

VITAMIN D: HOW THE “SUNSHINE VITAMIN” AFFECTS OUR HEALTH

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YOUNG REVIEWERS:



FARAH
AGE: 14



HAYTAM
AGE: 14



IMAN F
AGE: 14



KHAOULA B
AGE: 14



MARYAM H
AGE: 14



NAKAE T
AGE: 14

Human health is connected to nature in many ways. Two of these ways involve the sun and the healthy foods that we eat. Nature, particularly the sun, helps our bodies to make one of the vital nutrients, vitamin D, which keeps our bodies healthy. In this article, we explain how our bodies make vitamin D, which is also called the “sunshine vitamin.” We will also explain the important roles vitamin D plays in humans, such as helping the immune system, regulating our hormones, and keeping the bones, heart, and brain healthy.

WHAT ARE VITAMINS?

Micronutrients are nutrients that are essential in small amounts for the normal functioning of the human body. Vitamins are one type of micronutrients. Usually, our bodies do not synthesize micronutrients, so we need to get them from our diets. There are 13 essential vitamins that our bodies require. Vitamins can be sorted into two types: water-soluble vitamins and fat-soluble vitamins. As their names

MICRONUTRIENTS

Nutrients required in small amounts by the human body.

¹ Available online at: <https://ritual.com/articles/1-what-vitamins-are-water-soluble>

suggest, water-soluble vitamins are those can dissolve in water, and fat-soluble vitamins are those that can dissolve in fat. Water-soluble vitamins include vitamins B1, B2, B3, B5, B6, B7, B9, B12, and C. Meanwhile, vitamins A, D, E, and K fall under fat-soluble vitamins. Our bodies will not retain water-soluble vitamins, meaning that if we get more than we need, we will excrete the excess in urine; so, it is necessary to get water-soluble vitamins regularly through our diets. On the other hand, the liver and fatty tissues store any excess fat-soluble vitamins for future use¹. Each vitamin performs a unique function in the body. Therefore, it is necessary to eat a balanced diet, because one vitamin cannot make up for the shortage of another.

WHY IS VITAMIN D CALLED THE “SUNSHINE VITAMIN?”

The most beneficial micronutrient, sometimes called the “sunshine vitamin,” is a fat-soluble vitamin: vitamin D. Vitamin D has two slightly different types, called vitamin D₂ and vitamin D₃. Sunlight is the prime source of vitamin D. The cells in the top layer of the skin, called epidermal cells, contain a compound called pro-vitamin D.

Figure 1

Vitamin D synthesis: (1) UV light from the sun converts pro-vitamin D in the skin to pre-vitamin D₃. (2) Vitamins D₂ and D₃ are also obtained through diet. (3) The inactive forms of vitamin D are transported to the liver, where (4) they are converted to 25-hydroxyvitamin D₃. (5) This compound is then transported to the kidneys where it is converted into the active form of vitamin D. (6) The active form of vitamin D acts as an immune booster (created with BioRender.com).

