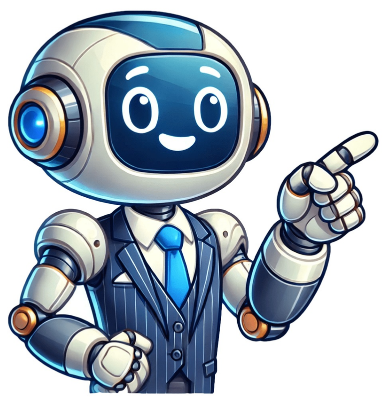

Vitamin B12 plays a crucial role in animal cell metabolism. It is essential for various bodily functions, including DNA synthesis, fatty acid and amino acid metabolism, nervous system functioning, and red blood cell maturation. Unlike plants, animals require vitamin B12 to carry out these processes. Vitamin B12 is the most chemically complex of all vitamins, but only some bacteria and archaea can synthesize it naturally. Humans must obtain it through their diet or supplements. The vitamin is found in animal-based foods like meat, fish, eggs, dairy products, and shellfish. Some breakfast cereals are also fortified with vitamin B12. Vitamin B12 deficiency is a common condition, particularly among people who follow plant-based diets or have limited access to animal food sources. It can be prevented and treated through supplements and medications. Vitamin B12 deficiency can be treated with intramuscular injections, especially in cases where oral treatment is not effective. The condition is more prevalent among young children, pregnant women, and elderly individuals, particularly in middle and lower-developed countries where malnutrition is common. The most frequent cause of vitamin B12 deficiency in developed nations is impaired absorption due to a decrease in gastric intrinsic factor (IF), which must be bound to a food source containing B12 for it to be absorbed. Another significant cause is age-related decline in stomach acid production (achlorhydria). Long-term antacid therapy can also increase the risk of vitamin B12 deficiency. Vegetarians and vegans often require dietary supplements to obtain sufficient amounts of B12, as their diets may not provide adequate levels. A deficiency in vitamin B12 can manifest with various symptoms such as limb neuropathy, blood disorders like pernicious anemia, fatigue, numbness in the hands and feet, depression, and confusion. Untreated vitamin B12 deficiency in infants can lead to neurological damage and anemia. Folate levels may influence the course of pathological changes and symptomatology associated with vitamin B12 deficiency. In pregnant women, vitamin B12 deficiency is linked to an increased risk of spontaneous abortion, congenital malformations like neural tube defects, and growth problems with the unborn child. The ability to absorb vitamin B12 declines with age, especially in individuals over 60 years old. Methylcobalamin is a stable form of vitamin B12 used in dietary supplements due to its resistance to degradation. However, there's no significant advantage in using it over other forms for treating vitamin B12 deficiency. Hydroxocobalamin can be injected intramuscularly or intravenously to treat the deficiency and cyanide poisoning, as it forms a non-toxic compound that is excreted in urine. Pseudovitamin B12 refers to corrinoids with a similar structure to the vitamin but lacks its activity. Spirulina, an algal health food, contains pseudovitamin B12, which is sometimes mistakenly believed to have vitamin activity. Vitamin B12 deficiency can cause severe and irreversible damage, especially to the brain and nervous system, leading to symptoms like fatigue, weakness, dizziness, headaches, and decreased appetite. It can also lead to neurological symptoms such as sensory or motor deficiencies, and subacute combined degeneration of the spinal cord. In children, vitamin B12 deficiency can result in developmental delay, regression, irritability, and hypotonia. Malabsorption is the most common cause of the deficiency, but it can also be due to low intake, immune gastritis, or certain medications. Vegans are at a higher risk because plant-sourced foods do not contain sufficient amounts of vitamin B12, while vegetarians who consume dairy products and eggs but not animal flesh are also at risk. Vitamin B12 deficiency has been observed in 40-80% of the vegetarian population who don't take supplements. Vitamin B12 Deficiency in Vegans: Risks and Prevention Severe vitamin B12 deficiency can be treated with intramuscular injections followed by oral supplements once the individual's serum levels recover. However, certain surgical procedures like Roux-en-Y gastric bypass surgery increase the risk of developing a B12 deficiency due to malabsorption issues.