it's a scandal. It's outrageous. It's obscene," states David Eisenberg, an adjunct associate professor of nutrition at Harvard T.H. Chan School of Public Health, Harvard. The article is relevant in supporting increased attention to nutrition in medicine. "Chan is ranked as the 2nd best *public health school* in the nation by *U.S. News & World Report*." (https://www.google.com/search?client=firefox-b-1-d&sxsrf=ALeKk03cHETmxhVRxb_I058HliGVoH5T1Q%3A1588029805584&ei=bWmnXvmal8SoytMP89qs-A8&q=harvard+t.+h.+chan+school+of+public+health+credible+source&oq=Harvard+T.+H.+Chan+School+of+Public+Health+credible&gs_lcp=CgZwc3ktYWIQARgBMgUIIRCgATIFCCEQoAE6BAgAEEc6BggAEBYQHjoCCCY6BggAEA0QHjoHCCEQChCgAVD7xQFYis8BYKPGAWgAcAR4AIABpAGIAZgHkgEDMi42mAEAoAEBqgEHZ3dzLXdpeg&client=psy-ab)

Ede, G., (2017). The Antioxidant Myth, *Psychology Today*.

<https://www.psychologytoday.com/us/blog/diagnosis-diet/201712/the-antioxidant-myth>

Georgia Ede, M.D., writes,

Yes, it is true that excess free radicals and oxidation can cause health problems over time. But consuming more antioxidants is NOT the answer. The answer is to understand what oxidation is and what causes it so you can fight it effectively with knowledge and common sense.

Dr. Ede states that the solution to reducing this excess is to "eat real whole foods, and avoid refined carbohydrates like sugar, flour, fruit juice, and processed cereals as much as you possibly can." The article discusses nutritional control of free radicals and

oxidation which is relevant in seeking optimal health of the brain and body. The site is credible and factual and science-based reports *Media Bias/Fact Check*.

<https://mediabiasfactcheck.com/psychology-today/>

Foods Linked to Better Brain power. (n.d.) *Health Beat, Harvard Health Medical*.

<https://www.health.harvard.edu/mind-and-mood/foods-linked-to-better-brainpower>

Harvard Beat provides a brief overview on foods that provide the nutrients needed for optimal brain health; these are the same foods that protect your heart and blood vessels. Brain health is central to mood. “The new health.harvard.edu launched by Harvard Health Publications offers easy accessibility to the most current practical, authoritative health information, drawing on the expertise of the 8,000 faculty physicians at the Harvard Medical School and its world-famous affiliated hospitals,” writes *HealthCare Business News*. <https://www.dotmed.com/news/story/7942/>

Gunnars, K., (2019), Are Vegetable and Seed Oils Bad for Your Health? *Healthline*.

<https://www.healthline.com/nutrition/are-vegetable-and-seed-oils-bad>

“Kris Gunnars is a nutrition researcher with a bachelor's degree in medicine. He founded the website Authority Nutrition, which he sold to Healthline in 2017. Evidence-based nutrition is his passion.” <https://www.healthline.com/nutrition-team>. Gunnars reviews Omega-6 and Omega-3 oils, advising that the human body has not had time to adapt to the large volume of omega-6 fatty acids introduced into the Western diet during the industrial age. Gunnars concludes that health is best served by finding a balance between omega-3 and omega-6 fatty acids; he recommends reducing the use of Omega-6 heavy vegetable and seed oils. Omega-3 fatty acids are important to mental health.

Media Bias/ Fact Check reports that *Healthline* “scientifically sources its information.”

<https://mediabiasfactcheck.com/healthline/>

Gunnars, K., (2018). How to Optimize Your Omega-6 to Omega-3 Ratio,” *Healthline*.

<https://www.healthline.com/nutrition/optimize-omega-6-omega-3-ratio#section4>

Gunnars asserts, “The most important thing you can do to reduce omega-6 intake is to eliminate processed vegetable oils from your diet, as well as the processed foods that contain them.” A chart showing the relative omega-6 contents of different oils is helpful in achieving a balance between omega-6 fatty acids and omega-3 fatty acids thus optimizing the omega-3 fatty acids available for the brain. Healthline is a reliable source. See Gunnars, (2019).

