**Function**

Vitamin B12 (B12), originally discovered as an anti-pernicious factor, has been named cobalamin because it contains the rare element cobalt in its chemical structure. Methylcobalamin and adenosylcobalamin are two biologically active forms of B12.

B12 is essential in activating folate to its metabolically active co-enzyme form, which is essential in DNA synthesis, as well as the synthesis of methionine. B12 plays a critical role in erythropoiesis as well as in the production of other blood cells.

**Digestion and Absorption**

The process of digestion and absorption of B12 takes place in a few stages and requires adequate synthesis of hydrochloric acid, proteases and the intrinsic factor (IF). B12 is released from dietary proteins by pepsin. Once released, B12 binds with R-proteins secreted in the saliva. In the small intestine, pancreatic proteases digest the R-proteins, making it possible for the IF to bind to the newly freed B12, forming an IF-B12 (or IF-Cbl) complex. B12 can be absorbed into the bloodstream either via receptor-mediated endocytosis in the distal ileum or, in the absence of IF, by passive diffusion.

**Recommendation**

Although the 1998 Institute of Medicine’s (IOM) Recommended Dietary Allowance (RDA) calls for intake of 2.4 µg/day by non-pregnant adults, 2.6 µg/day and 2.8 µg/day for pregnant and lactating women, respectively, newer research studies have shown that these recommendations have been underestimated and that adequate intake may be considerably higher. The European Food Safety Authority’s recommendations, issued in 2014, call for intake of 4.0, 4.5 and 5.0 µg/day by adults, pregnant, and lactating women, respectively.

Elderly vegetarians may need still higher doses due to age-related factors that lead to higher risk of B12 malabsorption.

**B12 Status of Vegetarians and Vegans**

Though it was once believed that B12 deficiency is rare and unlikely to develop, except in strict vegetarians, evidence from recent studies have shown that this view can no longer be supported. In fact, all of several recent reviews and one meta-analysis have shown that the prevalence of B12 deficiency among vegetarians of all types is high, often exceeding 50% of studied participants, ranging from 12% to as much as 94%, depending upon several factors including deficiency definition, assessment method of B12 status, and type of vegetarian diet (vegans usually have a higher deficiency prevalence). It should be emphasized that the incidence of B12 deficiency has been estimated based on the traditional assessment criteria, which, in most assessment methods, has been deflated, as described in the next section.

**Assessment of B12 Status**

Several B12 assessment methods are available. They include serum/plasma B12, mean corpuscular volume (MCV), homocysteine (Hcy), holo transcobalamin II (holoTCII), and serum and urinary methylmalonic acid (MMA). The table on the VN DPG website (link at end of document) includes the list of biochemical B12 assessments along with the traditional and evidence-based deficiency cutoffs.

**Deficiency**

In vegetarians, the most common cause of B12 deficiency is inadequate B12 intake. In addition, inadequate B12 status, increases the risk of several health problems, including atherosclerosis, diabetic complications (e.g. neuropathy, nephropathy,
macular edema, cognitive decline, brain atrophy, depression, and osteoporotic fractures. This detrimental impact is largely attributed to the increased homocysteine concentration, a result of inadequate B12 status.

Cases of vitamin B12 deficiency among infants and toddlers are of most concern. A number of case reports of B12-related complications among children born to vegetarian, especially vegan, mothers and/or children fed with vegetarian or vegan diets, have been published. Infants and toddlers who develop B12 deficiency are often diagnosed with profound developmental delays and neurological damage. These children may not be able to sit on their own, have anorexia, and severe deficient in weight, height and head circumference.

**Food Sources and Bioavailability of B12**

B12 is only synthesized by microorganisms and, thus, it is not found in foods of plant origin. It is, however, found in animal products, such as dairy products and eggs.

**Supplements and fortified foods**

B12 in a supplement form, mostly as cyanocobalamin, is widely available in pharmacies, grocery, and health food stores. Other forms of B12, such as methylcobalamin and hydroxycobalamin, can also be found. Recent findings have showed that administration of cyanocobalamin resulted in more than two-fold increase in holoTCII level in individuals with low and normal B12, compared to administration of hydroxocobalamin.

Several cereal products, fortified with B12, constitute a significant source of B12, often containing above 3 μg of B12 per 3.5 oz. serving. Additionally, some brands of nutritional yeast are fortified with vitamin B12. It is important to read labels as not all cereals, meat analogues, soymilks, and nutritional yeast are fortified with B12, and the amount of fortification can change.

**Unreliable “sources” of B12**

Although some bacteria in the small intestine produce B12, this amount does not appear to be substantial for maintenance of adequate B12 status in humans. Findings regarding B12 content of algae, such as spirulina, nori, and kombu, are inconsistent. Some studies have shown that they almost exclusively contain inactive analogues of B12, while other studies have shown that they do contain active B12.

Fermented soy products, such as tempeh and other plant foods, do not contain biologically active forms of B12. Using probiotics is not a reliable method of preventing B12 deficiency.

“Living” vitamin supplements, made from plants, do not contain biologically active B12.

**Recommendations for Vegetarians**

In order to prevent deficiency, vegetarians should ingest a reliable B12 source, such as fortified foods or supplements. Regularly ingesting eggs and dairy products is very unlikely to prevent B12 deficiency or insufficiency. Because food fortification practices change, the most reliable way for vegetarians to maintain adequate B12 status is through the intake of B12 supplements. The following are recommendations to ensure adequate B12 status:

All vegetarians, regardless of type, should periodically be screened for B12 deficiency. Lab results should be compared to recommendations using the link to the VN DPG website below.

All vegetarians, especially vegans, should be using B12 supplements regularly, particularly if elderly or during pregnancy. Higher doses will likely be needed for individuals who are already deficient. Doses between 100 μg/d for children to 2000 μg/d in adults have been used to treat cases of deficiency described in professional literature.

**Charts and References**

For a list of clinical manifestations of B12 deficiency, a list of B12 content on plant products, and references for this resource, visit [http://vndpg.org/resources/B12](http://vndpg.org/resources/B12)