The distribution of different elements in normal diet is given as follows (for a 70 Kg human):		
Na (5-10 gm)	K (3-4 gm)	Ca (0.8-1.0 gm)
P (0.8-1.0 gm)	Mg (0.3-0.4 gm)	Fe (10 mg for male, 15 mg for female)
Zn (15 mg)	Cu (2-3 mg)	Mn (3-5 mg)
I (150 µg)	Cr (50-150 µg)	F (1.5-3 mg)
Se (50-150 µg)	Co (3 µg, Vit. B_{12})	Mo (150-450 µg)

Effects of some elements on human health

Metal	Disease due to deficiency	Disease due to excessive accumulation
Na	Addison's disease; hyponatremia (reduced blood pressure)	hypernatremia (increase in blood pressure)
K	----------	Addison's disease, Cardiac failure
Ca	Abnormalities in bone nerve function	Cataracts, Stones in gall bladder and kidney
Fe	Anemia	Hemochromatosis, liver damage
Co	Pernicious anemia	Coronary failure
Cu	Anemia	Wilson's disease, liver damage
Zn	Dwarfism	Metal-fume fever due to inhaled Zn fume
Pb	Not known	Impaired kidney function
Hg	Not known	Minamata disease, Encephalitis
Cd	Not Known	Itai-itai disease

Addison’s disease or chronic adrenal insufficiency is a rare, chronic endocrine system (The endocrine system is the collection of glands, viz. pineal gland, pituitary gland, pancreas, etc., that produce hormones that regulate metabolism, growth and development, tissue function, reproduction, sleep, and mood, among other things.) disorder in which the adrenal glands do not produce sufficient steroid hormones.

The adrenal glands (also known as suprarenal glands) are endocrine glands that produce a variety of hormones including adrenaline and the steroids aldosterone and cortisol. They are found above the kidneys.

Addison’s disease is characterized by a number of relatively nonspecific symptoms, such as abdominal pain and weakness, but under certain circumstances, these may progress to Addisonian crisis, a severe illness which may include very low blood pressure and coma.

Addison's disease affects about 0.9 to 1.4 per 10,000 people in the developed world. Without treatment, an adrenal crisis can result in death.

Wilson's disease or hepatolenticular degeneration is an autosomal recessive genetic disorder. **Autosomal recessive** is one of several ways that a trait, disorder, or disease can be passed down through families.

An **autosomal recessive** disorder means two copies of an abnormal gene must be present in order for the disease or trait to develop.

Recessive is a quality found in the relationship between two versions of a gene. Individuals receive one version of a gene, called an allele, from each parent. If the alleles are different, the dominant allele will be expressed, while the effect of the other allele, called **recessive**, is masked.) in which copper accumulates in tissues; this manifests as neurological or psychiatric symptoms and liver damage. Medication reduces copper absorption or removes the excess copper from the body, but occasionally a liver transplant is required.

Pernicious anemia (also known as **vitamin B12 deficiency anemia**, **Biermer's anemia**, **Addison's anemia**, or **Addison–Biermer anemia**) is one of many types of the larger family of megaloblastic anemias. One way pernicious anemia can develop is by loss of gastric parietal cells, which are responsible, in part, for the secretion of intrinsic factor, a protein essential for subsequent absorption of vitamin B_{12} in the ileum.

Anemia, also spelled **anaemia**, is usually defined as a decrease in the amount of red blood cells (RBCs) or hemoglobin in the blood.[1][2] It can also be defined as a lowered ability of the blood to carry oxygen. When anemia comes on slowly the symptoms are often vague and may include: feeling tired, weakness, shortness of breath or a poor ability to exercise. Anemia that comes on quickly often has greater symptoms which may include: confusion, feeling like one is going to pass out, and increased thirst. Anemia must be significant before a person becomes noticeably pale.

Itai-itai disease ("it hurts-it hurts disease") was the name given to the mass cadmium poisoning of Toyama Prefecture, Japan, starting around 1912. The term "itai-itai disease" was coined by locals for the severe pains (**Japanese: itai**) people with the condition felt in the spine and joints. Cadmium poisoning can also cause softening of the bones and kidney failure.

One of the main effects of cadmium poisoning **is weak and brittle bones**. Spinal and leg pain is common, and a waddling gait often develops due to bone deformities caused by the cadmium. The pain eventually becomes debilitating, with fractures becoming more common as the bone weakens. Permanent deformation in bones can occur.

Other complications include coughing, anemia, and kidney failure, leading to death.

Minamata disease, sometimes referred to as **Chisso-Minamata disease**, is a neurological syndrome caused by severe **mercury** poisoning. Symptoms include **ataxia, numbness in the hands and feet, general muscle weakness, narrowing of the field of vision and damage to hearing and speech**. In extreme cases, insanity, paralysis, coma and death follow within weeks of the onset of symptoms. A congenital form of the disease can also affect foetuses.

Minamata disease was first discovered in Minamata City in Kumamoto prefecture, Japan in 1956. It was caused by the release of methylmercury in the industrial wastewater from the Chisso Corporation's chemical factory, which continued from 1932 to 1968. This highly toxic chemical bioaccumulated in shellfish and fish in Minamata Bay and the Shiranui Sea, which when eaten by the local populace resulted in mercury poisoning. While cat, dog, pig and human deaths continued over more than 30 years, the government and company did little to prevent the pollution.