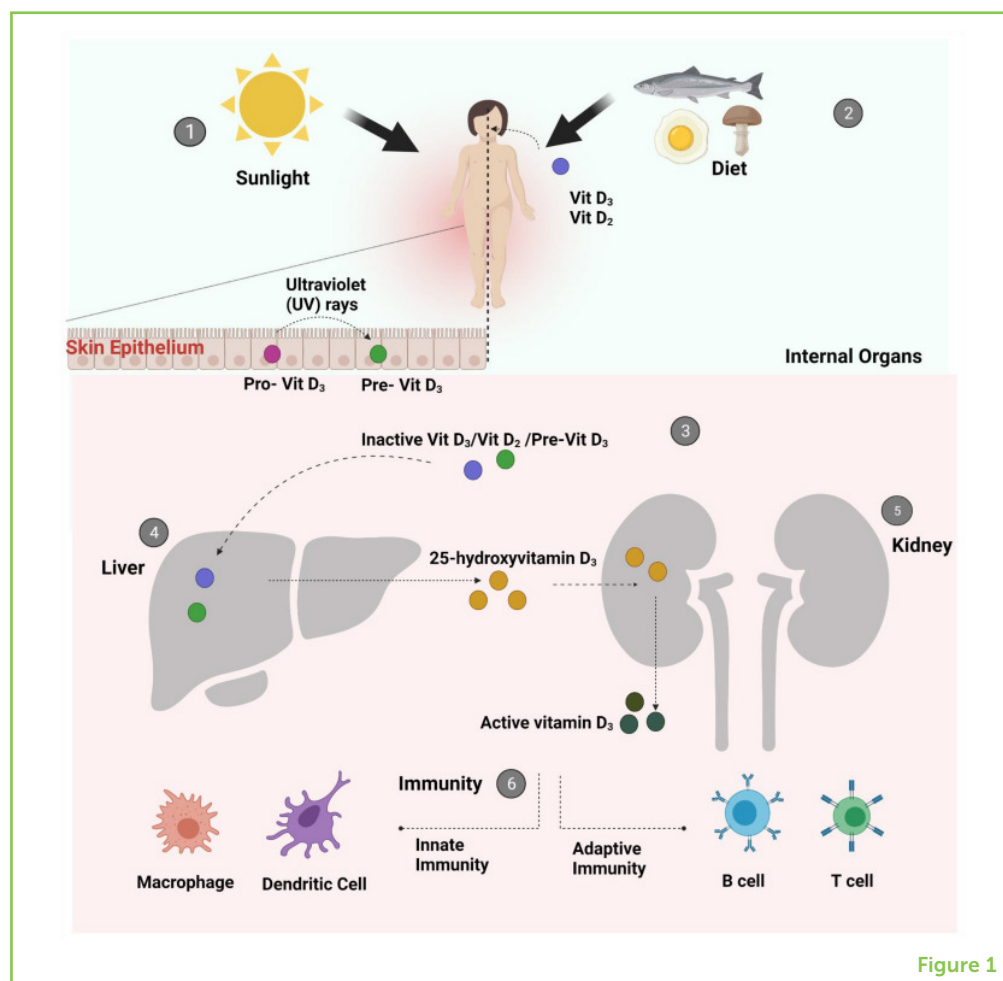


Figure 1

² Available online at: <https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/>

INNATE IMMUNITY

The branch of the immune system that we are naturally born with. A good example of innate immunity is our tears. Tears have enzymes that kill pathogens that enter our eyes.

ADAPTIVE IMMUNITY

The branch of the immune system that develops throughout our life. A special feature of adaptive immunity is that it remembers the pathogen (and the disease it causes) we encounter for the first time and protects our body from future attack by the same pathogen.

PATHOGEN

Any organism that cause diseases.

ANTIMICROBIAL PEPTIDES (AMPs)

Molecules produced by human cells that can directly kill pathogens like bacteria, fungi, or viruses, and even cancer cells.

The light from the sun converts pro-vitamin D into an intermediate substance called pre-vitamin D, which is then converted into vitamin D₃. This reaction is our main source of vitamin D—foods and dietary supplements are less important sources. Foods from animal sources, such as the flesh of fatty fish (trout, salmon, tuna, and mackerel), fish liver oils, beef liver, egg yolks, and cheese, usually contain vitamin D₃. In contrast, foods from plant sources, like mushrooms, contain vitamin D₂². Now, vitamins D₃ and D₂ are not the active forms of vitamin D, and they undergo chemical changes in the liver and kidneys (Figure 1) to create the active form of vitamin D [1].

WHY DO WE NEED VITAMIN D?

Vitamin D is important for our bodies in several ways. First, it helps our intestines to absorb calcium, helps keep our bones healthy, regulates the levels of a hormone called insulin, which helps our cells to get the energy they need from sugar, and supports the functioning of the body's immune system. Vitamin D is also known to help the body fight against cancer cells and to aid in the proper functioning of the heart and brain. Last, vitamin D also regulates blood pressure. For the rest of this article, we will focus on the role of vitamin D in the human immune system and in helping us get enough calcium.

WHAT IS THE ROLE OF VITAMIN D IN THE IMMUNE SYSTEM?

The immune system has two modes by which it protects our bodies from dangerous invaders: **innate immunity** and **adaptive immunity**. What are these two modes and how does vitamin D help?

Cells of the innate immune system fight against any **pathogen** (disease-causing organism) and act as the first line of defense when a pathogen attacks the human body. Innate immune cells include cell types called natural killer cells, macrophages, neutrophils, and dendritic cells. These cells produce substances called **antimicrobial peptides (AMPs)**, which are involved in killing pathogens. Vitamin D helps cells to make more AMP, thereby enhancing the functioning of the innate immune system.

Cells of the adaptive immune system are specific, which means certain cells only attack a certain pathogen. The adaptive immune system acts as the second line of defense during attack by a pathogen. B cells and T cells are the main cells of the adaptive immune system. There are various types of T cells: some increase inflammation and some decrease it. Vitamin D is known to suppress the T cells that promote inflammation and stimulate the T cells that reduce inflammation [2]. This is important because inflammation helps in healing only on a short

LUMEN

The inside space of any tubular structure (like intestine).

CALCIUM METABOLISM

The movement and regulation of calcium ions in and out of the body to maintain steady calcium levels.

