

WHAT IS A HEAVY METAL?

The term **heavy metal** refers to any metallic chemical **element** that has a relatively high density and is toxic or poisonous at low concentrations.

Group → ↓ Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo
Lanthanides				57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides				89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

<http://the-works.net/tag/picture-of-peroidic-table-of-elements>

HEAVY METALS



Arsenic



Lead



Tungsten



Barium



Nickel



Tin



Beryllium



Copper



Antimony



Uranium



Platinum



Thorium



Cadmium



Mercury



Cesium



Thallium



Aluminum



<http://drjockers.com/heavy-metal-testing/>

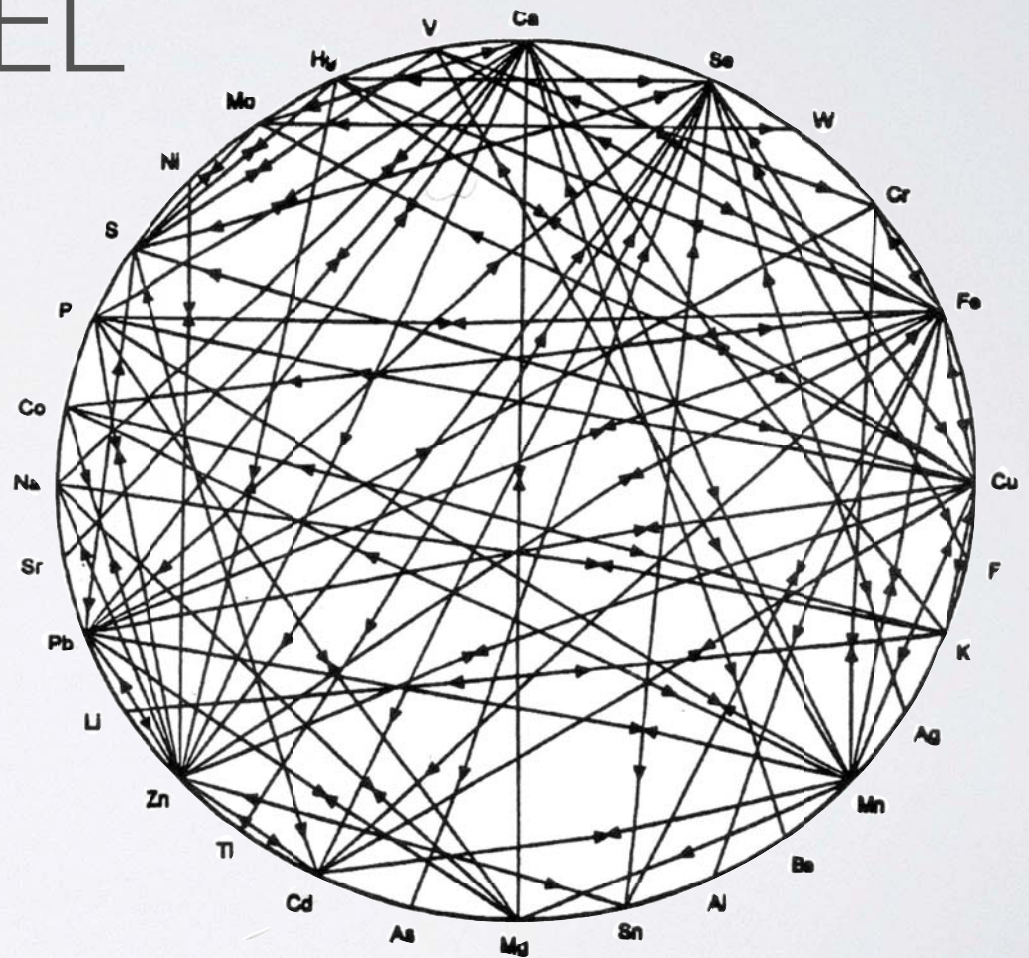
WHAT TOXINS ARE RELEASED TO THE AQUIFER BY ISL MINING?

HEAVY METALS OF:

uranium, beryllium, vanadium, aluminum,
selenium, cobalt, copper, lead, manganese,
chromium, thorium, strontium, molybdenum,
arsenic, cadmium, mercury, zinc, iron,
radionuclides A and B, radon gas, and radium

MINERAL INTERRELATIONSHIPS WHEEL

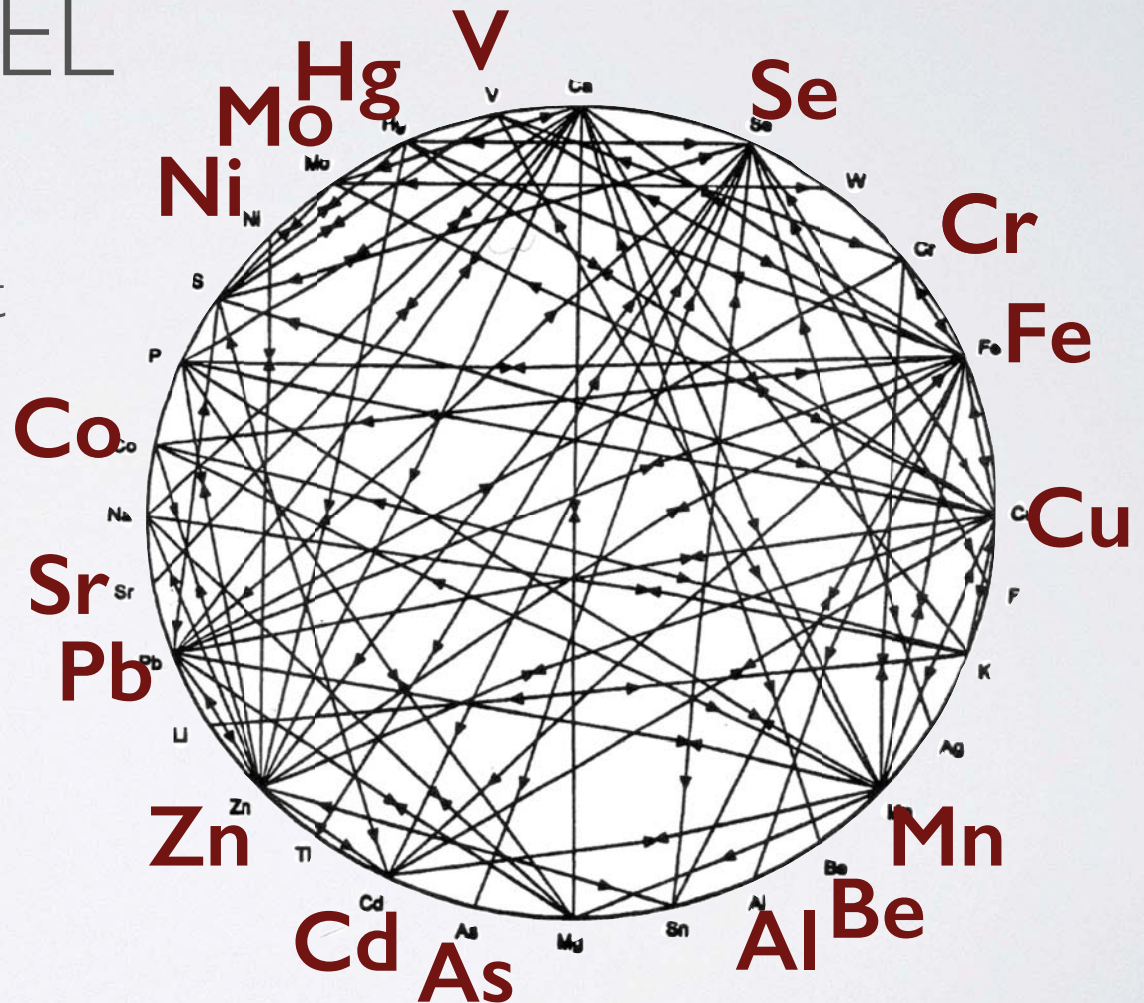
Documents the perfect relationship which exists between all minerals. Perfect mineral balance must exist in your body to maintain perfect health.



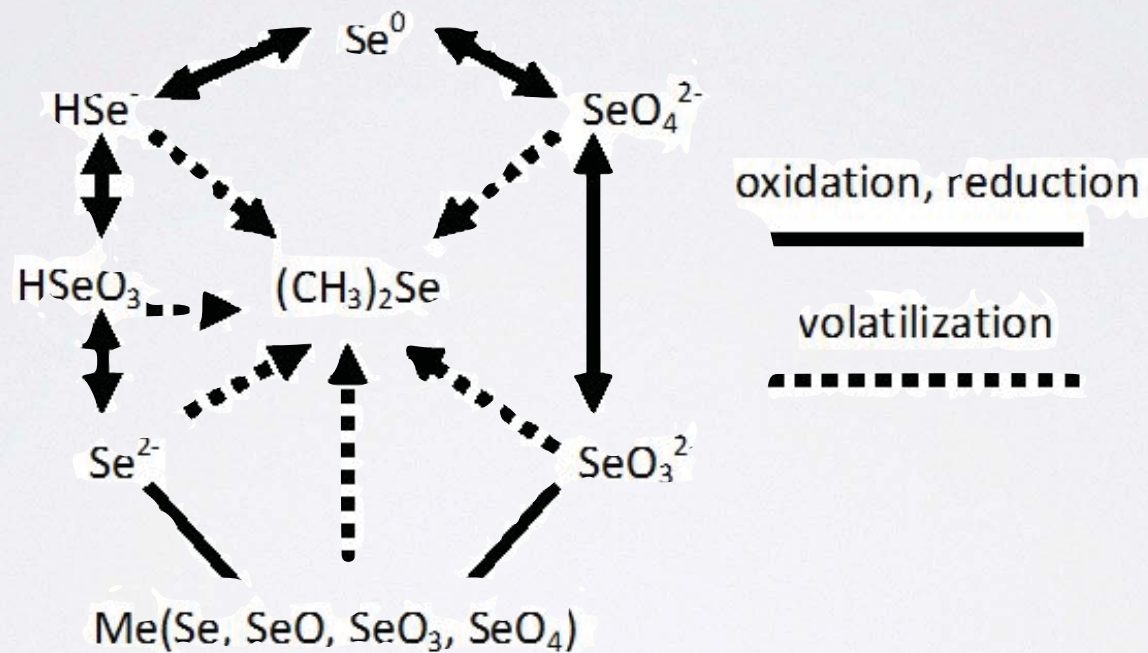
MINERAL INTERRELATIONSHIPS WHEEL

This wheel highlights the
heavy metals of mining

Documents the perfect
relationship which
exists between all
minerals. Perfect
mineral balance must
exist in your body to
maintain perfect health.



CHEMICAL ACTIVITY OF SELENIUM



<http://www.intechopen.com/books/antioxidant-enzyme/selenium-an-important-antioxidant-in-crops-biofortification>

USE OF CHELATES IN ANIMAL NUTRITION

MAIN OBJECTIVES :

1. Reduction of antagonism, interferences and competition among minerals.
2. Improve the bioavailability of minerals
3. Counteract antinutritional factors, which affecting minerals
4. Performance improvement
5. Health improvement (immune status, functional nutrition)
6. over all animal welfare
7. Improvement in animal produces quality (meat, milk, egg, wool etc.,)
8. Reduce degenerative effect of trace minerals on vitamins in premixes and feed.
9. Protect environment by reducing metal pollution.

