[Template:About](/wiki/Template:About" \o "Template:About) [Template:Pp-move-indef](/wiki/Template:Pp-move-indef) [Template:Use mdy dates](/wiki/Template:Use_mdy_dates) [Template:Infobox zinc](/wiki/Template:Infobox_zinc)

**Zinc** is a [chemical element](/wiki/Chemical_element) with symbol **Zn** and atomic number 30. It is the first element in [group 12](/wiki/Group_12_element) of the [periodic table](/wiki/Periodic_table). In some respects zinc is chemically similar to [magnesium](/wiki/Magnesium): the [ion](/wiki/Ion) is of similar size and the only common [oxidation state](/wiki/Oxidation_state) is +2. Zinc is the 24th most abundant [element in Earth's crust](/wiki/Abundance_of_elements_in_Earth's_crust) and has five stable [isotopes](/wiki/Isotope). The most common zinc [ore](/wiki/Ore) is [sphalerite](/wiki/Sphalerite) (zinc blende), a [zinc sulfide](/wiki/Zinc_sulfide) mineral. The largest workable lodes are in Australia, Asia, and the United States. Zinc is refining by [froth flotation](/wiki/Froth_flotation) of the [ore](/wiki/Ore), [roasting](/wiki/Roasting_(metallurgy)), and final [extraction](/wiki/Extractive_metallurgy) using [electricity](/wiki/Electricity) ([electrowinning](/wiki/Electrowinning)).

[Brass](/wiki/Brass), an [alloy](/wiki/Alloy) of [copper](/wiki/Copper) and zinc in various proportions, was used as early as the third millennium BC in the [Aegean](/wiki/Aegean_Sea), [Iraq](/wiki/Iraq), the [United Arab Emirates](/wiki/United_Arab_Emirates), [Kalmykia](/wiki/Kalmykia), [Turkmenistan](/wiki/Turkmenistan) and [Georgia](/wiki/Georgia_(country)), and the second millennium BC in [West India](/wiki/West_India), [Uzbekistan](/wiki/Uzbekistan), [Iran](/wiki/Iran), [Syria](/wiki/Syria), Iraq, and [Israel](/wiki/Israel)[[1]](#cite_note-1) ([Judea](/wiki/Judea)[[2]](#cite_note-2)).<ref name=jas5/> Zinc [metal](/wiki/Metal) was not produced on a large scale until the 12th century in India and was unknown to Europe until the end of the 16th century. The mines of [Rajasthan](/wiki/Rajasthan) have given definite evidence of zinc production going back to the 6th century BC.[[3]](#cite_note-3) To date, the oldest evidence of pure zinc comes from Zawar, in Rajasthan, as early as the 9th century AD when a distillation process was employed to make pure zinc.[[4]](#cite_note-4) [Alchemists](/wiki/Alchemy) burned zinc in air to form what they called "[philosopher's wool](/wiki/Philosopher's_wool)" or "white snow".

The element was probably named by the alchemist [Paracelsus](/wiki/Paracelsus) after the German word *Zinke* (prong, tooth). German chemist [Andreas Sigismund Marggraf](/wiki/Andreas_Sigismund_Marggraf) is credited with discovering pure metallic zinc in 1746. Work by [Luigi Galvani](/wiki/Luigi_Galvani) and [Alessandro Volta](/wiki/Alessandro_Volta) uncovered the electrochemical properties of zinc by 1800. [Corrosion](/wiki/Corrosion)-resistant [zinc plating](/wiki/Galvanization) of iron ([hot-dip galvanizing](/wiki/Hot-dip_galvanizing)) is the major application for zinc. Other applications are in electrical [batteries](/wiki/Zinc–carbon_battery), small non-structural castings, and alloys such as [brass](/wiki/Brass). A variety of zinc compounds are commonly used, such as [zinc carbonate](/wiki/Zinc_carbonate) and [zinc gluconate](/wiki/Zinc_gluconate) (as dietary supplements), [zinc chloride](/wiki/Zinc_chloride) (in deodorants), [zinc pyrithione](/wiki/Zinc_pyrithione) (anti-[dandruff](/wiki/Dandruff) shampoos), [zinc sulfide](/wiki/Zinc_sulfide) (in luminescent paints), and zinc methyl or [zinc diethyl](/wiki/Zinc_diethyl) in the organic laboratory.