VITAMIN D RECEPTOR

A chemical molecule that recognizes and allows binding of vitamin D to it.

CALBINDIN

Calcium binding proteins.

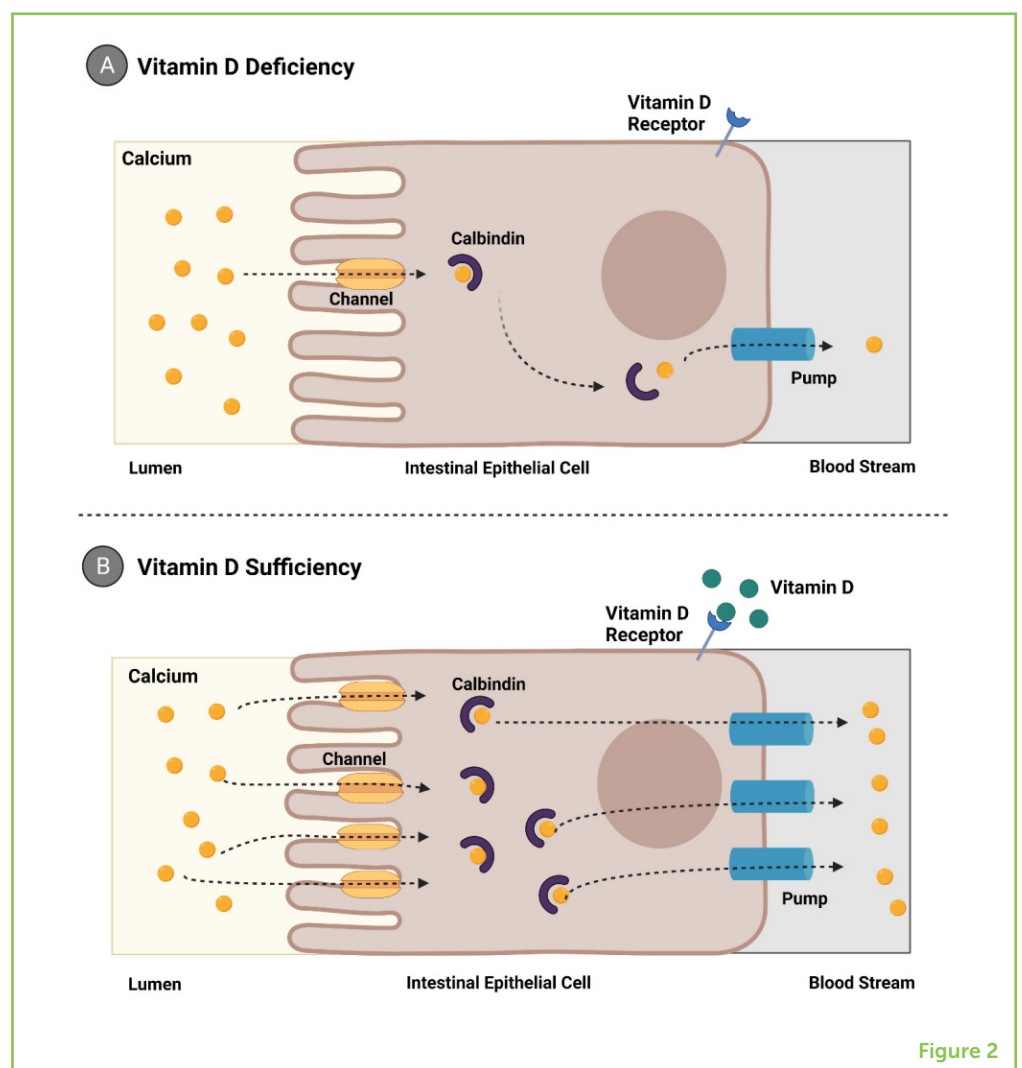
Figure 2

Role of vitamin D in calcium absorption. (A) In the absence of vitamin D, cells express a smaller number of calcium channels, calbindin, and pump molecules, so they absorb significantly less calcium. (B) In the presence of vitamin D, cells express more calcium channels, calbindin and pumps, promoting efficient calcium absorption (created with BioRender.com).

term; prolonged inflammation can cause damage to the body. So it is necessary to keep the inflammatory T cell population low.

WHAT IS THE ROLE OF VITAMIN D IN CALCIUM METABOLISM?