[40] To prevent this, patients may require high-dose oral supplementation or injected vitamin B12 after such surgeries. Vitamin B12 deficiency is often diagnosed through clinical evaluation and investigation results. A routine blood count can reveal anemia with elevated mean corpuscular volume (MCV), while a peripheral smear may show macrocytes and hypersegmented polymorphonuclear leukocytes.[51] Low serum B12 levels, typically below 150-180 pmol/L in adults, are also indicative of deficiency.[52] However, relying solely on blood tests can be misleading as serum values might remain within the normal range even when tissue stores are depleted. Therefore, healthcare professionals often consider additional indicators such as elevated homocysteine and methylmalonic acid levels to confirm B12 deficiency. When symptoms persist despite inconclusive test results or in cases where nervous system damage is suspected, a lumbar puncture may be performed to measure cerebrospinal fluid B12 levels.[55] It's worth noting that certain conditions like renal insufficiency in the elderly and metabolic disorders can also lead to elevated methylmalonic acid levels. Therefore, healthcare professionals must carefully evaluate each patient's condition to rule out other potential causes of deficiency. Treatment for severe vitamin B12 deficiency typically involves daily intramuscular injections followed by maintenance via monthly injections or high oral dosing (1000 μg daily). Oral supplementation is generally preferred due to its lower cost and reduced risk of injection side effects, which can include rash, itching, fever, nausea, dizziness, among others.[58] For treating cyanide poisoning, large doses of hydroxocobalamin may be administered intravenously, possibly combined with sodium thiosulfate.[60][61] The mechanism involves the displacement of toxic cyanide ions by the non-toxic cyanocobalamin, which is then excreted in urine.[62] Research suggests that many people in the United States and the United Kingdom consume sufficient vitamin B12.[2][11] However, some studies indicate that up to 40% of Western world populations may have low or marginal levels of this essential nutrient.[2] To address this issue, vitamin B12 can be added to grain-based foods, making them fortified. Supplements are also available as single or multivitamin tablets, while pharmaceutical preparations may be administered by intramuscular injection.[6][63] Vegans, in particular, require dietary supplements or fortified foods to ensure adequate intake, as there are few non-animal sources of this vitamin and insufficient consumption can lead to serious health consequences.[6] In developing countries, children in certain regions are at a higher risk due to increased requirements during growth coupled with diets low in animal-sourced foods. The US National Academy of Medicine updated estimated average requirements (EARs) and recommended dietary allowances (RDAs) for vitamin B12 in 1998.[6] The EAR for women and men ages 14 and older is set at 2.0 μg/day; the RDA is 2.4 μg/d, with higher values during pregnancy (2.6 μg/day) and lactation (2.8 μg/d). For infants up to 12 months, the adequate intake (AI) is established at 0.4–0.5 μg/day. AIs are used when there is insufficient information to determine EARs and RDAs. For children ages 1-13 years, the RDA increases with age from 0.9 to 1.8 μg/day. Older individuals (above 50 years) may struggle to absorb vitamin B12 naturally occurring in foods, requiring them to meet their RDA mainly through fortified foods or supplements containing this essential nutrient. As for safety, tolerable upper intake levels (ULs) are set for vitamins and minerals when sufficient evidence is available. In the case of vitamin B12, there is no UL, as there is no human data on adverse effects from high doses. The collective set of information, including EARs, RDAs, AIs, and ULs, is referred to as dietary reference intakes (DRIs).[12] The European Food Safety Authority (EFSA) refers to this collective set as "dietary reference values", with population reference intake (PRI) instead of RDA, and average requirement instead of EAR. AI and UL are defined by EFSA the same as in the United States. For women and men over 18 years old, the adequate intake (AI) is set at 4.0 μg/day. AIs for pregnancy and lactation are 4.5 μg/day and 5.0 μg/day, respectively. For children aged 1-14 years, the AIs increase with age from 1.5 to 3.5 μg/day. These AIs are higher than the U.S. RDAs.[41] The EFSA also reviewed the safety question and reached the same conclusion as in the United States—that there was not sufficient evidence to set a UL for vitamin B12.