The Key to Mental Health Can Be as Simple as Your Diet, (2018). *Australian Clinical Labs*,

(Reprinted from: Bernstein, E., 2018. Mood food: for better mental health, take a look at the menu, *The Australian*). [https://www.clinicallabs.com.au/about-us/functional-](https://www.clinicallabs.com.au/about-us/functional-media-releases/the-key-to-mental-health-can-be-as-simple-as-your-diet/)

[media-releases/the-key-to-mental-health-can-be-as-simple-as-your-diet/](https://www.clinicallabs.com.au/about-us/functional-media-releases/the-key-to-mental-health-can-be-as-simple-as-your-diet/)

The article discusses the role proper nutrition plays in mental and physical health, mentioning the Mediterranean diet as beneficial and linking low-quality food to increased depression. Bernstein mentions research led by epidemiologist Professor Felice Jacka of Victoria’s Deakin University, and discusses the importance of the intestinal biodome. Dr. Drew Ramsey, a psychiatrist in New York, an assistant clinical professor of psychiatry at Columbia, and the author of *Eat Complete* urges people to think of the brain as an organ, and points out that the only side-effect to good eating is

good health. *The Australian* is reported by *Media Bias/ Fact Check* to have a “clean fact check record.” <https://mediabiasfactcheck.com/the-australian/>

Lachance, L. & Ramsey, D., (2015). Food, Mood and Brain Health: Implications for the Modern Clinician, *Missouri Medicine*.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6170050/>

Laura Lachance, M.D., is at the University of Toronto. Drew Ramsey, M.D., is Assistant Clinical Professor of Psychiatry at Columbia University College of Physicians and Surgeons in New York, NY. Dr. Lachance and Dr. Ramsey write,

Improved, innovative strategies are needed for the prevention and promotion of recovery from mental illness as these disorders leading cause of disability worldwide. This article will review the evidence linking dietary pattern to brain-based illnesses and provide an overview of the mechanisms that underlie the association between brain health and the food we eat. Considerations for dietary intervention will be discussed including encouraging a shift towards a traditional or whole foods dietary pattern.”

The article cites 43 references. There is not much information on *Missouri Medicine*, but it is given an H score of 18 by *Scimago Journal and Country Review*.

<https://www.scimagojr.com/journalsearch.php?q=19081&tip=sid&clean=0> The journal is published by the Missouri State Medical Association which claims to have “a large and respected editorial board and regular participation by Missouri’s six medical schools on eight campuses.” <https://www.msma.org/missouri-medicine.html>

Luther, D., (2017). GMO Apples Hit American Stores This Month: How and Why to Avoid Them,

The Organic Prepper. <https://www.theorganicprepper.com/gmo-apples-hit-american-stores-this-month-how-and-why-to-avoid-them/?fbclid=IwAR22xingdlhY2U-iQQmSiGzMjnxwDcsXp6m9uZQg-MxxwFTdG94auo5itQl>.

Luther discusses the tie between a combination of flavonoids and polyphenols and the health benefits of apples. The enzyme silenced in GMO apples for cosmetic reasons is the polyphenol – polyphenol oxidase. A discussion of the nutritional impact of genetic modification is relevant in deciding if the GMOs can be part of a healthy diet at this point in the GMO experiment. Although *The Organic Prepper* does not appear to have been reviewed for credibility, the study referenced in the article is available <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC442131/> and lists over 80 references.

Markus, C. R. et al., (1998, August). Does Carbohydrate-Rich, Protein-Poor Food Prevent a Deterioration of Mood and Cognitive Performance of Stress-Prone Subjects When Subjected to a Stressful Task?, “*Appetite* (1), pp. 49-65. doi: 10.1006/appe.1997.0155. <https://pubmed.ncbi.nlm.nih.gov/9716435/>

