

# HAIR ELEMENTS



LAB#:  
 PATIENT:  
 SEX: Male  
 AGE: 5  
 CLIENT#:

## POTENTIALLY TOXIC ELEMENTS

TOXIC ELEMENTS	RESULT µg/g	REFERENCE RANGE	PERCENTILE	
			68 <sup>th</sup>	95 <sup>th</sup>
Aluminum	13	< 8.0		
Antimony	0.071	< 0.066		
Arsenic	0.040	< 0.080		
Beryllium	< 0.01	< 0.020		
Bismuth	0.052	< 0.13		
Cadmium	0.20	< 0.15		
Lead	5.2	< 1.0		
Mercury	0.95	< 0.40		
Platinum	< 0.003	< 0.005		
Thallium	0.001	< 0.010		
Thorium	< 0.001	< 0.005		
Uranium	0.002	< 0.060		
Nickel	0.56	< 0.40		
Silver	0.67	< 0.20		
Tin	0.48	< 0.30		
Titanium	0.90	< 1.0		
Total Toxic Representation				

## ESSENTIAL AND OTHER ELEMENTS

ELEMENTS	RESULT µg/g	REFERENCE RANGE	PERCENTILE				
			2.5 <sup>th</sup>	16 <sup>th</sup>	50 <sup>th</sup>	84 <sup>th</sup>	97.5 <sup>th</sup>
Calcium	797	125- 370					
Magnesium	44	12- 30					
Sodium	80	12- 90					
Potassium	99	12- 40					
Copper	15	8.0- 16					
Zinc	200	100- 190					
Manganese	0.39	0.20- 0.55					
Chromium	0.80	0.26- 0.50					
Vanadium	0.12	0.030- 0.10					
Molybdenum	0.10	0.050- 0.13					
Boron	0.99	0.60- 4.0					
Iodine	3.2	0.25- 1.3					
Lithium	0.007	0.007- 0.023					
Phosphorus	172	160- 250					
Selenium	0.95	0.95- 1.7					
Strontium	2.5	0.16- 1.0					
Sulfur	47400	45500- 53000					
Barium	0.91	0.16- 0.80					
Cobalt	0.022	0.013- 0.035					
Iron	12	8.0- 19					
Germanium	0.029	0.045- 0.065					
Rubidium	0.085	0.016- 0.18					
Zirconium	0.026	0.040- 1.0					

### SPECIMEN DATA

COMMENTS: 99453  
 Date Collected: 7/30/2006  
 Date Received: 8/17/2006  
 Date Completed: 8/19/2006  
 Methodology: ICP-MS

Sample Size: 0.199 g  
 Sample Type: Head  
 Hair Color:  
 Treatment:  
 Shampoo:

V06.99

### RATIOS

ELEMENTS	RATIOS	EXPECTED RANGE
Ca/Mg	18.1	4- 30
Ca/P	4.63	0.8- 8
Na/K	0.808	0.5- 10
Zn/Cu	13.3	4- 20
Zn/Cd	> 999	> 800

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## HAIR ELEMENTS REPORT INTRODUCTION

Hair is an excretory tissue for essential, nonessential and potentially toxic elements. In general, the amount of an element that is irreversibly incorporated into growing hair is proportional to the level of the element in other body tissues. Therefore, hair elements analysis provides an indirect screening test for physiological excess, deficiency or maldistribution of elements in the body. Clinical research indicates that hair levels of specific elements, particularly potentially toxic elements such as cadmium, mercury, lead and arsenic, are highly correlated with pathological disorders. For such elements, levels in hair may be more indicative of body stores than the levels in blood and urine.

All screening tests have limitations that must be taken into consideration. The correlation between hair element levels and physiological disorders is determined by numerous factors. Individual variability and compensatory mechanisms are major factors that affect the relationship between the distribution of elements in hair and symptoms and pathological conditions. It is also very important to keep in mind that scalp hair is vulnerable to external contamination of elements by exposure to hair treatments and products. Likewise, some hair treatments (e.g. permanent solutions, dyes, and bleach) can strip hair of endogenously acquired elements and result in false low values. Careful consideration of the limitations must be made in the interpretation of results of hair analysis. The data provided should be considered in conjunction with symptomology, diet analysis, occupation and lifestyle, physical examination and the results of other analytical laboratory tests.

**Caution:** The contents of this report are not intended to be diagnostic and the physician using this information is cautioned against treatment based solely on the results of this screening test. For example, copper supplementation based upon a result of low hair copper is contraindicated in patients afflicted with Wilson's Disease.

