

Soak Up the Sun

How Sun Affects and Protects the Brain

by Benjamin Dorfman



The Sun's rays travel millions of miles through the void of space empowering billions of life forms to grow and thrive here on Earth. This energizing process seems like it could be something of science fiction as every second of every day this remarkable synergistic relationship between the Sun and the organisms on Earth occurs. Humans are one of the many organisms on which sunlight exerts its 'magical' effects. Sunlight is known to affect many different cellular and metabolic pathways, several of which have remarkable effects on our brains.

Before we get into the powerful mind-altering effects of the sun, I will discuss what even is sunlight and what chemicals does its rays propagate? Sunlight is composed of a spectrum of rays. These rays include visible light, ultraviolet light (UV light) and infrared light. There are three types of UV light; UVA, UVB and UVC. UVC is blocked by the Earth's stratosphere so only UVA and UVB reach Earth's surface. It is thought that UVB radiation most greatly contributes to the production of a compound colloquially known as 'the sunshine vitamin'; vitamin D.¹ Vitamin D is one of the most exciting and useful substances that our body produces.

Now one may logically ask themselves how does UVB radiation from the sun lead to the production of vitamin D? When the sun makes contact with the skin, a compound within the skin called 7-dehydrocholesterol is converted to previtamin D3. The process is summarized below.

Vitamin D is synthesized in the spring and summer months when sunshine is abundant and the angle of incidence of the sun is the strongest. Now you may be asking yourself; why can't I just take vitamin D in supplement form? Well, you can but the vitamin D found in

supplements and in food supply will be much less effective at getting into your bloodstream compared to the vitamin D that will be produced from sunlight exposure. The vitamin D produced from the reaction of UV and skin lasts twice as long in the blood compared to exogenous vitamin D like the vitamin D sold as supplements or in food. Vitamin D serves an important function in many systems of the body as it exerts its effects on bones, intestines, immune and cardiovascular vascular systems, and the pancreas.² Although these bodily functions are important I believe one of the biggest impacts vitamin D has on the body is its power to profoundly change the mind. In addition to alleviating symptoms of depression and seasonal affective disorder, sunlight and vitamin D have proven to be helpful in combating some of the most poorly understood and complicated neurological disorders that affect millions of people. These disorders include some of the most tragic and common disorders

that affect our culture, but luckily recent studies are shedding light on how sunlight and vitamin D may serve as a giant step forward in the treatment of Parkinson's, multiple sclerosis, Alzheimer's and depression.

Sunlight Vitamin D and Depression

In our culture, one of the biggest culprits that shortens lifespans, impares productivity and ruins people's lives is depression. Depression is by far the leading cause of disability worldwide, affecting over 260 million people.³ Despite pharmacology's best efforts, there is no effective way to treat depression. Many who suffer from this disease try treatment after treatment in search of relief. Over half of the individuals who suffer from depression decide to discontinue their pharmacological treatment after two months.⁴ Additionally, the rates of depression have been rising dramatically in the United States for the last couple decades.