Abstract: This study investigates whether in stress-prone subjects, carbohydrate-rich, protein-poor food (CR/PP) prevents a deterioration of mood and performance under uncontrollable laboratory stress conditions. The assumption was that in stress-prone subjects there is a higher risk of serotonin deficiency in the brain and that carbohydrates may prevent a functional shortage of central serotonin during acute stress, due to their potentiating effect on brain tryptophan. Twenty-four subjects with a high stress-proneness (HS) and 24 subjects with a low stress-proneness (LS) participated in an uncontrollable stress

situation under both a CR/PP and a protein-rich, carbohydrate-poor (PR/CP) diet condition. The plasma ratio of tryptophan to the other large neutral amino acids (LNAA) (ratio Tryptophan/ summation operatorLNAA) was determined as a measure indicating the dietary effect on brain tryptophan and serotonin levels. Significant increases were found in the ratio tryptophan/ summation operatorLNAA during the CR/PP diet compared with the PR/CP diet. Experimental stress had significant effects on pulse rate, skin conductance, cortisol and mood in all subjects. During the CR/PP diet only the HS subjects did not show the stress-induced rise in depression, decline in vigour and cortisol elevation that they showed after the PR/CP diet. With respect to cognitive performance, significant dietary effects were found on reaction time. It is suggested that CR/PP food in HS subjects may increase personal control, probably under the influence of higher levels of brain tryptophan and serotonin.”

The study is of interest because it supports a correlation between food and better mental health. *Appetite* is highly rated by *Scimago Journal & Country Rank*.

<https://www.scimagojr.com/journalsearch.php?q=29994&tip=sid&clean=0>

Mount, R., (n.d.). How Do Genetically Modified Foods Affect Your Health?, *Oprah.com*.

<http://www.oprah.com/health/genetically-modified-foods-affect-health-and-body>

Mount mentions some of the risks that are associated with GMOs and argues that GE products should be labeled. Finding a review of *Oprah.com*'s validity one way or the other is difficult, but certainly Mount raises 2 valid points: GMOs have not been around

long enough to evaluate long-term effects on human health, and Americans have the right to know what they are eating.

National Academies of Science, (2020). Wikipedia.

https://en.wikipedia.org/wiki/National_Academies_of_Sciences,_Engineering,_and_Medicine

At the National Academies of Science” conflicts of interest are present for many of the scientists; “the Academies must take steps to ensure their panels are truly independent from the industries whose practices they often study” recommends the Center for Science in the Public Interest. For example, “10 out of 11 scientists on a ‘State Practices in Setting Mobile Source Emissions Standards’ panel had ties to carbon-emitting industries.” <https://cspinet.org/new/200607241.html> To ensure a fair review of controversial GMOs, it was important to have a source that might hope for a positive outcome for GMOs.

National Academies of Sciences, Engineering, and Medicine; Division on Earth and Life Studies; Board on Agriculture and Natural Resources; Committee on Genetically Engineered Crops, Past Experience and Future Prospects, (2016). Human Health Effects of Genetically Engineered Crops,. *Genetically Engineered Crops: Experiences and Prospects*, National Academies Press. <https://www.ncbi.nlm.nih.gov/books/NBK424534/>

In this chapter, the committee examines the evidence that substantiates or negates specific hypotheses and claims about the health risks and benefits associated with foods derived from genetically engineered (GE) crops. There are many reviews and official statements about the safety of foods from GE crops ..., but to conduct a fresh examination of the evidence, the committee read through

a large number of articles with original data so that the rigor of the evidence could be assessed.” See (National, 2020) for source credibility.

No Need to Avoid Healthy Omega-6 Fats (2019, August) Harvard Health Letter, *Harvard Health Publishing*. https://www.health.harvard.edu/newsletter_article/no-need-to-avoid-healthy-omega-6-fats

Another look into the benefits of Omega-3 and Omega-6 oils. There are benefits to Omega-6 fatty acids such lowering LDL cholesterol, boosting protective HDL and improving the body’s response to insulin. Because of the benefits of omega-6 fatty acids, balancing them with omega-3s is the answer.”

This article guides the reader on the health-related question of achieving optimal levels of omega-6 fatty acids and omega-3 fatty acids. The material in the Harvard Health letter is ‘rigorously’ reviewed by an “array of specialists.”

<https://jamanetwork.com/journals/jamainternalmedicine/article-abstract/586171>

Neurogenesis (n.d.). *Wikipedia*, <https://en.wikipedia.org/wiki/Neurogenesis>

The source is only used to define neurogenesis.