### Aluminum High

The Aluminum (Al) level in hair is a reliable indicator of assimilation of this element, provided that hair preparations have not added exogenous Al. Al is a nonessential element that can be toxic if excessively assimilated into cells.

Excess Al can inhibit the formation of alpha-keto glutarate and result in toxic levels of ammonia in tissues. Al can bond to phosphorylated bases on DNA and disrupt protein synthesis and catabolism. Al excess should be considered when symptoms of presenile dementia or Alzheimer's disease are observed. Hair Al is commonly elevated in children and adults with low zinc and behavioral/learning disorders such as ADD, ADHD and autism. Individuals with renal problems or on renal dialysis may have elevated Al.

Possible sources of Al include some antacid medications, Al cookware, baking powder, processed cheese, drinking water, and antiperspirant components that may be absorbed. Analyses performed at DDI indicate extremely high levels of Al are in many colloidal mineral products.

Al has neurotoxic effects at high levels, but low levels of accumulation may not elicit immediate symptoms. Early symptoms of Al burden may include: fatigue, headache, and symptoms of phosphate depletion.

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A urine elements test can be used to corroborate Al exposure. Al can be effectively complexed and excreted with silicon (J. Environ. Pathol. Toxicol. Oncol., 13(3): 205-7, 1994). A complex of malic acid and Mg has been reported to be quite effective in lowering Al levels (DDI clients).

#### Antimony High

Hair is a preferred tissue for analysis of Antimony (Sb) exposure and body burden. Elevated hair Sb levels have been noted as long as a year after exposure.

Sb is a nonessential element that is chemically similar to but less toxic than arsenic. Food and smoking are the usual sources of Sb. Thus cigarette smoke can externally contaminate hair, as well as contribute to uptake via inhalation. Gunpowder (ammunition) often contains Sb. Firearm enthusiasts often have elevated levels of Sb in hair. Other possible sources are textile industry, metal alloys, and some antihelminthic and antiprotozoic drugs. Sb is also used in the manufacture of paints, glass, ceramics, solder, batteries, bearing metals and semiconductors.

Like arsenic, Sb has a high affinity for sulfhydryl groups on many enzymes. Sb is conjugated with glutathione and excreted in urine and feces. Therefore, excessive exposure to Sb has the potential to deplete intracellular glutathione pools.

Early signs of Sb excess include: fatigue, muscle weakness, myopathy, nausea, low back pain, headache, and metallic taste. Later symptoms include hemolytic anemia, myoglobinuria, hematuria and renal failure. Transdermal absorption can lead to "antimony spots" which resemble chicken pox. Respiratory tissue irritation may result from inhalation of Sb particles or dust.

A confirmatory test for recent or current exposure is the measurement of Sb in the urine.

#### Cadmium high

Hair Cadmium (Cd) levels provide an excellent indication of body burden. Cd is a toxic heavy metal that has no metabolic function in the body. Moderately high Cd levels, about 4-8 µg/g, may be associated with hypertension, while very severe Cd toxicity may cause hypotension. Cd adversely affects the kidneys, lungs, testes, arterial walls, and bones and interferes with many enzymatic reactions. Chronic Cd excess can lead to microcytic, hypochromic anemia and proteinuria with loss of beta-2-microglobulin, and functional zinc deficiency. Cd excess is also commonly associated with fatigue, weight loss, osteomalacia, and lumbar pain.

Cd absorption is reduced by zinc, calcium, and selenium. Cd is found in varying amounts in foods, from .04 µg/g for some fruits to 3-5 µg/g in some oysters and anchovies. Cigarette smoking significantly increases Cd intake. Refined carbohydrates have very little zinc in relation to the Cd.

If hair zinc is not abnormal, external contamination may have caused the elevated hair Cd level. Exogenous contamination may come from permanent solutions, dyes, bleach, and some hair sprays. A confirming test for elevated body burden of Cd is urine analysis following administration of appropriate chelating agents: EDTA, sulfhydryl agents (DMSA, D-penicillamine, DMPS).

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### Lead Extremely High

This individual's hair Lead (Pb) level is considered to be extremely elevated and is consistent with toxicity. Hair is an excellent indicator of the body burden of Pb. However, elevated levels of Pb in head hair can be an artifact of hair darkening agents, or dyes, e.g., lead acetate. Although these agents can cause exogenous contamination, transdermal absorption can contribute to body burden. Hair levels of iron, boron, zinc, and calcium are commonly elevated in associated with Pb burden. Chelation therapy results in marked, transient increases in hair Pb during mobilization from deep tissue stores. Eventually, the hair Pb level will normalize after detoxification is complete.