[64] The Japan National Institute of Health and Nutrition sets the RDA for people ages 12 and older at 2.4 μg/day,[65] while the World Health Organization uses this value as the adult recommended nutrient intake for this vitamin.[66] For U.S. food and dietary supplement labeling purposes, Vitamin B12 is typically expressed as a "percent of daily value" (%DV), with 100% being 6.0 μg, but was revised downward to 2.4 μg in 2016. Compliance with updated labeling regulations required by January 2020 for manufacturers with $10 million or more in annual food sales, and by 2021 for those with lower volume sales. Vitamin B12 is naturally produced by certain bacteria and archaea, and some gut microbiota in humans and animals synthesize it. However, humans thought they could not absorb this as it's made in the colon. Ruminants like cows and sheep can absorb vitamin B12 from plant food that undergoes microbial fermentation. Other mammals consume high-fiber plants that pass through the gastrointestinal tract, allowing for bacterial fermentation and absorption of nutrients. Insects are a source of B12 for animals, including humans. Animal-derived foods such as liver and shellfish provide high concentrations of vitamin B12. Vitamin B12 is commonly found in fortified foods, such as breakfast cereals, plant-based milk substitutes, energy bars, and nutritional yeast. The fortification process typically involves converting adenosylcobalamin to cyanocobalamin with the help of potassium cyanide or thiocyanate. Currently, 19 countries require food fortification with vitamin B12, mainly in southeast Africa or Central America. Many vegan advocacy organizations recommend consuming B12 from fortified foods or supplements. In some countries, grain-based foods like bread and pasta are also fortified with B12. Non-prescription products can be purchased providing up to 1,000 μg each, and it's common to find B12 in energy drinks and shots. When used in supplementation, all vitamin B12 vitamers have been argued to be beneficial. The amount of cyanide in cyanocobalamin is generally not considered a health risk, as the daily consumption from food exceeds the 20 μg contained in a 1,000 μg dose. Injection of hydroxycobalamin is often used for impaired digestive absorption, but high-dose oral supplements can also provide sufficient amounts. Patients with cobalamin C disease can be treated with intravenous or intramuscular hydroxocobalamin. Targeted delivery of vitamin B12 is a major focus in modern prescriptions, aiming to convey the vitamin directly to bone marrow and nerve cells for myelin recovery. Researchers are developing nanocarrier strategies to improve vitamin B12 delivery, simplify administration, reduce costs, and enhance patient quality of life. Pseudovitamin-B12 refers to biologically inactive B12-like analogues found in some cyanobacteria and algae, such as Spirulina. These compounds can be mistaken for active vitamin B12 but do not provide any health benefits. Pseudovitamin-B12 compounds are often found in shellfish, edible insects, and as byproducts of dietary supplements. These pseudo-vitamins can be mistaken for biologically active B12 due to microbiological assays like Lactobacillus delbrueckii subsp. lactis. More advanced techniques involving silica gel pre-separation and E. coli bacteria assessment provide accurate B12 content readings. Synthetic antivitamin B12 compounds, which include rhodium or nickel replacements and inactive ligands, can interfere with true vitamin B12 activity. These substances have potential uses in analyzing B12 pathways or attacking B12-dependent pathogens. Gastric acid is essential for releasing protein-bound B12 from dietary sources. However, reduced gastric acid secretion due to H2 blockers or proton-pump inhibitors (PPIs) like omeprazole can decrease the absorption of dietary vitamin B12, but not supplemental forms. Long-term use of anti-diabetic metformin can reduce serum levels of vitamin B12 in up to 30% of individuals. Nonetheless, deficiency does not occur if dietary intake is adequate or prophylactic B12 supplementation is given. Certain medications like colchicine and antibiotics may also decrease the absorption of orally consumed vitamin B12. Anti-seizure medications such as phenobarbital can be associated with lower-than-normal serum vitamin concentrations, while valproate prescriptions are linked to