

# **LEAD Action NEWS**

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## **Food, Nutrition and Lead Absorption**

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## Research article

### Nutrition to Fight Lead Poisoning

*By Robert J. Taylor, additional references sourced by Elizabeth O'Brien, Edited by Anne Roberts, Photos by Catherine Sweeny. A Fact Sheet version of this Research Article can be found at [www.lead.org.au/fs/Fact\\_sheet-Nutrients that reduce lead poisoning June 2010.pdf](http://www.lead.org.au/fs/Fact_sheet-Nutrients%20that%20reduce%20lead%20poisoning%20June%202010.pdf)*

Note that this article is compiled by a layman with no specialized medical training. It is not meant to be used in place of qualified medical or nutritional advice. Because of its general nature the author has not attempted a work with direct citations, instead providing reading lists on individual nutrients for those who wish to follow up on topics. The nature of addressing a general audience has meant that many elements have been simplified. Please consult a medical professional or nutritionist before implementing dietary changes.

Please note also that, given the recognized toxicity of lead, almost all articles quoted studies of humans involving individuals or groups where lead levels are falling, and results may not hold for ongoing lead exposure, acute lead poisoning or consistent low blood lead levels (<5 µl/dl, see **Low Blood Lead Levels Do Not Appear to Be Further Reduced by Dietary Supplements EPH Vol 114 No8 Aug 2006 Brian L.Gulson, Karen J. Mizon, Michael J. Korsch, and Alan J. Taylor [www.ehponline.org/members/2006/8605/8605.pdf](http://www.ehponline.org/members/2006/8605/8605.pdf) ). Analysis of relationships between serum (blood) nutrient levels and lead levels must take into account the fact that lower serum nutrients may be influenced by lead toxicity, other toxin found with lead or lead related diseases. Animal studies must be treated with caution as by definition the human metabolism differs for that of animals used in these studies.**

A good base source is the Medscape Lead Fact Sheet (highlighting nutrition) at [www.medscape.com/viewarticle/552359\\_2](http://www.medscape.com/viewarticle/552359_2). A useful overview of lead toxicity is **Lead toxicity, a review of the literature Part 1**, written by Lyn Patrick and accessible at [www.thorne.com/media/Lead\\_2.pdf](http://www.thorne.com/media/Lead_2.pdf)

The following provides a good nutritional overview for children exposed to Lead: Chapter 4. Nutritional Assessment and Interventions, from "Managing Elevated Blood Lead Levels Among Young Children: Recommendations from the Advisory Committee on Childhood Lead Poisoning Prevention" by James Sargent, MD, Centers for Disease Control (CDC), US Dept of Health and Human Services, Public Health Service (2002) at [www.cdc.gov/nceh/lead/CaseManagement/chap4.pdf](http://www.cdc.gov/nceh/lead/CaseManagement/chap4.pdf)

### Individual Nutrients

The following is a list of individual nutrients and their relationship to lead levels in the body, with short lists of recommended reading. Additional material is available on iron, which, due to its complex metabolism has its own newsletter, which is "LEAD Action News vol 9 no 3 Lead Poisoning and Iron Nutrition" at [www.lead.org.au/lanv9n3/lanv9n3.html](http://www.lead.org.au/lanv9n3/lanv9n3.html). In the following paper, when a food type (eg. nuts) is followed by the names of particular foods in brackets eg (brazil, cashew, pecan) these foods are listed in declining order of relevant nutrient content.

A good source on the content of individual nutrients in different foods is the **Danish Food Composition Data Base – Ed. 7 Technical University of Denmark [www.foodcomp.dk/v7/fcdb\\_default.asp](http://www.foodcomp.dk/v7/fcdb_default.asp)** which ranks foods for

individual nutrients per 100g. The **USDA National Nutrient Database for Standard Reference, Release 21** US Department of Agriculture [www.nal.usda.gov/fnic/foodcomp/search/](http://www.nal.usda.gov/fnic/foodcomp/search/) is more widely quoted but does not provide it's per 100g data in easy to use charts. For a wider view of the value of individual nutrients, the Linus Pauling Institute website at <http://lpi.oregonstate.edu/infocenter/> can be a useful starting point. Another useful site is provided by the Feinberg School of Medicine Northwestern University [www.feinberg.northwestern.edu/nutrition/fact-sheets.html](http://www.feinberg.northwestern.edu/nutrition/fact-sheets.html). The US National Institute of Health (NIH) also provides useful factsheets on nutritional and dietary supplementation at [http://ods.od.nih.gov/Health\\_Information/Information\\_About\\_Individual\\_Dietary\\_Supplements.aspx](http://ods.od.nih.gov/Health_Information/Information_About_Individual_Dietary_Supplements.aspx)

It must be emphasized that there are massive differences between individual food samples, and different yet reputable websites can give very divergent values. Also the raw nutrient content does not reveal how much of a nutrient can be absorbed from it (bioavailability). Spinach is high in calcium and iron, yet humans can absorb less than 6% and 2% of these nutrients respectively, making it a poor source of these nutrients, though it is a good source of many others. For a more comprehensive view of the value of individual foods, the World's Healthiest Foods website is a useful source (at [www.whfoods.com/foodstoc.php](http://www.whfoods.com/foodstoc.php)), though it does seem to accentuate positive aspects.

For those worried about the potential risks of vitamin or mineral supplementation, **Safe Upper Levels for Vitamins and Minerals (May 2003)** UK Expert Group on Vitamins and Minerals [www.food.gov.uk/multimedia/pdfs/vitmin2003.pdf](http://www.food.gov.uk/multimedia/pdfs/vitmin2003.pdf) is a good starting point, providing a good summary of research prior to its publication. Vitamins and minerals found in food are generally not sufficiently concentrated to cause problems, though there are exceptions. For example, large-scale consumption of Brazil nuts (>25 a day) can lead to selenium poisoning, while as few as 5 nuts could raise your selenium intake above recommended daily upper intake levels. However, the primary risk remains unsupervised vitamin and mineral supplementation. The same is true for much interference between nutrients during absorption. The ability of metals such as zinc to significantly interfere with the absorption of other metallic nutrients has been demonstrated at levels unlikely to be obtained from un-supplemented food consumption. Significant vitamin or mineral supplementation, even of non-toxic vitamins such as vitamin C, should only be undertaken with the advice of your physician or a qualified dietitian. Recommended upper limits mentioned in this paper are for healthy young adults, and should be adjusted with qualified medical advice for children or older individuals. This paper avoids quoting recommended figures for children and older individuals (available from sites already mentioned), as, given possible variations for other conditions, this is best discussed with a medical professional.

**Vitamin C** Low levels of Vitamin C [ascorbic acid] are strongly linked to high lead levels. Individuals who consume more than 340 mg of vitamin C tend to have lower blood lead levels than those who consume less than 110 mg. Consumption of 1000 mg a day has been shown to significantly decrease lead levels in some, though not all, cases - apparently more through reduced absorption rather than increased excretion. Vitamin C has been consistently shown to protect the concentration of molecules such as ALAD that are associated with red blood cell manufacture. Vitamin C improves iron absorption if it can mix with food in the stomach (food or liquid being preferable forms), as well as increasing iron's capacity to displace lead during food absorption. There is some evidence that Vitamin C can inhibit lead uptake at a cellular level as well as lead's cytotoxicity (cellular toxicity). In combination with zinc, glycine and vitamin E, it has been found effective in partially protecting a

range of body organs, particularly the brain and liver, from lead-induced damage in animal experiments (see zinc, glycine and vitamin E entries in this paper). Rat experiments have demonstrated reduced lead impacts on a variety of body organs, even when administered alone. Vitamin C has been used as a chelator (metal remover) in a variety of naturopathic lead treatments, but experimental results on its ability to increase lead excretion contain significant inconsistencies. Similarly, while some studies have linked reduced hypertension to Vitamin C levels, this has not been confirmed in long-term human studies. Vitamin C is non-toxic, and no significant drawbacks for healthy young adults have been documented at daily intakes below 1000mg.

However, this should not be seen as an endorsement of megadoses of vitamin C, defined for this paper as consumption >2000mg per day (the recommended daily upper limit in the USA set by the Food and Nutrition Board for healthy adults), since, like other nutrients vitamin C has a range of consequences on essential nutrients (definitely increasing iron absorption while possibly reducing copper levels, which enable iron transport within the body) and body systems (including possible increased risk of cataract or kidney stone formation for some individuals at supplementation levels of around 1,000mg). Supplements of any type should only be taken with medical advice, particularly if medication is being consumed.

**FIGURE 7.1**  
**Plasma vitamin C concentrations achieve steady state at intakes in excess of 200 mg/day**

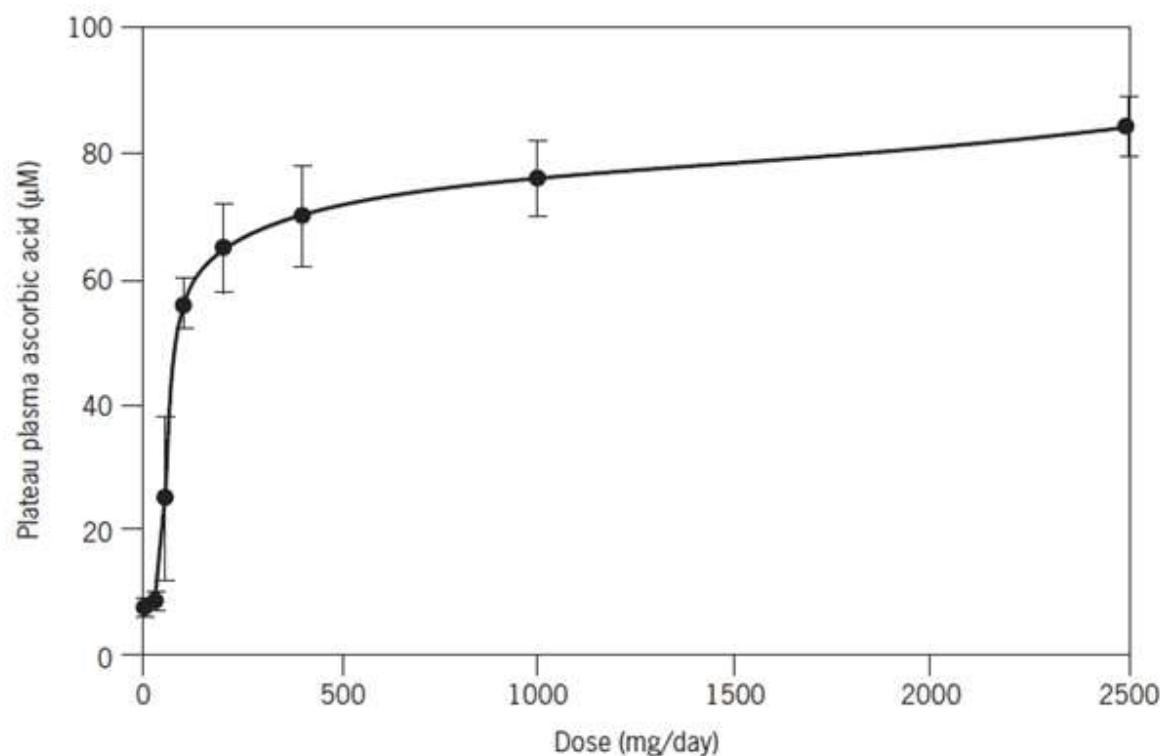


Figure 7.1: Plasma vitamin C concentrations achieve steady state at intakes in excess of 200 mg/day.  
[Source: Levine M et al. Vitamin C pharmacokinetics in healthy volunteers: evidence for a Recommended Dietary Allowance. *Proceedings of the National Academy of Sciences*, 1996, 93:3704–3709. ©The National Academy of Sciences 1996] Downloaded from [www.pnas.org/content/93/8/3704.full.pdf+html](http://www.pnas.org/content/93/8/3704.full.pdf+html) [Accessed 25<sup>th</sup> January 2010]

The fact that a plateau exists beyond which excess dietary or supplementary Vitamin C has little impact, while intravenously administered Vitamin C can result in serum (blood) vitamin C levels over six times higher, suggests there may be drawbacks to high levels of vitamin C, though few examples have as yet been well documented. Oral consumption of more than 500 mg at a time will not generally increase serum vitamin C above 500mg supplementation levels for more than a few hours, due to increased excretion and breakdown, though vitamin C proponents argue that various organs such as the retina of the eye, or the brain, can retain much higher levels (up to 100 times greater) than the blood. Maximizing serum (blood) Vitamin C concentrations requires new doses every four hours. There is some evidence from animal studies that extreme vitamin C intake can negate the benefits of vitamin C supplementation as a treatment for lead damage, as under certain circumstances ascorbic acid can act as an oxidizing agent rather than as an antioxidant.

For healthy young non-smoking adult individuals, 400 mg a day, a minimum recommended by the Linus Pauling Institute, seems both a reasonable and safe dietary goal, though this may not be adequate for all sectors of the population as vitamin C absorption may decline with age, or may be impacted by smoking, diet (including alcohol) or medication. High levels of vitamin C reduce the risk of Helicobacter pylori infections that can reduce stomach acidity, in turn reducing iron, zinc, copper, calcium and B12 absorption.



*Vitamin C: 480 g of the foods (pictured above) eaten raw should provide sufficient Vitamin C to reach 400 mg a day (much more if cooked, for juice equivalent check labels). Top row: parsley, guava (juice pictured), blackcurrant (juice pictured), kale Middle Row: radish, capsicum (bell pepper in US), kiwi fruits, broccoli Bottom row: feijoa, baby capsicums, brussel sprouts, guava, horse radish Not pictured: Mustard greens, red peppers, thyme*

Vitamin C is found in a wide range of fruits and vegetables. Cooking reduces vitamin C content, but the degree varies widely between foods (potatoes lose 20-30% from boiling, broccoli 50-60%) and cooking styles (steaming is generally the best, baking the worst) and its significance depends on the foods' initial content (boiled broccoli can still have more vitamin C than an orange). Vitamin C will continue to be lost if material is left in a warming trays, as a major loss is from enzymes produced by cooking whose activity continues in warm temperatures.

**1. Vitamin C** Jane Higdon *The Linus Pauling Institute*

<http://lpi.oregonstate.edu/infocenter/vitamins/vitaminC/> [A good overview of vitamin C as a nutrient with a short section on lead toxicity. Recommends 400 mg a day as a minimum intake. Supports caution for individuals who may be at risk of kidney stones, noting that studies are contradictory]

**2. Lead toxicity Part II: the role of free radical damage and the use of antioxidants in the pathology and treatment of lead toxicity** Patrick, Lyn *Alternative Medicine Review Vol 10, No 4 Dec 2005 www.thorne.com/altmedrev/fulltext/11/2/114.pdf* [Contains a good summary of research into Vitamin C and lead levels. Fig 4 is a graph of one study's findings, charting serum [blood] (rather than dietary) vitamin C and lead levels. Also quotes a study where 1000mg a day of vitamin C had no effect on serum lead levels]

**3. Relation of Nutrition to Bone Lead and Blood Lead Levels in Middle-aged to Elderly Men - The Normative Aging Study** Yawen Cheng, Walter C. Willett, Joel Schwartz, David Sparrow, Scott Weiss, and Howard H American *Journal of Epidemiology Vol. 147, No. 12 www.aje.oxfordjournals.org/cgi/content/abstract/147/12/1162* [Finds that individuals who consume over 340mg of vitamin C have significantly lower blood lead levels than those who consume under 110 mg]

**4. Relationship Of Ascorbic Acid To Blood Lead Levels** Simon, Joel A; Hudes, Esther S *JAMA, Vol. 281 No 24 pp 2289 – 2293 http://jama.ama-assn.org/cgi/content/full/281/24/2289* [Shows that adults with high levels of Vitamin C have approximately one third the risk of high lead levels, while the correlation with children over 6 years of age is even stronger.]

**5. Testing of chelating agents and vitamins against lead toxicity using mammalian cell cultures** Anna B. Fischer, Cristine Hess, Tilo Neubauer and Thomas Eikmann *Analyst, January 1998, Vol. 123 (55-58) www.rsc.org/delivery/ ArticleLinking/DisplayArticleForFree.cfm?doi=a705518h&JournalCode=AN* [Finds that in cell cultures Vitamin C inhibits lead uptake on a cellular level and reduces cytotoxicity]

**6. The Effect of Ascorbic Acid Supplementation on the Blood Lead Levels of Smokers** Earl B. Dawson, Douglas R. Evans, William A. Harris, MC Teter, WJ McGanity *J Am College of Nutr, Vol. 18, No. 2, 166–170 (1999) www.jacn.org/cgi/reprint/18/2/166.pdf* [Found that a supplement of 1000mg reduced blood lead levels while 200mg had no effect, even though there was no increase in lead excretion. Note that smoking reduces serum Vitamin C levels so supplementation required should be lower for non-smokers. Mentions previous research on Vitamin C's capacity to improve iron uptake relative to lead.]