Chelated Minerals in Animal Nutrition

Rajendran, C.Kathirvelan and V.Balakrishnan

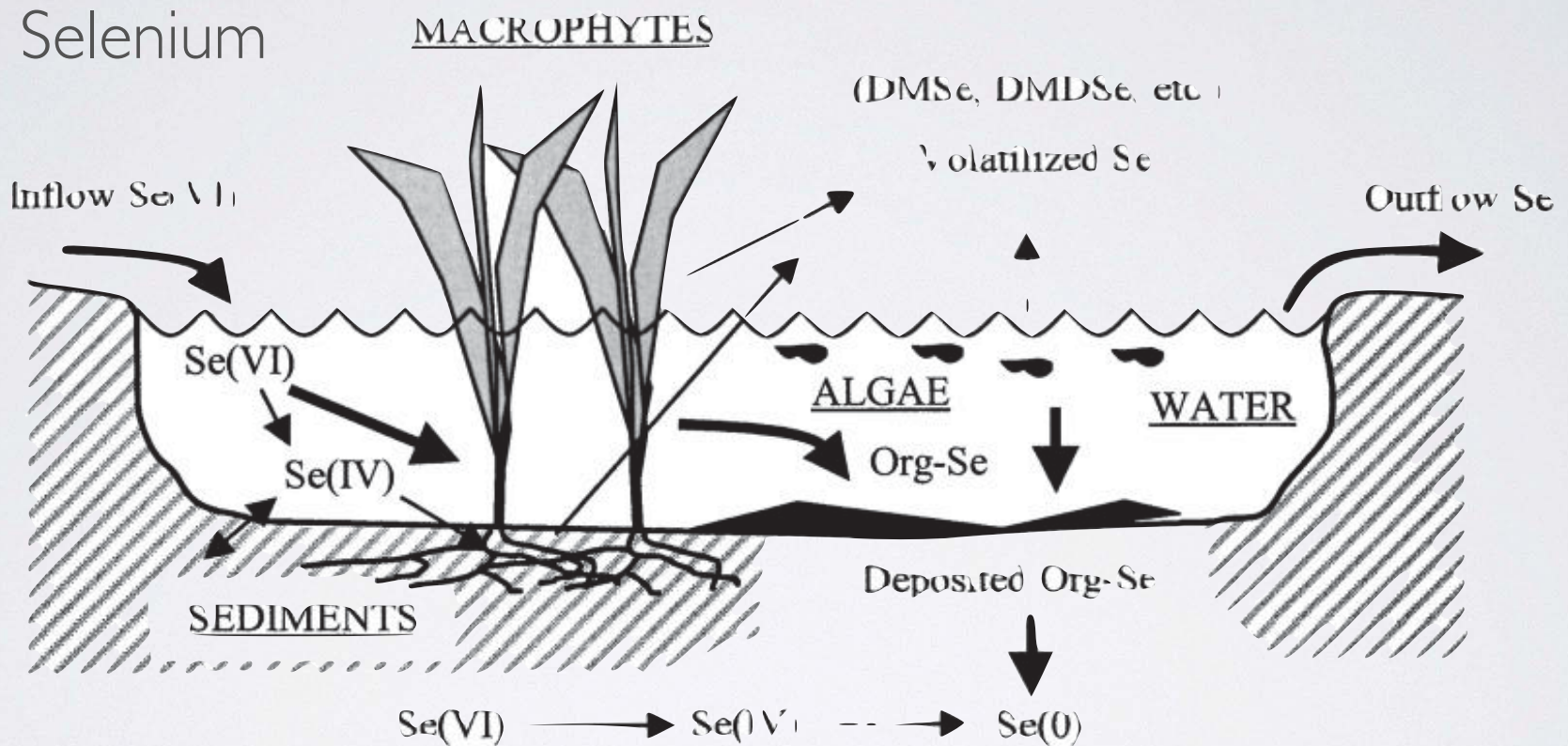
Madras Veterinary College, Chennai, INDIA



Arsenic



HOW INORGANIC CHEMICAL FORMS BECOME ORGANIC CHEMICAL FORMS IN NATURE



<https://dl.sciencesocieties.org/publications/jeq/abstracts/31/4/1146?show-t-%20%20f=tables&wrapper=no?access=0&view=article>

RIVER ALGAE AFFECTING MERCURY POLLUTION AT SUPERFUND SITE, STUDY SHOWS

Date:

March 13, 2015

Source:

Dartmouth College

Summary:

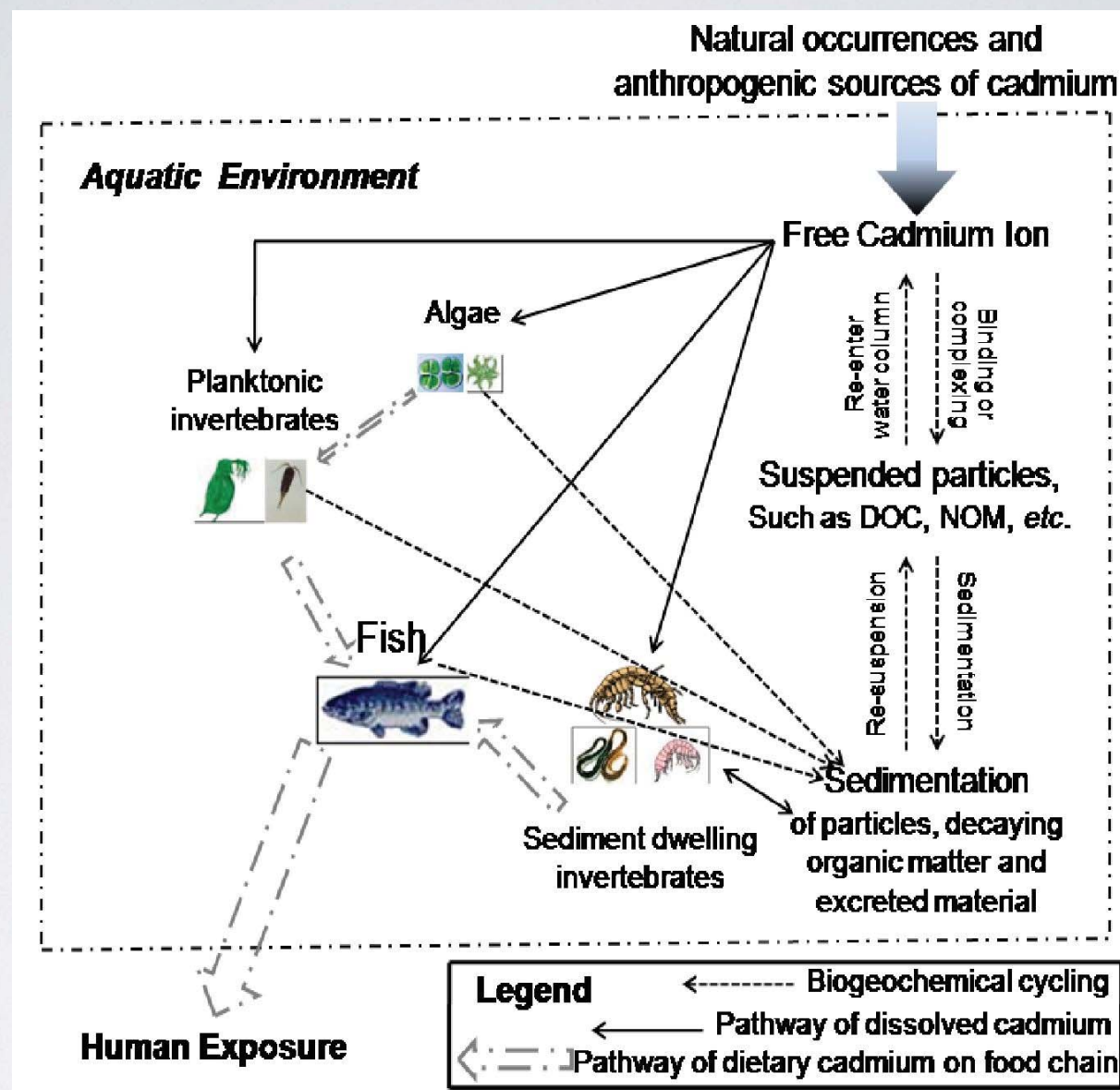
Periphyton -- a community of algae, bacteria and other natural material living on submerged surfaces -- is helping to transform mercury pollution from a Superfund site along a New Hampshire river into a more toxic form of the metal, researchers have found.

Story Source:

The above story is based on materials provided by Dartmouth College. Note: Materials may be edited for content and length.

Journal Reference:

Kate L. Buckman, Mark Marvin-DiPasquale, Vivien F. Taylor, Ann Chalmers, Hannah J. Broadley, Jennifer Agee, Brian P. Jackson, Celia Y. Chen. Influence of a chlor-alkali Superfund site on mercury bioaccumulation in periphyton and Low-trophic level fauna. Environmental Toxicology and Chemistry, 2015; DOI: 10.1002/etc.2964



<http://what-when-how.com/mechanisms-of-cadmium-toxicity-to-various-trophic-saltwater-organisms/toxicity-of-waterborne-cadmium-to-saltwater-aquatic-organisms-part-1/>

BIOACCUMULATION

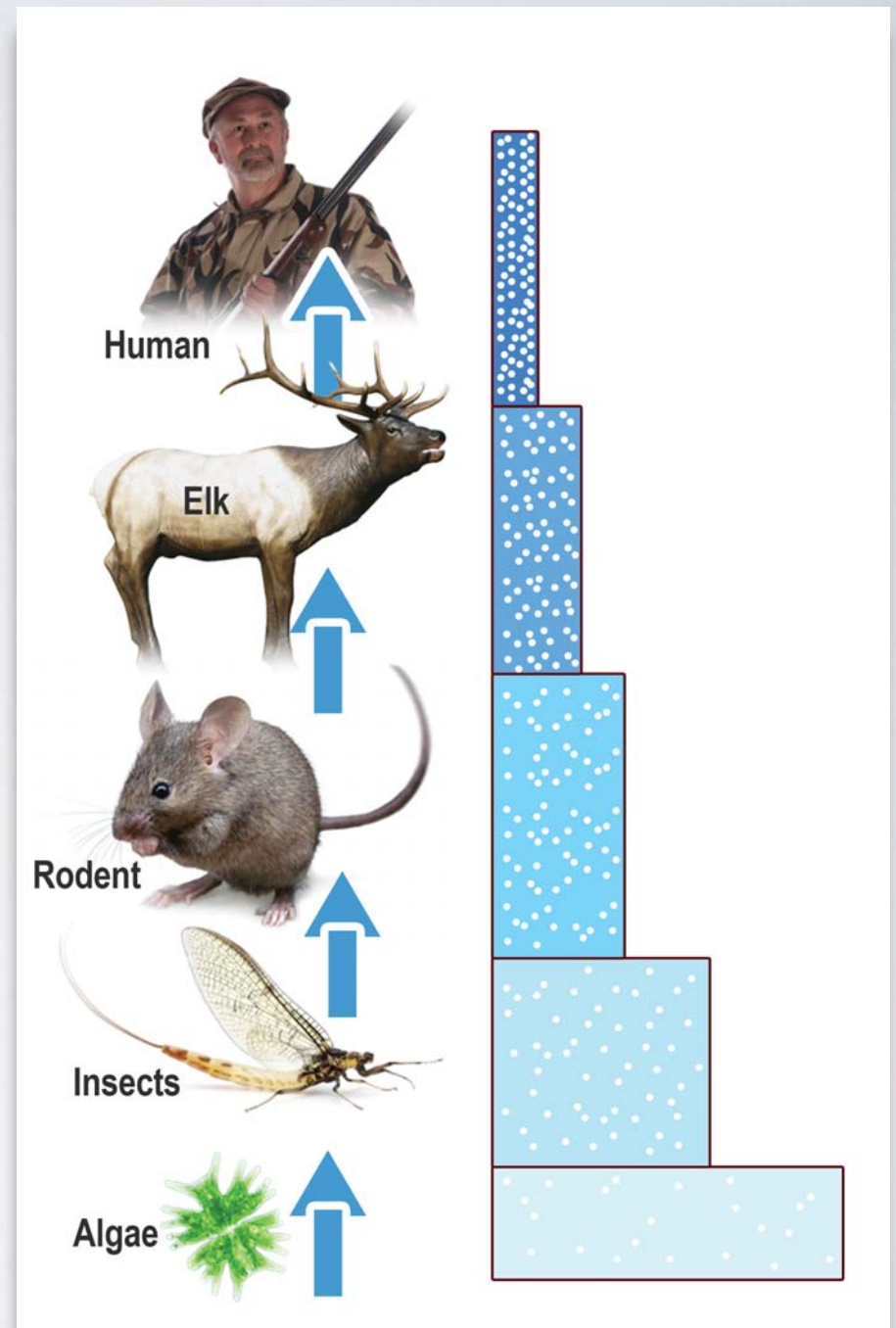
Bioaccumulation is the increase in concentration of a substance in living organisms as they take in contaminated air, water, or food.