Pb has neurotoxic and nephrotoxic effects and interferes with heme biosynthesis. Pb may also affect the body's ability to utilize the essential elements calcium, magnesium, and zinc. At high levels of body burden, Pb may have adverse effects on memory and cognitive abilities, nerve conduction, and metabolism of vitamin D. Impaired erythropoiesis and anemia may be present. Children with hair Pb levels above 3 µg/g have been reported to have more learning problems than those with less than 3 µg/g (Arch. Environ. Hlth. 51: 214-220, 1996).

Symptoms associated with excess Pb are vague, but include: loss of appetite and body weight, poor memory, fatigue, constipation, headaches, inability to concentrate, and decreased coordination.

Sources of exposure to Pb include: welding, old leaded paint (dust/chips), drinking water, some fertilizers, industrial waste, lead-glazed pottery, manufacture of stained glass, and newsprint.

Confirmatory tests for Pb excess are: urine elements analysis following provocation with intravenous EDTA, DMPS, or oral DMSA. Whole blood analysis only reflects recent or ongoing exposures and may not correlate with total body burden. Increased blood protoporphyrins is a finding consistent with Pb excess, but may occur with other toxic elements as well.

### Mercury High

Mercury (Hg) is toxic to humans and animals. The accumulation of Hg in the body is generally reflected by the hair Hg levels, but hair Hg levels can be artifactually high in association with the use of certain hair dyes. Individuals vary greatly in sensitivity and tolerance to Hg burden.

At hair levels below 3 µg/g, Hg can suppress biological selenium function and may cause or contribute to immune dysregulation in sensitive individuals. Hallmark symptoms of excess Hg include: loss of appetite, decreased senses of touch, hearing, and vision, fatigue, depression, emotional instability, peripheral numbness and tremors, poor memory and cognitive dysfunction, and neuromuscular disorders. Hair Hg has been reported to correlate with acute myocardial infarction and on average each 1 µg/g of hair Hg was found to correlate with a 9% increase in AMI risk (Circulation 1995; 91:645-655).

Sources of Hg include dental amalgams, contaminated seafood, water supplies, some hemorrhoidal preparations, skin lightening agents, instruments (thermometers, electrodes, batteries), and combustion of fossil fuels, some fertilizers, and the paper/pulp and gold industries. After dental amalgams are installed or removed a transient (several months) increase in hair Hg is observed. Also, "baseline" hair Hg levels for individuals with dental amalgams are higher (about 1

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to 2 µg/g) than are baseline levels for those without (below 1 µg/g).

Confirmatory tests for elevated Hg are measurement of whole blood as an indication of recent/ongoing exposure (does not correlate with whole body accumulation) and measurement of urine Hg following use of a dithiol chelating or mobilizing agent such as DMSA or DMPS (an indication of total body burden).

#### Nickel

Hair is a reasonable tissue for monitoring accumulated body stores of Nickel (Ni). However, hair is commonly contaminated with Ni from hair treatments and dyes. When hair Ni is measured at more than .6 ppm, the possible use of hair dyes or colorings should be investigated before concluding that excessive Ni is present.

There is substantial evidence that Ni is an essential element which is required in extremely low amounts. However, excess Ni has been well established to be nephrotoxic, and carcinogenic. Elevated Ni is often found in individuals who work in the electronic and plating, mining, and steel manufacture industries. A cigarette typically contains from 2 to 6 mcg of Ni; Ni is absorbed more efficiently in the lungs than in the gastrointestinal tract. Symptoms of chronic Ni exposure include dermatitis, chronic rhinitis, and hypersensitivity reactions. Ni can hypersensitize the immune system, subsequently causing hyperallergenic responses to many different substances.

Symptoms of Ni toxicity are dermatitis and pulmonary inflammation (following exposure to Ni dust, smoke). Long term or chronic Ni toxicity may lead to liver necrosis and carcinoma.

A confirmatory test for elevated Ni is the measurement of urine Ni before and after administration of chelating agents that mobilize Ni i.e., D-penicillamine, EDTA.

#### Silver High

Hair Silver (Ag) levels have been found to reflect environmental exposure to the element. However, hair is commonly contaminated with Ag from hair treatments such as permanents, dyes, and bleaches.

Ag is not an essential element and is of relatively low toxicity. However, some Ag salts are very toxic.

Sources of Ag include seafood, metal and chemical processing industries, photographic processes, jewelry making (especially soldering), effluents from coal fired power plants and colloidal silver products.