**7. Antioxidant effects of α tocopherol, ascorbic acid and L-methionine on lead-induced oxidative stress to the liver, kidney and brain in rats** R. C. Patra, D. Swarup and S. K. Dwivedi *Toxicology Vol 162, No 2, 11 May 2001, Pages 81-88 www.ncbi.nlm.nih.gov/pubmed/11337108* [Found that vitamin C reduced lead impacts on these organs without reducing blood and tissue lead levels, even raising lead levels in the kidneys]

**8. Influence of vitamin C supplementation on lead-induced histopathological alterations in male rats** Mahmoud Shaban El-Neweshy and Mahmoud Shaban and Yasser Said El-Sayed *Experimental and Toxicologic Pathology Article in Press, Corrected Proof online 6 January 2010 http://dx.doi.org/10.1016/j.etp.2009.12.003* [A very recent piece of animal research demonstrating the capacity of vitamin C to reduce lead impacts on a variety of body organs.]

**9. Effect of Ascorbic Acid and Thiamine Supplementation at Different Concentrations on Lead Toxicity in Liver** Chunhong Wang, Jiancheng Liang, Chunlian Zhang, Y Bi, X Shi And Q Shi *Ann. Occup. Hyg., Vol. 51, No. 6, pp. 563–569, 2007 http://annhyg.oxfordjournals.org/cgi/reprint/51/6/563* [Found that in mice, while the vitamins mentioned significantly reduced lead-induced liver damage they had no effect at all at the highest vitamin C dose.]

**10. Vitamin C pharmacokinetics in healthy volunteers: Evidence for a recommended dietary allowance** Mark Levine, Cathy Conry-Cantilenat, Yaohui Wang, Richard W. Welch, Philip W. Washko, Kuldeep R. Dhariwal, Jae B. Park, Alexander Lazarev, James F. Graumlich, Jean Kings, And Louis R. Cantilena *Proc. Natl. Acad. Sci. USA Vol. 93, pp. 3704-3709, April 1996 www.ncbi.nlm.nih.gov/pmc/articles/PMC39676/pdf/pnas01515-0554.pdf* [Finds that

supplemental doses above 200mg tend to be excreted within 24 hours and that little prolonged increase in serum Vitamin C is achieved above 400mg per day.]

**11. Criteria and Recommendations for Vitamin C Intake** Mark Levine; Steven C. Rumsey; Rushad Daruwala; Jae B. Park; Yaohui Wang. *JAMA*. 1999;281(15):1415-1423 <http://jama.ama-assn.org/cgi/content/full/281/15/1415> [indicates doses of more than 500mg have little impact on serum vitamin C levels and recommends caution for doses of 1000 mg a day or higher.]

**12. Vitamin C Pharmacokinetics: Implications for Oral and Intravenous Use** Sebastian J. Padayatty; He Sun,; Yaohui Wang, ; Hugh D. Riordan; Stephen M. Hewitt; Arie Katz; Robert A. Wesley; and Mark Levine *Annals of Internal Medicine* Vol 140 No 7 533-528 [www.annals.org/cgi/content/abstract/140/7/533](http://www.annals.org/cgi/content/abstract/140/7/533) [Notes the much higher levels of serum vitamin C that can be achieved through intravenous injection. Figure 2, p 536 clearly indicates that maximizing serum [blood] vitamin C levels by oral supplementation requires new doses about every 4 hours.]

**13. Vitamin C Requirements: Optimal Health Benefits Vs Overdose** Ronald Roth *Acu-Cell* [www.acu-cell.com/vitc.html](http://www.acu-cell.com/vitc.html) [A cautionary exploration of the wider impacts of Vitamin C supplementation]

**14. Correlation Between Helicobacter pylori Infection and Vitamin C Levels in Whole Blood, Plasma, and Gastric Juice, and the pH of Gastric Juice in Korean Children** Park, Jae H.; Kim, Su Y.; Kim, Dong W.; Lee, Woo G.; Rhee, Kwang H.; Youn, Hee S. *J. of Pediatric Gastroenterology and Nutrition: July 2003 Vol 37 Is 1 p53-62* [http://journals.lww.com/jpgn/Abstract/2003/07000/Correlation\\_Between\\_Helicobacter\\_pylori\\_Infection.9.aspx](http://journals.lww.com/jpgn/Abstract/2003/07000/Correlation_Between_Helicobacter_pylori_Infection.9.aspx) [Indicates that individuals with higher vitamin C levels have lower rates of H. pylori infection and less severe infections]

**15. Vitamin C supplements and the risk of age-related cataract: a population-based prospective cohort study in women** Susanne Rautianen, Birgitta Ejdervik Lindblad, Ralf Morgenstern and Alicja Wolk *Am J Clin Nutr* 2010; Vol. 91, No. 2, 487-493, Feb 2010. [www.ncbi.nlm.nih.gov/pmc/articles/PMC2816010/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2816010/) [Finds a higher risk of cataracts among older women taking vitamin C supplements estimated to average 1000mg per day particularly if using HRT (Hormone Replacement Therapy) or corticosteroids (anti-inflammatory agents found in arthritis and asthma medication as well as several others)]

**16. Lack of Long-Term Effect of Vitamin C Supplementation on Blood Pressure** Mi Kyung Kim; Satoshi Sasaki; Shizuka Sasazuki; Shunji Okubo; Masato Hayashi; Shoichiro Tsugane *Hypertension*. 2002;40:797-803 <http://hyper.ahajournals.org/cgi/content/full/40/6/797> [A large five year study that found no link between hypertension and vitamin C supplementation or serum vitamin C levels]

**17. Why are Whole Food Dietary Supplements Better than Single Nutrient Supplements? A Review Based on the Vitamin C Literature** Jane Ramberg; Lam Le; Shayne McAnalley; C. Michael Koepke; Eileen Vennum, and Bill McAnalley *Mens-Women Health* [www.mens-womens-health.com/supplements.html](http://www.mens-womens-health.com/supplements.html) [a good outline of why it is better to obtain Vitamin C from food (or mixed with foods) rather than as a separate supplement. Notes that citrus fruit (oranges, lemons etc) have more of an impact on serum vitamin C levels than their vitamin C content suggests.]

**18. Top 10 Foods Highest in Vitamin C** HealthAliciousNess [www.healthaliciousness.com/articles/vitamin-c.php](http://www.healthaliciousness.com/articles/vitamin-c.php) [a useful list of the richest common sources of vitamin C]

**Vitamin B1 (Thiamine or Thiamin)** is associated with lower level of blood lead and is comparable to vitamin C in this regard, though it is not as effective on all serum (blood) measures. In animal studies it increases lead excretion, particularly from the brain. From animal studies it appears it may even be able to partially repair some lead-induced brain damage.

Good levels of thiamin are found in yeast, pork, whole grains, legumes (eg. beans, peas and lentils), nuts, oranges and milk. Thiamine absorption and utilization are reduced by alcohol consumption. Thiamine is a compulsory food additive for bread in Australia and many western countries, though organic bread is not fortified. No upper limit has generally been set for thiamine since toxicity appears to be extremely low, and negative side effects are rare (rarer than with vitamin C). Short-term side effects, such as headaches, nausea and weakness have occasionally occurred at supplemental doses above 5g but cease if dosages are reduced.



*Vitamin B1: the above items are rich in thiamine* *Top row:* nuts (cashew nuts pictured), milk, Milo, whole-grain biscuits (Vita-Wheat) *Middle Row:* lentils, orange, whole grain bread *Bottom row:* pork, snow peas, peas, beans.

- 1. Thiamin** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/vitamins/thiamin/> [a good overview of thiamine as a nutrient]
- 2. Determinants of the Blood Lead Level of US Women of Reproductive Age** Lee, Mi-Gyung; Chun, Ock Kyoung and Sung, Wan O. *J Am College of Nutr.*, Vol. 24, No. 1, 1–9 (2005) [www.jacn.org/cgi/reprint/24/1/1](http://www.jacn.org/cgi/reprint/24/1/1) [Finds that thiamine levels are linked to significantly lower blood lead levels, with individuals who consumed at least 1mg a day 7.5 times less likely to be in the top 10% of blood lead levels compared to those with minimal thiamine intake.]
- 3. Lead Poisoning In Silver Refiners And Its Prevention** S.K. Tandon, M. Chatterjee, A. Bhargava, V. Shukla and V. Behari *Industrial Toxicology Research Centre, Lucknow-226001, India* [www.cprm.gov.br/pgagem/Manuscripts/tandonsk.htm](http://www.cprm.gov.br/pgagem/Manuscripts/tandonsk.htm) [Finds that thiamine can reduce lead levels as effectively as vitamin C, but that Vitamin C has wider effects on blood lead toxicity, such as ALAD levels.]
- 4. Selection of micronutrients used along with DMSA in the treatment of moderately lead-intoxicated mice** Yingjun Liao, Fei Yu, Yaping Jin, Chunwei Lu, Gexin Li, Xuping Zhi, Li An and Jun Yang *Arch Toxicol* (2008) 82:37–43 <http://202.118.40.5/OHOM/uploadfile/doc/kxy/jyp/w/5.pdf> [Contains a good brief overview of research that thiamine can increase lead excretion, on page 42; also mentions taurine and zinc research.]
- 5. Selection of Nutrients for Prevention or Amelioration of Lead-Induced Learning and Memory Impairment in Rats** Guangqin Fan, Chang Feng, Yu Li, C Wang, J Yan, W Li, J Feng, X Shi and Y Bi *Annals of Occup Hygiene* 2009 53(4):341-351 <http://annhyg.oxfordjournals.org/cgi/content/abstract/53/4/341> [Indicates that thiamin may actually repair some lead damaged learning and memory functions.]
- 6. Effect of Ascorbic Acid and Thiamine Supplementation at Different Concentrations on Lead Toxicity in Liver** Chunhong Wang, Jiancheng Liang, Chunlian Zhang, Y Bi, X Shi And Q Shi *Ann. Occup. Hyg.*, Vol. 51, No. 6, pp. 563–569, 2007 <http://annhyg.oxfordjournals.org/cgi/reprint/51/6/563> [Demonstrates that, at least for the liver, optimum results from thiamine can be obtained from a moderate rather than very high dose. Note however, that being an animal study, the dose to body mass should not simply be copied for human consumption].
- 7. Testing of chelating agents and vitamins against lead toxicity using mammalian cell cultures** Anna B. Fischer, Cristine Hess, Tilo Neubauer and Thomas Eikmann *Analyst*, January 1998, Vol. 123 (55-58)

[www.rsc.org/delivery/\\_ArticleLinking/DisplayArticleForFree.cfm?doi=a705518h&JournalCode=AN](http://www.rsc.org/delivery/_ArticleLinking/DisplayArticleForFree.cfm?doi=a705518h&JournalCode=AN) [Finds that in cell cultures thiamin inhibits lead uptake on a cellular level and reduces cytotoxicity (cell toxicity).]

**Vitamin B6 and Taurine** Vitamin B6 (pyridoxine), along with cysteine, is used to manufacture the amino acid taurine in the body, though taurine is found in food and can be absorbed in its own right. Vitamin B6 may be able to reduce lead uptake on a cellular level and reduce cytotoxicity (cell toxicity) and increase lead excretion. Taurine has been shown to significantly reduce and possibly repair some lead damage to organs in animal experiments, particularly the brain. Vitamin B6 has no known impact on lead-induced brain damage. Taurine appears not to significantly influence lead absorption or excretion. Taurine can also reduce hypertension, including lead-induced hypertension. Taurine improves the body's retention of magnesium, which can also reduce hypertension.



*Taurine:* the above items are high in Taurine or B6 *Back Row:* Meat, energy drinks, milk, yogurt, cheese *Front row:* Eggs, sardines, salmon, haddock. *Not pictured:* sea weed

Taking more than 200 mg of vitamin B6 supplements can result in sensory neuropathy (pain and numbness), although no similar finding have been made for food consumption possibly due to the existence of three types of B6. The US Food and Nutrition Board of the Institute of Medicine recommends no more than 100 mg per day be taken. Taurine has no known toxicity and is readily excreted.

Vitamin B6 is found in yeast, vegemite, dill weed, wheat germ or bran, pistachio nuts, garlic, frog legs, curry powder, fish (tuna, salmon, garfish), liver (ox, chicken, duck), seeds (sesame, linseed), breakfast cereals, and while bananas and potatoes have lower levels they can impact on B6 levels because on the quantities consumed. Vitamin B6 content is significantly reduced by cooking or processing. Taurine is found in high quantities in meat, fish, eggs, dairy products and some energy drinks. For vegans certain seaweeds are the only vegetable source of taurine, vegans tend to have low taurine levels.

1. **Vitamin B<sub>6</sub>** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/vitamins/vitaminB6/> [Yet another good overview from the Linus Pauling Institute.]

**2. Taurine: a conditionally essential amino acid in humans? An overview in health and disease R.**

Lourenço and M. E. Camilo *Nutr. Hosp.* (2002) XVII (6) 262-270

[www.grupoaulamedica.com/web/nutricion/pdf/062002/02\\_Taurine.pdf](http://www.grupoaulamedica.com/web/nutricion/pdf/062002/02_Taurine.pdf) [A good, easy to follow, if somewhat technical outline of the role of taurine. Those wishing a short introduction may prefer the Wikipedia entry.]

**3. Taurine Wikipedia <http://en.wikipedia.org/wiki/Taurine>** [Effective outline on the role of taurine, more up to date than the previous article, shorter but not as easy to read]

**4. There's A Pill For That I: Taurine** Melissa McEwan *Hunt Gather Love* posted 26/3/2010

<http://huntgatherlove.com/content/theres-pill-i-taurine> [an exploration of the possibility of taurine deficiency, even though it is manufactured inside the body]

**5. Testing of chelating agents and vitamins against lead toxicity using mammalian cell cultures** Anna B. Fischer, Cristine Hess, Tilo Neubauer and Thomas Eikmann *Analyst*, January 1998, Vol. 123 (55-58) [www.rsc.org/delivery/\\_ArticleLinking/DisplayArticleForFree.cfm?doi=a705518h&JournalCode=AN](http://www.rsc.org/delivery/_ArticleLinking/DisplayArticleForFree.cfm?doi=a705518h&JournalCode=AN) [Found that in cell cultures B6 inhibits lead uptake on a cellular level and reduces cytotoxicity]

**6. Influence of Pyridoxine (Vitamin B6) on Lead Intoxication in Rats** Sushil K. Tandon, Swaran J.S. Flora and Surendra Singh *INDUSTRIAL HEALTH* Vol.25, No.2(1987)pp.93-96

[www.journalarchive.jst.go.jp/english/jnlabstract\\_en.php?cdjournal=indhealth1963&cdvol=25&noissue=2&startpage=93](http://www.journalarchive.jst.go.jp/english/jnlabstract_en.php?cdjournal=indhealth1963&cdvol=25&noissue=2&startpage=93) [Found that B6 reduced levels of lead in the blood, kidneys and liver but not the brain]

**7. Antioxidant Effect of Taurine Against Lead-Induced Oxidative Stress** H. Gürer, H. Özgünes, E. Saygin and N. Ercal *Arch of Env Cont Tox* Vol 41, No 4 Nov, 2001 [www.springerlink.com/content/8dckmh9ur01tgdh/](http://www.springerlink.com/content/8dckmh9ur01tgdh/) [Finds that taurine has no impact on blood lead but did have neurologically protective properties]

**8. Influences of different developmental periods of taurine supplements on synaptic plasticity in hippocampal CA1 area of rats following prenatal and perinatal lead exposure** Shan-Shan Yu, Ming Wang, Xin-Mei Li, Wei-Heng Chen, Ju-Tao Chen, Hui-Li Wang and Di-Yun Ruan *BMC Developmental Biology* 2007, 7:51 doi [www.biomedcentral.com/1471-213X/7/51](http://www.biomedcentral.com/1471-213X/7/51) [Demonstrates the importance of taurine to brain development if lead exposure occurs]

**9. Selection of Nutrients for Prevention or Amelioration of Lead-Induced Learning and Memory**

**Impairment in Rats** Guangqin Fan, Chang Feng, Yu Li, C Wang, J Yan, W Li, J Feng, X Shi and Y Bi *Annals of Occup Hygiene* 2009 53(4):341-351 <http://annhyg.oxfordjournals.org/cgi/content/abstract/53/4/341> [Shows that in combination with methionine, taurine can protect against lead-induced brain damage, while taurine can also repair some lead-damaged memory and learning functions]

**Folate (Vitamin M) and Folic Acid (Vitamin B9)**, different forms of the same substance (folic acid is the supplementary form), increase lead absorption in the gut but improve lead excretion and may make it harder for lead to bind to blood elements. Recent studies indicate it is associated with lower blood lead, and more importantly, may protect to some degree from the intellectual impairment associated with even moderate blood lead levels in children - though the mechanisms are not yet understood. Folate deficiency can exacerbate lead-induced anemia by adding megaloblastic anemia (depressed red blood cell production) to hypochromic (caused by oxygen deficient red blood cells) and microcytic (due to small short lived red blood cells) anaemia.