higher levels. Additionally, some drugs like amoxicillin may interfere with laboratory tests for vitamin B12. Cobalt is the central metal ion in vitamin B12, and it exists as a +3 oxidation state when isolated as an air-stable solid. Vitamin B12 can undergo reductive processes to access its "reduced" (+2) and "super-reduced" (+1) forms, which allows it to participate in various biochemical reactions. The ability of vitamin B12 to shuttle between these different oxidation states is responsible for its versatility in serving as a donor of deoxyadenosyl radical or methyl cation equivalent. The structure of vitamin B12 consists of a corrin ring and a dimethylbenzimidazole group, with the reactive center being occupied by either a cyano, hydroxyl, methyl, or 5′-deoxyadenosyl group. This covalent carbon-cobalt bond is an early example of carbon-metal bonds in biology. Animals can convert cyanocobalamin and hydroxocobalamin into bioactive forms such as adenosylcobalamin and methylcobalamin by replacing the cyano or hydroxyl groups. Several methods have been used to determine vitamin B12 content in foods, including microbiological assays, chemiluminescence assays, polarographic, spectrophotometric, and high-performance liquid chromatography processes. Vitamin B12 functions as a coenzyme, requiring its presence for some enzyme-catalyzed reactions. It is involved in three classes of enzymes: isomerases, which use adenosylcobalamin; methyltransferases, which use methylcobalamin; and dehalogenases, which have potential commercial applications for degrading chlorinated pollutants. Methylmalonyl-CoA mutase's role in corrinoid biosynthesis or dependency on exogenous vitamin B12 varies among species. In humans, two coenzyme-dependent enzyme families are known, with methylmalonyl-CoA mutase (MUT) utilizing adenosylcobalamin for L-methylmalonyl-CoA conversion to succinyl-CoA. Deficiency in MUT leads to increased serum methylmalonic acid levels and impaired myelin synthesis. Similarly, methionine synthase, reliant on vitamin B12, converts homocysteine to methionine through a methyltransferase reaction. Vitamin B12 deficiency disrupts this process, causing neurological deterioration due to methylmalonate formation. This condition also leads to increased homocysteine levels and folate trapping. Methylmalonyl-CoA mutase's functionality is essential for succinyl-CoA production in amino acid catabolism. Its loss can be measured clinically through elevated serum methylmalonic acid concentrations. Vitamin B12 deficiency affects myelin synthesis, leading to neurological damage. In the folate methionine cycle, vitamin B12 plays a crucial role in converting homocysteine to methionine. Deficiency disrupts this process, resulting in ineffective DNA production and cell turnover. However, sufficient dietary folate can restore the effects of B12 deficiency. Vitamin B12 absorption relies on specific transport proteins, including haptocorrin, intrinsic factor, and transcobalamin II. The transport process involves a complex interplay between these proteins and membrane receptor proteins. Once absorbed, vitamin B12 undergoes neutralization in the stomach and then binds to transcobalamin II for tissue delivery. Vitamin b12 absorption explained by bicarbonate,[122] and pancreatic proteases release the vitamin from HC, making it available to be bound by IF, which is a protein secreted by gastric parietal cells in response to food. IF delivers the vitamin to cubilin and amnionless proteins that together form the cubam receptor in the distal ileum. The receptor only binds to vitamin b12 when attached to if.[12][121] Studies show that the upper limit of absorption per dose is about 1.5 micrograms, with 50% efficiency. In contrast, passive diffusion can occur at much higher doses, but with low efficiency. This means that high doses of supplements can help treat certain conditions without fixing underlying issues. The if-b12 complex binds to cubam and then disassociates, allowing the vitamin to enter the portal circulation. It is then transferred to TC2, which acts as a circulating plasma transporter. Vitamin B12 plays a crucial role in cellular reprogramming, tissue regeneration, and epigenetic regulation through its involvement in one-carbon metabolism. The process of cellular reprogramming allows somatic cells to be converted into a pluripotent state, and vitamin B12 levels have been shown to affect histone modification