The bacteriostatic properties of Ag have been long recognized and Ag has been used extensively for medicinal purposes; particularly in the treatment of burns. There is much controversy over the long term safety of consumption of colloidal silver. Very high intake of colloidal silver has been reported to give rise to tumors in the liver and spleen of animals (Metals in Clinical and Analytical Chemistry, eds. Seiler, Segel and Segel, 1994). However, these data may not have relevance to the effects of chronic, low level consumption by humans.

#### Tin High

Hair Tin (Sn) levels have been found to correlate with environmental exposure. Depending on chemical form, Sn is a potentially toxic element. Inorganic Sn has a low degree of toxicity, while organic Sn has appreciable toxicity.

The main source of Sn is food. Other possible sources are: dental amalgams, cosmetics, preservatives, food and beverage containers, pewter, bronze, and anticorrosive platings. Symptoms of excess Sn include: skin, eye, and GI tract irritation, muscle weakness, anemia, and testicular degeneration.

A confirmatory test for excessive accumulation of Sn is the measurement of Sn in urine before and after provocation with a chelation/complexing agent.

#### Magnesium High

Magnesium (Mg) is an essential element with both electrolyte and enzyme-activator functions. However, neither of these functions takes place in hair. Body excess of Mg is rare but may occur from excessive oral or parenteral supplementation or as a result of renal damage or insufficiency.

If one rules out external contamination of hair as a result of recent hair treatment, elevated hair Mg is more likely to indicate maldistribution of the element. Physiological Mg dysfunction may or may not be present. Maldistribution of Mg can occur as a result of chronic emotional or physical stress, toxic metal or chemical exposure, physiological imbalance of calcium and phosphorus, bone mineral depletion, and renal insufficiency with poor clearance of Mg (and other metabolites). Elevated hair Mg has been correlated with hypoglycemia and an inappropriately low ratio of dietary Ca : P.

Mg status can be difficult to assess; whole blood and packed blood red cell Mg levels are more indicative than serum/plasma levels. Amino acid analysis can be helpful in showing rate-limited steps that are Mg-dependent (e.g. phosphorylations).

#### Potassium High

High hair Potassium (K) is not necessarily reflective of dietary intake or nutrient status. However, elevated K may be reflective of metabolic disorders associated with exposure to potentially toxic elements.

K is an electrolyte and a potentiator of enzyme functions, but neither of these functions take place in hair. Elevated K in hair may reflect overall retention of K by the body or maldistribution of this element. In adrenocortical insufficiency, K is increased in blood, while it is decreased in urine; cellular K may or may not be increased. Also, hair is occasionally contaminated with K from some shampoos. Observations at DDI indicate that K and sodium levels in hair are commonly high in association with toxic element burden. The elevated K and sodium levels are often concomitant with low levels of calcium and magnesium in hair. This apparent phenomena requires further investigation.

Elevated hair potassium should be viewed as a screening test. Appropriate tests for excess body K include measurements of packed red blood cell K; serum or whole blood K and sodium/K ratio,

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measurement of urine K and sodium/K ratio; and an assessment of adrenocortical function.

#### Copper Normal

Hair Copper (Cu) levels are usually indicative of body status, except that exogenous contamination may occur giving a false normal (or false high). Common sources of contamination include: permanent solutions, dyes, bleaches, and swimming pools/hot tubs in which Cu compounds have been used as algacides.

Cu is an essential element that activates specific enzymes. Erythrocyte superoxide dismutase (SOD) is a Cu (and zinc) dependent enzyme; lysyl oxidase which catalyzes crosslinking of collagen is another Cu dependent enzyme. Adrenal catecholamine synthesis is Cu dependent, because the enzyme dopamine beta-hydroxylase, which catalyzes formation of norepinephrine from dopamine, requires Cu.

If hair Cu is in the normal range, this usually means tissue levels are in the normal range. However, under circumstances of contamination, a real Cu deficit could appear as a (false) normal. If symptoms of Cu deficiency are present, a whole blood or red blood cell elements analysis can be performed for confirmation of Cu status.

#### Zinc High

A result of high hair Zinc (Zn) may be indicative of low Zn in cells, and functional Zn deficiency. Zn can be displaced from proteins such as intracellular metallothionein by other metals, particularly cadmium, lead, copper, and mercury (Toxicology of Metals, 1994), resulting in paradoxically elevated hair Zn. Zn may also be high in hair as a result of the use of Zn-containing anti-dandruff shampoo. Rough or dry, flaky skin is a symptom of Zn deficiency, so it is not uncommon for Zn deficient patients to use an anti-dandruff shampoo. A result of high hair Zn warrants further testing to assess Zn status.