As bigger animals eat smaller animals, the level of contamination in the food is added to the level of contamination already in their body.

Bioaccumulation is a problem in the north because of higher concentrations of toxic pollution.

Also, northern animals have a lot of fat to keep them warm, toxins accumulate mostly in fat

Organically bound minerals/metals have a faster and more complete uptake in the living body. With toxic metals, that can make them even more toxic.



EPIGENETICS

The Toxins That Affected Your Great-Grandparents Could Be In Your Genes -By Jeneen Interlandi

Biologist Michael Skinner has enraged the chemical community and shocked his peers with his breakthrough research



Smithsonian Magazine
December 2013

<http://www.smithsonianmag.com/innovation/the-toxins-that-affected-your-great-grandparents-could-be-in-your-genes-180947644/#dUvVOukmtKkFRB0l.99>



**Exploring the genetic basis of metal
tolerance in populations of the
brown trout (*Salmo trutta* L.)**



**Josephine Paris, Andrew King &
Jamie Stevens**



<http://www.slideshare.net/NickWRT/wrt-ca-bacrfconference1214andyking>



What we've found

15 populations
641 individuals

25 microsatellite loci
9 potentially under
selection

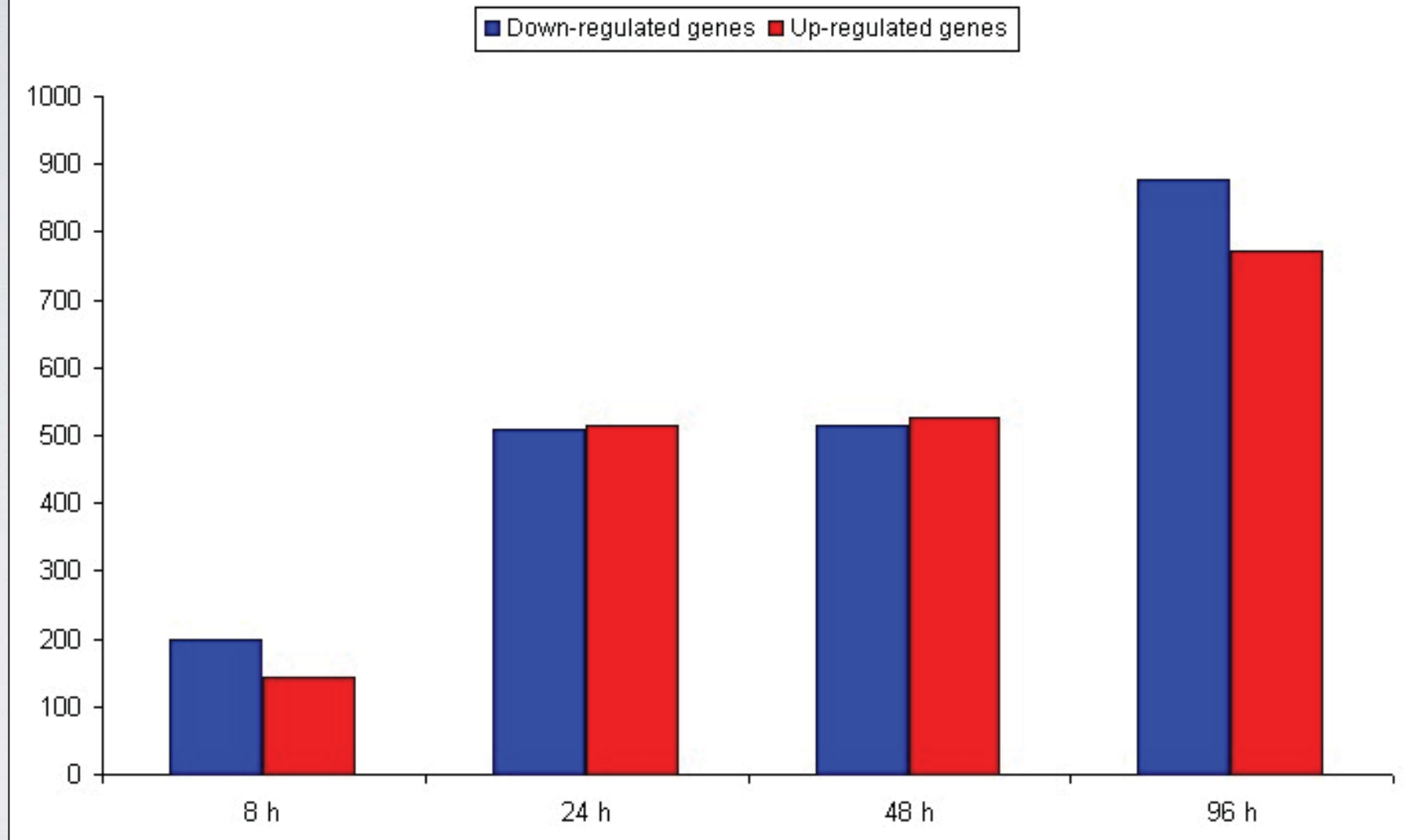
Metal impacted populations have **lower genetic diversity** compared to reference 'clean' rivers... evidence of population bottlenecks & local adaptation

Each trout metal population has a **different genetic profile** compared to trout from clean rivers, and other metal populations

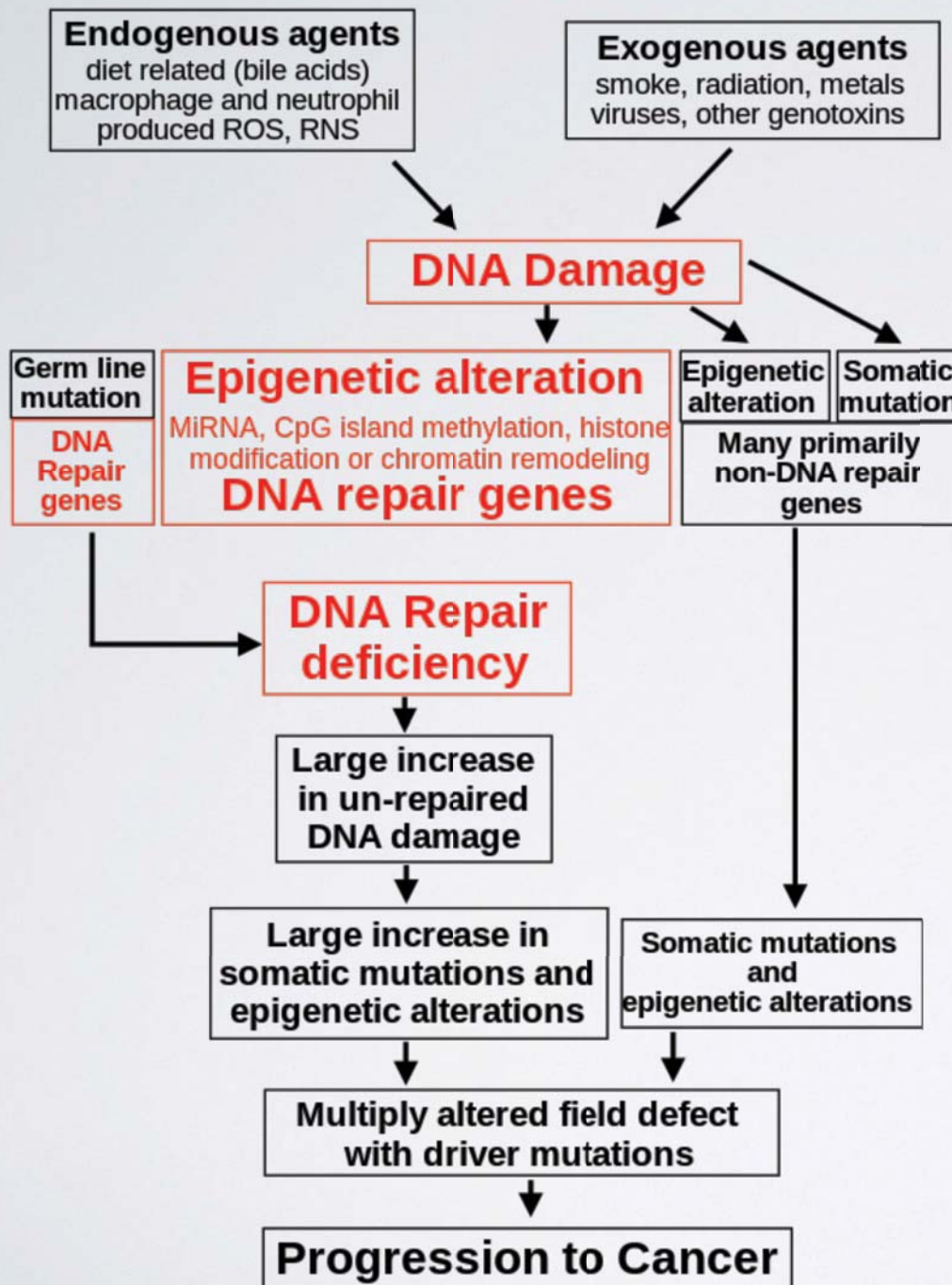
We have timed the generation of each distinct heavy metal population to historical events relating to mining activity

<http://www.slideshare.net/NickWRT/wrt-ca-bacrfconference1214andyking>

Number of genes significantly deregulated by mercury as mapped to human homologous genes

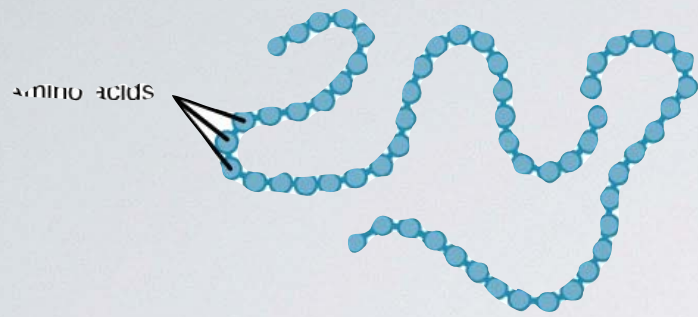


<http://www.biomedcentral.com/1471-2164/11/212>

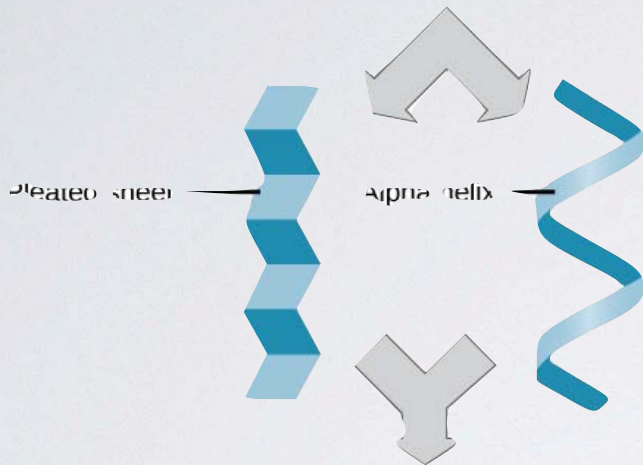


THE CENTRAL ROLE OF DNA DAMAGE AND EPIGENETIC DEFECTS IN DNA REPAIR GENES IN CARCINOGENESIS

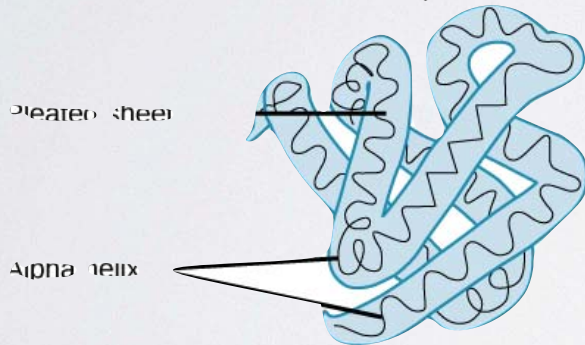
<http://en.wikipedia.org/wiki/Carcinogenesis>