Parletta, N., Zarnowiecki, D., Cho, J., Wilson, A.,; Bogolmolova, S., Villani, A., Itsiopoulos, C.,

Niyonsenga, T., Blunden, S., Meyer, B., Segal, L., Baune, B., O’Dea, K., (2017). A

Mediterranean-style dietary intervention supplemented with fish oil improves diet

quality and mental health in people with depression: A randomized controlled trial

(HELFIMED), *Nutritional Neuroscience > An International Journal on Nutrition, Diet and*

Nervous System: Volume 22(7).

[https://www.tandfonline.com/doi/full/10.1080/1028415X.2017.1411320?mod=article_](https://www.tandfonline.com/doi/full/10.1080/1028415X.2017.1411320?mod=article_inline&)
[line&](https://www.tandfonline.com/doi/full/10.1080/1028415X.2017.1411320?mod=article_inline&)

“The researchers investigated whether a Mediterranean-style diet (MedDiet) supplemented with fish oil can improve mental health in adults suffering depression. DISCUSSION: This is one of the first randomized controlled trials to show that healthy dietary changes are achievable and, supplemented with fish oil, can improve mental health in people with depression....A range of essential nutrients are required for healthy brain function and they also work synergistically; therefore improving the whole diet is likely to have far greater benefit for mental health than any single nutrient alone.”

The study has a substantial list of sources. It was hard to find too much information on the journal, except that it is peer-reviewed, and is given an SJR score of 0.939 by *Scimago Journal and Country Rank*,

<https://www.scimagojr.com/journalrank.php?country=GB&type=j&category=2801>

meaning that the journal is cited at a nearly average (1) rate.

The journal is published on the web by Taylor & Francis, which is mentioned by *International Science Editing* as a publisher that would be used by a reputable journal.

<https://www.internationalscienceediting.com/avoid-predatory-journals/>

Peairs, F. B., (2014). Managing Corn Pests with Bt Corn, *Colorado State University Extension*.

<https://extension.colostate.edu/topic-areas/agriculture/managing-corn-pests-with-bt-corn-0-708/>

Peairs delves into some of the science behind Bt corn. Understanding the scope of GMO variations, even within the same product, casts light on the extent of testing required to ensure that GMOs are a healthy inclusion in the diet of humans seeking optimal health.

F.B. Peairs, is an entomologist and professor in bioagricultural sciences and pest management at Colorado State University Extension. Colorado State University offers a number of M.A. and Ph. D. programs in bioagriculture.

<https://catalog.colostate.edu/general-catalog/colleges/agricultural-sciences/bioagricultural-sciences-pest-management/#graduate-text> The university “holds exclusive statewide authority for programs in agriculture, forestry, natural resources, and veterinary medicine.”

<https://www.phdportal.com/universities/11257/colorado-state-university.html>

Porterfield, A., (2015). Are GMOs to blame for the loss of nutrients in our fruits and vegetables?, *The Genetic Literacy Project*,

<https://geneticliteracyproject.org/2015/11/19/gmos-blame-loss-nutrients-fruits-vegetables/>

Porterfield mentions a few reasons for a decline of nutrients in fruits and vegetables, suggesting that breeding for certain traits might cause a decline in others, such as the nutrients in-GMO food. The article is a discussion, rather than a study, but his hypothesis merits testing. The Genetic Literacy Project is rated high for factual content by *Media Bias/ Fact Check*. <https://mediabiasfactcheck.com/genetic-literacy-project/>

Samsel, A. & Seneff, S., (2013). Glyphosate, Pathways to Modern Diseases II: Celiac Sprue and

Gluten Intolerance, *Interdisciplinary Toxicology*, 6(4), pp. 159-84.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3945755/>