H3K36me3, which suppresses illegitimate transcription outside of gene promoters. In mice undergoing in vivo reprogramming, a depletion of B12 was observed, leading to signs of methionine starvation. However, supplementing reprogramming mice and cells with B12 increased efficiency, indicating a cell-intrinsic effect. This suggests that vitamin B12 is essential for successful reprogramming. Vitamin B12 is derived from a tetrapyrrolic structural framework created by the enzymes deaminase and cosynthetase. The biosynthesis of B12 involves several steps, including the incorporation of methyl groups, which were investigated using 13C methyl-labelled S-adenosyl methionine. A genetically engineered strain of Pseudomonas denitrificans was used to determine the complete sequence of methylation and other steps in the pathway. Several species of bacteria are known to synthesize B12, including Propionibacterium shermanii, Pseudomonas denitrificans, Streptomyces griseus, and others. Industrial production of B12 is achieved through fermentation of selected microorganisms. The commercial source of vitamin B12 has varied over time, with Streptomyces griseus being the primary source for many years. In 2008, the total world production of vitamin B12 was 35,000 kg. The complete laboratory synthesis of B12 was achieved by Robert Burns Woodward and Albert Eschenmoser in 1972, but this synthesis is of no practical consequence due to its length and low chemical yield. Vitamin B12 Discovery Timeline In 1849-1887, key discoveries were made regarding pernicious anemia, including descriptions of macrocytes by Hayem and identification of megaloblasts by Paul Ehrlich. The 1920s saw George Whipple discover that large liver ingestion helped cure anemia in dogs, leading to further research on liver extracts as a treatment. In 1934, George Whipple shared the Nobel Prize with William P Murphy and George Minot for discovering an effective treatment using liver concentrate, which contained a large amount of vitamin B12. Mary Shaw Shorb worked at the Bureau of Dairy Industry and developed an assay method to identify the active compound in Lactobacillus lactis Dorner. Shorb collaborated with Karl Folkers and Alexander R Todd at the University of Cambridge to extract the anti-pernicious anemia factor from liver extracts, purify it, and name it vitamin B12. Dorothy Hodgkin elucidated the structure of the vitamin in 1955 and was awarded the Nobel Prize in Chemistry in 1964. In the 1970s, Dr. John A. Myers developed a treatment called the "Myers' cocktail" that involved injecting vitamins and minerals intravenously for various medical conditions. However, this practice has been largely debunked by scientific evidence, with no proven benefits for treating fatigue, low energy, stress, anxiety, or other conditions. Intravenous micronutrient therapy has become a popular treatment in some clinics and spas, often using unsubstantiated claims to promote weight loss and other health benefits. However, the Mayo Clinic has concluded that there is no solid evidence to support these claims. Additionally, research suggests that many people, particularly elderly individuals, are receiving unnecessary cyanocobalamin injections, which have been shown to be ineffective in preventing subclinical B12 deficiency. The scientific community has also highlighted the importance of proper vitamin B12 delivery and assimilation mechanisms, with studies revealing potential disorders related to cobalamin. Overall, while vitamins and minerals are essential for human health, there is a need for more rigorous scientific research and regulation of treatments involving intravenous micronutrient therapy. Vitamin B12 is an essential nutrient that plays a crucial role in various bodily functions, including energy production and nerve function. The recommended daily intake of vitamin B12 varies by age and sex, but most adults need at least 2 micrograms per day. According to recent studies, many people, especially women, do not meet their daily vitamin B12 needs due to inadequate dietary intake or poor absorption. In fact, a study published in the Cochrane Database of Systematic Reviews found that vitamin B12 supplementation during pregnancy can improve maternal and child health outcomes. Vitamin B12 deficiency is a common condition, particularly among older adults, and can lead to anemia, fatigue, and neurological problems. The condition is often associated with