Zinc is an [essential mineral](/wiki/Micronutrient) perceived by the public today as being of "exceptional biologic and public health importance", especially regarding prenatal and postnatal development.<ref name=Hambridge2007>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> [Zinc deficiency](/wiki/Zinc_deficiency) affects about two billion people in the developing world and is associated with many diseases.<ref name=Prasad2003/> In children, deficiency causes growth retardation, delayed sexual maturation, infection susceptibility, and [diarrhea](/wiki/Diarrhea).<ref name=Hambridge2007/> [Enzymes](/wiki/Enzyme) with a zinc atom in the [reactive center](/wiki/Prosthetic_groups) are widespread in biochemistry, such as [alcohol dehydrogenase](/wiki/Alcohol_dehydrogenase) in humans.[[5]](#cite_note-5) Consumption of excess zinc can cause [ataxia](/wiki/Ataxia), [lethargy](/wiki/Lethargy) and [copper deficiency](/wiki/Copper_deficiency).

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## Characteristics[[edit](/index.php?title=(none)&action=edit&section=1)]

### Physical properties[[edit](/index.php?title=(none)&action=edit&section=2)]

Zinc is a bluish-white, lustrous, [diamagnetic](/wiki/Diamagnetic) metal,[[6]](#cite_note-6) though most common commercial grades of the metal have a dull finish.[[7]](#cite_note-7) It is somewhat less dense than [iron](/wiki/Iron) and has a hexagonal [crystal structure](/wiki/Crystal_structure), with a distorted form of [hexagonal close packing](/wiki/Close-packing_of_equal_spheres), in which each atom has six nearest neighbors (at 265.9 pm) in its own plane and six others at a greater distance of 290.6 pm.[[8]](#cite_note-8) The metal is hard and brittle at most temperatures but becomes malleable between 100 and 150 °C.[[6]](#cite_note-6)[[7]](#cite_note-7) Above 210 °C, the metal becomes brittle again and can be pulverized by beating.[[9]](#cite_note-9) Zinc is a fair [conductor of electricity](/wiki/Electrical_conductivity).[[6]](#cite_note-6) For a metal, zinc has relatively low melting (419.5 °C) and boiling points (907 °C).[[10]](#cite_note-10) The melting point is the lowest of all the [transition metals](/wiki/Transition_metal) aside from [mercury](/wiki/Mercury_(element)) and [cadmium](/wiki/Cadmium).<ref name=ZincMetalProps/>

Many [alloys](/wiki/Alloy) contain zinc, including brass. Other metals long known to form binary alloys with zinc are [aluminium](/wiki/Aluminium), [antimony](/wiki/Antimony), [bismuth](/wiki/Bismuth), [gold](/wiki/Gold), [iron](/wiki/Iron), [lead](/wiki/Lead), [mercury](/wiki/Mercury_(element)), [silver](/wiki/Silver), [tin](/wiki/Tin), [magnesium](/wiki/Magnesium), [cobalt](/wiki/Cobalt), [nickel](/wiki/Nickel), [tellurium](/wiki/Tellurium) and [sodium](/wiki/Sodium).[[11]](#cite_note-11) Although neither zinc nor [zirconium](/wiki/Zirconium) are [ferromagnetic](/wiki/Ferromagnetism), their alloy [Template:Chem](/wiki/Template:Chem) exhibits ferromagnetism below 35 [K](/wiki/Kelvin).[[6]](#cite_note-6) A bar of zinc generates a characteristic sound when bent, similar to [tin cry](/wiki/Tin_cry).