Abstract: Celiac disease, and, more generally, gluten intolerance, is a growing problem worldwide, but especially in North America and Europe, where an estimated 5% of the population now suffers from it. Symptoms include nausea, diarrhea, skin rashes, macrocytic anemia and depression. It is a multifactorial disease associated with numerous nutritional deficiencies as well as reproductive issues and increased risk to thyroid disease, kidney failure and cancer. Here, we propose that glyphosate, the active ingredient in the herbicide, Roundup[®], is the most important causal factor in this epidemic. Fish exposed to glyphosate develop digestive problems that are reminiscent of celiac disease. Celiac disease is associated with imbalances in gut bacteria that can be fully explained by the known effects of glyphosate on gut bacteria. Characteristics of celiac disease point to impairment in many cytochrome P450 enzymes, which are involved with detoxifying environmental toxins, activating vitamin D3, catabolizing vitamin A, and maintaining bile acid production and sulfate supplies to the gut. Glyphosate is known to inhibit cytochrome P450 enzymes. Deficiencies in iron, cobalt, molybdenum, copper and other rare metals associated with celiac disease can be attributed to glyphosate's strong ability to chelate these elements. Deficiencies in tryptophan, tyrosine, methionine and selenomethionine associated with celiac disease match glyphosate's known depletion of these amino acids. Celiac disease patients have an increased risk to non-Hodgkin's lymphoma, which has also been

implicated in glyphosate exposure. Reproductive issues associated with celiac disease, such as infertility, miscarriages, and birth defects, can also be explained by glyphosate. Glyphosate residues in wheat and other crops are likely increasing recently due to the growing practice of crop desiccation just prior to the harvest. We argue that the practice of “ripening” sugar cane with glyphosate may explain the recent surge in kidney failure among agricultural workers in Central America. We conclude with a plea to governments to reconsider policies regarding the safety of glyphosate residues in foods.

PMC includes only peer-reviewed research. <https://ajhb.org/journal/pubmed-and-pmc/> and *Interdisciplinary Toxicology* is given a good H-index ranking by *Scimago Journal and Country Rank*.

<https://www.scimagojr.com/journalsearch.php?q=19700177407&tip=sid&clean=0>

Other published studies also have found a link between celiac disease and intestinal flora <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4555153/>

as well as a link between glyphosate and damage to the intestinal biodome.

<https://www.ncbi.nlm.nih.gov/pubmed/31442459>

Scientists Explore How Nutrition May Feed Mental Health, (2017). *Clinical Psychological Science*, Association for Psychological Science.

<https://www.psychologicalscience.org/news/releases/scientists-explore-how-nutrition-may-feed-mental-health.html>

“Clinical Psychological Science is a journal of the Association for Psychological Science.

Decades of research have shown the importance of proper nutrition in preventing and

treating the ill effects of inflammation and stress, physiological processes that are intimately linked with mental health.” A number of studies are cited. The journal has a good rating in *Scrimago Journal & Country Ratings*.

<https://www.scimagojr.com/journalsearch.php?q=21100274406&tip=sid&clean=0>

Selhub, E. (2015). Nutritional psychiatry: Your brain on food, *Harvard Health Publishing*

<https://www.health.harvard.edu/blog/nutritional-psychiatry-your-brain-on-food-201511168626>

Selhub delves briefly but informatively into nutritional psychiatry and how nutrition and mood are connected. She mentions the benefits of a traditional or Mediterranean diet as well as the important role of the intestinal microbiome and cites a number of studies. Harvard Medical School is rated #5 and its research #8.

<https://www.scimagojr.com/institution.php?idp=58731>

Spritzler, F., (2019). 6 Foods That Cause Inflammation, Healthline.

<https://www.healthline.com/nutrition/6-foods-that-cause-inflammation#1>

Spritzler explains that some inflammation is useful at times, but chronic inflammation can lead to illness. Inflammation can be eased by the right food choices. She advises against eating sugar and corn syrup, trans fats, vegetable and seed oils, refined carbohydrates, excessive alcohol and processed meat. Franziska Spritzler, RD, CDE, “has a BSc in nutrition and dietetics. She is a registered dietitian and Certified Diabetes Educator with expertise in carbohydrate-restricted diets for diabetes and weight management.” <https://www.healthline.com/nutrition-team> Healthline is a reliable source. See Gunnars, 2019.

Spritzler, F. (2019). 8 Health Benefits of Nuts, *Healthline*:

<https://www.healthline.com/nutrition/8-benefits-of-nuts>

Spritzler details the varied nutritional benefits of nuts; nuts “have a number of impressive health and weight benefits.” Walnuts are mentioned as specifically beneficial for the brain in “Foods Linked to Better Brain Power,” *Health Beat*; nuts were mentioned in general in the Mediterranean diet. The purpose of this article was to confirm that nuts beyond walnuts are a good addition to a healthy diet which because of the interconnectivity of the mind and body would aid in the pursuit of happiness.