gastrointestinal disorders, such as acid reflux, which can impair the absorption of this essential nutrient. Researchers have explored various forms of vitamin B12 supplements, including those in liquid or solid form, but some studies suggest that these may not be more effective than others in preventing or treating deficiency. In addition to its importance for human health, vitamin B12 also plays a critical role in the production of red blood cells and the maintenance of healthy nerve function. The National Institutes of Health recommends that adults consume 2 micrograms of vitamin B12 per day, while the Institute of Medicine provides guidelines for vitamin B12 intake by age and sex. Overall, maintaining adequate vitamin B12 levels is crucial for overall health and well-being, particularly among vulnerable populations such as pregnant women and older adults. Vitamin B12 is an essential nutrient that can be found in various food sources. However, some foods, such as spirulina, may contain a form of vitamin B12 called pseudovitamin B12, which is not effective for humans. A deficiency in vitamin B12 can cause a range of health problems, including anemia, nerve damage, and psychiatric symptoms like psychosis. It can also affect fertility and increase the risk of miscarriage. Vitamin B12 deficiency can be difficult to diagnose, as the symptoms can be subtle and similar to those of other conditions. However, if left untreated, it can lead to serious health complications. Certain groups, such as vegans, are at a higher risk of vitamin B12 deficiency because they do not consume animal products, which are natural sources of the nutrient. To prevent deficiency, it's essential to consume reliable sources of vitamin B12, such as fortified foods or supplements. Some plant-based foods, like fermented foods and algae, may contain small amounts of vitamin B12, but these sources are not sufficient to meet daily needs. Therefore, vegans must be particularly mindful of their vitamin B12 intake to maintain good health. Some common symptoms of vitamin B12 deficiency include fatigue, weakness, and pale skin. In severe cases, it can cause neurological problems, such as numbness or tingling in the hands and feet. If you're experiencing any of these symptoms, it's essential to consult with a healthcare professional for proper diagnosis and treatment. In addition to dietary sources, vitamin B12 can also be obtained through supplements. However, it's crucial to choose a high-quality supplement that contains the correct form of vitamin B12. Some forms, such as cyanocobalamin, may not be effective for everyone, especially those with certain medical conditions. Overall, vitamin B12 is a critical nutrient that plays a vital role in maintaining good health. By being aware of the risks of deficiency and taking steps to ensure adequate intake, individuals can reduce their risk of developing related health problems. A diet lacking in vitamin B12 can lead to deficiencies in individuals who follow a vegan lifestyle. Several studies have demonstrated this, including case studies on infants, children, and adults. A review of existing research found that vegans are at risk of developing vitamin B12 deficiency due to limited exposure through food sources. The World Health Organization (WHO) has established dietary reference values for vitamin B12, which are essential for maintaining healthy blood levels. However, these standards may not be met by all individuals following a vegan diet. Research suggests that maternal vitamin B12 status during pregnancy can impact the risk of preterm birth and low birth weight. Moreover, studies have shown associations between a vegetarian or vegan diet during pregnancy and various health outcomes in mothers and offspring. Additionally, certain medical procedures like bariatric surgery and gastric bypass can lead to nutrient deficiencies, including vitamin B12 deficiency. In such cases, supplementation may be necessary to prevent complications. Overall, while a well-planned vegan diet can provide adequate nutrition, it is essential for individuals following this lifestyle to take precautions to avoid vitamin B12 deficiency and other related health issues. The article discusses various aspects of vitamin B12 and folate disorders, including diagnosis and treatment guidelines, controversies surrounding homocysteine's role in neurology, and the importance of methylmalonic acidemia. The text also