Folate is found in good quantities in green leafy vegetables, fortified breakfast cereals, legumes, some seeds or fruit, liver and baker's yeast. Australia began compulsory fortification of bread with B9 in mid September 2009, as have other countries including the USA, but organic bread is not fortified. Pasteurized cow's milk contains reasonable levels, while some fermented products (some yogurts and soft cheeses) have higher levels. Equally importantly, cow's milk may enhance the body's ability to utilize folate. Prolonged cooking can destroy most folate from vegetable sources but has little impact on folate from animal sources. Alcohol, smoking, and to a lesser extent coffee consumption can reduce serum (blood) folates, while deficiencies in thiamine (B1), riboflavin (B2), niacin (B3) and cobalamin (B12) can interfere with folate use within the body. It is generally recommended that

folate/folic acid intake not exceed 1mg a day, as higher amounts may conceal vitamin B12 deficiency, which can lead to neurological and nerve damage. High levels of serum folate have been partially linked to mental decline in the elderly and tentatively, at least in its supplemental form (folic acid), some cancers.



*Folate or folic acid (vitamin B9):* Found predominantly in vegetables. Significant quantities are obtained from breakfast cereal [cornflakes, pictured] while the cow's milk (rear row) consumed with these products can enhance folate use inside the body. Yeast abstract [vegemite, pictured] is extremely high in folate as is liver (chicken, ox, calf, pig, goose) (centre, second row). Other good sources include wheat germ, some cheeses (left centre row) particularly soft cheeses and some yogurt (not pictured), beans (mung, soy, white [pictured]), chickpeas (right, centre row), parsley root, kale, chervil, spinach, and broccoli (front row). All non-organic bread in Australia by law must be made with folic acid enhanced flour (centre left).

1. **Folic Acid** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/vitamins/fa/> [A good introduction but not as comprehensive of recent research as the wikipedia entry. Has a good, brief easy to understand explanation of interactions between B9, B6 and B12 to produce methionine (mentioned later in this article) and cysteine (used to manufacture glutathione).]
2. **Folic Acid** Wikipedia [http://en.wikipedia.org/wiki/Folic\\_acid](http://en.wikipedia.org/wiki/Folic_acid) [Not as easy to read as the Linus Pauling Institute article but is more comprehensive of recent developments. It is recommended that you read this article after the Linus Pauling article for a rounded general introduction to the role of folate.]
3. **Determinants of the Blood Lead Level of US Women of Reproductive Age** Lee, Mi-Gyung; Chun, Ock Kyoung; Sung, Wan O. *J Am College of Nutr*, Vol. 24, No. 1, 1–9 (2005) [www.jacn.org/cgi/reprint/24/1/1](http://www.jacn.org/cgi/reprint/24/1/1) [Finds that low folate levels are associated with higher blood lead levels. Makes the point of the different effects of folate on lead absorption and excretion.]

**4. Associations between Cognitive Function, Blood Lead Concentration, and Nutrition among Children in the Central Philippines** Solon, Orville; Ridell, TJ; Qumbo, SA; Butrick, E; Aylward, GP; Bacate, ML & Peabody, JW *The Journal of Pediatrics*, Volume 152, Issue 2, Pages 237-243. <http://linkinghub.elsevier.com/retrieve/pii/S0022347607008530> [Finds that not only is folate associated with lower blood lead but that it is linked with lower lead-induced IQ damage in children. Further research would be needed to confirm this link.]

**5. Effect of cow's milk on food folate bioavailability in young women** Mary Frances Picciano, Sheila G West, Amanda L Ruch, Penny M Kris-Etherton, Guixiang Zhao, Kelley E Johnston, Deborah H Maddox, Valerie K Fishell, Douglas B Dirienzo, and Tsunenobu Tamura *Am J Clin Nutr* 2004;80:1565-9. Dec 2004 [www.ajcn.org/cgi/reprint/80/6/1565](http://www.ajcn.org/cgi/reprint/80/6/1565) [Indicates that some folate indicators are improved by consuming folate with dairy products, even when serum folate is unaffected]

**6. Plasma Folate, Vitamin B6, Vitamin B12, and Homocysteine and Pancreatic Cancer Risk in Four Large Cohorts** Eva Schernhammer, Brian Wolpin, Nader Rifai, Barbara Cochrane, Jo Ann Manson, Jing Ma, Ed Giovannucci, Cynthia Thomson, Meir J. Stampfer, and Charles Fuchs *Cancer Res* 2007; 67: (11). June 1, 2007 <http://cancerres.aacrjournals.org/cgi/reprint/67/11/5553> [Found that while folate in food slightly reduced the risk of pancreatic cancer taking multi-vitamins (which use folic acid) may increase the risk. This is one of a number of studies that indicates that in its supplemental form, folic acid, it may increase cancer risks, notably among smokers, though the evidence about folate or folic acid in food is less clear.]

**Vitamin B12** This vitamin, known as cobalamin, plays a major role in the formation of red blood cells. Like folate deficiency, B12 deficiency can seriously exacerbate lead-induced anemia by adding megaloblastic anemia (depressed red blood cell production) to hypochromic (caused by oxygen deficient red blood cells) and microcytic (due to small, short-lived red blood cells) anemia. B12 deficiency also produces neurological damage. Studies in rats indicate B12 can play a role in repairing brain function after lead exposure.

Excessively large doses of folate can mask B12 deficiency, since the two operate symbiotically within the body. B12 is found in good quantities in meat (particularly liver), fish, shellfish and dairy products. The vitamin B12 in eggs is poorly bioavailable and the B12 available from plant foods is almost wholly indigestible to humans, possibly even reducing the capacity to absorb usable B12. Vegans must rely on fortification of food or supplementation and are vulnerable to deficiency. B12 deficiency is common among the elderly, as the ability to absorb vitamin B12 declines with age. Because significant quantities are stored in the liver there is a considerable delay before the consequences of B12 deficiency manifest themselves. Milk and fish in the diet have the highest impact on serum (blood) vitamin B12 levels according to a recent Norwegian study. No upper limit has been established but intakes of 1-2 mg are considered safe.

**1. Vitamin B12** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/vitamins/vitaminB12/> [Good summary of B12 nutritional role]

**2. Clioquinol and vitamin B12 (cobalamin) synergistically rescue the lead-induced impairments of synaptic plasticity in hippocampal dentate gyrus area of the anesthetized rats in vivo** W.-H. Chen, M. Wang, S.-S. Yu, L. Su, D.-M. Zhu, J.-Q. She, X.-J. Cao and D.-Y. Ruan *Neuroscience* Vol 147, Issue 3, 13 July 2007, Pages 853-864 [www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6T0F-4NX2VYH-1](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T0F-4NX2VYH-1) [finds that in rats some lead-induced damage to the brain can be reduced by B12 supplementation.]

**3. Dietary sources of vitamin B-12 and their association with plasma vitamin B-12 concentrations in the general population: the Hordaland Homocysteine Study** Anna Vogiatzoglou, A David Smith, Eha Nurk, Paula Berstad, Christian A Drevon, Per M Ueland, Stein E Vollset, Grethe S Tell and Helga Refsum *Am J Clin Nutr* (February 3, 2009) [www.ajcn.org/cgi/content/abstract/ajcn.2008.26598v1](http://www.ajcn.org/cgi/content/abstract/ajcn.2008.26598v1) [Finds milk to have the highest influence on serum (blood) B12 levels, followed by fish]



Vitamin B12:cobalamin is not available from plant sources. The best sources are liver (ox, lamb [*Pictured right*] calf, goose, pig, chicken), kidney ( lamb, ox, calf [*front row centre*], pig), heart (beef) [*Front row right*], crab, kippers, sardines, oysters [*back row 1*], cod, fish roe and octopus [*not pictured*] Eggs contain good levels, but it is poorly bioavailable (less than 10% can be absorbed). Cow's milk [*Right centre*] has low levels but because of both the quantity consumed and bioavailability can have the largest influence on serum blood levels.

**Vitamin E** is an essential nutrient but supplementation is not recommended for pregnant women (due to potential heart problems in the fetus) and individuals at risk of stroke, on anti-coagulant medication or with Vitamin K deficiency (due to anti-coagulant properties). There are 8 forms of Vitamin E, and only one form, (alpha-tocopherol) is retained in significant quantity within the body and is generally used in supplements but supplementation with one form can reduce levels of the other forms with unknown impacts.

In a similar manner to vitamin C a number of studies have found Vitamin E to be inversely associated with blood lead levels as well increasing the robustness of lead-impacted red blood cells. In addition, a number of studies in rats have found Vitamin C and E to be protective of lead-induced kidney, liver and brain damage particularly in conjunction with each other, partially because vitamin C can recycle Vitamin E into its active form. Vitamin C operates within body fluids, including cellular fluids, destroying oxidizing molecules, while vitamin E acts to protect structures such as cell membranes. Some animal studies have indicated an impact on indicators relating to hypertension, but impacts on hypertension have not been confirmed by human studies.



*Vitamin E: Tocopherol is found predominantly with vegetable oils. The following contain high levels: Back row: vegetable oils (wheat germ, sunflower, safflower, palm, linseed, peanut, corn, olive [pictured]), curry paste (or powder), marzipan, wheat germ. Front row: nuts(Almond, hazel, pine), margarine. Not Pictured: fish liver and oils (haddock, cod), fish roe*

Vitamin E is found in good quantities in a wide range of nuts, seeds and vegetable oils. There is, however, some evidence that vitamin E supplementation can slightly reduce the average lifespan, though it may reduce risks in some subgroups, e.g. dialysis patients, some diabetic individuals, or smokers at least 66 years of age with high vitamin C levels. Consuming 814IU (560mg) of vitamin E a day was recommended as safe by the UK government's Expert Group on Vitamins and Minerals, though considerable uncertainty exists on long-term impacts.

- 1. Vitamin E** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/vitamins/vitaminE/> [A good general summary]
- 2. Vitamin E** Wikipedia [http://en.wikipedia.org/wiki/Vitamin\\_E](http://en.wikipedia.org/wiki/Vitamin_E) [also see related article tocopherol web link within article]
- 3. Graded Associations of Blood Lead and Urinary Cadmium Concentrations with Oxidative-Stress-Related Markers in the U.S. Population: Results from the Third National Health and Nutrition Examination Survey** Duk-Hee Lee, Ji-Sun Lim, Kyungeun Song, Yongchool Boo, and David R. Jacobs Jr *Environmental Health Perspectives VOLUME 114 / NUMBER 3 / March 2006* [www.ncbi.nlm.nih.gov/articlerender.fcgi?artid=1392227](http://www.ncbi.nlm.nih.gov/articlerender.fcgi?artid=1392227) [Finds that low vitamin E levels are associated with higher blood lead levels. Figure one allows a comparison of the impact of vitamin C and vitamin E levels on blood lead]
- 4. Antioxidant effects of  $\alpha$  tocopherol, ascorbic acid and L-methionine on lead-induced oxidative stress to the liver, kidney and brain in rats** R. C. Patra, D. Swarup and S. K. Dwivedi *Toxicology Vol 162, No 2, 11 May 2001*,

Pages 81-88 [www.ncbi.nlm.nih.gov/pubmed/11337108](http://www.ncbi.nlm.nih.gov/pubmed/11337108) [Found that vitamin C, E and methionine reduced damage to these three organs, but that vitamin E had larger impacts on the brain and liver]

**5. Effect of treating lactating rats with lead acetate and its interaction with vitamin E or C on neurobehavior, development and some biochemical parameters in their pups** A. A. Hassan and H. M. Jassim *Iraqi Journal of Veterinary Sciences*, Vol. 24, No. 1, 2010 (45-52) [www.vetmedmosul.org/ijvs/media/10-1-9e.pdf](http://www.vetmedmosul.org/ijvs/media/10-1-9e.pdf) [The conclusion has a good brief summary of the differing yet interconnected impacts of vitamin C and E as antioxidants.]

**6. Increased nitric oxide inactivation by reactive oxygen species in lead-induced hypertension** Nosratola D Vaziri, Kaihui Liang and Yaoxian Ding *Kidney International* (1999) 56, 1492-1498 [www.nature.com/ki/journal/v56/n4/pdf/4491060a.pdf](http://www.nature.com/ki/journal/v56/n4/pdf/4491060a.pdf) [Demonstrates a role for vitamin E in reducing lead-induced hypertension, at least in rats. But see next entry]

**7. Does Increased Oxidative Stress Cause Hypertension?** Ehud Grossman *Diabetes Care* 31 (Suppl. 2):S185-S189, 2008 [http://care.diabetesjournals.org/content/31/Supplement\\_2/S185.full.pdf+html](http://care.diabetesjournals.org/content/31/Supplement_2/S185.full.pdf+html) [A critical appraisal of the use of antioxidants to treat hypertension. Page S187 column 1 has a review of the disappointing studies of vitamin C and E supplementation and hypertension.]

**8. Decision Analysis Supports the Paradigm That Indiscriminate Supplementation of Vitamin E Does More Harm than Good** Yedidya Dotan; Ilya Pinchuk; Dov Lichtenberg; Moshe Leshno *Arteriosclerosis, Thrombosis, and Vascular Biology*. 2009;29:1304 <http://atvb.ahajournals.org/cgi/content/short/29/9/1304> [An examination of a range of studies that finds individuals who take supplemental vitamin E on average live 4 months less in life-quality adjusted terms].

**9. Vitamin E may increase and decrease mortality** Harri Hemilä letter and reply by Lichtenberg American Heart Association at <http://atvb.ahajournals.org/cgi/eletters/29/9/1304#919> [Hemila quotes his own study of older smokers to show Vitamin E can be beneficial. Lichtenberg makes the point that the article he co-wrote (cited above) never disputed this, citing studies of renal and diabetic patients.]

**Carotenoids** An area that needs more research. There is some evidence that low carotene levels are associated with higher blood lead but the correlation is not as strong as with vitamin C or E and does not apply to all carotenoids (lutein/ zeaxanthin show no correlation to blood lead levels). Their strongest impact may be indirect, as some can, when consumed with vitamin C, largely negate the inhibition of iron absorption by polyphenols, found in such commonly consumed items as tea, coffee, red wine and beer, and reduce the inhibitory impact of phytates, found in whole grains, nuts and seeds, on iron absorption (see iron fact sheet). Carotenoids are vegetable pigments found in most vegetables that are not light green: the type best known to the public is probably beta-carotene (a vitamin A compound found in carrots).

**1. Graded Associations of Blood Lead and Urinary Cadmium Concentrations with Oxidative-Stress-Related Markers in the U.S. Population: Results from the Third National Health and Nutrition Examination Survey** Duk-Hee Lee, Ji-Sun Lim, Kyungeun Song, Yongchool Boo, and David R. Jacobs Jr *Environmental Health Perspectives* VOLUME 114 / NUMBER 3 / March 2006 [www.ncbi.nlm.nih.gov/articlerender.fcgi?artid=1392227](http://www.ncbi.nlm.nih.gov/articlerender.fcgi?artid=1392227) [Shows an apparent link between carotene levels and blood lead. It must be emphasized however that without further research it cannot be automatically assumed to be causative, given the link is with serum (blood) rather than dietary carotenoids]

**Garlic** Animal studies have consistently shown that garlic is not only able to reduce blood lead but reduce lead levels in key organs, notably the kidney and liver. It may also be protective of glucose metabolism. There are indications it may be neuroprotective against some lead-induced brain damage. This range of effects is probably due to a range of sulfur based compounds including methionine that play a key role in the synthesis of amino acids and antioxidants such as glutathione. However, significant human studies are needed to demonstrate the applicability of the animal results to humans. Some studies indicate that fresh garlic may be more effective than garlic capsules, but again, more research is needed.