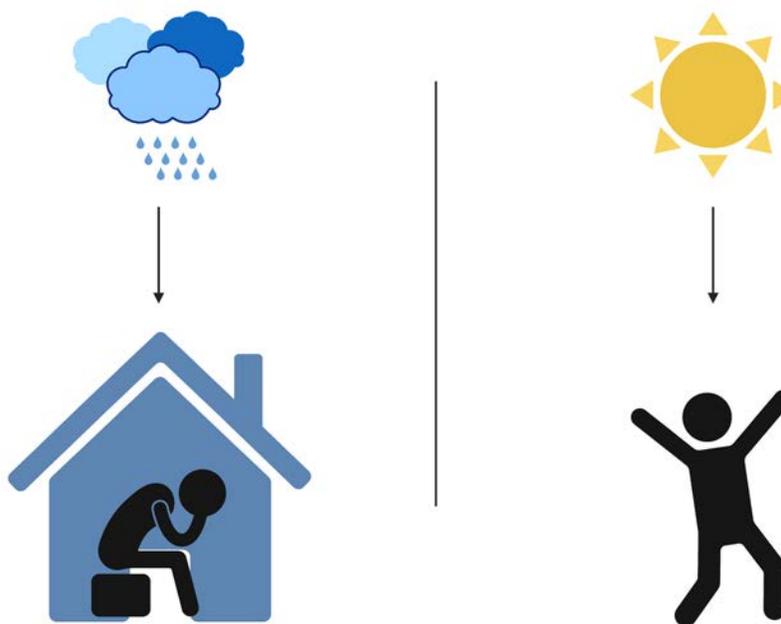


Figure 1. Sunlight, and in turn, Vitamin D production, lead to positive neurological changes that have been associated with many positive mental states. Original image by Benjamin Dorfman. Created in BioRender.

This suggests that preventative and treatment measures for this debilitating disease need to improve and therefore new implementations may be necessary. One of the many treatments for alleviating depression that has been used is called heliotherapy. Heliotherapy is the use of light to alleviate illness, in this case depression. There are still many questions as to why heliotherapy works as a treatment for depression but researchers think it may have to do with increased levels of vitamin D and increases in dopamine following treatment. In one study researchers gave participants an exposure to either one hour of sunlight, a dose of vitamin D or a placebo control. After a given period of time, the researchers found that those who received one hour of sunlight or a dose of vitamin D had significantly reduced reported symptoms of depression.⁵ This research suggests that there may be an underutilized use of sunlight and vitamin D as potential treatment for a debilitating disease that has seemed to stump medical professionals during the recent era. Despite the studies being 'new',

the knowledge of the sun having a profound impact on mental states is extremely old. However this old wisdom has only recently been seriously investigated in a clinical manner.

Sunlight Vitamin D and Parkinson's

The cause of Parkinson's disease is unknown but is tied to dysfunction of the neurotransmitter dopamine. Several treatments are used to treat this disease most notably L-Dopa. Unfortunately, L-Dopa is not 100% effective and comes with pretty nasty side effects. The part of the brain responsible for dopamine production is called the substantia nigra. Damage to this region is a hallmark of Parkinson's disease. Researchers think that vitamin D and Parkinson's may be connected because the vitamin D receptor is highly expressed in the substantia nigra.⁶ The vitamin D receptor is the principal site by which vitamin D exerts its effects in the brain. More striking evidence that suggests vitamin D may play a role in Parkinson's is the connection between motor function and the

vitamin D receptor. One of the hallmark symptoms of Parkinson's disease is dysfunction in normal motor functioning. Mice who do not express vitamin D receptors show high levels of impairment in motor function. The high prevalence between vitamin D deficiency and Parkinson's was first noticed in 1997.⁷ The exact mechanism by which vitamin D may help Parkinson's patients is still unknown but several hypotheses are being tested. One theory is that vitamin D increases the expression of two compounds called neurotrophin 3 (NT-3) and Glial Cell Line derived neurotrophic factor (GDF). These compounds play an important role in protecting the brain from foreign compounds. Another theory by which vitamin D protects against Parkinson's is vitamin D's role in changing how some gaseous molecules act. Vitamin D inhibits the synthesis of a molecule called INOS which in high concentrations, can severely damage neurons.

Sunlight, Vitamin D and Multiple Sclerosis

Another disease that is highly intertwined with vitamin D is multiple sclerosis. Multiple sclerosis is an autoimmune disease, meaning that it is a condition that involves irregular function of the immune system. This is important because vitamin D's beneficial effect on multiple sclerosis patients is because of vitamin D's effect on the immune system. Multiple sclerosis is mainly characterized by over-activity of the immune response and is largely tied to a group of cells called T-Cells. Vitamin D may help mitigate the immune response by acting on T-Cells. Vitamin D reduces the activity of several compounds that T-cells release called cytokines. It