covers topics such as diagnosing vitamin B-12 deficiency, the machinery of human cobalamin metabolism, and the significance of elevated cobalamin levels in blood. Additionally, the article highlights the administration routes for supplementation, including oral and nasal routes, as well as the use of hydroxocobalamin/sodium thiosulfate as a cyanide antidote. The text also discusses food sources highest in vitamin B12, tolerable upper intake levels, and dietary reference intakes. Furthermore, the article cites various studies and publications from reputable sources, including the European Food Safety Authority, the World Health Organization, and the National Institutes of Health. The Dietary Supplement Label Database (DSLD) provides information on food and dietary supplements, including their nutritional content. The FDA introduced changes to the Nutrition Facts label in 2016, which included updated guidelines for vitamin B12 labeling. Vitamin B12 is essential for human health, but its production is complex and influenced by various factors such as diet, gut microbiome, and environmental conditions. Research has shown that certain microorganisms can produce vitamin B12, while others may contribute to its conservation in the body. Studies have explored the bioavailability of vitamin B12 from different food sources, including meat, dairy products, and plant-based options like tempeh and soybeans. The FDA's guidelines for labeling vitamin B12 supplements are also relevant, as some research suggests that certain carnivores may require additional supplementation to meet their nutritional needs. Overall, understanding the production, bioavailability, and importance of vitamin B12 is crucial for promoting optimal health and well-being. Research has shown that there are various plant-based sources of vitamin B12, which is essential for vegetarians. Studies have identified specific foods such as Chlorella vulgaris and traditional Korean foods as containing this vital nutrient. Additionally, microbes can produce vitamin B12, making it possible to obtain it through microbial production. Experts have debated whether certain forms of vitamin B12 (such as methylcobalamin) are more effective than others in preventing or treating deficiency. However, a scientific consensus suggests that different coenzyme forms may not necessarily be superior to other forms. Oral versus parenteral therapy for vitamin B12 deficiency has been studied, with some research suggesting that oral treatment may be just as effective as intramuscular injections. A systematic review of randomized controlled trials concluded that oral vitamin B12 is a viable option for treating deficiency. Finally, the importance of diagnosing and managing vitamin B12 deficiency in adults was emphasized by experts in a Delphi consensus study. The article discusses various studies and research on vitamin B12, also known as cobalamin. It cites several papers that explore its bioavailability, pharmacokinetics, and interactions with other substances. For example, one study found that nanocarrier strategies can improve vitamin B12 absorption and reduce costs for patients. Another study looked at the degradation of vitamin B12 in dietary supplements, while others examined its relationship to metformin use and antiepileptic drugs. The text also mentions various methods for analyzing vitamin B12 levels, including immunoaffinity and ultra-high performance liquid chromatography. Additionally, it touches on the importance of vitamin B12 in health and disease, citing studies that discuss its role in folate metabolism and its potential therapeutic applications. Overall, the article presents a collection of research findings and perspectives on vitamin B12, highlighting its significance in both human health and disease. Vitamin B12 plays a crucial role in various bodily functions, including energy production, DNA synthesis, and nerve function. A deficiency in vitamin B12 can lead to neurological problems, anemia, and other health issues. Research has shown that vitamin B12 is essential for the activity of methylmalonyl-CoA mutase, an enzyme involved in the breakdown of fatty acids. The vitamin also helps to maintain a healthy methionine remethylation cycle, which is important for DNA synthesis and repair. Vitamin B12 is absorbed in the small intestine through a process involving the protein transcobalamin II and its receptor. A deficiency in this process can