Healthline is a reliable source. See (Gunnars, 2019).

Sprouse, S., (n.d.). Master your mood, *Ask the Scientists*. <https://askthescientists.com/science-of-mood/>

Sydney Sprouse is a freelance science writer based out of Forest Grove, Oregon. She holds a bachelor of science in human biology from Utah State University, where she worked as an undergraduate researcher and writing fellow. Sydney is a lifelong student of science and makes it her goal to translate current scientific research as effectively as possible. She writes with particular interest in human biology, health, and nutrition. In this article she reviews the chemistry behind moods and methods to increase positive moods.

There were no reviews of the credibility of this source, but the article is well-referenced and is only being used as a source of biological information about brain chemicals, which can be easily confirmed.

“Superweeds” Sprout Farmland Controversy Over GMOs, (2014, January), *NBC News*.

<https://www.nbcnews.com/business/economy/superweeds-sprout-farmland-controversy-over-gmos-n214996>

“Weeds are developing resistance to herbicides, because the modified seeds can tolerate greater use of certain herbicides and pesticides. And it's reportedly costing farmers \$1 billion in lost crops.” *NBC* is well rated by *Media Bias/ Fact Check*.

<https://mediabiasfactcheck.com/nbc-news/>

Szalay, J., (2018). What Is Inflammation?. *Live Science*.

<https://www.google.com/amp/s/www.livescience.com/amp/52344-inflammation.html>

Szalay differentiates between useful inflammation which heals wounds and the adverse effects of chronic inflammation or of an inflammation response where it is not needed. He recommends an anti-inflammatory diet, and mentions the Mediterranean diet as an option. This information was important in defining inflammation; an inflammatory diet is associated with depression. The article also ended up being relevant in considering the consequences of GMOS; GMOs are associated with elevated white blood cell count in the National Academies of Sciences review of studies done on GMOs and Szalay connects a high white blood cell count with inflammation. *Live Science* is a reputable source that is rated “High for factual reporting due to proper sourcing and a clean fact check record.” <https://mediabiasfactcheck.com/live-science/>

Western Pattern Diet, (n.d.). *Wikipedia*.

https://en.m.wikipedia.org/wiki/Western_pattern_diet

Wikipedia defines the western pattern of eating, also called the Standard American Diet. The article describes this style of eating, for example that only 13% of Americans

consume the recommended amount of vegetables, and mentions health drawbacks associated with this style of eating. This article was useful as a general overview of American eating habits so that general patterns might be contrasted to a traditional diet. The article does have some limitations such as needing more medical references, but has a number of sources. A deeper study of American eating habits and physical health repercussions would be a subject for another paper.”

Notes on GMOs from:

National Academies of Sciences, Engineering, and Medicine; Division on Earth and Life Studies; Board on Agriculture and Natural Resources; Committee on Genetically Engineered Crops, Past Experience and Future Prospects, (2016). Human Health Effects of Genetically Engineered Crops,. *Genetically Engineered Crops: Experiences and Prospects*, National Academies Press.

<https://www.ncbi.nlm.nih.gov/books/NBK424534/>

A review of cited facts for the purpose of determining if GMOs can play a role in a healthy traditional diet if they are not connected to Glyphosate.

Some of the flaws listed by the Scientists in reviewing testing for the safety of GMOs:

- As part of the regulatory process of establishing substantial equivalence, GE crop developers submit data comparing the nutrient and chemical composition of their GE plant with a similar (isoline) variety of the crop. In the United States, submitting such data to FDA is voluntary, although as of 2015 this seems to always be done by developers.
- Some differences between a GE food and its non-GE counterpart are intentional and identifiable (for example, the presence of a *Bt* toxin in maize kernels) or are due to practices directly associated with the use of the GE crops (for example, increased use of glyphosate) New routes of exposure to, for example the naturally-occurring plant toxin

Bt introduced into maize in order to create pest resistance “could result in unanticipated effects.”

In contrast with such intended differences, some potential differences between GE crops and their non-GE counterparts are unintentional and can be difficult to anticipate and discern (NRC, 2004). Two general sources of unintended differences could affect food safety:

Unintended effects of the targeted genetic changes on other characteristics of the food (for example, the intended presence of or increase in one compound in plant cells could result in changes in plant metabolism that affect the abundance of other compounds).