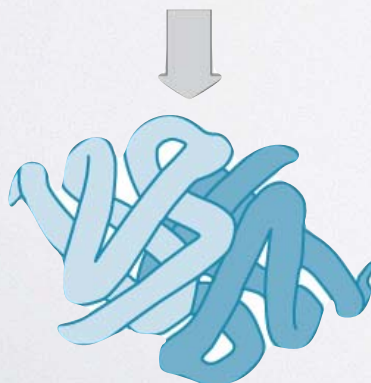
Primary Protein structure
sequence of a chain of amino acids



Secondary Protein structure
hydrogen bonding of the peptide backbone causes the amino acids to fold into a repeating pattern

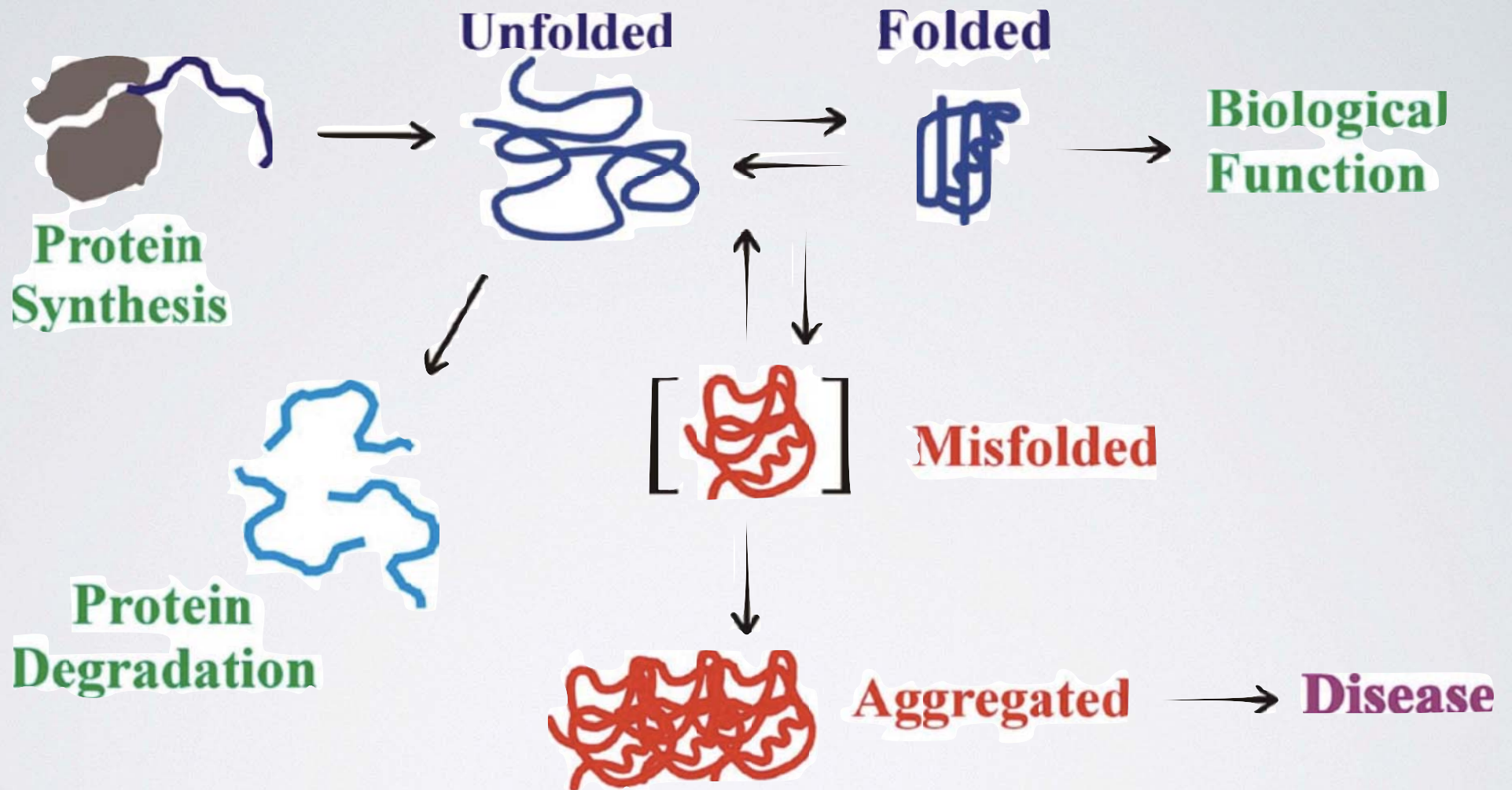


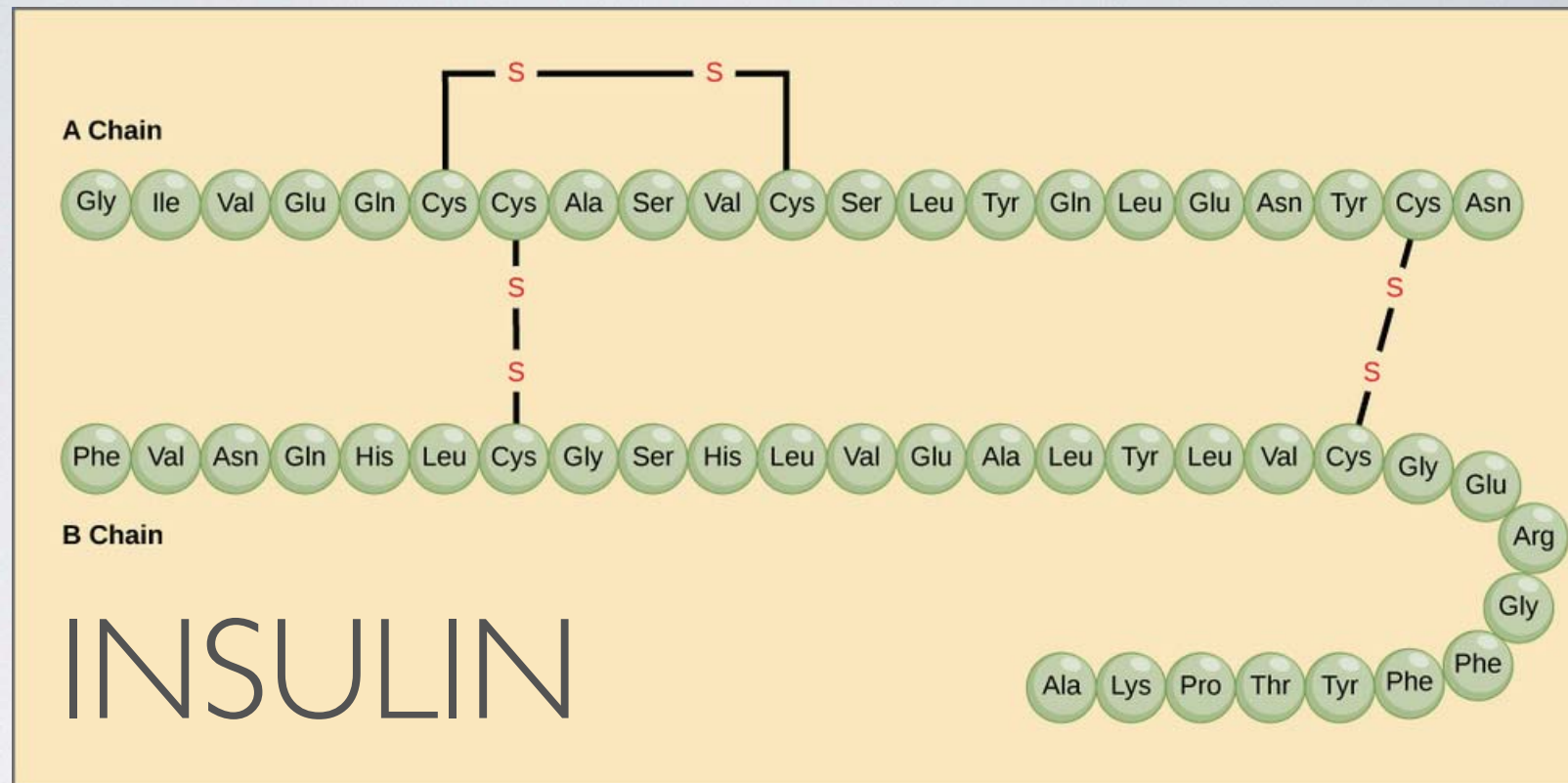
Tertiary protein structure
three-dimensional folding pattern of a protein due to side chain interactions



Quaternary protein structure
protein consisting of more than one amino acid chain

[https://
www.boundless.com/
biology/textbooks/
boundless-biology-
textbook/biological-
macromolecules-3/
proteins-56/protein-
structure-304-11437/](https://www.boundless.com/biology/textbooks/boundless-biology-textbook/biological-macromolecules-3/proteins-56/protein-structure-304-11437/)





The A chain of insulin is 21 amino acids long and the B chain is 30 amino acids long, and each sequence is unique to the insulin protein.
 Source: Boundless. "Protein Structure." Boundless Biology. Boundless, 12 Dec. 2014. Retrieved 10 Mar. 2015

<https://www.boundless.com/biology/textbooks/boundless-biology-textbook/biological-macromolecules-3/proteins-56/protein-structure-304-11437/>

SELENIUM

[http://www.filonverde.org/
images/
informe_selenio_en_minas_a
_cielo_abierto.pdf](http://www.filonverde.org/images/informe_selenio_en_minas_a_cielo_abierto.pdf)



TOXIC WATER DEFORMS FISH

February 27, 2012 **Candice Chandler**

(POLLUTION) IDAHO — Brown trout collected by scientists near a mining zone in southern Idaho have been found with physical mutations, including two heads. The mining company, J.R. Simplot Company, claims to have tested the water and confirmed that the toxic pollutant present, selenium, met regulation amounts. Harmful to birds, fish, reptiles and humans, an investigation is now underway focusing on how much selenium is in the water, and what levels are acceptable.