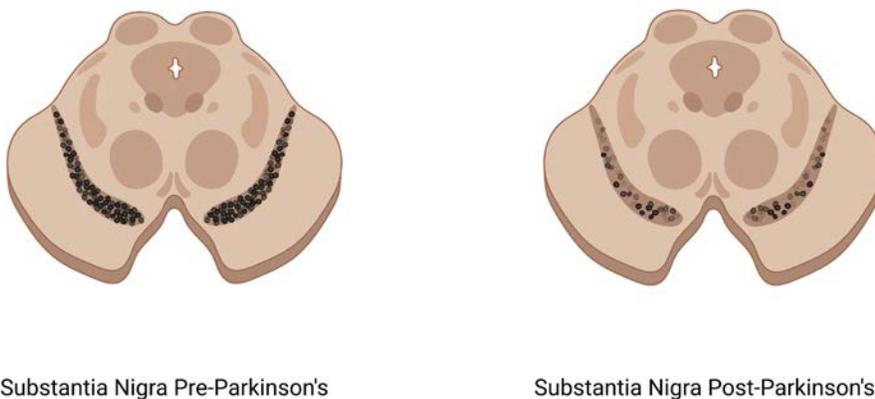


Figure 2. The Substantia Nigra pre-Parkinson's and post-Parkinson's. Dopamine neurons represented by the black dots have severely decreased after Parkinson's diagnosis. The loss of dopamine has been tied to Vitamin D loss. Original image by Benjamin Dorfman. Created in BioRender.



Figure 3. Children being treated for a variety of mental conditions with nature's oldest treatment, the sun. National Library of Medicine, Science Photo Library. 1926.

has been shown in large population based studies that individuals with higher levels of Vitamin D reduce their risk for developing multiple sclerosis. Additionally, patients who already have multiple sclerosis have a reduction in symptoms following treatment (such as heliotherapy) that increases vitamin D levels.

Sunlight, Vitamin D and Alzheimer's

Alzheimer's disease is the most common neurodegenerative disease amongst elderly individuals. This tragic condition is best characterized by progressive memory loss. Bone mineral density is also significantly decreased in the earlier stages of Alzheimer's disease. The symptoms of Alzheimer's disease suggests severe defects in proper endocrine system functioning. This is where vitamin D may be able to alleviate some of the symptoms of Alzheimer's as well as decrease one's risk for Alzheimer's by changing the processes in the endocrine system. In one study, 54% of Alzheimer's patients displayed 'osteomalacic' levels of vitamin D, meaning that the levels of vitamin

D were deficient enough to cause bone weakening. Additionally, vitamin D may be implicated in Alzheimer's disease patients as it was found that there is decreased vitamin D receptor expression in the hippocampal layer of Alzheimer's disease patients. An enzyme called the angiotensin converting enzyme (ACE) is found to have higher levels of activity in Alzheimer's patients. Treatment with calcitriol (the active form of vitamin D) has been found to decrease the levels of ACE activity in bovine endothelial cells. Irregularities of glucose metabolism are a hallmark of Alzheimer's disease patients so much so that type 2 diabetes has been shown as a major risk factor for patients with Alzheimer's disease. Patients with Alzheimer's disease have much higher body mass indexes than the majority of the populus. This suggests that a regulatory mechanism for glucose and feeding habits might prevent the onset or may help risk mitigation in Alzheimer's disease patients. Presently there is no cure for this terrible disease that causes parents to forget their children's names after a lifetime of connection.

Although there is no cure, there are treatments that may alleviate some of the symptoms and there may be preventative measures one can take to reduce their risk of getting Alzheimers. This is where sunlight and vitamin D enters the equation. Vitamin D clears amyloid plaques, which are a signature of Alzheimer's. Amyloid plaques consist of misfolded proteins that are present between cells of the nervous system. Vitamin D exerts its effects on the vitamin D receptors that are ubiquitous throughout the brain. In a study conducted in 2017, it was found that vitamin D is a potent therapeutic agent for Alzheimer's.⁸

Vitamin D as a Neuroprotective Agent and Cognitive Enhancer/Nootropic

One of the reasons vitamin D may be a good candidate for reducing the chances of acquiring Alzheimer's is that it plays an essential role in neural development. In mice models, it has been shown that vitamin D



Figure 4. Left: A boy in the 1970s who suffers from Rickets due to Vitamin D deficiency. The boy's legs and arms are deformed due to weakening of the bones from Vitamin D deficiency. Right: Two children suffering from sunlight deficiency are exposed to a sunlight bath. London 1915.