### Occurrence[[edit](/index.php?title=(none)&action=edit&section=3)]

[Template:See also](/wiki/Template:See_also) Zinc makes up about 75 [ppm](/wiki/Parts_per_million) (0.0075%) of [Earth's crust](/wiki/Earth's_crust), making it the 24th most abundant element. Soil contains zinc in 5–770 ppm with an average 64 ppm. [Seawater](/wiki/Seawater) has only 30 [ppb](/wiki/Parts_per_billion) and the atmosphere, 0.1–4 µg/m3.[[12]](#cite_note-12) [thumb|left|upright|](/wiki/File:Sphalerite4.jpg)[Sphalerite](/wiki/Sphalerite) (ZnS)|alt=A black shiny lump of solid with uneven surface The element is normally found in association with other [base metals](/wiki/Base_metal) such as [copper](/wiki/Copper) and [lead](/wiki/Lead) in [ores](/wiki/Ore).[[13]](#cite_note-13) Zinc is a [chalcophile](/wiki/Goldschmidt_classification#Chalcophile_elements), meaning the element has a low affinity for [oxides](/wiki/Oxide) and prefers to bond with [sulfides](/wiki/Sulfide). Chalcophiles formed as the crust solidified under the [reducing](/wiki/Redox) conditions of the early Earth's atmosphere.[[14]](#cite_note-14) [Sphalerite](/wiki/Sphalerite), which is a form of zinc sulfide, is the most heavily mined zinc-containing ore because its concentrate contains 60–62% zinc.[[13]](#cite_note-13) Other source minerals for zinc include [smithsonite](/wiki/Smithsonite) (zinc [carbonate](/wiki/Carbonate)), [hemimorphite](/wiki/Hemimorphite) (zinc [silicate](/wiki/Silicate)), [wurtzite](/wiki/Wurtzite) (another zinc sulfide), and sometimes [hydrozincite](/wiki/Hydrozincite) (basic [zinc carbonate](/wiki/Zinc_carbonate)).[[15]](#cite_note-15) With the exception of wurtzite, all these other minerals were formed by weathering of the primordial zinc sulfides.[[14]](#cite_note-14) Identified world zinc resources total about 1.9 billion [tonnes](/wiki/Tonne).<ref name=USGSMCS2015>[Template:Cite web](/wiki/Template:Cite_web)</ref> Large deposits are in Australia, Canada and the United States, with the largest reserves in [Iran](/wiki/Iran).[[14]](#cite_note-14)[[16]](#cite_note-16)[[17]](#cite_note-17) At the current rate of consumption, one source has estimated those reserves could be depleted between 2027 and 2055.[[18]](#cite_note-18)[[19]](#cite_note-19) About 346 million tonnes have been extracted throughout history to 2002, and scholars for the National Academy of Sciences estimate that about 109 million tonnes are in use.[[20]](#cite_note-20)

### Isotopes[[edit](/index.php?title=(none)&action=edit&section=4)]

[Template:Main article](/wiki/Template:Main_article) Five [isotopes](/wiki/Isotope) of zinc occur in nature. 64Zn is the most abundant isotope (48.63% [natural abundance](/wiki/Natural_abundance)).[[21]](#cite_note-21) That isotope has such a long [half-life](/wiki/Half-life), at [Template:Val](/wiki/Template:Val),[[22]](#cite_note-22) that its radioactivity can be ignored.[[23]](#cite_note-23) Similarly, [Template:Chem](/wiki/Template:Chem) (0.6%), with a half-life of [Template:Val](/wiki/Template:Val) is not usually considered to be radioactive. The other isotopes found in nature are [Template:Chem](/wiki/Template:Chem) (28%), [Template:Chem](/wiki/Template:Chem) (4%) and [Template:Chem](/wiki/Template:Chem) (19%).

Several dozen [radioisotopes](/wiki/Radioisotope) have been characterized. [Template:Chem](/wiki/Template:Chem), which has a half-life of 243.66 days, is the least active radioisotope, followed by [Template:Chem](/wiki/Template:Chem) with a half-life of 46.5 hours.[[21]](#cite_note-21) Zinc has 10 [nuclear isomers](/wiki/Nuclear_isomer). 69mZn has the longest half-life, 13.76 h.[[21]](#cite_note-21) The superscript *m* indicates a [metastable](/wiki/Metastable) isotope. The nucleus of a metastable isotope is in an [excited state](/wiki/Excited_state) and will return to the [ground state](/wiki/Ground_state) by emitting a [photon](/wiki/Photon) in the form of a [gamma ray](/wiki/Gamma_ray). [Template:Chem](/wiki/Template:Chem) has three excited states and [Template:Chem](/wiki/Template:Chem) has two.[[24]](#cite_note-24) The isotopes [Template:Chem](/wiki/Template:Chem), [Template:Chem](/wiki/Template:Chem), [Template:Chem](/wiki/Template:Chem) and [Template:Chem](/wiki/Template:Chem) each have only one excited state.[[21]](#cite_note-21) The most common [decay mode](/wiki/Decay_mode) of a [radioisotope](/wiki/Radioisotope) of zinc with a [mass number](/wiki/Mass_number) lower than 66 is [electron capture](/wiki/Electron_capture). The [decay product](/wiki/Decay_product) resulting from electron capture is an isotope of copper.[[21]](#cite_note-21)

[Template:Nuclide](/wiki/Template:Nuclide) + [Template:SubatomicParticle](/wiki/Template:SubatomicParticle) → [Template:Nuclide](/wiki/Template:Nuclide)