Vitamin D is known to play an essential role in the absorption of calcium present in the **lumen** into the intestinal cells. The calcium that we eat needs to be absorbed by the small intestines and passed into the bloodstream to supply calcium to the body. This process is known as **calcium metabolism**. For calcium to be absorbed by the small intestines, vitamin D is required. Vitamin D binds to a molecule called the **vitamin D receptor** (VDR), which is present on almost all cells, including intestinal cells. The binding of vitamin D to the VDR results in a greater number of calcium channels on the surface of intestinal cells, which allow more calcium to enter into the cells. **Calbindin** is a protein that binds to calcium inside cells and carries it to a molecule



that acts like a pump—these pump molecules pump the calcium into the bloodstream (Figure 2) [3].

WHAT HAPPENS IF WE DO NOT GET ENOUGH VITAMIN D?

Now you understand why vitamin D is crucial for the normal functioning of the human body, both for regulating calcium levels and maintaining the efficient functioning of the immune system. Too little vitamin D in the blood leads to various problems, as depicted in Figure 3. A simple blood test can be performed to check our vitamin D levels. A normal level is 20–50 ng/mL. Less than 20 ng/mL is called vitamin D deficiency, and more than 50 ng/mL can also be dangerous. Our bones are mainly made up of calcium and phosphorus. Vitamin D deficiency leads to poor absorption of calcium from the foods we eat, and hence the bones do not get enough calcium. Vitamin D deficiency also decreases phosphorus, and since calcium and phosphorus are unavailable to the bones, the bones ultimately become weak and soft. In children, this condition is called rickets; and in adults, it is called osteomalacia. A condition called osteoporosis is also common in adults when calcium levels are low. In osteoporosis, the bones become porous (full of tiny holes) and less dense; fractures can happen more easily in these cases.

Vitamin D deficiency also affects the functioning of the immune system, which can lead to various health issues, such as heart diseases and cancer [4].

Figure 3

Effects of vitamin D. **(A)** In the vitamin D-sufficient state, when there is enough vitamin D, the brain, heart and bones are maintained in a healthy condition, hormone levels are balanced leading to protection against cancer. **(B)** In the vitamin D-deficient condition, the brain, heart, bones, and hormone levels are poorly maintained causing various diseases (created with BioRender.com).

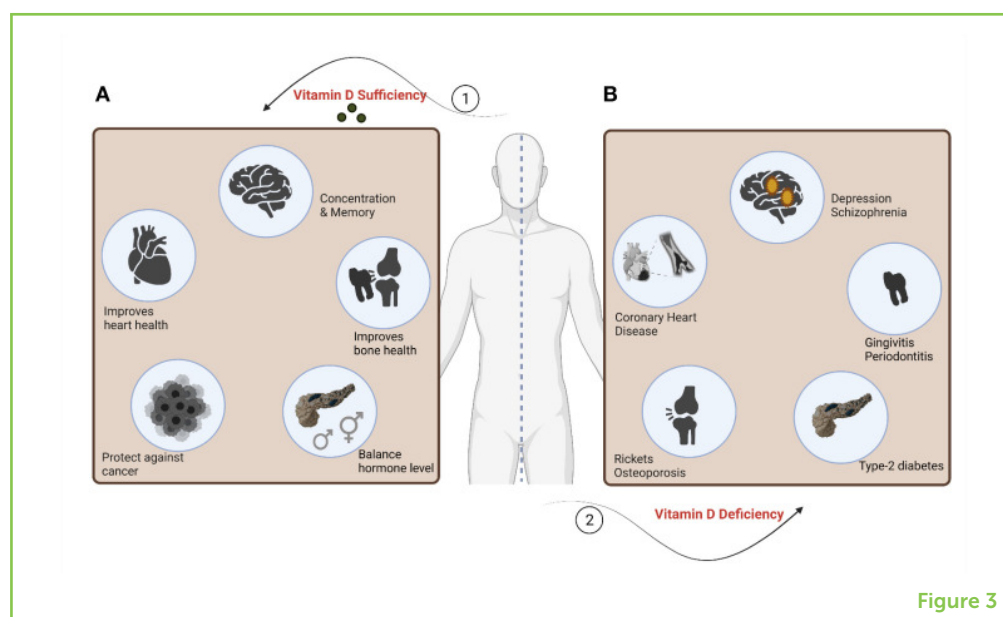


Figure 3

MELANIN

Substance secreted by the cells that gives pigment (or color) to the skin.

WHO IS AT RISK OF VITAMIN D DEFICIENCY?