deficiencies correlate with learning and memory deficits as well as grooming behavior irregularities.⁹ Another study showed that vitamin D was essential at the beginning of life in order to decrease risk to serious pathological diseases like schizophrenia. Vitamin D also has neuroprotective effects that protect the brain from dangerous pathogens. In early life, vitamin D has protective effects that affect how brain cells divide, connect, and develop. The cognitive effects of vitamin D are so striking that in one study patients were asked to take a cognitive function test called the Mini-mental state examination. In this study it showed that individuals with sufficient levels of vitamin D were much more likely to score higher on the examination than patients who were vitamin D deficient. In one animal model, a study showed that vitamin D deficient animals were much more likely to have reduced spatial memory compared to their controls. Long term treatment with vitamin D has been shown to increase the amount of neurons in a region important to memory called the CA1 region. After all these profound effects, one may question why vitamin D isn't discussed more as a healthy alternative to many

pharmacological interventions that are currently used.

Sunlight, Vitamin D and Obesity

Many of the chronic diseases that we struggle with are largely preventable. Diseases like cancer, cardiovascular disease and obesity account for 60% of global mortality.¹⁰ Obesity is defined by an unhealthy weight which is often defined by body mass index or BMI. 42.4% of Americans are classified as obese.¹¹ The downstream effects of obesity include higher risk of death from virtually all diseases. A large percentage of this premature mortality could be mitigated by changing our lifestyles by incorporating higher levels of outdoor exposure and therefore higher vitamin D levels in the population. Many studies have suggested that sunlight exposure and vitamin D have profound effects on obesity levels. Shockingly, several studies have shown that there is an inverse correlation between body mass index and serum vitamin D levels.¹² In adipose tissue, commonly known as fat tissue, the process of lipogenesis or 'the birth of fat tissue' increases when an individual

is vitamin D deficient. Both obesity and vitamin D deficiency should be taken seriously as public health risks. The prevalence of both of these conditions contributes greatly to the loss of several years of many people's lives and is largely preventable and reversible with the proper education and intervention.

Evolutionary Rationale Behind the Vitamin D Deficiency

Many scientists hypothesize that many of the neurological and psychological diseases we experience today are a result of a changing environment. Less exposure to vitamin D may be a piece of this puzzle. Our ancestors lived in environments and consumed foods that were high in vitamin D. Additionally, our early ancestors evolved near the equator and were therefore exposed to high levels of vitamin D throughout the entire year. As humans spread throughout the world we expanded further and further north to latitudes that see very little sunlight. This migratory pattern as well as the advent of clothing and extremely comfortable home environments has taken away from our natural exposure to vitamin D. Once humanity started building tall buildings and big cities, the sun was shielded from many people. This shielding of the sun was so pronounced that it led to a remarkable outbreak of Rickets, a disease characterized by severe bone softening and weakening. In the late 1800's it is estimated that an astonishing 90% of all children living in industrialized Europe and North America had been affected by Rickets.¹³

By the beginning of the 20th century, doctors throughout the world were prescribing sunlight to prevent rickets. Additionally many children were put in front of

mercury lamps to help absorb more UV and prevent Rickets. Rickets was not the only disease that was able to be treated by sunlight, later in the 20th century it was discovered that Tuberculosis could be treated by solar exposure. The response of doctors was to send Tuberculosis patients to sunny areas and have them return when healed. With the power of the sun, Western society started to appreciate the 'glazed tan' look that sunshine produced and thus launched a series of tourism and beauty industries that are based on looking tan.

Conclusion

The outdoors has a profound effect on both physical and psychological factors that play a key role in reducing the level of stress and anxiety that is often tied with many devastating illnesses. A large component of the positive effects of the outdoors is the increased exposure to natural light. Even when it's cloudy there is still enough natural light for production of vitamin D. Our society is structured in a way where people spend far less time outside than they should, therefore reducing

their exposure to natural light. This is a public health risk as it limits the positive subjective effects of the outdoors or heliotherapy and the biological production of important compounds for health like vitamin D. Reestablishing the connection to the outdoor world is a crucial component of improving the mental and physical health of many individuals in Western society. Kids need to learn the benefits of the healing powers of light rather than being inside and possessed by a screen. ■

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