This brown trout is the victim of selenium poisoning.

greateryellowstone.org

RINGS AROUND THE HOOF WALL DUE TO SELENIUM TOXICITY



<http://photos.emsvet.com/displayimage.php?pid=95>

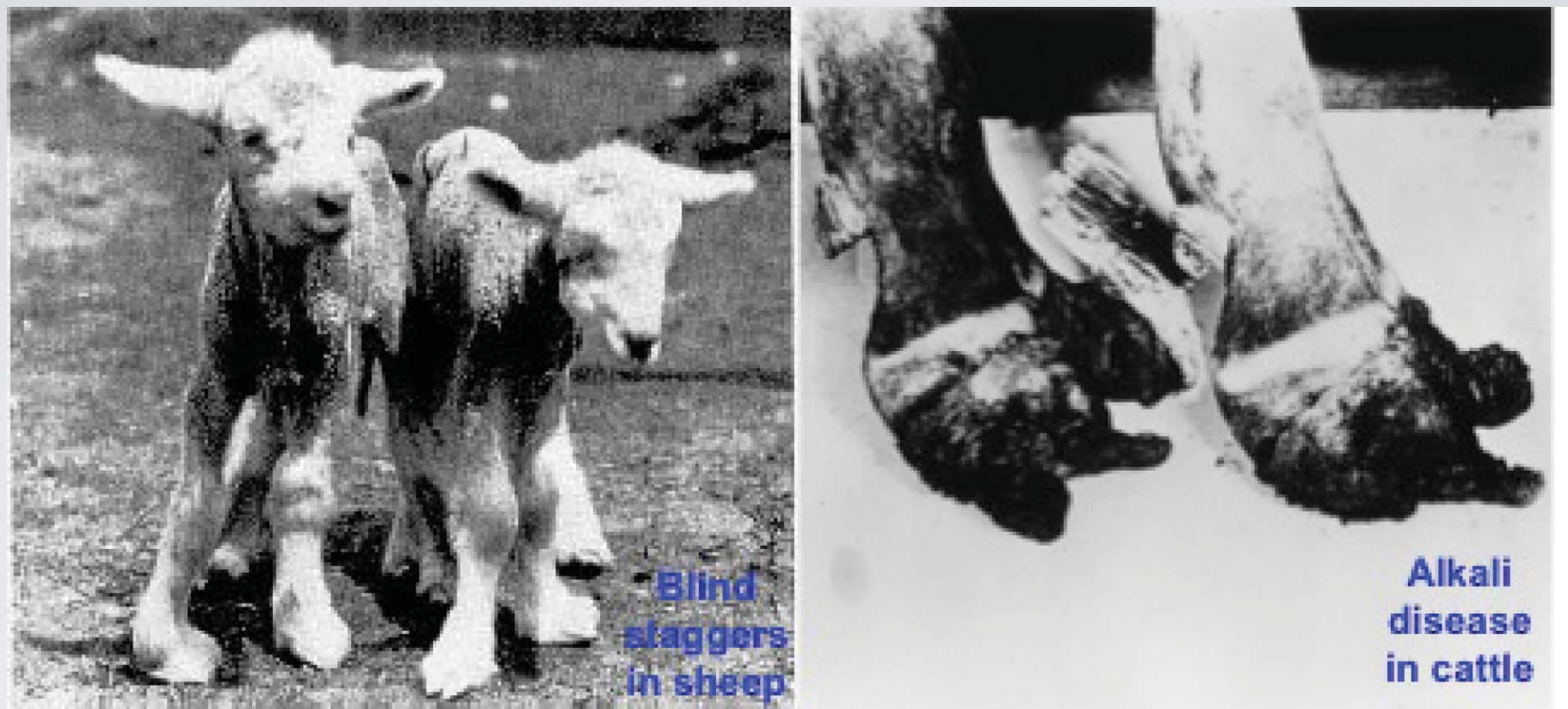


Figure 9. Common Se toxicity signs in animals.

Figure10. Blind staggers in sheep caused by acute selenium toxicity (<http://www.ansci.cornell.edu/plants/toxicagents/selenium.html>) (left) and Alkali disease in cattle (Oldfield, 2001) (right) caused by chronic Se toxicity. Note the severely damaged hoofs resulting from Se excess.

A MAJOR POLLUTANT GOES UNREGULATED

BY LLOYD G. CARTER
SATURDAY JUL 3RD, 2010 3:11 PM

Sibling embryos of the bird species Stilt collected from a single nest on the same day from a Tulare Basin evaporation pond in the Southern San Joaquin Valley in 2001. The overtly teratogenic embryo on the left, exhibiting stunted growth, no eyes, deformed bones (in the right foot) contained 72 parts per million selenium (dry weight, whole egg), while the overtly normal sibling, on the right, contained 16 parts per million selenium. Selenium triggered massive wildlife deformities in birds at the Kesterson National Wildlife Refuge in Merced County in the early 1980s. The deformities were caused by selenium in drainage water from the Westlands Water District moving up the food chain into the birds nesting at Kesterson. The federal government has never enforced international and federal bird protection laws in the Tulare Basin to halt the selenium poisoning.

Photo courtesy of U.S. Fish and Wildlife Service.



<http://www.indybay.org/newsitems/2010/07/03/18652583.php>



**WHITE MUSCLE
DISEASE**

**NORMAL
MUSCLE**

Source: <http://www.upei.ca/~morph/webct/Modules/Muscle/skeletal.html>



<http://medicalassessmentonline.com/terms.php?R=530&L=M>

THE SKY IS FALLING: STORMWATER AS A VECTOR FOR ENVIRONMENTAL ...

wordpress.vermontlaw.edu

An example of such 288 × 275 mining activities is West Virginia mountaintop mining where selenium-bearing overburden is exposed to weathering.

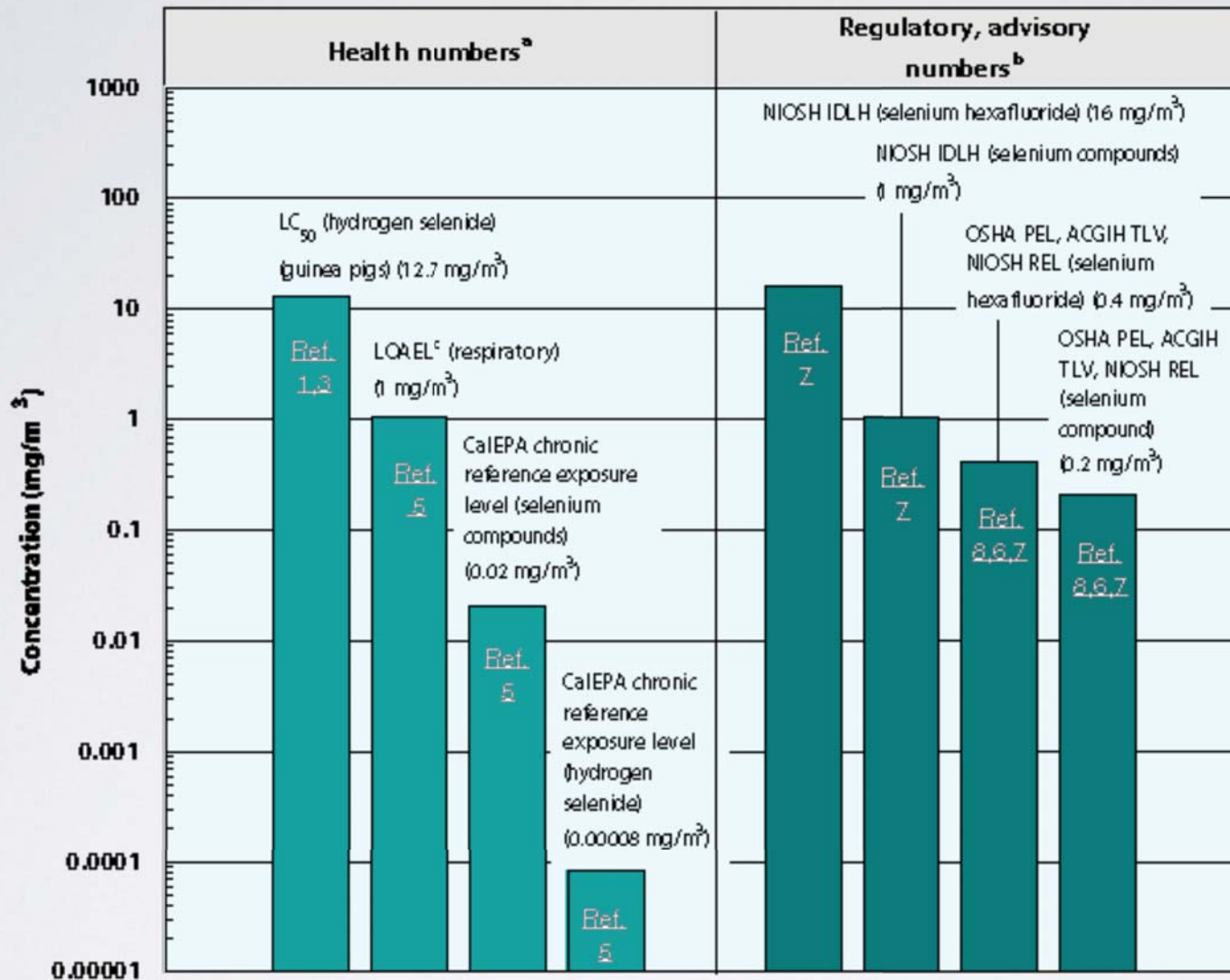


THE SKY IS FALLING: STORMWATER AS A VECTOR FOR ENVIRONMENTAL ...

wordpress.vermontlaw.edu



Selenium



Selenium Compounds | Technology Transfer Network Air Toxics Web ...

www.epa.gov

Arsenic poisoning

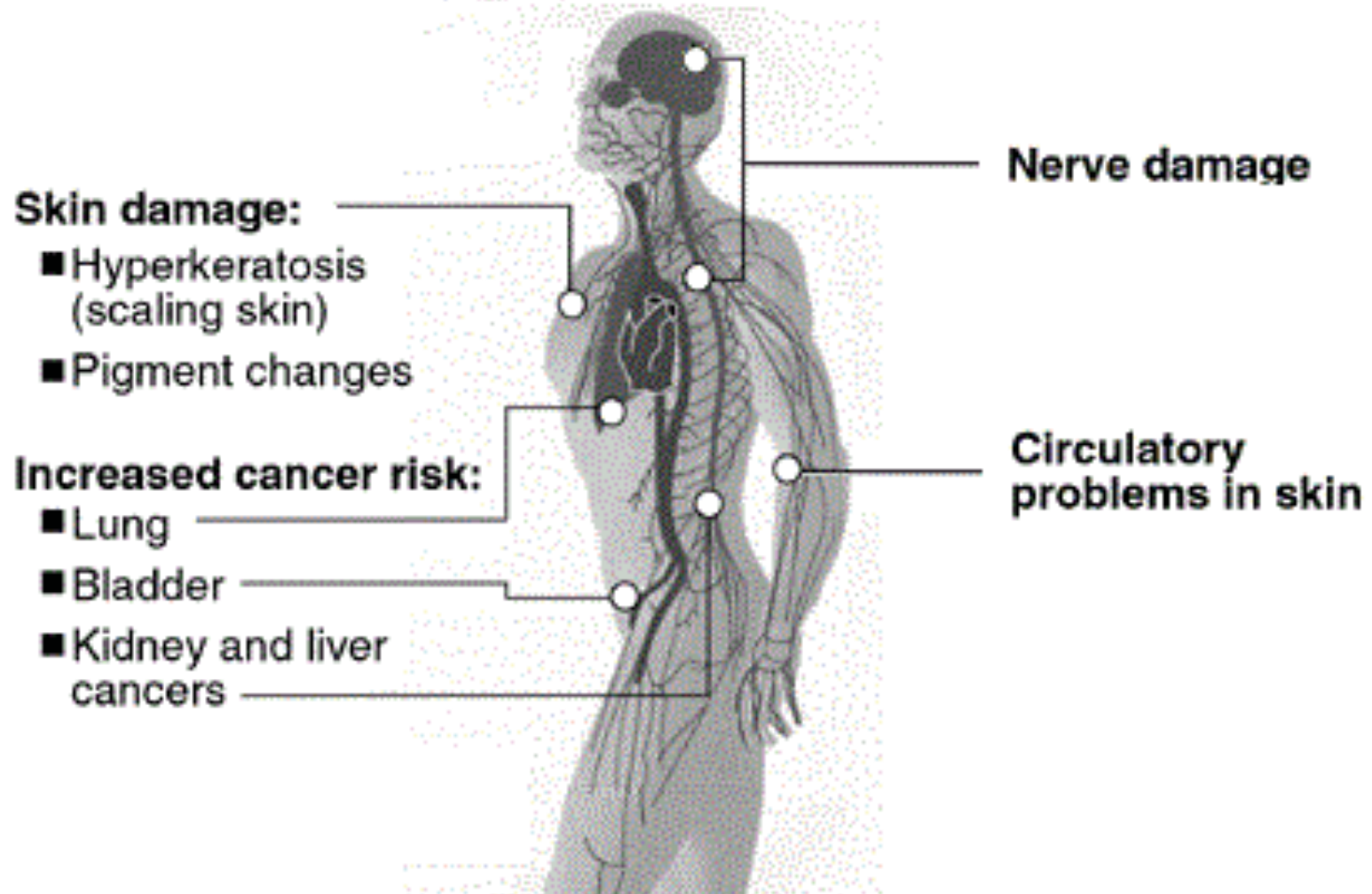
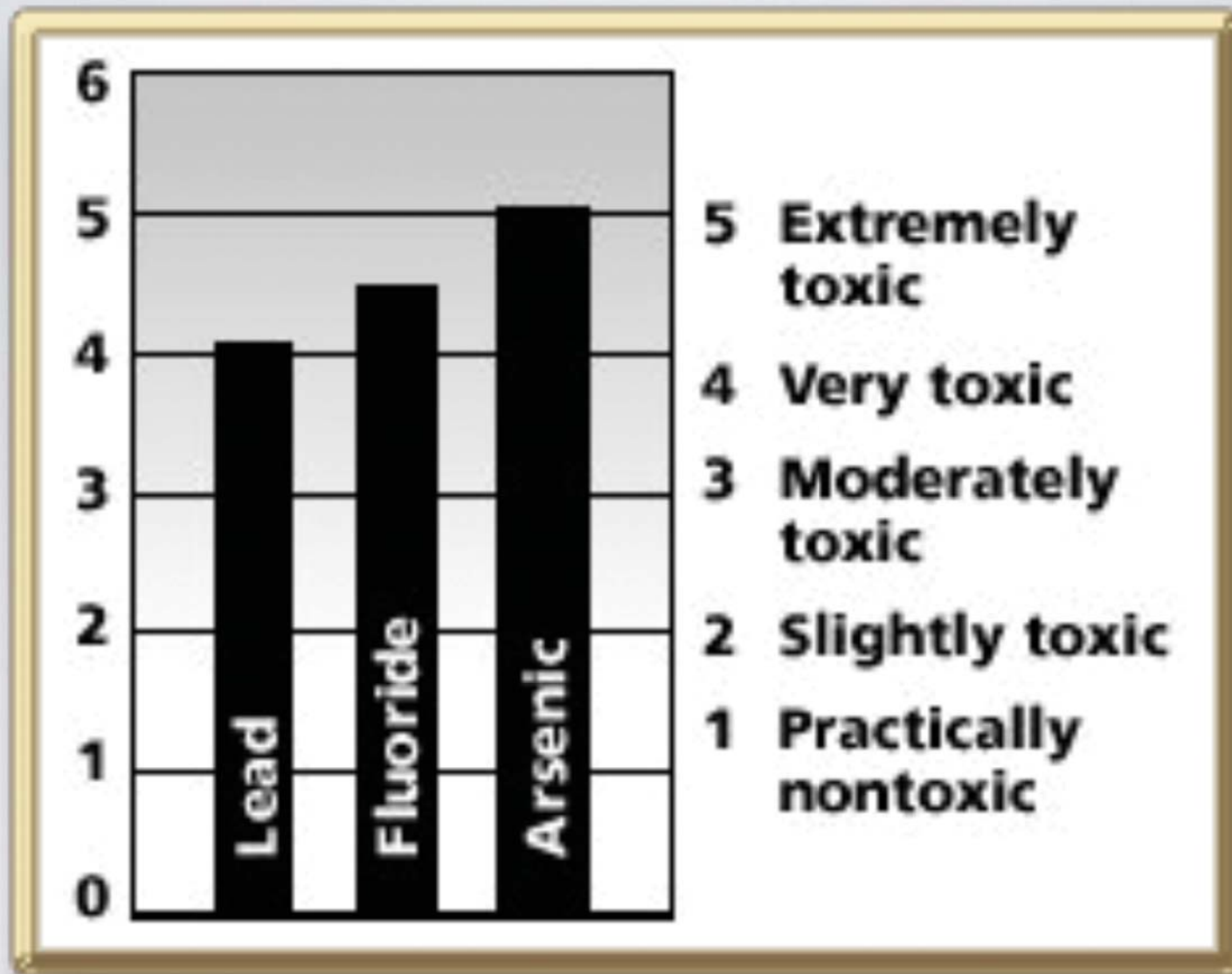