**1. Prophylactic Efficacy of Crushed Garlic Lobes, Black Seed or Olive Oils on Cholinesterase Activity in Central Nervous System Parts and Serum of Lead Intoxicated Rabbits** Maged M. Yassin *Turk J Biol* 29 (2005) 173-180 <http://journals.tubitak.gov.tr/biology/issues/biy-05-29-3/biy-29-3-7-0503-12.pdf> [Finds that consuming fresh garlic not only lowers blood lead levels but also partially protects the liver and brain from some lead-induced damage. Finds smaller effects from black seed and olive oil.]

**2. Effect Of Garlic And Vitamin B-Complex In Lead Acetate Induced Toxicities In Mice** MSH Khan, M Mostofa, MS Jahan, MA Sayed and MA Hossain *Bangl. J. Vet. Med.* (2008). 6 (2): 203-210 [www.banglajol.info/index.php/BJVM/article/viewFile/2337/2052](http://www.banglajol.info/index.php/BJVM/article/viewFile/2337/2052) [Finds that garlic and B-complex vitamins have better impacts on blood lead, liver toxicity and kidney toxicity when consumed together rather than in isolation]

**3. The Effect of Concurrent use of Fresh Garlic or Garlic Tablet with Lead Acetate on Lead(Pb) Burden in Serum and Some Body Tissue of Dog** M. Pour Jaffar, I. Karimi,, E. Saraeian,, M. Shakhs Niyaee, , Kh. Badiei, *Journal of Iran University of Medical Science [IJMUS] Vol 14, No 2* [www.iums.ac.ir/ijs/jiums/article-A-10-1-753-1-en.html](http://www.iums.ac.ir/ijs/jiums/article-A-10-1-753-1-en.html) [Finds that garlic capsules are less effective than fresh garlic in reducing lead levels in the blood or kidneys, but in sufficient quantity can still impact on bone, kidney and liver lead levels, though not necessarily blood lead levels]



Carotenoids: Higher levels of the following carotenoids have been linked to lower blood lead levels but the link has yet to be explained Lycopene: tomatoes, pink grapefruit, guava, [center rear] watermelon [rear left]; α-Carotene/β-carotene: red chili [middle row center], smilax, cassava, bananas [not pictured], orange [rear row right], carrots [front row left], pumpkin [rear row right], ridge gourd [not pictured], green chilli [middle row left], tomato [middle row center], green peas, field and french beans [middle row center], sweet potato [rear row right], kale, watercress [front row center], spinach [rear row center]; α-cryptoxanthin/β-cryptoxanthin: red capsicum [middle row right], pumpkin [rear row right], squash [not pictured], mandarins [can rear row left], coriander [front row left], carrots [front row left], papaya [middle row. left], cilantro [not pictured], orange [rear row right], corn [front row right], watermelon [rear left], Serrano pepper [not pictured], avocados [front row right] and grapefruit [centre rear]. A different set of carotenoids may help negate the inhibitory effect of polyphenols and phytates on iron absorption (see iron factsheet). Far stronger evidence indicates Garlic [front row left] has a range of ameliorating affects on lead toxicity though it still has yet to be validated in human trials.

**Vitamin D** (calciferol) has a mixed reputation: it increases the uptake of lead, calcium and iron. In different studies it is associated with both higher and lower lead levels. It may increase blood lead levels when dietary calcium and iron intake is inadequate. It is possible to speculate that good levels of vitamin D may reduce lead deposition in the bones if calcium, magnesium and phosphorus nutrition is adequate, but may release lead from bone if calcium, magnesium and phosphorus intake is inadequate due to increased bone resorption (the recycling of calcium and other minerals including lead from the bone to the bloodstream). Vitamin D is essential to the effective utilization of calcium

for bone formation and significant deficiency can negate or even reverse some of the advantages of calcium supplementation. It also increases magnesium and phosphorus absorption but unfortunately calcium competes with phosphorus for absorption. Solid Vitamin D levels may help protect against H. pylori infections that reduce stomach acidity, in turn reducing iron, zinc, copper, calcium and vitamin B12 absorption.

Distortion of the vitamin D metabolism is one effect of lead toxicity, reducing the amount transformed into the form most useful to the human body (1,25-dihydroxycholecalciferol [(1,25(OH)<sub>2</sub>D)]), though at moderate lead levels (less than 20 µg/Dl), this appears to have major impacts only when other nutrient intakes, notably calcium, are inadequate. Vitamin D is produced in the body from exposure to sunlight, but individuals who get insufficient sun exposure, always wear sunscreen when outdoors, or are dark skinned and living in temperate/boreal zones may need to obtain significant vitamin D from their diet. In the USA most milk, though not milk products (eg. cheese, yogurt), are fortified with vitamin D, and fortified dairy products are available in other countries. The primary source of vitamin D in unfortified food is fish, with wild fish tending to have higher levels of vitamin D and omega 3 than farmed fish, due to differing food consumption. Egg yolks and livers also contain smaller amounts of vitamin D, while for vegans mushrooms grown under ultraviolet light contain vitamin D levels similar to fish though this product has yet to become widely available. High levels of vitamin D supplementation can increase calcium deposition in soft tissues (hypercalcaemia) leading to renal and heart problems, so supplementation at more than 0.025 mg (1,000 IU) a day should only be undertaken with medical supervision, according to the UK Expert Group on Vitamins and Minerals. The risk of renal (kidney) stones may increase for some individuals at lower dosages (from around 400 IU), but on the whole vitamin D supplementation appears to lower risks of mortality.



**Vitamin D:** There are few good food sources of vitamin D. Some food sources such as some milk types have vitamin D added (rear picture) but the primary unfortified source is fish (centre row: haddock, salmon and sardines) though similar quantities are available from mushrooms grown under ultraviolet light (not yet widely available). Much smaller quantities are available from egg yolks (front right) and liver.

**1. Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers, and cardiovascular disease** Michael F Horlick *American Journal of Clinical Nutrition*, Vol. 80, No. 6, 1678S-1688S, December

2004 [www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/) [outlines the role of sunlight in generating vitamin D and the food sources for vitamin D]

**2. Relation of Nutrition to Bone Lead and Blood Lead Levels in Middle-aged to Elderly Men: The Normative Aging Study** Yawen Cheng, Walter C. Willett, Joel Schwartz, David Sparrow, Scott Weiss, and Howard H American Journal of Epidemiology Vol. 147, No. 12 [www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/) [Finds that low Vitamin D is associated with higher bone lead levels and has more of an impact than calcium intake.]

**3. Maternal Blood Lead Concentration, Diet During Pregnancy, and Anthropometry Predict Neonatal Blood Lead in a Socioeconomically Disadvantaged Population** Lawrence M. Schell, Melinda Denham, Alice D. Stark, Marta Gomez, Julia Ravenscroft, Patrick J. Parsons, Aida Aydermir, and Renee Samelson Environmental Health Perspectives Volume 111, Number 2, Feb 2003 [www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/) [Finds that calcium is a slightly better predictor of blood lead but broadly agrees with the previous study. It must be noted that both studies are from the US where milk is routinely supplemented with vitamin D so a close relationship with calcium would be expected.]

**4. Effects of Micronutrients on Metal Toxicity** Marjorie A. Peraza, Felix Ayala-Fierro, David S. Barber, Elizabeth Casarez, and Leonard T. Rael Environ Health Perspect 106(Suppl 1):203-216 (Feb 1998). [www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/) [Has a good, one paragraph summary of research on vitamin D and lead absorption on page 207 column 1]

**5. Elevated Blood Lead Concentrations and Vitamin D Deficiency in Winter and Summer in Young Urban Children** Kemp, Francis A; Netti, P; Howell, RW; Wenger, P; Louria; Bogden JD Environ Health Perspect Vol 115 No4, April 2007 [www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/) [Finds that vitamin D levels possibly contribute to seasonal variations in children's blood lead levels with higher vitamin D levels associated with higher blood lead levels]

**6. Serum Vitamin D Metabolites and Bone Mineralization in Young Children With Chronic Low to Moderate Lead Exposure** Winston W.K. Koo, Susan K. Krug-Wispe, Jean J. Steinchen, Reginald C. Tsang, Paul A. Succop, Robert L. Bornschein, Omer G. Berger Pediatrics Vol. 87 No. 5 May 1991, pp. 680-687 <http://pediatrics.aappublications.org/cgi/content/abstract/87/5/680> [Found that at blood lead levels below 20 µg/Dl lead did not have significant effects on 1,25-dihydroxycholecalciferol levels if levels of calcium, phosphorus and Vitamin D were adequate]

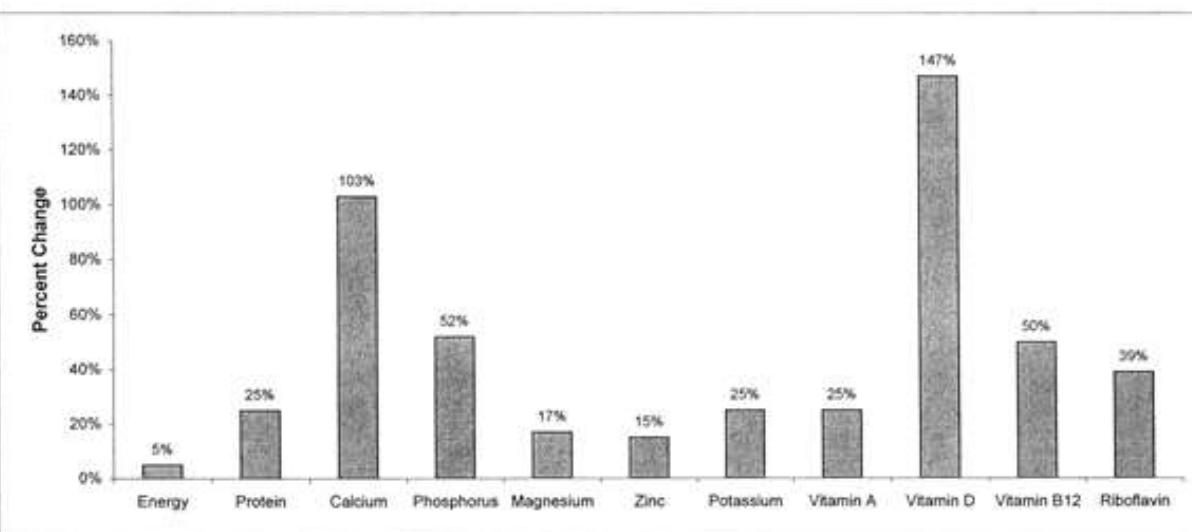
**7. The Influence of Serum 25-hydroxy Vitamin D Levels on Helicobacter Pylori Infections in Patients with End-Stage Renal Failure on Regular Hemodialysis** Hamid Nasri and Azar Baradaran Saudi Journal of Kidney Diseases and Transplants 2007;18(2):215-219 [www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/) [Found a relationship between vitamin D levels and H. pylori infections]

**8. Vitamin D Supplementation and Total Mortality** Philippe Autier; Sara Gandini Arch Intern Med. 2007;167(16):1730-1737 [www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1368113/) [finds that vitamin D supplementation, unlike most antioxidant supplementation, tends to reduce mortality rates]

**Calcium** is one of the most important nutrients to combat lead levels in bone, brain and the nervous system. Lead and calcium compete for the same locations within the body and are stored in the bone, though lead has a greater affinity for many calcium binding sites than calcium itself, making the displacement of lead by calcium exceedingly unlikely. Higher quantities of calcium should increase the chance of binding sites being occupied by calcium before lead is bound to them. Small quantities of lead replace larger quantities of calcium used in activating key neurotransmitters, notably protein kinase C, impeding message transmission in the brain and nervous system. The ability of lead to replace calcium is believed to be a probable cause of its ability to pass through and damage the blood/ brain barrier, though the lack of a blood/brain barrier is believed to be a reason for the susceptibility of infants to lead neurotoxicity.

Lead is released from the bone through resorption (the recycling of calcium and other minerals including lead from the bone to the bloodstream) during pregnancy, and there is strong evidence that calcium supplements reduce blood lead during this crucial period, in turn reducing lead levels in the newborn child. Breastfeeding does not appear to significantly increase the lead burden of the

newborn compared to the period of pregnancy itself, and slight reductions in breast milk lead can be obtained from ongoing supplementation.



#### **Increasing Milk Consumption Improves Older Women's Diet Quality.**

The above chart shows the improvement in serum nutrient levels when individuals over 55 with low dairy consumption (around 400ml or less in milk equivalent) add over 700ml of milk to their diet for 12 weeks. The vitamin D levels obtained are unlikely to be typical outside of the USA since the US practices routine vitamin D fortification of milk. Note that many of the nutrients cited have impact on blood lead or lead toxicity. From Miller et al **The Importance of Meeting Calcium Needs with Foods** *Journal of the American College of Nutrition*, Vol. 20, No. 2, 168S–185S (2001)

Unfortunately calcium interferes with the absorption of iron and should not be consumed in significant quantities (more than one glass of milk or 2 slices of cheese) in conjunction with iron rich meals. Calcium can also interfere with phosphorus absorption.

Milk or milk products remain the best sources of calcium since they also provide a range of other essential nutrients and are not as reliant on stomach acidity (which declines with age) or vitamin D (whose effective levels can be lead impaired) for absorption. Calcium, particularly in the form of low fat milk, also can reduce the risk of hypertension (and the consequent risk of type 2 diabetes), though the extent of its impact on lead-induced hypertension is not known, as part of the reduced risk is due to reduced fat absorption. Cow's milk should not be fed to infants less than one year of age as it increases intestinal bleeding, reduces iron levels and might be linked to type 1 diabetes.



Calcium: This nutrient has many sources Back row: Chinese cabbage, yogurt, milk, cheese, aniseed seeds (fennel), bok choi Middle row: seeds (poppy, sesame), tofu and coriander Front row: Fish (sardines, salmon anchovy), dill, kale, broccoli. Not pictured: Chinese spinach (araminth), mustard greens.

For vegans (who do not consume animal products) or lactose intolerant individuals (most south Europeans, south and central Africans, native Americans, Australian aborigines and east Asians) the best sources of calcium are tofu made with calcium sulfate, bok choi, choy sum, mustard greens, chinese spinach (aramanth), kale, some seeds (poppy, fennel or sesame) and various fish, particularly if consumed with their bones (notably sardines, salmon and anchovy). Calcium absorption is significantly inhibited by oxalates (in many dark green vegetables, most berries, some nuts or seeds, legumes, cocoa, chocolate and black tea) though several studies indicate this predominantly affects only the calcium in the oxalate rich food while phytates (in whole grains, bran, nuts or seeds) reduce calcium absorption by as much as 65% from any food consumed with them. Caffeine, tannins (found in tea) and phosphates other than phytates (such as are found in soft drinks) can inhibit calcium absorption but appear to have little impact on well nourished individuals. From animal studies it appears alcohol, particularly when combined with lead, depletes calcium in body organs potentially increasing lead uptake.

The well publicized impact of soft drink consumption on bone mass seems to be related to the displacement of calcium and protein from the diet rather than any inherent inhibition of calcium absorption. Proteins (particularly animal proteins though not soy proteins) improve calcium absorption though high protein levels can increase resorption due to changes in body acidity.



Phytates: The items pictured are high in phytates and can reduce the absorption of calcium and zinc by up to 67%, magnesium absorption by somewhat less and iron absorption by up to 90%. Phytate content is reduced when baked with yeast (right rear: wholegrain bread), fermented (as with some soy products) or subject to prolonged soaking in water (used with beans) and iron absorption is improved if consumed with vitamin C (left rear: apple & blackcurrant juice). Middle row: baked beans, beans (black turtle, black eye, lima, white, barlotti), bran, peanuts Front row: sunflower & sesame seeds, peas, beans, nuts (almond, brazil, cashew), muesli. Individuals seeking to boost levels of iron, calcium and zinc should avoid consuming these foods within 2-3 hours of meals rich in the mentioned nutrients. This is less important in the case of magnesium as high phytate food is usually also high in magnesium.

For adolescents, high calcium diets can reduce bone resorption by a third when compared to low calcium diets, though it appears, from studies of children, that supplementing calcium rich diets may have little or no impact. Moderate alcohol consumption (1-4 standard drinks a day, particularly red wine and beer), tea (particularly green tea), vegetable based diets and moderate physical exercise have also been linked to lower rates of resorption while low magnesium levels, sugar, chocolate, soft drinks (particularly cola drinks), cereal based diets (including whole grain), heavy alcohol consumption (> 4 standard drinks a day) and thyroid problems may increase resorption. Taking calcium three hours before exercise can reduce bone resorption associated with exercise. There is evidence that lead itself increases bone resorption.

High lead exposures require continuing maintenance of calcium levels as bone resorption in individuals who have achieved their peak bone mass density (achieved in the mid- to late-twenties) results in a net loss of minerals, including lead, from the bone to the bloodstream, and the decline of cognitive abilities caused by the ongoing release of lead may continue for at least two decades. Resorption releases significant lead from the bone during pregnancy, lactation and menopause, making women particularly vulnerable.