Unintended effects associated with the genetic-engineering process (for example, DNA changes resulting from plant tissue culture).

In some cases, the unintended effects are somewhat predictable or can be determined; in such cases, tests can be designed. In other cases, the change or risk could be something that has not even been considered, so the only effective testing is of the whole food itself. ... there is a tradeoff between costs of such testing and societal benefits of reduction in risks

- OECD (1998a) made general recommendations, such as those used in Hammond et al. (2004), for the number of units (cages with two animals) per treatment. Following these guidelines leads to the assumption that less than a 25-percent change in the white blood cell count was not biologically relevant.

Note: Unlike acute inflammation, chronic inflammation can have long-term and whole-body effects. Chronic inflammation is also called persistent, low-grade inflammation because it

produces a steady, low-level of inflammation throughout the body, as judged by a small rise in immune system markers found in blood or tissue. This type of systemic inflammation can contribute to the development of disease, according to a summary in the Johns Hopkins Health Review.

Low levels of inflammation can be triggered by a perceived internal threat, even when there isn't a disease to fight or an injury to heal, and sometimes this signals the immune system to respond. As a result, white blood cells swarm but have nothing to do and nowhere to go, and they may eventually start attacking internal organs or other healthy tissues and cells, Walker said (Szalay, 2018).

- The problem in most whole-food animal studies is in determining how large a biological difference is relevant. Most of the statistically significant differences observed in the literature on the animal-testing data were around a 10- to 30-percent change, but the authors do not give detailed explanations of why they conclude that a statistically significant difference is not biologically relevant. A general statement is sometimes made that the difference is within the range for the species, but because the range of values for the species typically come from multiple laboratories, such a statement is not useful unless the laboratories, instrumentation, and health of the animals were known to be comparable.
- RECOMMENDATION: Before an animal test is conducted, it is important to justify the size of a difference between treatments in each measurement that will be considered biologically relevant.

- Rice was genetically engineered to produce the kidney bean lectin... in rats: “biological effects including significant differences in weight of small intestines, stomach, and pancreas and in plasma biochemistry were found.”
- Most of them were conducted in one prolific laboratory (Walsh et al., 2011, 2012a,b, 2013; Buzoianu et al., 2012a,b,c,d, 2013a,b). The authors of the studies generally concluded that *Bt* maize does not affect health of the pigs, but they reported a number of statistically significant differences between *Bt* maize treatment and control maize treatment.
- In addition to the work of Séralini et al. (2012, 2014), there have been other long-term rodent studies, some of which included multiple generations. Magana-Gomez and de la Barca (2009), Domingo and Bordonaba (2011), Snell et al. (2012), and Ricroch et al. (2013b) reviewed the studies. Some found no statistically significant differences, but quite a few found statistically significant differences that the authors generally did not consider biologically relevant, typically without providing data on what was the normal range.

For example, Kiliç and Akay (2008) conducted a three-generation rat study in which 20 percent of the diet was *Bt* maize or a non-*Bt* maize that otherwise was genetically similar. The authors found statistical differences in kidney and liver weights and long kidney glomerular diameter between the GE and non-GE treatments but considered them not biologically relevant. Similarly, statistically significant differences were observed in amounts of globulin and total protein between the two groups. There was

no presentation of standards used for judging what would be a biologically relevant difference or for what the normal range was in the measurements.

- The standard deviations in measurements of the traits (that is, effects) of individual animals in a treatment in the long-term studies were similar to those of studies of shorter duration. Therefore, the power of the tests to detect statistically significant differences was in the range of 10–30 percent. The committee could not find justification for considering this statistical power sufficient. It can be argued that the number of replicates (number of units of two animals per treatment) in the studies should be substantially increased, but one argument against an increase in numbers is related to the ethics of subjecting more animals to testing (EC, 2010b). ***One could also argue that it is unethical to conduct an underpowered study.***
- If a straightforward application of Bonferonni correction is used, each animal study that measures multiple outcomes, whether for GE crops or any other potential toxicant, could require over 1,000 animals to obtain reasonable statistical power (Dunn, 1961).
- When a gene has been added specifically to alter one metabolic pathway of a plant, a number of predicted and unpredicted changes have been found.
- The logic behind the approach starts with the fact that any gene for a protein that comes from a plant that is known to cause food allergies has a higher likelihood of causing allergenicity than any gene from a plant that does not cause an allergic response. If the introduced protein is similar to a protein already known to be an allergen, it becomes suspect and should be tested in people who have an allergy to the related protein. Finally, if a protein fits none of the above characteristics but is not