Table 2. Acute LD₅₀ values for some arsenic compounds (oral administration to mice and rats) (Data compiled from Kaise et al., 1992; Shiomi et al., 1994; Donohue et al., 1999).

Arsenic species	LD ₅₀ values (mg·kg ⁻¹)
As(III)	15-42
As(V)	20-800
TETRA	890
MA	700-1,800
DMA	1,200-2,600
AC	6,500
AB	>10,000

For explanation of the acronyms, see **table 1**.



<http://bestmeal.info/food/fluoridation.shtml>

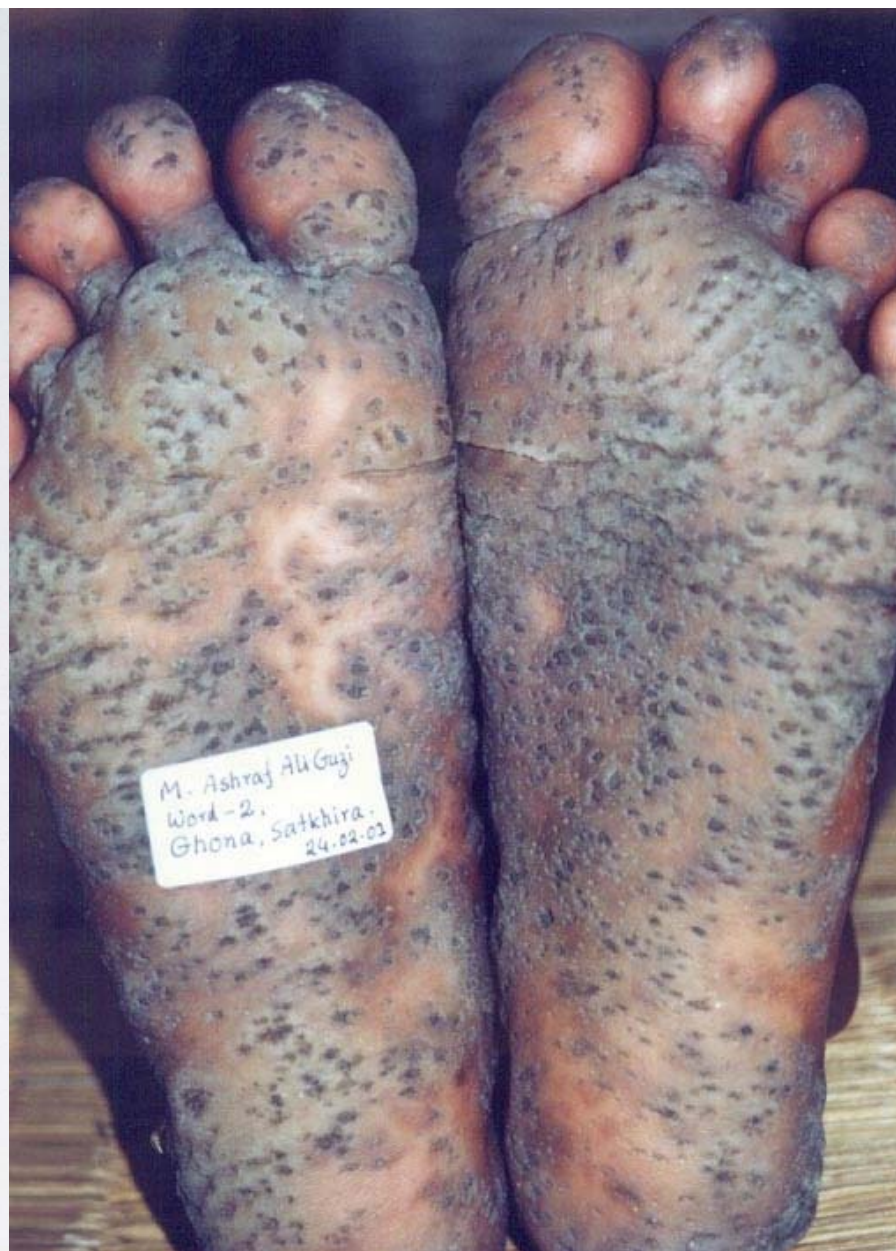
CHRONIC ARSENIC POISONING



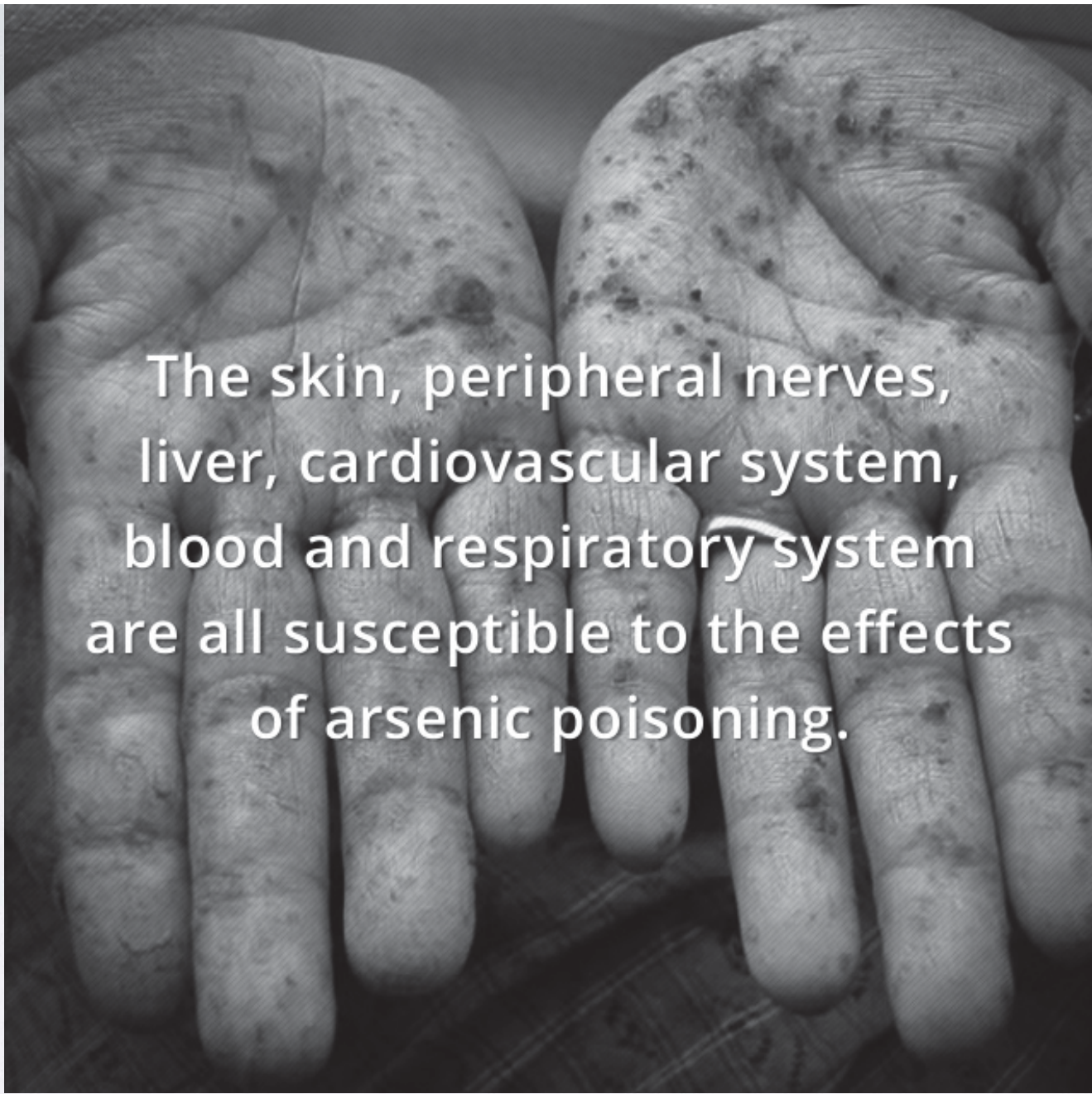
CHRONIC ARSENIC POISONING



<http://dermnetnz.org/reactions/arsenic.html>



<https://palashranjansanyal.wordpress.com/2014/06/23/groundwater-arsenic-poisoning-in-bangladesh-an-interview-with-dr-manzurul-hassan-re-blogged/>



The skin, peripheral nerves,
liver, cardiovascular system,
blood and respiratory system
are all susceptible to the effects
of arsenic poisoning.