Arsenic poisoning is a medical condition that occurs due to elevated levels of arsenic in the body.

If arsenic poisoning occurs over a brief period of time, symptoms may include **vomiting, abdominal pain, encephalopathy, and watery diarrhea that contains blood**. Long-term exposure can result in **thickening of the skin, darker skin, abdominal pain, diarrhea, heart disease, numbness, and cancer**.

The most common reason for long-term exposure is contaminated drinking water. Groundwater most often becomes contaminated naturally; however, contamination may also occur from mining or agriculture. Recommended levels in water are less than 10–50 µg/L (10–50 parts per billion).

Arsenic acts by changing the functioning of around 200 enzymes.

Hemochromatosis is a disorder where too much iron builds up in our body. Sometimes it's called "**iron overload**."

Normally, our intestines absorb just the right amount of iron from the foods we eat. But in hemochromatosis, our body absorbs too much, and it has no way to get rid of it. So, our body stores the excess iron in our joints and in organs like our liver, heart, and pancreas. This damages them. If it's not treated, hemochromatosis can make your organs stop working.

Metal fume fever (MFF) is a well-documented acute disease induced by intense inhalation of metal oxides. MFF is primarily associated with the inhalation of zinc oxide fumes that are produced when zinc-oxide coated steel (galvanized) or zinc containing alloys (eg, brass) is exposed to high temperatures. MFF is a self-limited syndrome characterized by fever, myalgias, headache, and nausea. Symptoms develop 4-12 hours after exposure and typically last several hours; severe cases generally resolve in 1-2 days

Removal of toxic metal ions by chelation therapy

The basic requirements of a chelating antidote in metal detoxification

- **Conditional stability constant**: bind the toxic metal sufficiently strongly to compete with the endogenous biological ligands such as proteins

- **Lipophilicity of the chelating drugs:** be sufficiently lipophilic (**Lipophilicity** refers to the ability of a chemical compound to dissolve in fats, oils, lipids, and non-polar solvents such as hexane or toluene.) to penetrate the lipid membranes to reach the body compartment where the toxic metal is accumulated.

- **HSAB (hard and soft acids and bases) theory and selection of chelating drugs:** The HSAB concept is an initialism for "hard and soft (Lewis) acids and bases". Also known as the Pearson acid base concept, HSAB is widely used in chemistry for explaining stability of compounds, reaction mechanisms and pathways.

It assigns the terms 'hard' or 'soft', and 'acid' or 'base' to chemical species. 'Hard' applies to species which are small, have high charge states (the charge criterion applies mainly to acids, to a lesser extent to bases), and are weakly polarizable. 'Soft' applies to species which are big, have low charge states and are strongly polarizable. The concept is a way of applying the notion of orbital overlap to specific chemical cases.

The gist of this theory is that soft acids react faster and form stronger bonds with soft bases, whereas hard acids react faster and form stronger bonds with hard bases, all other factors being equal. The classification in the original work was mostly based on equilibrium constants for reaction of two Lewis bases competing for a Lewis acid.

Hard acids and hard bases tend to have the following characteristics:

- small atomic/ionic radius
- high oxidation state
- low polarizability
- high electronegativity (bases)
- hard bases have highest-occupied molecular orbitals (HOMO) of low energy, and hard acids have lowest-unoccupied molecular orbitals (LUMO) of high energy.

Examples of hard acids are: H^+, light alkali ions (Li through K all have small ionic radius), Ti^{4+}, Cr^{3+}, Cr^{6+}, BF_3.
(Smaller ions from Gr. 1, 2 and the left hand side of the transition metals, particularly when in high O.S. and these form the most stable complexes with N and O donors.)
Examples of hard bases are: OH^-, F^-, Cl^-, NH_3, H_2O, CH_3COO^-, CO_3^{2-}. The affinity of hard acids and hard bases for each other is mainly ionic in nature.

Soft acids and **soft bases** tend to have the following characteristics:

- large atomic/ionic radius
- low or zero oxidation state bonding
- high polarizability
- low electronegativity
- soft bases have HOMO of higher energy than hard bases, and soft acids have LUMO of lower energy than hard acids. (However the soft-base HOMO energies are still lower than the soft-acid LUMO energies.)

Examples of soft acids are: CH_3Hg^+, Pt^{2+}, Pd^{2+}, Cu^+, Ag^+, Au^+, Hg^{2+}, Hg_2^{2+}, BH_3.

(These include ions from R.H.S. of the transition series, and also transition metal complexes with low O.S. These form the most stable complexes with ligands such as I^-, SCN^-, CN^-)

Examples of soft bases are: $H^–$, R_3P, $SCN^–$, $I^–$. The affinity of soft acids and bases for each other is mainly covalent in nature.