Zn is an essential element that is required in many very important biological processes. However, Zn can be toxic if exposure is excessive. Although very uncommon, high hair Zn might be indicative of Zn overload which could result from Zn contaminated water (galvanized pipes), welding or gross, chronic over-supplementation (100 mg/day). Other sources of Zn include: manufacture of brass, bronze, white paint, and pesticide production. Symptoms of Zn excess include: gastrointestinal disorders, decreased heme synthesis (copper deficiency), tachycardia, blurred vision, and hypothermia.

Confirmatory tests for Zn status are whole blood or packed red blood cell elements analysis, urine amino acid analysis, and serum ceruloplasmin (low with Zn induced copper deficiency).

#### Chromium High

A high hair Chromium (Cr) level is likely to indicate excess exposure to Cr. Hair Cr levels do not appear to be affected by permanent solutions, dyes, or bleaches, but external contamination is possible.

Trivalent Cr is considered to be an essential trace element with a low order of toxicity. Cr toxicity via oral ingestion is not likely. However, it is noteworthy that self-supplementation has been reported to be associated with insomnia and increased unpleasant dream activity in some individuals (J. Nutr. Med.;

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3(43), 1992).

In contrast, hexavalent Cr compounds are considerably more toxic and are primarily absorbed via inhalation as a result of industrial exposure. Industrial exposure to high amounts of Cr has been reported to be associated with allergic dermatitis, skin ulcers, bronchitis, and lung carcinoma. Elevated hair Cr levels have also been observed in patients with cerebral thrombosis and cerebral hemorrhage.

Sources of exposure to hexavalent Cr include: manufacture and use of ferrochromium and stainless steel, wood finishing and leather tanning industries, and handling of cement.

Tests to confirm excess exposure to Cr include analysis of Cr in plasma (trivalent) versus packed red blood cells (hexavalent); both analyses are more indicative of recent exposure than of body burden. A urine elements analysis will confirm recent exposure and serum hyaluronidase activity is reported to be elevated with excessive exposure to Cr.

#### Vanadium High

High levels of Vanadium (V) in hair may be indicative of excess absorption of the element. It is well established that excess V can have toxic effects in humans. Although it appears that V may have essential functions, over zealous supplementation is not warranted.

Excess levels of V in the body can result from chronic consumption of fish, shrimp, crabs, and oysters derived from water near offshore oil rigs (Metals in Clinical and Analytical Chemistry, 1994). Industrial/environmental sources of V include: processing of mineral ores, phosphate fertilizers, combustion of oil and coal, production of steel, and chemicals used in the fixation of dyes and print.

Symptoms of V toxicity vary with chemical form and route of absorption. Inhalation of excess V may produce respiratory irritation and bronchitis. Excess ingestion of V can result in decreased appetite, depressed growth, diarrhea/gastrointestinal disturbances, nephrotoxic and hematotoxic effects. Pallor, diarrhea, and green tongue are early signs of excess V and have been reported in human subjects consuming about 20 mg V/day (Modern Nutrition in Health and Disease, 8th edition, eds. Shils, M., Olson, J., and Mosha, S., 1994).

Confirmatory tests for excess V are red blood cell elements analysis, and urine V which reflects recent intake.

#### Strontium High

Hair usually reflects the body burden of Strontium (Sr), and Sr levels usually correlate with calcium levels in body tissue. However, hair levels of Sr can be raised by external contamination, usually from hair treatment products. Elevated Sr in hair treated with permanent solutions, dyes, or bleaches is likely to be an artifact of hair treatment and probably does not reflect the level of Sr in other tissues.

Diseases of excess Sr have not been reported, except for Sr rickets. In general, Sr excess is not of clinical concern in the U.S. It's bad reputation comes from its radioactive isotopes which were widespread in the western U.S. as a result of nuclear testing in the 1950's. Stable Sr (not radioactive Sr) is measured and reported by DDI.

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Other tests indicative of Sr status or excess are measurements of Sr in whole blood, Sr/calcium ratio in blood, and Sr in urine.

#### Total Toxic Element Indication

The potentially toxic elements vary considerably with respect to their relative toxicities. The accumulation of more than one of the most toxic elements may have synergistic adverse effects, even if the level of each individual element is not strikingly high. Therefore, we present a total toxic element "score" which is estimated using a weighted average based upon relative toxicity. For example, the combined presence of lead and mercury will give a higher total score than that of the combination of silver and beryllium.