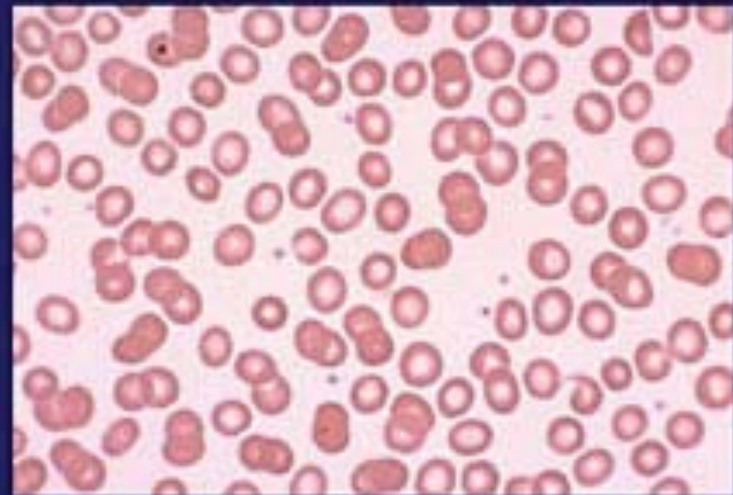
http://www.slideshare.net/jamie_dickinson/8/arsenic-poisoning-claims

Laboratory Findings

CBC: pancytopenia; basophilic stippling* may be seen on peripheral smear

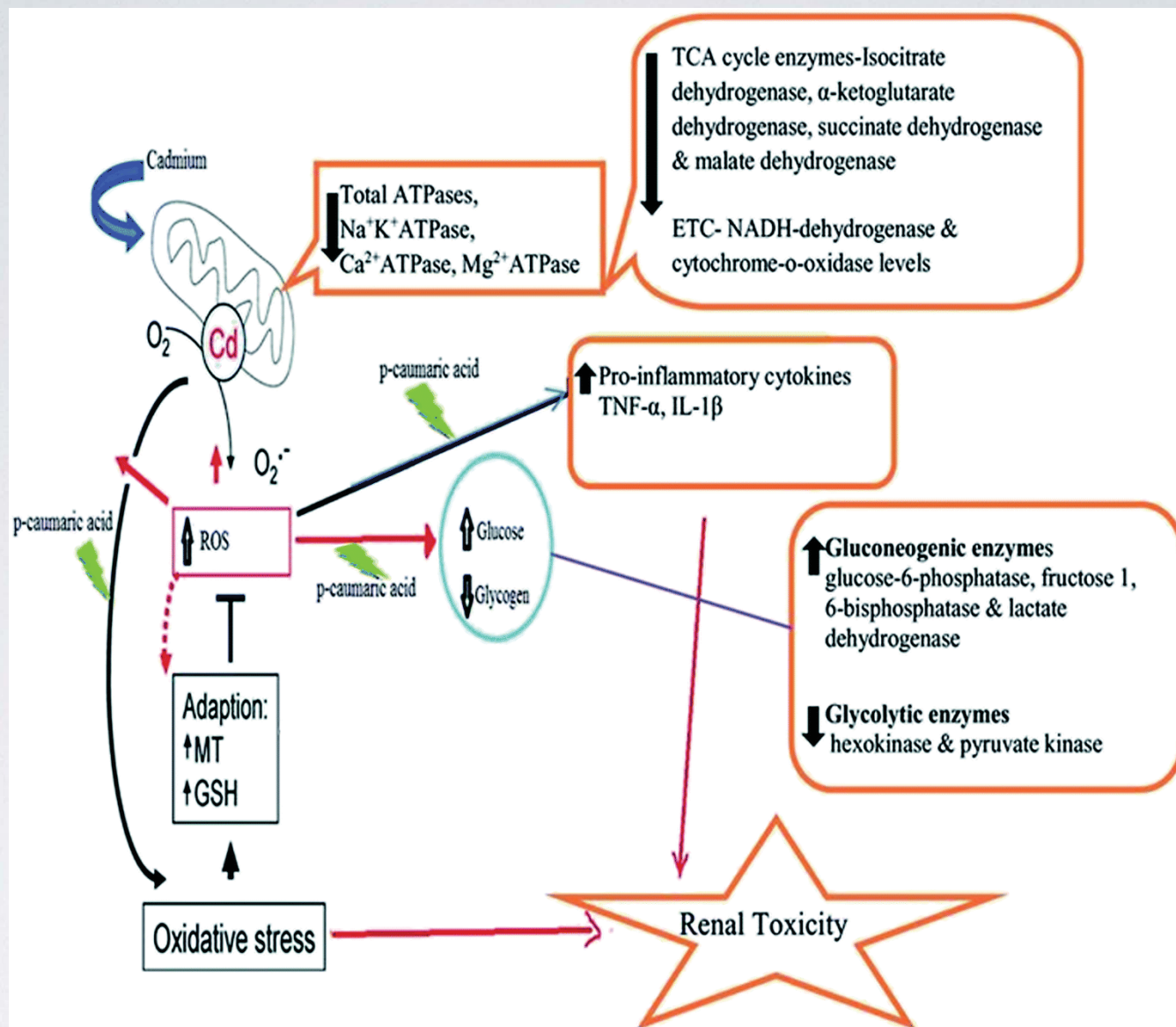


arsenic poisoning



normal red blood cells

*** Also seen in lead poisoning**



<http://what-when-how.com/mechanisms-of-cadmium-toxicity-to-various-trophic-saltwater-organisms/toxicity-of-waterborne-cadmium-to-saltwater-aquatic-organisms-part-1/>

Cadmium toxicity

Research has shown that cadmium affects the developing brain in children. Here are some other parts of the body it can effect.

RELATED HEALTH ISSUES

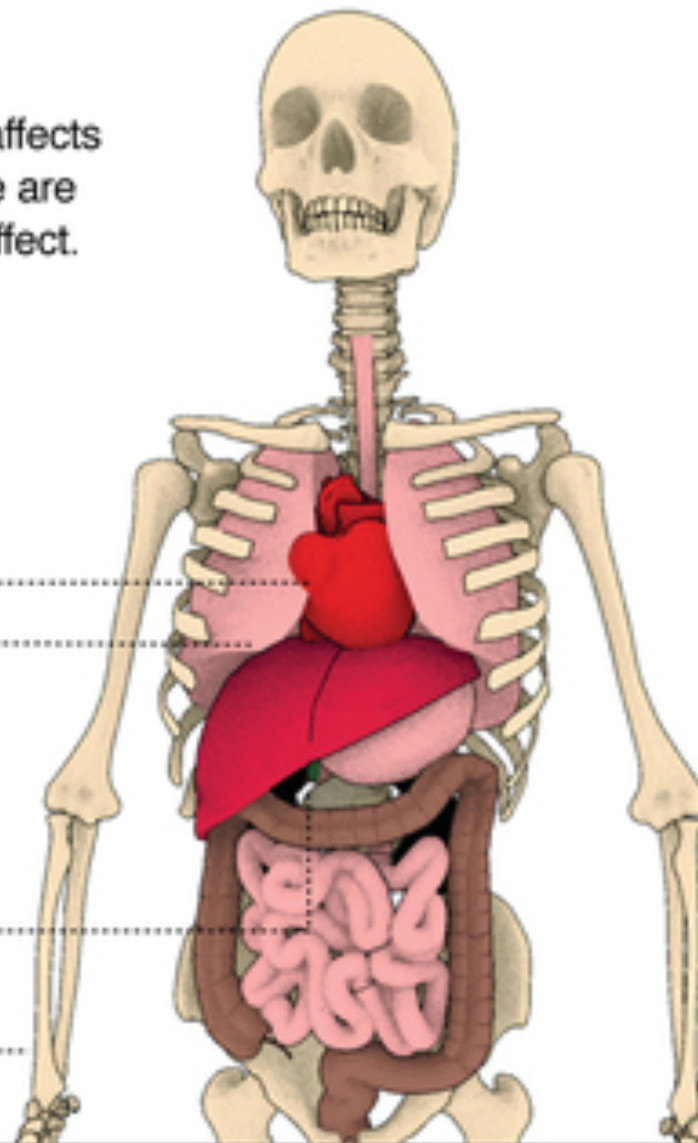
A recent study has linked it to breast cancer.

Cardiovascular disease

Obstructive pulmonary disease

The kidneys lose function, which can also cause gout, a form of arthritis.

Bones lose density and fracture.



SOURCES: Dr. Aimin Chen; Casarett & Doull's Toxicology, (Curtis D. Klaassen); Environmental Health Perspectives, Dec. 2009

AP

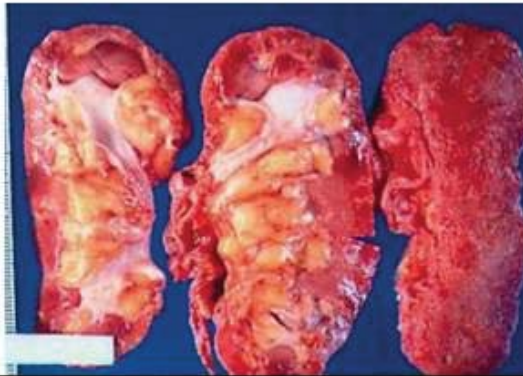
Adverse Health Effects

- Kidneys

- Accumulation of CdMT in the renal cortex can cause tubular dysfunction
- Further accumulation can cause renal failure

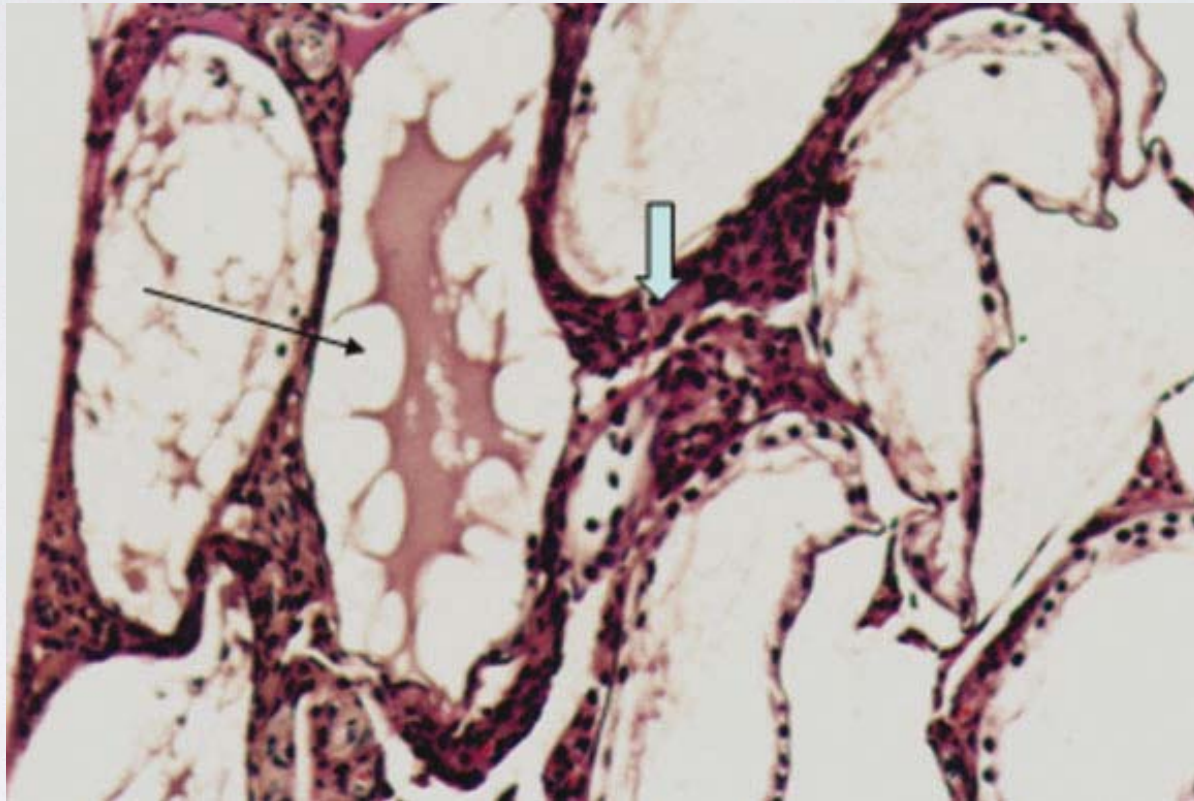
- Musculoskeletal System

- Direct Effects
- Indirect Effects



<https://www.youtube.com/watch?v=i949O7gQMww>

Testes of male albino rats intoxicated with cadmium chloride alone showing complete testicular necrosis and sloughing of all layers, Ischemic necrosis, ...,