digested by simulated gastric fluid, it could be a novel food allergen. The latter factor comes from research demonstrating that some, but not all, proteins already known to be food allergens are resistant to digestion by gut fluid.

- Therefore, researchers have relied on multiple indirect methods for predicting whether an allergic response could be caused by a protein that is either added to a food by genetic engineering or appears in the food as an unintended effect of genetic engineering. Endogenous protein concentrations with known allergic properties also have to be monitored because it is possible that their concentration could increase due to genetic engineering.
- The testing does not cover endogenous allergens whose concentrations have been increased by unintended effects of genetic engineering.
- There can be a connection between immune response and allergenicity. One well-cited study brought up in the public comment period was that by Finamore et al. (2008), who assessed the effect of *Bt* maize ingestion on the mouse gut and peripheral immune system. They found that *Bt* maize produced small but statistically significant changes in percentage of T and B cells and of CD4+, CD8+, $\gamma\delta$ T, and $\alpha\beta$ T subpopulations at gut and peripheral sites and alterations of serum cytokines in weanlings fed for 30 days and in aged mice.
- To ensure that allergens did not remain in the food system, the *Safety of Genetically Engineered Foods* report called for a two-step process of pre-commercialization testing and post-commercialization testing. Even though progress has been made on allergenicity prediction since that report was published in 2004, the committee found

that post-commercialization testing would be useful in ensuring that no new allergens are introduced. There have been no steps toward post-commercialization testing since 2004. The committee recognized that such testing would be logistically challenging,

- FINDING: There is a substantial population of persons who have higher than usual stomach pH, so tests of digestibility of proteins in simulated acidic gastric fluid may not be relevant to this population.
- The committee presents the available data knowing that they include a number of sources of bias, including changes over time in survey methods and in the tools for detection of specific chronic diseases. As imperfect as the data may be, they are in some cases the only information available beyond animal experiments for formulating or testing hypotheses about possible connections between a GE food and a specific disease. ***The committee points out [that] the lack of rigorous data on incidence of disease.***
- Assessment of glyphosate is relevant to the committee's report because it is the principal herbicide used on HR crops (Livingston, et al. 2015), and it has been shown that there are higher residues of glyphosate in HR soybean treated with glyphosate than in non-GE soybean
- The 2015 IARC Working Group found that, ... there is "*sufficient evidence* in experimental animals for the carcinogenicity of glyphosate" (IARC, 2015:78). Furthermore, IARC noted that there is mechanistic support in that ***glyphosate induces oxidative stress***, which could cause DNA damage, and some epidemiological data that support the classification.

- Smith (2013) hypothesized that consuming GE foods increased gut permeability.
- *Bt* gene and protein in pigs that have digestive systems that are more similar to that of humans. They found no evidence of the gene or protein in any organs or blood after 110 days of feeding on *Bt* maize, but they did find them in the digestive contents of the stomach, cecum, and colon. Fragments of Cry1Ab transgene (as well as other common maize gene fragments) but not the intact *Bt* gene were found in blood, liver, spleen, and kidney of pigs raised on *Bt* maize
- No consistent pattern of positive associations indicating a causal relationship between total cancer (in adults or children) or any site-specific cancer and exposure to glyphosate. [*In contrast to the statement above saying that glyphosate does cause cancer in animals.*]
- Conclusion:

As acknowledged at the beginning of the chapter, understanding the health effects of any food, whether non-GE or GE, can be difficult. The properties of most plant secondary metabolites are not understood, and isolating the effects of diet on animals, including humans, is challenging. Although there are well-developed methods for assessing potential allergenicity of novel foods, these methods could miss some allergens.

Long-term epidemiological studies have not directly addressed GE food consumption,