A person's location on Earth is one of the significant risk factors for vitamin D deficiency. High-latitude areas (areas that are near the poles of the earth's surface) receive less sunlight than low-latitude areas (areas that are located nearby the equator) do. Hence, people living at higher latitudes are more susceptible to vitamin D deficiency. Skin color is another risk factor. Can you guess why? The pigment **melanin**, which gives skin its color, naturally protects us from the UV rays of the sun. Dark-skinned people have more melanin than light-skinned people do, so they are at higher risk of vitamin D deficiency. Obese people tend to be at higher risk of being deficient in vitamin D, too [5]. Also, as people grow older, their risk of vitamin D deficiency increases because pro-vitamin D, the precursor of vitamin D that is present in the skin, is at lower levels in older people than younger people.

HOW CAN WE PREVENT VITAMIN D DEFICIENCY?

Scientists suggest that 5–30 min of sun exposure (to the face, arms, hands, and legs, without sunscreen), especially between 10 AM and 4 PM daily or at least twice a week, usually leads to sufficient vitamin D synthesis. Also, taking vitamin D supplements is a widely used method to overcome vitamin D deficiency. A daily intake of 1,000 IU (international units, or 25 mcg) of vitamin D₃ is generally recommended to maintain an optimal level of this vitamin in the body [6]. We must be careful with supplements, because too much vitamin D is harmful and can cause hypercalcemia (excess of calcium in human body) which in turn can lead to nausea and vomiting.

So now that you know how important vitamin D is for the body, you can take some important steps to assure that you are getting enough vitamin D, but not too much. Make sure to eat a healthy diet, take the prescribed number of vitamin D supplements, and go outside in the sunlight and be active. The "sunshine vitamin" can help us connect with nature by spending time in the sun, so that we can keep our bodies fit and healthy by making the right amount of vitamin D.

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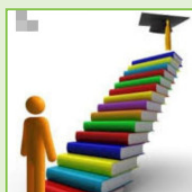
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YOUNG REVIEWERS

FARAH, AGE: 14

My name is Farah, I am 14 years old, my school level is the 1st year of high school, my favorite subjects are physics and mathematics, in my free time I read books and surf the net. As a social person, I like discussions on scientific phenomenas and discoveries, my dream is to be an engineer.





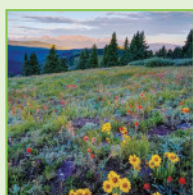
HAYTAM, AGE: 14

My name is Haytam, I am 14 years old. My academic level is the third preparatory. My favorite subjects are: maths, physics, science, and English. My hobbies are: swimming, drawing, and reading. I have practiced taekwondo for 2 years. I speak English and French fluently, I have previously participated in the Arab reading challenge and I participated in the math Olympiad too. My dream is to be a doctor or a vet.



IMAN F, AGE: 14

My name is Iman F, I am 14 years old, and my academic level is the third preparatory. My favorite subjects are physics and mathematics. My hobbies are reading, research and drawing. I have participated in school festivals. I speak French and I love English. My dream is to become an engineer.



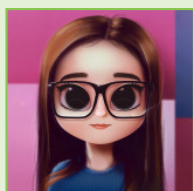
KHAOULA B, AGE: 14

Hello, my name is Khaoula B, I am 14 years old. My school level is the third preparatory. My favorite subjects are: maths, physics, and history. In my free time, I like to read books and novels and watch movies, I like basketball and cycling. I do not have a dream yet, I want to learn more and develop myself and my skills.



MARYAM H, AGE: 14

Hi, my name is Maryam H. I am 14 years old, I like to read books and play football. I am obsessed with arts and animals. I believe that hard work is the key to success.



NAKAE T, AGE: 14

My name is Nakae T, I am 14 years old. My school level is the third preparatory. My favorite subjects are: art education and mathematics. My hobbies are: drawing and scientific research. Pizza is my favorite food. I have participated in the reading challenge contest. I speak French and English, my dream is to become a surgeon.

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Harshini Rajendran is a final-year biotechnology student at SASTRA Deemed to be University, Tamil Nadu, India. She is most fascinated by microbes—the role microorganisms play in the everyday life of humans, their dual nature either being immensely useful or being extremely terrifying. She is also keenly interested in learning about the gut microbiota of humans and food technology. Her hobbies are reading fiction novels, listening to Korean-pop music and watching Korean dramas.



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Adline Princy Solomon, Associate Dean—Research in the School of Biotechnology at the SASTRA Deemed University who has 16 years of professional teaching/research experience post Ph.D. Being a molecular biologist by training, her research interest primarily focuses on infectious diseases, as well as looking at novel drugs as alternative anti-infective therapies manipulating Quorum sensing and host pathogen relationships using inter-disciplinary approaches. A mother of two lovely daughters, teaching is her passion (but not to her naughty cuties). She always dreams about being the best teacher and tirelessly works toward it! She is an autodidact mandala artist love to create her own mandalas that keeps her focused on what she does. *adlineprinzy@sastra.ac.in