lead to malabsorption of vitamin B12. Certain medications, such as proton pump inhibitors and histamine 2 receptor antagonists, have been linked to an increased risk of vitamin B12 deficiency. Additionally, age-related declines in stomach acid production can also contribute to reduced vitamin B12 absorption. Vitamin B12 is essential for maintaining healthy levels of homocysteine, a molecule that can be toxic if present in excess. Elevated homocysteine levels have been linked to an increased risk of cardiovascular disease and other health problems. Studies have shown that vitamin B12 plays a critical role in cellular plasticity and tissue repair, with deficiencies leading to impaired cellular function and tissue damage. Overall, vitamin B12 is a vital nutrient that plays a crucial role in maintaining overall health and preventing various diseases. Vitamin B12 is an essential nutrient produced by microorganisms, which can be used in various industrial applications. The biosynthesis of vitamin B12 involves a complex process that requires specific enzymes and conditions. Researchers have identified key steps in this pathway, including the formation of the macrocycle and the synthesis of cobamides. Several studies have investigated the production of vitamin B12 through microbial fermentation, with varying levels of success. Some strains of bacteria, such as Propionibacterium spp., are known to produce vitamin B12 as a byproduct of their metabolism. Other researchers have developed synthetic methods for producing vitamin B12, including Woodward's synthesis. The clinical aspects of cobalamin metabolism and its clinical applications have also been studied extensively. Research has shown that vitamin B12 plays a crucial role in the production of red blood cells and the maintenance of healthy nerve function. Overall, the study of vitamin B12 biosynthesis and production is an active area of research, with ongoing efforts to develop more efficient methods for producing this essential nutrient. The history of vitamin B12 research is a complex one, with several key figures contributing to our understanding of the nutrient. George H. Whipple's work on anemia in rats ^ "George H. Whipple – Biographical". www.nobelprize.org. Archived from the original on 13 September 2017. Retrieved 10 October 2017. ^ "The Nobel Prize in Physiology or Medicine 1934". NobelPrize.org. Retrieved 23 February 2023. ^ "Mary Shorb Lecture in Nutrition". Archived from the original on 4 March 2016. Retrieved 3 March 2016. ^ Shorb MS (May 10, 2012). "Annual Lecture". Department of Animal & Avian Sciences, University of Maryland. Archived from the original on December 12, 2012. Retrieved August 2, 2014. led to the identification of vitamin B12 as a crucial factor in preventing pernicious anemia. However, it wasn't until the work of Dorothy Hodgkin and her team that the crystal structure of vitamin B12 was fully understood ^ Hodgkin DC, Pickworth J, Robertson JH, Trueblood KN, Prosen RJ, White JG (1955). "Structure of Vitamin B12: The Crystal Structure of the Hexacarboxylic Acid derived from B12 and the Molecular Structure of the Vitamin". Nature. 176 (4477): 325–28. Bibcode:1955Natur.176..325H. doi:10.1038/176325a0. PMID 13253565. S2CID 4220926. ^ Hodgkin DC, Kamper J, Mackay M, Pickworth J, Trueblood KN, White JG (July 1956). "Structure of vitamin B12". Nature. 178 (4524): 64–66. Bibcode:1956Natur.178...64H. doi:10.1038/178064a0. PMID 13348621. S2CID 4210164. that allowed for the development of more effective treatments. The use of vitamin B12 injections as a treatment for various conditions has been debated, with some arguing that they are unnecessary or even harmful ^ Gaby AR (October 2002). "Intravenous nutrient therapy: the "Myers' cocktail"". Altern Med Rev. 7 (5): 389–403. PMID 12410623. ^ Silverstein WK, Lin Y, Dharma C, Croxford R, Earle CC, Cheung MC (July 2019). "Prevalence of Inappropriateness of Parenteral Vitamin B12 Administration in Ontario, Canada". JAMA Internal Medicine. 179 (10): 1434–1436. doi:10.1001/jamainternmed.2019.1859. ISSN 2168-6106. PMC 6632124. PMID 31305876. However, others argue that they can be beneficial in certain situations ^ Carpenter KJ. "The Nobel Prize and the discovery of vitamins". nobelprize.org. Archived from the original on 20 August 2023. Retrieved 19 November 2023.

Is cobalt vitamin b12. Does b12 have cobalt in it. Is b12 cobalt. Does b12 contain cobalt. Does b12 come from cobalt.