Bone resorption: Dietary elements pictured left decrease resorption: vegetable based diets (eg capsicum, carrot, broccoli [front row, left]), up to four glasses of alcohol per day particularly beer and red wine and tea, particularly green tea.[rear row, left] dietary elements pictured to the right increase resorption potentially releasing more lead from the bones: cereal based diets (bread and crackers- wholegrain.[front row, right]), chocolate [centre row ,right], sugar, soft drinks- particularly cola and more than four standard glasses of alcohol. [rear row, right].

High levels of calcium intake can result in hypercalcaemia, the deposition of calcium in soft tissue leading to heart and renal problems, so consumption should not be overdone. This is more likely to be a problem if intakes of magnesium, phosphorus, vitamin B6, vitamin D and/or vitamin K are low, since calcium is used in bone formation in conjunction with these and other nutrients (zinc effects bone strength and lead content but not necessarily the amount of bone deposition). The US Food and Nutrition Board of the Institute of Medicine recommends an upper limit of 2.500 mg a day (the equivalent of a little under 2.5 liters of unfortified milk) of calcium consumption (for a maximum absorption of approximately 750 mg). To give an idea of magnitude, compare this with a maximum daily absorption of under 5mg and an average closer to 1mg of iron from food sources.

#### Suggested Reading:

1. **Calcium** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/minerals/calcium/> [A good overview of calcium as a nutrient with a short section on lead toxicity]
2. **Calcium or zinc supplementation reduces lead toxicity: assessment of behavioral dysfunction in young and adult mice** Ranham P.J. Prasanthi, Gadi H. Reddy, Gottipolu R. Reddy *Nutritional Research Volume 26, Issue 10, Pages 537-545 (October 2006)* <http://dx.doi.org/10.1016/j.nutres.2006.09.004> [Finds that calcium has more of an effect on lead-Impaired neural related performance than zinc, though both have significant impact]

**3. How Does Lead affect the Nervous System?** Anjali Patel *Bryn Mawr College, Biology 202 paper* <http://serendip.brynmawr.edu/bb/neuro/neuro00/web2/Patel.html> [A good brief summary of the impact of lead on the brain and nervous system, particularly as it relates to calcium]

**4. Effects of Micronutrients on Metal Toxicity** Marjorie A. Peraza, Felix Ayala-Fierro, David S. Barber, Elizabeth Casarez, and Leonard T. Rael *Environ Health Perspect* 106(Suppl 1):203-216 (Feb 1998). [www.ncbi.nlm.nih.gov/picrender.fcgi?artid=1533267&blobtype=pdf](http://www.ncbi.nlm.nih.gov/picrender.fcgi?artid=1533267&blobtype=pdf) [Has a good summary of research on calcium and lead and lead absorption, on p 206-207]

**5. Impact of Diet on Lead in Blood and Urine in Female Adults and Relevance to Mobilization of Lead from Bone Stores** BL Gulson, KR Mahaffey, CW Jameson, N Patison, AJ Law, KJ Mizon, MJ Korsch & D Pederson *Environ Health Perspect* 107:257-263 (1999) [www.ehponline.org/members/1999/107p257-263gulson/gulson-full.html](http://www.ehponline.org/members/1999/107p257-263gulson/gulson-full.html) [Demonstrates that release of lead stored in the bone can outweigh other lead inputs]

**6. Maternal Blood Lead Concentration, Diet During Pregnancy, and Anthropometry Predict Neonatal Blood Lead in a Socioeconomically Disadvantaged Population** Schell, LM; Denham, M; Stark, AD; Gomez, M; Ravenscroft, J; Parsons, PJ; Aydermir, A; Samelson, R *Environ Health Perspect Vol 111, No 2, Feb 2003* [www.ncbi.nlm.nih.gov/picrender.fcgi?artid=1241350&blobtype=pdf](http://www.ncbi.nlm.nih.gov/picrender.fcgi?artid=1241350&blobtype=pdf) [Shows that higher calcium consumption can lower the lead levels of the fetus]

**7. Effect of Calcium Supplementation on Blood Lead Levels in Pregnancy: A Randomized Control Trial** Adrianse S Ettinger, Héctor Lamadrid-Figueroa, Martha M. Téllez-Rojo, Adriana Mercado-García, Karen E Peterson, Joel Schwartz, H Hu, and M Hernández-Avila *Environ Health Perspectives Vol 117 No 1 Jan 2009* [www.ehponline.org/members/2008/11868/11868.pdf](http://www.ehponline.org/members/2008/11868/11868.pdf) [Finds that a calcium supplement of 1200mg administered to pregnant women can safely reduce both blood lead levels (by over 20% in some groups) and possible hypertensive side effects of lead exposure]

**8. Influence of Maternal Bone Lead Burden and Calcium Intake on Levels of Lead in Breast Milk over the Course of Lactation** AS Ettinger, MM Te' Ilez-Rojo, C Amarasiriwardena, KE Peterson, J Schwartz, A Aro, H Hu and M Hernández-Avila *Am J of Epidemiology 2006 Vol. 163, No. 1* <http://aje.oxfordjournals.org/cgi/content/full/163/1/48> [Demonstrates that for the infant, lactation is not a significant source of lead relative to pregnancy, and that lead release during lactation can be slightly reduced by maintaining high calcium levels.]

**9. A Randomized Trial of Calcium Supplementation for Childhood Lead Poisoning** Morri E. Markowitz, Mark Sinnett and John F. Rosen *PEDIATRICS Vol. 113 No. 1 January 2004, pp. e34-e39* <http://pediatrics.aappublications.org/cgi/content/full/113/1/e34> [Finds no impact on blood lead from calcium supplementation of children under 6 who are already consuming sufficient calcium]

**10. Cumulative Lead Dose and Cognitive Function in Adults: A Review of Studies That Measured Both Blood Lead and Bone Lead** Regina A. Shih, Howard Hu, Marc G. Weisskopf, and Brian S. Schwartz *Environ Health Perspect, Vol 115, No 3, Mar 2007* [www.ehponline.org/members/2006/9786/9786.html](http://www.ehponline.org/members/2006/9786/9786.html) [A review of some of the many studies that demonstrate ongoing cognitive decline as lead leaches from bone.]

**11. Do You Have Strong Bones Or Are You At Risk For Osteoporosis?** Priscilla Slagle M.D. *The Way Up Newsletter 12/01/08 Volume 40* [www.thewayup.com/newsletters/120108.htm](http://www.thewayup.com/newsletters/120108.htm) [This is an excellent short summary of the importance of many vitamins and minerals to bone health and why it is a mistake to focus on calcium in isolation, particularly if you are relying on calcium supplements.]

**12. Protein and Bone Health** Jane E. Kerstetter *Dairy Farmer's of Canada: Research summaries* [www.dairygoodness.ca/en/health-professionals/dairy-nutrition/nutrition-articles-and-research/protein-and-bone-health.htm](http://www.dairygoodness.ca/en/health-professionals/dairy-nutrition/nutrition-articles-and-research/protein-and-bone-health.htm) [This research appears to demonstrate that the increased urinary calcium excretion associated with higher protein intake (mentioned in the Slagle newsletter) is due to higher absorption and blood levels rather than reduced retention]

**13. Moderate alcohol consumption and increased bone mineral density: potential ethanol and non-ethanol mechanisms** R. Jugdaohsingh, M. A. O'Connell, S. Sripanyakorn and J. J. Powell *Proceedings of the Nutrition Society* (2006), 65, 291-310 [http://journals.cambridge.org/download.php?file=%2FPNS%2FPNS65\\_03%2FS002966510600036Xa.pdf&code=aa8b9589cdc7b47f8a9e7b504bdd5319](http://journals.cambridge.org/download.php?file=%2FPNS%2FPNS65_03%2FS002966510600036Xa.pdf&code=aa8b9589cdc7b47f8a9e7b504bdd5319) [Reviews the growing evidence that alcohol itself can reduce resorption and that other elements such as polyphenols found in beer and red wine can reinforce this tendency.]

- 14. Bone mineral density, polyphenols and caffeine: a reassessment** T. P. Dew, A. J. Day and M. R. A. Morgan *Nutrition Research Reviews* (2007), 20, 89–105 [http://journals.cambridge.org/download.php?file=%2FNRR%2FNRR20\\_01%2FS0954422407738805a.pdf&code=b4b91b793bf6c](http://journals.cambridge.org/download.php?file=%2FNRR%2FNRR20_01%2FS0954422407738805a.pdf&code=b4b91b793bf6c) [Indicates that the negative role of caffeine in bone health may have been overstated and ability of substances like polyphenols and flavonoids to reduce bone resorption have been underestimated]
- 15. Dietary Intake of Dairy Products, Calcium, and Vitamin D and the Risk of Hypertension in Middle-Aged and Older Women** Lu Wang, JoAnn E. Manson, Julie E. Buring, I-Min Lee, Howard D. Sesso *Hypertension* 2008;51:1073-1079 <http://hyper.ahajournals.org/cgi/reprint/51/4/1073> [found that dietary, though not supplementary calcium and vitamin D, significantly reduced the risk of hypertension, particularly when delivered in the form of low fat dairy products. Note that full fat dairy products do not have significant effects.]
- 16. The Importance of Meeting Calcium Needs with Foods** Gregory D. Miller, Judith K. Jarvis, Lois D. McBean, *Journal of the American College of Nutrition*, Vol. 20, No. 2, 168S–185S (2001) [www.jacn.org/cgi/reprint/20/2/168S](http://www.jacn.org/cgi/reprint/20/2/168S) [Provides a good overview of why one should seek to obtain calcium from food sources rather than supplements. Table 2 (p 177S) provides a good comparison of bioavailability of calcium in various foods and can be particularly recommended to lactose intolerant individuals or vegans.]
- 17. The Bioavailability of Dietary Calcium** León Gueguen and Alain Pointillart *Journal of the American College of Nutrition*, Vol. 19, No. 2, 119S–136S (2000) [www.jacn.org/cgi/reprint/19/suppl\\_2/119S](http://www.jacn.org/cgi/reprint/19/suppl_2/119S) [provides strong coherent arguments on the importance of dairy products in the diet]
- 18. Absorption of zinc and retention of calcium: Dose-dependent inhibition by phytate** Kerstin Fredlund, Mats Isaksson, Lena Rossander-Hultén, Annette Almgren and Ann-Sofie Sandberga *J. of Trace Elements in Medicine & Biology* Vol 20, Is 1, 10 May 2006, p 49-57 <http://dx.doi.org/10.1016/j.jtemb.2006.01.003> [demonstrates that calcium absorption can be reduced by around 65% (from 31% to 11%) if sufficient phytates are present]

**Phosphorus** has been linked to blood lead levels in some studies but not consistently. This could relate to phosphorus as a key material for bone health, with phosphorus deficiency increasing bone resorption, even if other bone forming nutrients are present in adequate amounts. Phosphorus can reduce lead absorption from the intestine, particularly in conjunction with calcium, though calcium has more impact than phosphorus when each nutrient is administered alone. But phosphorus is oversupplied in most diets, with average US males consuming over twice their recommended daily intake, so there is probably little to be gained from increasing phosphorus intake unless your intake is unusually low.

Very high phosphorus levels can interfere with calcium absorption and utilization leading to problems with bone formation and increasing calcium deposition in soft tissues, but this is usually only a problem if renal (kidney) function has been impaired, as phosphorus is readily excreted. High levels of calcium intake interfere with phosphorus absorption. Phosphorus is found in large quantities in dairy products, meat, fish, soft drinks, beans, nuts and whole grains. The UK Expert Group on Vitamins and minerals concluded that consuming 3,700 mg a day is safe for most individuals, with the primary risk being to individuals with impaired renal function, which can be lead-induced.

- 1. Phosphorus** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/minerals/phosphorus/> [A good overview of phosphorus as a nutrient, particularly explaining why concerns over high phosphate intake may be exaggerated.]
- 2. Effect of calcium and phosphorus on the gastrointestinal absorption of 203Pb in man** K. C. H. Blake and M. Mann *Environmental Research* Vol 30, No 1, Feb 1983, Pages 188-194 [http://dx.doi.org/10.1016/0013-9351\(83\)90179-2](http://dx.doi.org/10.1016/0013-9351(83)90179-2) [Found that phosphorus inhibited lead absorption but not as well as calcium; the two minerals worked better in combination than alone]
- 3. Determinants of the Blood Lead Level of US Women of Reproductive Age** Lee, Mi-Gyung Chun, Ock Kyoung Sung, Wan O. *Journal of the American College of Nutrition*, Vol. 24, No. 1, 1–9 (2005) [www.jacn.org/cgi/reprint/24/1/1](http://www.jacn.org/cgi/reprint/24/1/1) [ A large study that found no linkage between blood lead levels and dietary phosphorus]

#### **4. Factors Associated With Iron Status Among WIC Infants and Toddlers in Rural West Virginia**

Cindy Fitch USDA December 2007 [www.ers.usda.gov/publications/CCR35/CCR35.pdf](http://www.ers.usda.gov/publications/CCR35/CCR35.pdf) [Page 35 of the report notes a correlation between phosphorus intake and blood lead levels, but observes that almost all subjects have adequate calcium intake.]

**Iron** is a key nutrient. It is part of the oxygen- bearing component of red blood cells (haemoglobin), and the prevention of haemoglobin formation by the presence of lead is the primary cause of lead-induced anaemia (hypochromic anaemia). Hypochromic anemia is produced by significant iron deficiency even if no lead is present. Iron also plays a significant role in brain activity and a wide range of other bodily functions.

Iron competes with lead for absorption in the gut and uptake within the body, and vitamin C can enhance its ability to displace lead. It has been linked to blood and organ lead levels and may protect the blood/brain barrier from lead impacts as well as reducing lead induced apoptosis (cellular suicide) within the brain. Individuals who are severely iron deficient can absorb up to 7 times more lead, as the body responds to iron deficiency by dispatching increasing amounts of the iron transporter DMT1 into the gut. Unfortunately DMT1 can carry eight metals including lead and will transport lead if insufficient iron is available. Unlike calcium, iron has a stronger affinity for its binding sites than lead, so is unlikely to be displaced by lead if iron levels are adequate; so there is considerable doubt whether iron supplementation has much impact within the body if adults are iron replete (with sufficient iron in storage, generally around 1000mg: the average amount stored by a western male omnivore), as the body stores excess iron or reduces absorption, with iron stores having considerably more impact than dietary content or iron bioavailability on iron absorption.

Iron deficiency is one of the most common nutrient deficiencies. Pre-menopausal women, pregnant women and infants are at higher risk of iron deficiency. Iron deficiency, particularly in children, has independent impacts on the brain that can exacerbate lead impacts.

Iron itself is toxic and high iron levels have a range of negative effects although it is much rarer than iron deficiency, particularly among pre-menopausal women, pregnant women, infants and vegetarians. A US organization offering free testing on the east coast of the USA has found there are five individuals who have low iron levels, for every one individual with high iron levels. Infants and young children are unable to reduce absorption when high amounts of iron are ingested, so are highly susceptible to iron poisoning. Consumption of adult iron supplements has been the most common form of infant poisoning in the USA.

Meat consumption (particularly red meat), cooking acidic vegetables in non enameled cast iron pots, significant dietary vitamin C consumption with meals (100 mg producing maximum impact) and limited alcohol consumption (2 glasses per day) can reduce the risk of iron deficiency. Unfermented soy products, phytates (in whole grains, bran, nuts or seeds), some polyphenols (notably those in tea and coffee), egg whites and large quantities of calcium rich products (more than 1 glass of milk or two slices of cheese) significantly inhibit iron absorption. Polyphenols and phytates should be consumed separately from iron rich meals and/or with vitamin C and carotenoids (vegetable pigments in bright non-green and some dark green vegetables) which can reduce their impact on iron absorption. The fact that removing key polyphenols from the diet can have little impact on iron status would indicate

that other factors in the diet can almost completely counteract them, with vitamin C and carotenoids being the logical candidates. No similar findings have been made for phytates. Alcohol consumption reverses the impact of iron levels on the genes regulating the key hormone, hepcidin, generally leading to increased absorption of iron and lead as the body reacts to adequate iron levels as if iron deficient.



*Iron cooking vessels:* The following items have their iron content more than doubled when cooked in iron container without a protective surface. This is particularly useful for vegans or vegetarians. *Rear Row:* red cabbage, tomato, rice, corn meal *Front Row:* tomatoes, capsicum (bell or banana peppers in USA), pureed vegetables, wild rice, apple sauce, scrambled egg, corn meal, *Foreground:* scrambled egg *Not pictured:* milk.