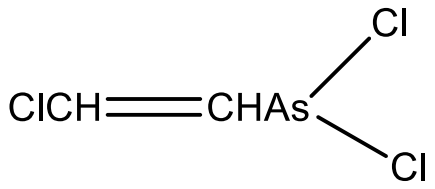
According to this theory, to remove a hard toxic metal ion, a chelating drug with hard donor sites is preferred, and to detoxify a soft metal, the chelating drug should have the soft binding sites.

- **Designing of antidotes with the binding sites mimicking the endogeneous binding sites:** The binding sites of the chelaing drugs should be similar to endogeneous binding sites

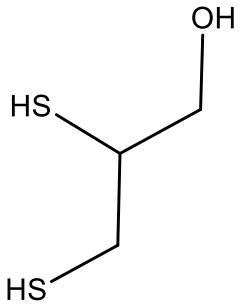
- **Toxic effect of the chelating drug:** The administered should not be toxic and must have higher LD_{50} value

- **Urinary and bilary excretion**: To remove the toxic metal from an interior compartment, the drug must form a lipophilic complex in the body compartment, and then it must change to a hydrophilic complex (Having an affinity for water; readily absorbing or dissolving in water.) upon reacting with the blood plasma so that elimination of metal complex is possible through urinary excretion rather than its redistribution back in the tissues.

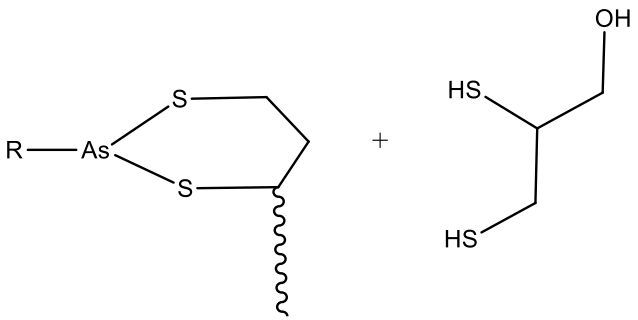
2,3-dimarcapto-1-propanol (**British anti-Lewisite or British antilewisite** (abbreviated BAL): The drug was developed by the British scientist Sir Rudolph Peters during the Second World War to treat the patients affected by the poison gas Lewisite. Lewisite can block the –SH groups of different enzymes to cause the toxicity but BAL can remove the enzyme bound As-compound to restore the activity of the enzymes, and As-BAL complex is excreted through urine. The detoxification process is presented as:



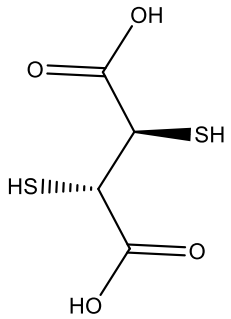
Dichloro(2-chlorovinyl)arsine
(**Lewisite**)



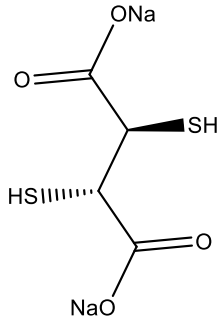
2,3-dimarcapto-1-propanol



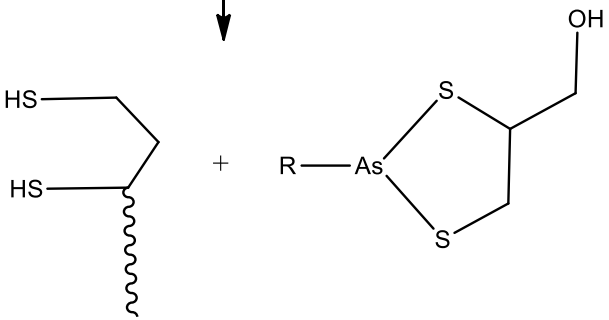
Lewisite Enzyme complex



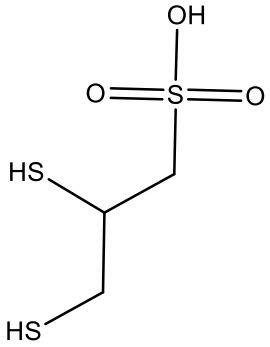
Meso-2,3-Dimarcaptosuccinic acid



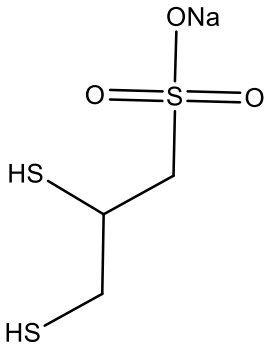
Sodium meso-2,3-dimercaptosuccinate



Free-enzyme active



2,3-Dimarcapto 1-propane-sulfonic acid



Sodium 2,3-dimercaptopropane-1-sulfonate

For Cu- poisoning (Wilson's disease), BAL can show its antidotal activity (remedy). In fact BAL is recommended for the treatment of poisoning by different heavy metals like Hg, Au, Tl, Bi. But in detoxification of methyl mercury, the neutral chelate $(CH_3Hg)_2$ $BALH_2$ formed can pass through the biological membrane to enhance the toxicity by its redistribution. BAL is found to increase the toxicity of Cd and Pb in experimental animals:

$$2CH_3Hg^+ + BAL \rightarrow (CH_3Hg)_2 + BALH_2 + 2H^+$$