http://www.scielo.cl/scielo.php?pid=S0717-95022009000300020&script=sci_arttext

Physiological effects of lead on adults and children

Effects on adults

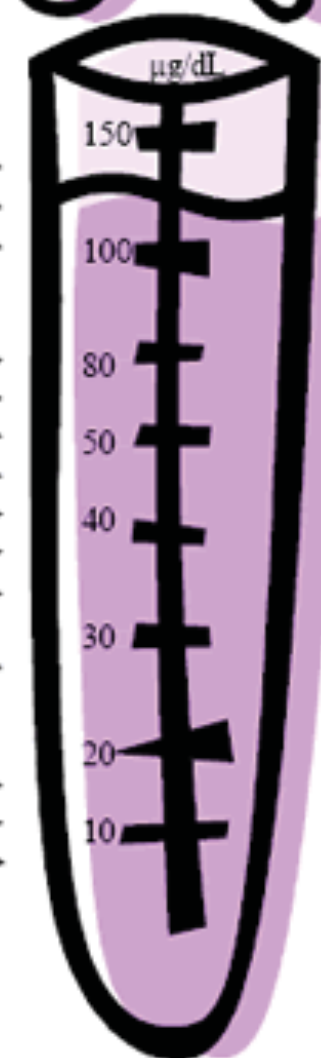
Brain disease
Anemia
Colic

Non-specific symptoms*
Memory impairment
Sperm abnormalities
Kidney disease
Possible gout
Spontaneous abortion
Possible non-specific symptoms*

Possible memory impairment

Reduced birth weight
Hypertension and kidney dysfunction
Possible postnatal developmental delay

**Non-specific symptoms may include headache, fatigue, sleep disturbance, anorexia, constipation, joint pain, muscle pain, and decreased libido.*



Effects on children

Death
Coma
Convulsions
Brain disease
Kidney disease
Frank anemia
Colic

Decreased capacity to transport oxygen
Increased risk of hypertension in adulthood

Body can't maintain adequate calcium levels

Developmental toxicity
Decreased IQ level
Decreased hearing
Decreased growth
Impaired nerve function
Trans-placental transfer

Adapted from: *J Clin. Invest.* 116:853-857 (2006)
Data also obtained from: *Environ Health Perspect* 115:463-471 (2007) and
www.atsdr.cdc.gov/csem/lead/pbphysiologic_effects2.html

Various gastrointestinal symptoms are associated with lead toxicity.
At low levels, lead may cause vague, nonspecific abdominal symptoms, ...

Table 1

BLL and Clinical Manifestations

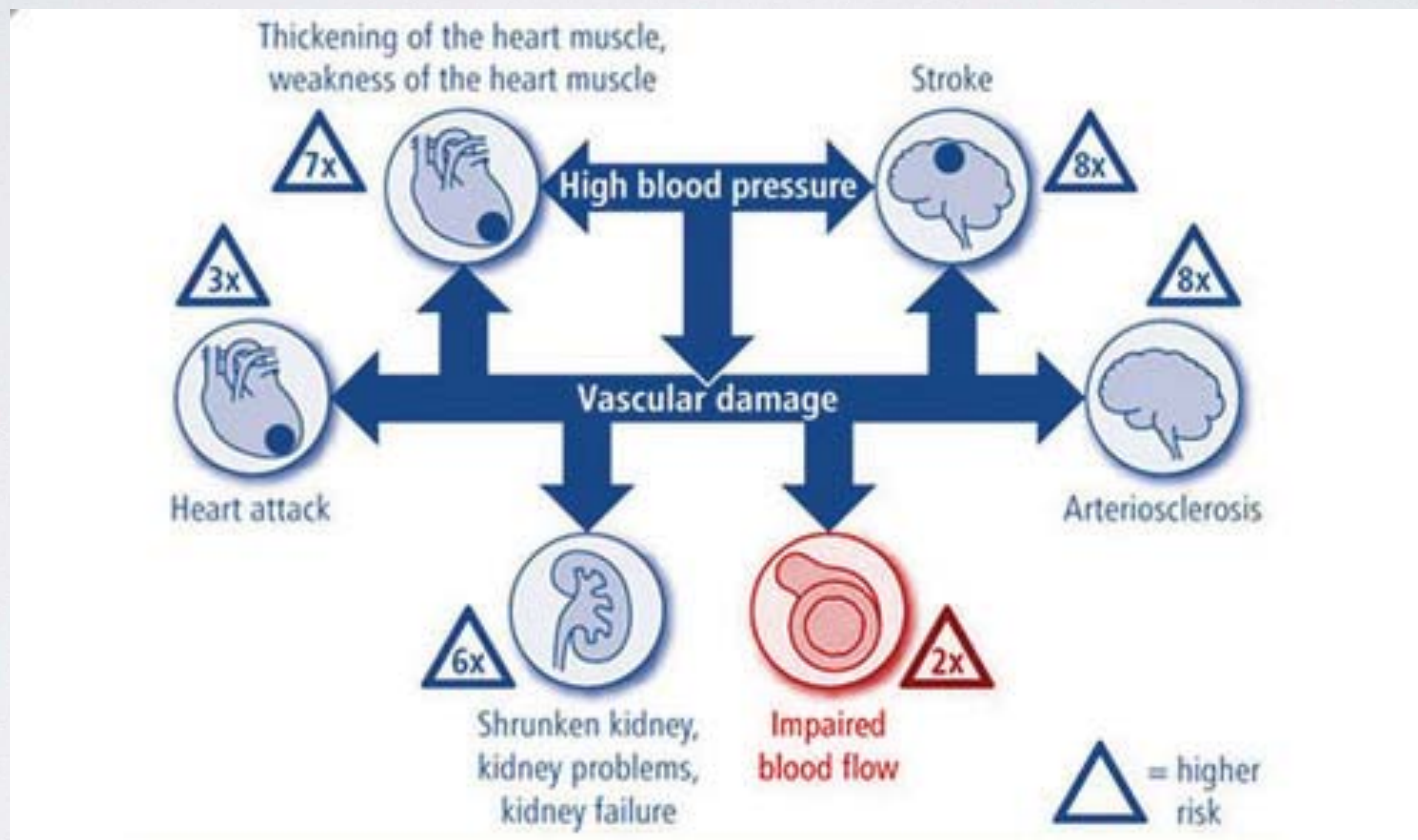
BLL	<10 mcg/dL in children <25 mcg/dL in adults	10-30 mcg/dL in children 25-50 mcg/dL in adults	>30 mcg/dL in children >50 mcg/dL in adults
Neurologic manifestations	Parasthesias, fatigue, irritability, personality changes, unusual tastes	Tremor, impaired concentration, short-term memory loss, incoordination	Encephalopathy, paralysis, somnolence, coma
Muscle/joint manifestations	Myalgia, arthritis	Muscle exhaustibility	Paralysis
Gastrointestinal manifestations	Abdominal discomfort	Vomiting, constipation, weight loss	Lead colic
Sexual manifestations	Decreased libido	Impotence	

*BLL: Blood lead level.
Source: references 16, 18, 31.*

http://www.uspharmacist.com/content/c/10189/?t=alzheimer's_and_dementia,neurology

Digication e-Portfolio :: Environmental History Journal :: The Effects of Lead Exposure on Human Health

Lead's impact on human health is of grave concern. It can also cause blindness and brain damage

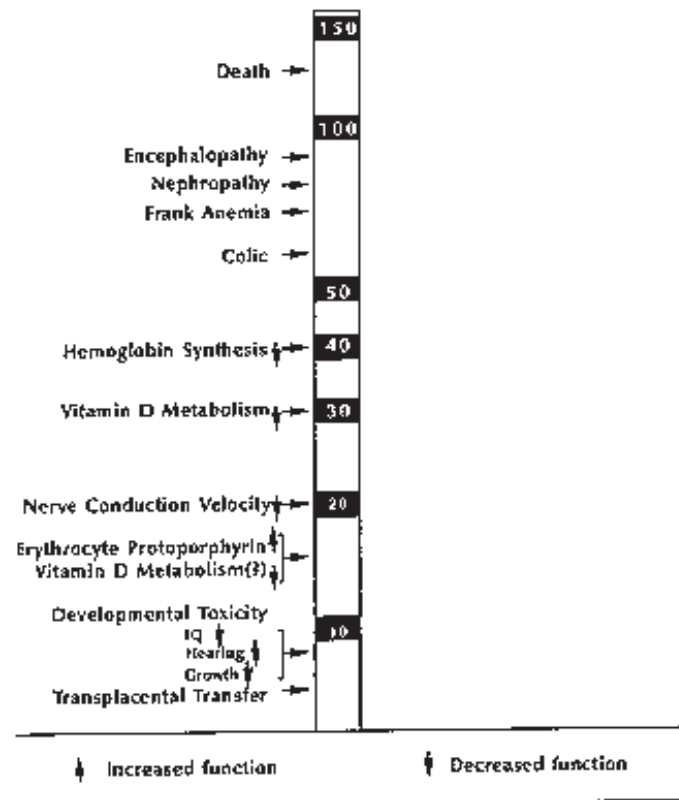


Preventing Lead Poisoning in Young Children

U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control

Publication date: 10/01/1991

Figure 2-1. Lowest observed effect levels of inorganic lead in children*



*Note: The levels in this diagram do not necessarily indicate the lowest levels at which lead exerts an effect. These are the levels at which studies have adequately demonstrated an effect.

Source: ATSDR, 1990.

Abnormal Development - Heavy Metals - Embryology

The industrialization of the modern world has led to the proliferation in our environment of many different metal compounds.

Some metals, such as zinc and iron are required in trace amounts for...

Classification of naturally occurring metals by toxicity and hydrologic availability

[Metals that normally do not exist as dissolved species in natural waters or are very rare in crustal rocks are in italics]

Non toxic		Low toxicity			Moderate to high toxicity		
Aluminum	Magnesium	Barium	<i>Praseodymium</i>	<i>Actinium</i>	Indium	Polonium	Uranium
Bismuth	Manganese	<i>Cerium</i>	<i>Promethium</i>	Antimony	<i>Iridium</i>	<i>Radium</i>	Vanadium
Calcium	Molybdenum	<i>Dysprosium</i>	<i>Rhenium</i>	Beryllium	Lead	<i>Ruthenium</i>	Zinc
Cesium	Potassium	<i>Erbium</i>	<i>Rhodium</i>	Boron	Mercury	Silver	<i>Zirconium</i>
Iron	Strontium	<i>Europium</i>	<i>Samarium</i>	Cadmium	Nickel	<i>Tantalum</i>	
Lithium	Rubidium	<i>Gadolinium</i>	Scandium	Chromium	<i>Niobium</i>	Thallium	
	Sodium	<i>Gallium</i>	<i>Terbium</i>	Cobalt	<i>Osmium</i>	Thorium	
		Germanium	Thulium	Copper	Palladium	<i>Titanium</i>	
		<i>Gold</i>	<i>Tin</i>	<i>Hafnium</i>	Platinum	<i>Tungsten</i>	
		<i>Holmium</i>	<i>Ytterbium</i>				
		<i>Neodymium</i>	<i>Yttrium</i>				

U.S. GEOLOGICAL SURVEY CIRCULAR 1133, 1995