Phytates, which are the strongest iron inhibitors (reducing absorption by up to 90%), also inhibit calcium and zinc absorption by up to approximately two-thirds while reducing magnesium absorption by somewhat less. Haeme iron, found in meat and fish (particularly red meat), is more easily absorbed (approximately 15-40% as compared to 1-15%) and is only significantly inhibited by large quantities of dairy products, while fish and meat proteins enhance non-haeme iron absorption.

Because the body tightly regulates iron absorption, rapid changes in iron status should not be expected, and as iron status improves from deficiency, measurable iron levels (serum ferritin) may initially decline as iron storage is not the body's highest priority. Those considering taking iron supplements, unless severely deficient, may wish to consume them on an other than daily basis (generally twice the daily amount bi-weekly) since it reduces the risk of side effects, impacts on other nutrients and impaired absorption of non-haeme iron.

It should be noted there are a range of medical reasons for iron deficiency, so medical advice should always be sought.

For more information, see the relevant fact sheet or the longer article in our newsletter, Lead Action News, Volume 9, number 3.

**1. Are You Getting Enough Iron** [including Vegetarian Sources of Iron and the 2006 revised Nutrient Reference Values], Sanitarium, updated on 8/7/09 by Michelle Reid, Dietitian, Sanitarium  
[www.lead.org.au/fs/SANITARIUM\\_Are\\_you\\_getting\\_enough\\_iron\\_20090708.pdf](http://www.lead.org.au/fs/SANITARIUM_Are_you_getting_enough_iron_20090708.pdf)

**2. Fact Sheet - Iron Nutrition and Lead Toxicity** Taylor, Robert  
[www.lead.org.au/fs/Iron\\_Nutrition\\_&\\_Lead\\_Toxicity\\_Fact\\_Sheet\\_20090630.pdf](http://www.lead.org.au/fs/Iron_Nutrition_&_Lead_Toxicity_Fact_Sheet_20090630.pdf)

**3. Relationships of Lead, Copper, Zinc, and Cadmium Levels versus Hematopoiesis and Iron Parameters in Healthy Adolescents** Jong Weon Choi and Soon Ki Kim *Annals of Clinical & Laboratory Science* 35:428-434 (2005)  
[www.annclinlabsci.org/cgi/reprint/35/4/428](http://www.annclinlabsci.org/cgi/reprint/35/4/428) [Found a significant relationship between blood lead levels and iron status even in individuals without iron deficiency]

**4. Interaction of lead with some essential trace metals in the blood of anemic children from Lucknow, India** M. Ahamed, S. Singha, J.R. Beharib, A. Kumarc and M.K.J. Siddiquia *Clinica Chimica Acta Volume 377, Issues 1-2, 2 February 2007, Pages 92-97* <http://dx.doi.org/10.1016/j.cca.2006.08.032> [Finds that children with anemia, including lead induced anemia, are likely to have lower iron levels]

**5. Protective Value of Dietary Copper and Iron against Some Toxic Effects of Lead in Rats** David S. Klauder and Harold G. Petering *Environmental Health Perspectives Vol. 12, pp. 77-80, 1975*  
[www.ncbi.nlm.nih.gov/pmc/articles/PMC1475026/pdf/envhper00496-0079.pdf](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1475026/pdf/envhper00496-0079.pdf) [A dated but interesting article that found that iron in combination with copper (now known to be essential in iron transport) could modify lead-induced anemia and protect the kidneys]

**Zinc** The impact of zinc is similar in nature to iron but the relationship is not as strong. Along with iron and calcium, zinc competes with lead for absorption inside the gut, but zinc does not seem to be as effective in displacing lead, though consumption with the amino acid lysine can help. The evidence for zinc supplementation having an effect on blood lead appears weak, with a very large double blind study finding no impact, though a number of studies have found impacts in conjunction with other nutrients or chelators. One study on rats (Tandon 2000) claimed "the use of becozinc (a pharmacological preparation containing vitamins of the B-complex group, vitamin C, and zinc) as a safe alternate to treatment of lead poisoning with chelating agents," finding becozinc produced higher excretion than vitamin C or thiamin alone.

Animal studies indicate that zinc may reduce lead damage to some brain functions, probably because zinc concentrations are particularly high in the brain. Its impact is this regard, however, may be less than that of calcium. Animal studies also show dietary zinc reduces lead uptake and toxicity in the kidney, liver and testes but may worsen lead's impact on the thyroid gland and its functions, potentially impacting on bone resorption. It may also decrease the depletion of calcium and magnesium in organs by lead and alcohol. Zinc deficiency increases bone resorption that can lead to higher blood lead levels. Supplementary zinc reduces lead accumulation in the bones of rats but can also reduce bone density (increasing the risk of osteoporosis). Prolonged high levels of zinc supplementation (above 29mg a day) can block copper absorption, leading to sideroblastic anaemia (inability to incorporate iron in haemoglobin) and iron toxicity as copper is essential to iron absorption and transfer within the body.



Zinc: is found in a variety of food. Rear row: pecan nuts, sesame seeds, cashews, dates, linseed, wheat germ. Middle row: cocoa, oysters, crab, poppy seeds, beef. Front Row: blue cheese, eggs, pine seeds

Zinc is found in significant quantities in oysters, wheat germ, cocoa, crab, seeds (poppy, sesame, linseeds, alfalfa), nuts (pine, cashew, pecan), beef, dates, eggs and blue cheese. Zinc is strongly inhibited by phytates, (found in nuts, seeds and whole grains), with zinc absorption being reduced by up to 67% when consumed with high phytate food. Folic acid is also a significant inhibitor. The UK Expert Group on Vitamins and Minerals recommends no more than 25mg of zinc should be taken as a supplement and that total daily intake should not exceed 42mg a day. If you are seeking to maximize your iron levels, zinc supplements totaling more than 15mg should not be consumed within 2-3 hours of iron rich meals or iron supplements. Zinc can also interfere with magnesium absorption but this probably only has significance with very high levels of supplementation.

**1. Iron and/or Zinc Supplementation Did Not Reduce Blood Lead Concentrations in Children in a Randomized, Placebo-Controlled Trial** Jorge L. Rosado, Patricia Lo'pez, Katarzyna Kordas, G. Garcí'a-Vargas, D. Ronquillo, J. Alatorre, and R. J. Stoltzfus *J. Nutr. 2006* 136: 2378-2383. <http://jn.nutrition.org/cgi/content/full/136/9/2378> [A large double blind study that found no impact on blood lead levels from daily supplementation with 30 mg a day of iron and/or zinc.]

**2. Selection of Nutrients for Prevention or Amelioration of Lead-Induced Learning and Memory Impairment in Rats** Guangqin Fan, Chang Feng, Yu Li, C Wang, J Yan, W Li, J Feng, X Shi and Y Bi *Annals of Occupational Hygiene* 2009 53(4):341-351 <http://annhyg.oxfordjournals.org/cgi/content/abstract/53/4/341> [Shows that zinc may help protect against lead damage to some memory and learning functions, at least in rats. It found, however, that no single nutrient alone played an adequate role in protecting brain function, and that zinc worked most effectively with Vitamin C and glycine]

**3. Therapeutic Influence of Zinc and Ascorbic Acid Against Lead-induced Biochemical Alterations** Anil Kumar Upadhyay, Ramesh Mathur, Monika Bhadauria and Satendra Kumar Nirala *Thérapie* 2009 Novembre-Décembre;

64 (6): 383-388 [www.journal-therapie.org/index.php?option=article&access=doi&doi=10.2515/therapie/2009055](http://www.journal-therapie.org/index.php?option=article&access=doi&doi=10.2515/therapie/2009055) [Further research demonstrating the importance of combining vitamin C with zinc to protect against lead-induced brain damage].

**4. Calcium or zinc supplementation reduces lead toxicity: assessment of behavioral dysfunction in young and adult mice** Rantham P.J. Prasanthi, Gadi H. Reddy, Gottipolu R. Reddy *Nutritional Research Volume 26, Issue 10, Pages 537-545 (October 2006)* <http://dx.doi.org/10.1016/j.nutres.2006.09.004> [Finds that zinc has a significant effect on lead-impaired neural related performance, though less than calcium.]

**5. Role of vitamins in treatment of lead intoxication** Sushil K. Tandon, Surendra Singh, *The Journal of Trace Elements in Experimental Medicine, Vol 13 No 3, Pages 305 – 315, (2000)* [www3.interscience.wiley.com/journal/72510361/abstract?CRETRY=1&SRETRY=0](http://www3.interscience.wiley.com/journal/72510361/abstract?CRETRY=1&SRETRY=0) [Finds that Benozinc, a compound containing vitamin B complex, vitamin C and zinc reduced blood lead levels more than vitamin C or thiamin in rats]

**6. Study on the influence of L-lysine and zinc administration during exposure to lead and ethanol in rats** Maria Chichovska and Anguel Anguelov *Vet. arhiv 76, 65-73, 2006.* <http://hrcak.srce.hr/5086> [Finds that zinc and lysine (an amino acid) reduce uptake of lead to organs, particularly the brain and reduce alcohol's exacerbating effect on lead toxicity.]

**7. Effects of Zinc Coadministration on Lead Toxicities in Rats** Fengyuan Piao, Fanyin Cheng, Haibo Chen, Gang Li, Xianc Sun, Shang Lui, Toru Yamauchi and Kazuhito Yokoyama *Industrial Health 2007, 45, 546-551* [www.jstage.jst.go.jp/article/indhealth/45/4/546/\\_pdf](http://www.jstage.jst.go.jp/article/indhealth/45/4/546/_pdf) [Finds that zinc reduces the impact of lead on the testes but increases its impact on the vital thyroid gland]

**8. Marginal Zinc Deficiency Exacerbates Bone Lead Accumulation and High Dietary Zinc Attenuates Lead Accumulation at the Expense of Bone Density in Growing Rats** Jennifer A. Jamieson, Carla G. Taylor, and Hope A. Weiler *Toxicological Sciences 92(1), 286–294 (2006)* <http://toxsci.oxfordjournals.org/cgi/reprint/92/1/286> [Found that high zinc levels decrease both bone lead levels and bone density while zinc deficiency increases bone lead levels but not lead toxicity]

**9. Interaction of lead with some essential trace metals in the blood of anemic children from Lucknow, India** M. Ahamed, S. Singha, J.R. Beharib, A. Kumarc and M.K.J. Siddiquia *Clinica Chimica Acta Volume 377, Issues 1-2, 2 February 2007, Pages 92-97* <http://dx.doi.org/10.1016/j.cca.2006.08.032> [Found that children with lead-induced anemia are likely to have lower zinc levels]

**10. Element of caution: a case of reversible cytopenias associated with excessive zinc supplementation** Julie A. Irving, Andre Mattman, Gillian Lockitch, Kevin Farrell and Louis D. Wadsworth *CMAJ July 22, 2003; 169 (2)* [www.cmaj.ca/cgi/content/full/169/2/129](http://www.cmaj.ca/cgi/content/full/169/2/129) [demonstrates the ability of zinc supplementation to block copper absorption]

**Magnesium** is an essential mineral for bone health. Magnesium intake should be more than half your calcium intake to maximize bone formation. Magnesium absorption (close to 50%) from diets is normally considerably higher than calcium absorption (roughly 10-30%). Low levels of magnesium are linked to higher bone resorption, potentially releasing more lead from the bone to the blood, and higher lead in body organs. Higher blood lead has been linked to lower levels of blood magnesium, though it must be noted blood magnesium may not be an accurate gauge of magnesium status other than deficiency. There is limited evidence from animal studies that suggest magnesium may reduce lead retention in blood and tissues. Good levels of magnesium in blood cells may ameliorate lead-induced hypertension. While the evidence is scant, and complicated by the fact that blood magnesium levels are not necessarily directly related to tissue or dietary magnesium levels, it is probably wise to maintain good levels of magnesium consumption if your blood lead is elevated.

Magnesium absorption is inhibited by oxalates and phytates (to lesser degree than iron, zinc or calcium) while vitamin D, pectin and protein may enhance absorption. Phytates inhibit magnesium absorption but most high phytate foods such as seeds or nuts are very high in magnesium, so it is unlikely to be a cause of concern. Magnesium is significantly removed by boiling, de-husking (in the case of grain, predominantly for flour manufacture) and a range of other processing. White or

wholemeal bread has much less magnesium than whole grain bread. Alcohol, particularly in conjunction with lead, appears to deplete magnesium in animal studies. Magnesium has low toxicity and the UK Expert Group on Vitamins and Minerals recommends that supplementing your diet with 400mg a day should be safe for almost all individuals, with the primary concern being for individuals with impaired renal (kidney) function, which can be lead-induced. For that reason lower levels of supplementation are recommended for older individuals even though they are more likely to be magnesium deficient due to declining absorption. Magnesium is readily available and found in high quantities in coriander, cocoa, wheat bran or germ, dill, seeds (fennel, linseed, sesame, poppy and coriander), nuts (brazil, almond, pine and cashew), curry powder, oats, rose hip, soy beans or flour, tea and coffee.

- 1. Magnesium** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/minerals/magnesium/> [a good basic outline of the role of magnesium]
- 2. Do You Have Strong Bones Or Are You At Risk For Osteoporosis?** Priscilla Slagle M.D. *The Way Up Newsletter* 12/01/08 Volume 40 [www.thewayup.com/newsletters/120108.htm](http://www.thewayup.com/newsletters/120108.htm) [provides a short layman's summary of the role of magnesium in bone health.]
- 3. The modification of blood calcium and blood magnesium in the professional exposure to lead** Ligia Fat and Victoria Coldea *Toxicology Letters* Vol. 95, Sup 1, July 1998, p 128 [http://dx.doi.org/10.1016/S0378-4274\(98\)80508-0](http://dx.doi.org/10.1016/S0378-4274(98)80508-0) [finds that lead exposure is associated with low levels of magnesium in the blood]
- 4. Low Blood Lead Levels Do Not Appear to Be Further Reduced by Dietary Supplements** Brian L. Gulson, Karen J. Mizon, Michael J. Korsch, and Alan J. Taylor *Environ Health Perspect* Vol 114, No 8, August 2006 [www.ehponline.org/members/2006/8605/8605.pdf](http://ehponline.org/members/2006/8605/8605.pdf) [provides a very brief overview of animal research on magnesium in the conclusion]
- 5. Blood cell lead, calcium, and magnesium levels associated with pregnancy-induced hypertension and preeclampsia** Earl B. Dawson, D. R. Evans, R. Kelly and J. W. Van Hook *Biological Trace Element Research* Vol 74, No 2 May 2000 [www.springerlink.com/content/d681155v71707317/](http://www.springerlink.com/content/d681155v71707317/) [Indicates that blood magnesium levels can influence the impact of lead on hypertension]
- 6. Combined exposure to lead and ethanol on tissue concentration of essential metals and some biochemical indices in rats** S. J. S. Flora , Deo Kumar, S. R. S. Sachan and S. Das Gupta *Biological Trace Element Research* Vol 28 No 2 February 1991 [www.springerlink.com/content/e114062566104376/](http://www.springerlink.com/content/e114062566104376/) [Found that lead and ethanol (alcohol) reduced concentrations of calcium and magnesium in the liver and blood, increased lead concentrations in the blood, liver and brain, magnified liver damage and increased blood zinc protoporphyrin (a sign of hypochromic anemia).]

**Copper** deficiency can cause sideroblastic anaemia (the inability to incorporate iron into haemoglobin for red blood cells) as it is essential to iron transport inside the body, and according to some animal experiments may also affect lead-induced anaemia. On the other hand, animal studies have also indicated that high copper levels can exacerbate lead poisoning. But it should be noted that copper's absorption is inhibited if it is consumed with iron and zinc, and copper levels within the body are reduced by lead, cysteine and vitamin C. This may be a particular concern for pregnant women, as copper deficiencies have significant impacts on the unborn fetus. Copper levels are also reduced by iron deficiency.

On the whole, it would appear that an individual with significant lead exposure should seek to maintain good levels of copper in their diet, without aiming for high levels. Copper is found in quantity in unfiltered piped water, shellfish (oysters, clams) crustaceans (crab, lobster), liver (sheep, goose, ox, duck, calf, pig), yeast, seeds (sesame), tea, cocoa, nuts (cashew, brazil, hazel, walnuts, pasticcio, pecan, pine), wheat bran and curry powder. Consumption of up to 10mg a day is considered safe, but could lead to copper accumulation over the longer term. Up to 9mg can be present from

food and unfiltered water (contributing up to 6mg) so any supplementation should be handled with care, particularly above 1mg a day for prolonged periods. Zinc can completely block copper absorption while iron and low stomach acidity interfere with copper absorption. On the other hand, copper levels are reduced by iron and zinc deficiency. Soybean protein and fructose strongly inhibit copper absorption but phytates have minimal impact.

- 1. Copper** Jane Higdon *The Linus Pauling Institute* <http://lpi.oregonstate.edu/infocenter/minerals/copper/>
- 2. Protective Value of Dietary Copper and Iron against Some Toxic Effects of Lead in Rats** David S. Klauder and Harold G. Petering *Environmental Health Perspectives Vol. 12, pp. 77-80, 1975* [www.ncbi.nlm.nih.gov/pmc/articles/PMC1475026/pdf/envhper00496-0079.pdf](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1475026/pdf/envhper00496-0079.pdf) [A dated but interesting article that found that iron in combination with copper (now known to be essential in iron transport) could modify lead-induced anemia and protect the kidneys]
- 3. Influence of Dietary Copper on Lead Toxicity in the Young Male Rat** Florian L. Cerklewski And Richard M. Forbes *J. Nutr. 107: 143-146, 1977.* <http://jn.nutrition.org/cgi/reprint/107/1/143> [Found that copper accentuated the impact of lead toxicity]
- 4. Iron and copper, and their interactions during development** Lorraine Gambling, Henriette S. Andersen and Harry J. McArdle *Biochemical Society Transactions (2008) Volume 36, part 6* [www.biochemsoctrans.org/bst/036/1258/0361258.pdf](http://www.biochemsoctrans.org/bst/036/1258/0361258.pdf) [A short summary of the impacts of iron and copper deficiency during pregnancy; important since both the presence of lead and nutrients used to counter it can reduce copper levels]
- 5. Copper absorption and bioavailability** Raul A Wapnir *Am J Clin Nutr 1998;67(suppl):1054S-60S* [www.ajcn.org/cgi/reprint/67/5/1054S.pdf](http://www.ajcn.org/cgi/reprint/67/5/1054S.pdf) [Good outline of factors affecting copper absorption]

**Selenium** appears to be protective against lead-induced impairment. Animal studies indicate it protects against and reduces lead impact on the liver, kidneys, and brain, while human studies indicate it reduces lead-induced hearing loss. It has been linked to lower blood lead levels in some studies. The mechanism for this appears to be the tendency of lead and selenium to form non-toxic compounds. At high levels selenium can exacerbate lead toxicity, at least in some animals.

Australians and New Zealanders tend to have low selenium levels as our soils are selenium deficient. Brazil nuts are one of the best sources of selenium: 2 nuts a day ensures your recommended daily intake, 16 nuts a day would be likely to raise your average intake above recommended maximum levels (400 (g) and more than 25 a day would put you at high risk of selenium poisoning. Kidneys (pig, ox, duck and calf) and kippers can provide even higher levels of selenium, while other good sources are alfalfa seeds, seafood (fish, crustaceans, mollusks) liver, and eggs. Selenium supplementation may slightly lower average mortality, though the evidence is not yet firm.

- 1. Protective Effects of Selenium and Zinc on Changes in Catecholamine Levels of Brain Regions in Lead Intoxified Rats** A.A. Moshtaghie, E. Aghadavod, M. Ani and M. Fazilati *Pakistan J. of Biological Sciences Vol. 10 Is. 17, www.ansijournals.com/abstract.php?doi=pjbs.2007.2964.2967* [finds selenium is protective of some lead-induced brain damage; there is a similar article by the same team on acetyl cholinesterase at <http://journals.mui.ac.ir/rps/article/viewFile/1214/451> ]
- 2. A case-control study on the relationship of hearing function and blood concentrations of lead, manganese, arsenic, and selenium** Hung-Yi Chuang, Ching-Hsia Kuo, Yu-Wen Chiu, Chi-Kung Ho,, Chi-Jung Chen and Trong-Neng Wu *Science of the Total Environment Vol 378, Is 1-3, 15 November 2007, Pages 79-85* [www.ncbi.nlm.nih.gov/pubmed/17764724](http://www.ncbi.nlm.nih.gov/pubmed/17764724) [Found higher selenium levels are associated with less lead-induced hearing loss]
- 3. Role of selenium against lead toxicity in male rats** Azza I. Othman, Mohammed A. El Missiry *Journal of Biochemical and Molecular Toxicology Vol 12 No 6, p 345 – 349* [www3.interscience.wiley.com/journal/40000327/abstract?CRETRY=1&SRETRY=0](http://www3.interscience.wiley.com/journal/40000327/abstract?CRETRY=1&SRETRY=0) [Found that selenium can reduce the impacts of lead on the liver and kidneys]

**4. Influence of Dietary Selenium on Lead Toxicity in the Rat** Florian L. Cerklewski and Richard M. Forbes *Journal of Nutrition* 106 (6): 778. (1976) <http://jn.nutrition.org/cgi/reprint/106/6/778> [Found that while at lower levels selenium reduced the impacts of lead toxicity; at higher levels it accentuated them]

**5. Interactions between essential and toxic elements in lead exposed children in Katowice, Poland** Katarina Osman, Andrejs Schütz, Björn Åkesson, Anna Maciąg and Marie Vahter *Clinical Biochemistry* Vol 31, No 8, Nov 1998, Pages 657-665 [http://dx.doi.org/10.1016/S0009-9120\(98\)00071-X](http://dx.doi.org/10.1016/S0009-9120(98)00071-X) [finds a correlation between selenium levels and blood lead levels, particularly at lower blood lead levels]

**6. Brazil nuts: an effective way to improve selenium status** Christine D Thomson, Alexandra Chisholm, Sarah K McLachlan and Jennifer M Campbell *Am J Clin Nutr* 2008;87:379–84. [www.ajcn.org/cgi/content/full/87/2/379](http://ajcn.org/cgi/content/full/87/2/379) [Finds that with two brazil nuts providing between 20-84µg of selenium (lower than quoted on some databases) they are an effective source of selenium.]

**7. Mortality in Randomized Trials of Antioxidant Supplements for Primary and Secondary Prevention Systematic Review and Meta-analysis** Goran Bjelakovic; Dimitrinka Nikolova; Lise Lotte Gluud; Rosa G. Simonetti; Christian Gluud. *JAMA*. 2007;297:842-857 <http://jama.ama-assn.org/cgi/reprint/297/8/842> [Finds selenium supplementation slightly reduced mortality rates but the effect disappeared when potentially high-bias studies were excluded. Recommends further research.]

**Methionine** is an essential amino acid. Animal studies indicate it may reduce and repair some lead-induced learning and memory decline. It has been demonstrated to protect against lead-induced liver damage in animals, particularly when combined with zinc and thiamine (vitamin B1). It has strong anti-oxidant impacts. It is also manufactured inside the body using vitamin B9 and B12 based enzymes. Very high levels of methionine intake (more than five times normal) can increase cardiovascular and hepatic (liver) risks but this can be counteracted with taurine. High levels of methionine exacerbate psychological problems in schizophrenics and, from experiments with mice, may increase the risk of Alzheimer's disease. Methionine can be converted to cystine (a more stable form of cyteine) and then used to form glutathione, one of the body's major antioxidants. Methionine is found in meat, fish, beans, eggs, garlic, lentils, onions, yogurt and seeds. Methionine absorption is reduced if consumed with taurine. Supplementary doses of up to 250mg are considered safe. The capacity of supplemental methionine to be absorbed seems variable.

**1. Antioxidant effects of α tocopherol, ascorbic acid and L-methionine on lead-induced oxidative stress to the liver, kidney and brain in rats** R. C. Patra, D. Swarup and S. K. Dwivedi *Toxicology* Vol 162, No 2, 11 May 2001, Pages 81-88 [www.ncbi.nlm.nih.gov/pubmed/11337108](http://www.ncbi.nlm.nih.gov/pubmed/11337108) [Research that indicates significant protective influences on the brain and kidneys]

**2. Selection of Nutrients for Prevention or Amelioration of Lead-Induced Learning and Memory Impairment in Rats** Guangqin Fan, Chang Feng, Yu Li, C Wang, J Yan, W Li, J Feng, X Shi and Y Bi *Annals of Occupational Hygiene* 2009 53(4):341-351 <http://annhyg.oxfordjournals.org/cgi/content/abstract/53/4/341> [Shows that methionine may protect against lead damage to some memory and learning functions, at least in rats.]

**3. S-adenosyl-L-methionine improves impaired hippocampal long-term potentiation and water maze performance induced by developmental lead exposure in rats** Xiu-Jing Cao, Sheng-Hai Huang, Ming Wang, Ju-Tao Chen and Di-Yun Ruan, *European Journal of Pharmacology* Vol 595 Is 1-3 Oct 2008 [www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6T1J-4T4XRDC-4&](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T1J-4T4XRDC-4&_) [finds that a form of methionine may repair some lead-induced learning/memory impacts on rats]

**4. Toxicity of Methionine in Humans** Peter J. Garlick *J. Nutr.* 136: 1722S-1725S, 2006. <http://jn.nutrition.org/cgi/reprint/136/6/1722S> [While the toxicity of methionine is low, it is not non-existent, a fact an alarming number of sites gloss over]

**5. Taurine Red Bull or Red Herring?** Sebastiaan Wesseling; Maarten P. Koeners; Jaap A. Joles *Hypertension*. 2009;53:909-911 <http://hyper.ahajournals.org/cgi/content/full/53/6/909> [Mentions the fact that taurine can counteract the toxicity of high methionine intakes and that taurine interferes with methionine absorption]

**Glycine** is an essential amino acid like methionine. It is manufactured by the body and is also found in high protein foods such as meat, fish, beans and dairy products. It has been found to be protective of brain function in animal studies, particularly in combination with zinc and vitamin C.

- 1. Selection of Nutrients for Prevention or Amelioration of Lead-Induced Learning and Memory Impairment in Rats** Guangqin Fan, Chang Feng, Yu Li, C Wang, J Yan, W Li, J Feng, X Shi and Y Bi *Annals of Occup Hygiene* 2009 53(4):341-351 <http://annhyg.oxfordjournals.org/cgi/content/abstract/53/4/341> [Shows that glycine may protect against lead damage to some memory and learning functions, at least in rats.]

**Glutathione and cysteine** Glutathione is a major antioxidant that undertakes key functions within the body, particularly in the brain and liver, where it plays a major role in detoxifying xenobiotics (foreign compounds) and carcinogens. The depletion of glutathione in these two organs is a major impact of lead toxicity, with glutathione deficiencies being linked to brain cell death. Glutathione is poorly absorbed, at least from supplements, but it is manufactured within the body, so the optimum way to maximize levels is through maintaining good levels of the precursor molecules: cysteine, glutamic acid (glutamate as a salt) and glycine. Cysteine is the rarest of these in western diets, and is found in red peppers, garlic, onions, broccoli, brussel sprouts, oats and wheat germ. It is readily destroyed by heat and processing, so little survives in cooked eggs or pasteurized milk, though significant amounts are found in undenatured (processed at low temperature) whey protein; and whey has been consistently linked with higher glutathione levels. However, should cysteine be unavailable, new cystine (the stable form of cysteine) can be formed by breaking down methionine. Glutamate is more common and is found in food flavorings such as MSG and a variety of protein-rich foods, including meat, fish and beans. It can also be manufactured inside the liver from other amino acids.

Glutathione also requires vitamin B6 for its manufacture but, in a demonstration of the complexities involved, B6 deficiency can actually increase glutathione levels. Given that glutathione manufacture occurs and is regulated inside the body, it cannot be automatically assumed that consumption of glutathione precursors, or glutathione itself, will directly relate to glutathione levels within the body, though it may maximize possible production.

- 1. Glutathione** Wikipedia <http://en.wikipedia.org/wiki/Glutathione>
- 2. The systemic availability of oral glutathione** A. Witschi, S. Reddy, B. Stofer and B. H. Lauterburg *European Journal of Clinical Pharmacology* Vol 43 No 6 Dec 1992 [www.springerlink.com/content/051307ur34175737/](http://www.springerlink.com/content/051307ur34175737/)
- 3. Lead-Induced Cell Death Of Human Neuroblastoma Cells Involves GSH Deprivation** Chellu S. Chetty, Mohan C. Vemuri, Khamisi Campbell And Challa Suresh *Cellular & Molecular Biology Letters* Volume 10, (2005) pp 413 – 423 [www.cmlb.org.pl/pdf/Vol10\\_p413.pdf](http://www.cmlb.org.pl/pdf/Vol10_p413.pdf) [Shows that glutathione depletion plays a significant role in neuron (brain cell) death.]

**Curcumin** There is some evidence that this compound, found predominantly in the Indian spice turmeric, may be neuroprotective against lead-induced damage (at least in mice). It also has therapeutic impacts on *H. pylori* infections that reduce stomach acidity, in turn reducing iron, zinc, calcium and vitamin B12 absorption. Unfortunately, the amount of curcumin in turmeric is highly variable (even in supplements) and turmeric is frequently lead-contaminated. One study from India indicates that over 99% of local turmeric may be lead-contaminated possibly because traders adulterate turmeric powder with coal tar dyes or lead chromate to mimic the vivid saffron colour. However, the Organic Farming Association of India claims that organically grown turmeric (haldi) is

widely available within India and that India grows 80% of the world's turmeric. Individuals with low iron levels should be aware that curcumin could reduce iron levels through acting as an iron chelator.

**1. Protective effect of curcumin against lead neurotoxicity in rats** P K Shukla and V K Khanna *Human & Experimental Toxicology*, Vol. 22, No. 12, 653-658 (2003) <http://het.sagepub.com/cgi/content/abstract/22/12/653> [finds that curcumin mitigates lead contamination of the brain in rats]

**2. Test your turmeric** Pushpa Girimaji *Tribune, India, Sunday, October 3, 2004* [www.tribuneindia.com/2004/20041003/spectrum/right.htm](http://www.tribuneindia.com/2004/20041003/spectrum/right.htm) [Reports research on the contamination of turmeric with arsenic, cadmium and lead]

**3. Goodness of haldi: Maximise your health benefits with organically grown turmeric** Claude Aalvares, Director of the central secretariat of the Organic Farming Association of India, and editor of Organic Farming Source Book *InToday* 24 September 2009 <http://health.einnews.com/news.php?wid=257268294>

**4. Ironing out complementary medicine** Robert T. Means, Jr *Blood*, 8 January 2009, Vol. 113, No. 2, pp. 270-271. <http://bloodjournal.hematologylibrary.org/cgi/content/full/113/2/270> [Notes the ability of curcumin to have negative impacts on the iron metabolism, at least in mice]

**Pectin** According to Wikipedia, “[Pectin] is produced commercially as a white to light brown powder, mainly extracted from citrus fruits, and is used in food as a gelling agent particularly in jams and jellies. It is also used in fillings, sweets, as a stabilizer in fruit juices and milk drinks and as a source of dietary fiber.” Wikipedia also gives the following concentrations of pectin in foods: Apples (1–1.5%), carrots (1.4%) apricot (1%), quince, plums, gooseberries, oranges (0.5–3.5%) and other citrus fruits (citrus peels 30%) contain much pectin, while soft fruits like cherries (0.4%), grapes and strawberries contain little pectin.



Pectin: is contained in the following fruit. Rear row; pink grape fruit, lemon, orange, apple Front row: Kiwi fruit, plums, carrots, mandarin marmalade

Pectin prophylaxis has been used to increase lead elimination in both children and adults. However, there has been some criticism of recent studies and claims, though these do not refute the base claim that there are some impacts on lead excretion from pectin. It should be noted that pectin interferes with Vitamin C and B12 absorption.

**1. Dr Isaac Eliaz: With the Seasons AUGUST NEWSLETTER [2008]**, Dr Isaac Eliaz at [www.dreddyclinic.com/forum/viewtopic.php?f=11&t=11192](http://www.dreddyclinic.com/forum/viewtopic.php?f=11&t=11192) –[Modified Citrus Pectin (MCP) study on 7 lead poisoned Chinese children who in a 4-week trial all showed a reduction in blood lead level from above to below 20 micrograms per decilitre (ug/dL).]

**2. The prophylactic use of pectin in chronic lead exposure in industry** [ABSTRACT only in English, original article is in Russian]  
[www.ncbi.nlm.nih.gov/pubmed/7483521?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed\\_ResultsPanel.Pubmed\\_DiscoveryPanel.Pubmed\\_Discovery\\_RA&linkpos=1&log\\$=relatedarticles&logdbfrom=pubmed](http://www.ncbi.nlm.nih.gov/pubmed/7483521?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_Discovery_RA&linkpos=1&log$=relatedarticles&logdbfrom=pubmed) [Elimination of lead from lead acid battery workers was found to be on the increase after intake of pectin-vitamin preparation.]

**3. Is Modified Citrus Pectin an Effective Mobilizer of Heavy Metals in Humans?** Walter J. Crinnion, ND  
*Alternative Medicine Review Volume 13, Number 4 2008* [www.thorne.com/altmedrev/.fulltext/13/4/283.pdf](http://www.thorne.com/altmedrev/.fulltext/13/4/283.pdf) [A questioning of some research into pectin]

**4. The Business of Chelation** *Smart publications* [www.smart-publications.com/heart\\_attacks/business\\_of\\_chelation.php](http://www.smart-publications.com/heart_attacks/business_of_chelation.php)  
[A strongly worded though not well referenced look at the promotion of different types of chelation including pectin]

**Melatonin** has been shown in animal studies to reduce the impact of lead induced anaemia. It can also protect the brain, liver and kidneys from some lead induced damage. As a key sleep regulator melatonin in significant quantities will increase drowsiness with all the attendant risk if operating machinery. Supplemental melatonin should be taken shortly before bedtime at a consistent time to avoid disrupting your body clock.

It is manufactured inside the brain from the amino acid tryptophan, and as with most molecules manufactured and regulated by the body, the exact relationship between dietary melatonin or melatonin precursors and serum melatonin cannot be said to be transparent. Melatonin is found in small quantities some seeds (White & Black mustard, Wolf berry, fenugreek, sunflower, fennel and alfalfa) and tart cherries, particularly Montmorency.

**1. Melatonin, a potent agent in antioxidative defense: Actions as a natural food constituent, gastrointestinal factor, drug and prodrug** Rüdiger Hardeland and SR Pandi-Perumal *Nutrition & Metabolism* 2005, 2:22 [www.nutritionandmetabolism.com/content/2/1/22](http://www.nutritionandmetabolism.com/content/2/1/22) [A good overview of melatonin]

**2. Role of melatonin in ameliorating lead induced haematotoxicity** A. I. Othman, S. Al Sharawy and M. A. El-Missiry *Pharmacological Research Vol 50, Is 3, Sep 2004, p301-307* <http://dx.doi.org/10.1016/j.phrs.2004.01.013> [Found that melatonin can reduce the impact of lead-induced anemia in rats]

**3. Prophylactic Effect Of Melatonin In Reducing Lead Induced Neurotoxicity In The Rat** Gamal H. El-Sokkary, Esam S. Kamel And Russel J. Reiter *Cellular & Molecular Biology Letters Volume 8, (2003) pp 461 – 470* [www.cmbl.org.pl/pdf/Vol8\\_p461.pdf](http://www.cmbl.org.pl/pdf/Vol8_p461.pdf) [Found that melatonin can play a significant role in reducing lead-induced oxidative damage to the brain.]

**4. Melatonin protects against lead-induced hepatic and renal toxicity in male rats** Gamal H. El-Sokkary, Gamal H. Abdel-Rahman and Esam S. Kamel *Toxicology Vol 213, Is 1-2, 15 September 2005, Pages 25-33* [www.sciencedirect.com/science/journal/0300483X](http://www.sciencedirect.com/science/journal/0300483X) [found that melatonin significantly reduced oxidative damage to the kidney and liver]

## 1. Miscellaneous References

**Breastfeeding and Lead - What do Mothers Need to Know?** The LEAD Group Inc..  
[www.lead.org.au/lav6n2/update002.html](http://www.lead.org.au/lav6n2/update002.html)

**Tofu Consumption and Blood Lead Levels in Young Chinese Adults** Chen, Changzhong, *American Journal of Epidemiology*, <http://aje.oxfordjournals.org/cgi/reprint/153/12/1206>

**Scientific Nutrition for Autism & PDD**, Kirkman Laboratories, Oregon, USA, [www.kirkmanlabs.com](http://www.kirkmanlabs.com)

**Dietary** For dietary suggestions see “Fight Lead Poisoning With A Healthy Diet” by the Environmental Protection Agency (EPA), US at [www.epa.gov/lead/pubs/nutrition.pdf](http://www.epa.gov/lead/pubs/nutrition.pdf).

## 2. Mushrooms and Lead

Book Extract from *Mycelium Running: How Mushrooms Can Help Save the World*, 2005, by Paul Stamets. Published by 10 Speed Press, Berkeley.

### Page 110:

Most mushrooms do not actively concentrate lead above the level of concentration in the environment, with a few exceptions. One such exception, the morel, proliferates in burned habitats where fire has reduced the bulk of organic matter, an event that increases baseline metals in the "soil". Lead is made less soluble, and hence less extractable, in soils where the pH is near neutral; adding lime (calcium carbonate) significantly reduces the solubility of lead, cadmium and other metals, thus locking them up and reducing infiltration into water and/or living organisms. In contrast, acidic soils allow lead to be easily absorbed by plants and mushrooms. According to Garcia and others (1998), saprophytic mushrooms absorb more lead than mycorrhizal ones, shaggy manes, especially those found in cities, could be bioindicators of lead contamination. Naturally, one wonders if the very presence of shaggy manes could indicate lead contamination? I don't know, but I am suspicious when I find shaggy manes near industrial sites and avoid eating them.

...Mushrooms growing along roadsides, particularly where there is exposure to leaded gasoline [leaded petrol], should not be eaten.

## 3. Factsheet: Veganism

How do you obtain all the nutrients from a vegan diet, that are important to lead exposed individuals?

*By Rose Lennon, B.A. UNSW, March 2010*



*Photo: Title: Backyard vegies.*

*Lead-Safety Message: These backyard vegies are organic and lead-free. Are yours?  
A winning entry in the 2013 Volcano Art Prize by Photographer: Gabriel Anderson.*

## **What is Veganism?**

Veganism is a lifestyle that aims to eliminate exploitation of, and cruelty to, animals, as much as is practically possible<sup>1</sup>. Vegans eat a plant-based diet. They do not consume or use any animal products, such as meat, dairy, eggs, honey, leather, wool, feathers, lanolin, and beeswax. In addition, vegans avoid supporting products and services that involve the exploitation of animals, such as animal circuses and toiletries that were produced with the assistance of vivisection.

## **Why vegan?**

The main reasons for becoming vegan are ethical concerns against animal cruelty and animal exploitation. Other ethical motivations include the environmental degradation caused by factory farming practices and raising livestock for human consumption<sup>2</sup>. Health reasons may also be a factor for choosing a vegan diet.

## **An important note**

Please keep in mind that while the information presented in this factsheet has drawn upon the suggestions of various accredited dieticians it should not be considered medical advice. If you are considering a vegan diet based on any information in this factsheet, then please refer to an accredited practicing dietician or medical specialist for confirmation of your own specific nutritional needs.

## **Variety**

While this factsheet focuses on specific nutrients relevant to lead levels in the body and the vegan diet, this is not to suggest that these particular nutrients are more important than others are. Rather, this factsheet hopes to promote a varied, whole-foods diet, which when planned properly should ensure a good coverage of all nutrients.

## **Calcium**

Vegetarian diets tend to be more alkaline, while diets that focus on animal-sourced food (i.e. meat, dairy, eggs etc) are usually more acidic<sup>3</sup>. Calcium balance is generally better supported by plant-based diets as fruits and vegetables produce an alkaline ash<sup>4</sup>. A diet high in protein and sodium can contribute to leaching of calcium from the body<sup>5</sup>. For example, consuming 1gm of protein is equal to losing 1mg of calcium through urine, while consuming 1gm of sodium can result in the body losing 23-26mg of calcium<sup>6</sup>. Try to spread your calcium intake throughout the day, as this allows your body to absorb calcium more efficiently<sup>7</sup>.

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<sup>1</sup> ‘Who we are’, *The Vegan Society*, accessed 15 March 2010, <http://www.vegansociety.com/about/who-we-are.aspx>.

<sup>2</sup> H Steinfeld, P Gerber, T Wassenaar, V Castel, M Rosales & C de Haan, *Livestock’s long shadow: environmental issues and options*, FAO, 2006, Rome, accessed 15 March 2010, <http://www.fao.org/docrep/010/a0701e/a0701e00.htm>.

<sup>3</sup> B Davis & V Melina, *Becoming vegan: the complete guide to adopting a healthy plant-based diet*, Book Publishing Company, Summertown, 2000, p. 94.

<sup>4</sup> ibid.

<sup>5</sup> ‘Where do I get my calcium if I don’t drink cow’s milk?’, *Vegetarian Food for Thought*, podcast, presented by Colleen Patrick-Goudreau from Compassionate Cooks, 18 March 2006, <http://feeds.feedburner.com/VegetarianFoodForThought>, accessed 15 March 2010.

<sup>6</sup> Davis & Melina, *Becoming vegan*, pp. 93-94.

<sup>7</sup> ibid., p. 97.

## **Vitamin D**

Vitamin D is important for calcium absorption<sup>8</sup>. It can be produced in the body through exposure to UV rays/sunlight, preferably on the arms and legs for approx 10-15 minutes, although a longer amount of time may be required for those with darker skin and the elderly<sup>9</sup>. If using supplements and vitamin D fortified foods, vegans will need to ensure they take vitamin D<sub>2</sub>, which is usually sourced from yeast, while avoiding the animal-derived D<sub>3</sub><sup>10</sup>.

## **Iron**

Worldwide, iron deficiency is one of the most common nutrient deficiencies among both vegetarians and omnivores<sup>11</sup>. Eat iron-rich foods, in conjunction with Vitamin C to aid iron absorption<sup>12</sup>. Try to avoid consuming black or green tea, coffee, or dairy at the same time as main meals as these foods can inhibit iron absorption<sup>13</sup>.

## **Vitamin B12**

Vegans must get their B12 through fortified foods and supplements<sup>14</sup>. Those over the age of 50 (including omnivores) may have trouble absorbing B12 from their normal diet and may need to use a B12 supplement or include some B12 fortified foods into their diet<sup>15</sup>.

## **Omega-3 Fatty Acids**

The most important where nutrition is concerned are Alpha-linolenic acid (ALA), Docosahexaenoic acid (DHA), and Eicosapentaenoic acid (EPA)<sup>16</sup>. Humans cannot produce ALA themselves and therefore are reliant on their diet for sufficient intake. ALA can be found in dark green leafy vegetables, broccoli, seaweeds, flax seeds, walnuts, soybeans, and the oils of some of these foods, for example, flax seed oil<sup>17</sup>. Humans can convert ALA into DHA and EPA, although it is generally recommended that for those who do not eat dairy, eggs, or fish that have fed on microalgae, that they also incorporate DHA supplements or fortified foods into their diet<sup>18</sup>.

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<sup>8</sup> ibid., p. 98.

<sup>9</sup> J Norris, ‘Bones, vitamin D, and calcium’, *VeganHealth.org*, December 2009, accessed on 15 March 2010, <http://www.veganhealth.org/articles/bones/>.

<sup>10</sup> ibid.

<sup>11</sup> ‘An essential mineral: iron’, *Vegetarian Food for Thought*, podcast, presented by Colleen Patrick-Goudreau from Compassionate Cooks, 29 January 2007, <http://feeds.feedburner.com/VegetarianFoodForThought>, accessed 15 March 2010.

<sup>12</sup> V Messina, ‘Vegetarian nutrition’, *Vegetarian diets: a dietitian’s guide*, 2010, accessed on 15 March 2010, <http://www.vegnutrition.com/nutrition/index.html>.

<sup>13</sup> ibid.

<sup>14</sup> ibid.

<sup>15</sup> J Norris, ‘Special concerns for those over 50’, *VeganHealth.org*, 2009, accessed on 15 March 2010, <http://www.veganhealth.org/b12/older>.

<sup>16</sup> R Mangels, ‘Questions and answers about omega-3 fatty acids for vegans’, *Vegetarian Journal*, vol. 26, no. 1, 2007, p. 22, accessed 15 March 2010, <http://www.vrg.org/journal/vj2007issue1/vj2007issue1.pdf>.

<sup>17</sup> Davis & Melina, *Becoming vegan*, p. 66.

<sup>18</sup> Mangels, ‘Questions and answers about omega-3 fatty acids for vegans’, pp. 22-23.

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13. ibid.
14. ibid.
15. J Norris, 'Special concerns for those over 50', *VeganHealth.org*, 2009, accessed on 15 March 2010, <http://www.veganhealth.org/b12/older>.
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## 4. “Quotable Quotes” from Tom Robbins’ *Villa Incognito*

*LEAD Group President Elizabeth O’Brien recently read “Villa Incognito”, a Bantam Book, first published in 2003, and chose the following snippets for this newsletter, either because they relate in some way to **lead** (see bolded words below), or because she was just really impressed with them.*

*To understand the lead connection, you’ll need to know, for the quote from page 98 (below), that according to “Principles of clinical toxicology” (page 195) by Thomas A. Gossel and J. Douglas Bricker, CRC Press, 1994, “**Calcium disodium EDTA [CaNa<sub>2</sub>-EDTA (ethylene diamine tetra acetate)]** is the **drug of choice** for acute and chronic lead poisoning and lead encephalopathy. Calcium disodium EDTA increases urinary lead excretion by 20- to 50-fold.”*

*Permission to reprint the following quotes was kindly granted by Random House, Inc. (US) New York.  
[Front cover sourced from:*

[http://upload.wikimedia.org/wikipedia/en/thumb/3/37/Villa\\_incognito\\_cover\\_photo.jpg/200px-Villa\\_incognito\\_cover\\_photo.jpg](http://upload.wikimedia.org/wikipedia/en/thumb/3/37/Villa_incognito_cover_photo.jpg/200px-Villa_incognito_cover_photo.jpg) ]

**Page 29:** After the monkeys came down from the trees and learned to hurl sharp objects, they had had to move into caves for protection- not only from the big predatory cats but, as they began to lose their monkey fur, from the elements. Eventually, they started transposing their hunting fantasies onto cave walls in the form of pictures, first as an attempt at practical magic and later for the strange, unexpected pleasure they discovered in artistic creation.

Time passed. Art came off the walls and turned into ritual. Ritual became religion. Religion spawned science. Science led to big business. And big business, if it continues on its present mindless, voracious trajectory, could land those of us lucky enough to survive its ultimate legacy back into caves again.

### **Page 78:**

“ How then does soul differ from spirit?” You’re probably asking yourself,” although he *must* have been reasonably sure nobody was. “Well, soul is darker of color, denser of volume, saltier of flavor, rougher of texture, and tends to be more maternalistic than paternalistic: soul is connected to Mother Earth, just as spirit is connected to Father Sky.

### **Page 80:**

“They nailed him on Guam. His flight was diverted. I saw him on CNN. In handcuffs. They were hauling your stuff away. It’s been three or four days now.” In Dickie’s tone there was both the pig iron of despair and the **stained glass** of hysteria.

### **Page 98:**

The mystery of mayonnaise – and others besides Dickie Goldwire have surely puzzled over this - is how egg yolks, vegetable oil, vinegar (wine’s angry brother), salt, sugar (earth’s primal grin-energy), lemon juice, water, and, naturally, a pinch of the ol’ **calcium disodium EDTA** could be combined in such a way as to produce a condiment, to versatile, satisfying, and outright majestic that mustard, ketchup and their ilk must bow down before it (though at two bucks a jar, mayonnaise certainly doesn’t put on airs) or else slink away in disgrace. Who but the French could have wrought this gastronomic miracle? Mayonnaise is France’s gift to the New World’s muddled palate, a boon that combines humanity’s ancient instinctive craving for the cellular warmth of pure fat with the modern, romantic fondness for complex flavors: mayo (as the lazy call it) may appear mild and prosaic, but

behind it's creamy veil it fairly seethes with tangy disposition. Cholesterol aside, it projects the luster that we astro-orphans have identified with well-being ever since we fell from the stars.

#### **Page 133:**

Okay, we have just passed through the Michener zone, and , assuming that narcolepsy hasn't **leadened** our lids, that we've not been Lao-this'd and Lao-that'ed into a comatose state, we're now in a position, as we rejoin the narrative flow, to conclude that Fan Nan Nan was a Lao Theung community. Are we not?

#### **Page 175:**

There is no activity in the cosmos more unvarying, more predictable than the rate at which **uranium turns into lead**. That's a good thing. If the universal clock was based on the rate at which novelty turns into routine, we might *never* show up at the dentist on time. Yet, sooner or later, however capriciously and imprecisely, the "oh wow" does decay into the "ho-hum"...

#### **Page 241:**

The air was musky with the fate of fallen fruit and collapsing mushrooms, brisk with the historic hustle of harvest, and a flock of crows flapped through it, teasing everybody and everything with their impenetrable koans. In flight, a twitchy curve of ebony luster, they formed the false mustache of the world.

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