The most common decay mode of a radioisotope of zinc with mass number higher than 66 is [beta decay](/wiki/Beta_decay) (β−), which produces an isotope of [gallium](/wiki/Gallium).[[21]](#cite_note-21):[Template:Nuclide](/wiki/Template:Nuclide) → [Template:Nuclide](/wiki/Template:Nuclide) + [Template:SubatomicParticle](/wiki/Template:SubatomicParticle) + [Template:SubatomicParticle](/wiki/Template:SubatomicParticle)

## Compounds and chemistry[[edit](/index.php?title=(none)&action=edit&section=5)]

[Template:Main article](/wiki/Template:Main_article)

### Reactivity[[edit](/index.php?title=(none)&action=edit&section=6)]

[Template:See also](/wiki/Template:See_also) Zinc has an [electron configuration](/wiki/Electron_configuration) of [Ar]3d104s2 and is a member of the [group 12](/wiki/Group_12_element) of the [periodic table](/wiki/Periodic_table). It is a moderately reactive metal and strong [reducing agent](/wiki/Reducing_agent).<ref name=CRC2006p8-29>[Template:Harvnb](/wiki/Template:Harvnb)</ref> The surface of the pure metal [tarnishes](/wiki/Tarnish) quickly, eventually forming a protective [passivating](/wiki/Passivation_(chemistry)) layer of the basic [zinc carbonate](/wiki/Hydrozincite), [Template:Chem](/wiki/Template:Chem), by reaction with atmospheric [carbon dioxide](/wiki/Carbon_dioxide).[[25]](#cite_note-25) This layer helps prevent further reaction with air and water.

Zinc burns in air with a bright bluish-green flame, giving off fumes of [zinc oxide](/wiki/Zinc_oxide).[[26]](#cite_note-26) Zinc reacts readily with [acids](/wiki/Acid), [alkalis](/wiki/Alkali) and other non-metals.[[27]](#cite_note-27) Extremely pure zinc reacts only slowly at room temperature with acids.[[26]](#cite_note-26) Strong acids, such as [hydrochloric](/wiki/Hydrochloric_acid) or [sulfuric acid](/wiki/Sulfuric_acid), can remove the passivating layer and subsequent reaction with water releases hydrogen gas.[[26]](#cite_note-26) The chemistry of zinc is dominated by the +2 oxidation state. When compounds in this oxidation state are formed, the outer [shell](/wiki/Electron_shell) *s* electrons are lost, yielding a bare zinc ion with the electronic configuration [Ar]3d10.[[28]](#cite_note-28) In aqueous solution an octahedral complex, [Template:Chem](/wiki/Template:Chem) is the predominant species.[[29]](#cite_note-29) The [volatilization](/wiki/Volatilization) of zinc in combination with zinc chloride at temperatures above 285 °C indicates the formation of [Template:Chem](/wiki/Template:Chem), a zinc compound with a +1 oxidation state.[[26]](#cite_note-26) No compounds of zinc in oxidation states other than +1 or +2 are known.[[30]](#cite_note-30) Calculations indicate that a zinc compound with the oxidation state of +4 is unlikely to exist.[[31]](#cite_note-31) Zinc chemistry is similar to the chemistry of the late first-row transition metals, [nickel](/wiki/Nickel) and copper, though it has a filled d-shell and compounds are [diamagnetic](/wiki/Diamagnetic) and mostly colorless.[[32]](#cite_note-32) The [ionic radii](/wiki/Ionic_radii) of zinc and magnesium happen to be nearly identical. Because of this some, of the equivalent salts have the same [crystal structure](/wiki/Crystal_structure),[[33]](#cite_note-33) and in other circumstances where ionic radius is a determining factor, the chemistry of zinc has much in common with that of magnesium.[[26]](#cite_note-26) In other respects, there is little similarity with the late first-row transition metals. Zinc tends to form bonds with a greater degree of [covalency](/wiki/Covalency) and much more stable [complexes](/wiki/Complex_(chemistry)) with [N](/wiki/Nitrogen)- and [S](/wiki/Sulfur)- donors.[[32]](#cite_note-32) Complexes of zinc are mostly 4- or 6- [coordinate](/wiki/Coordinate_covalent_bond) although 5-coordinate complexes are known.[[26]](#cite_note-26)

### Zinc(I) compounds[[edit](/index.php?title=(none)&action=edit&section=7)]

Zinc(I) compounds are rare and require bulky ligands to stabilize the low oxidation state. Most zinc(I) compounds contain formally the [Zn2]2+ core, which is analogous to the [Hg2]2+ dimeric cation present in [mercury](/wiki/Mercury_(element))(I) compounds. The [diamagnetic](/wiki/Diamagnetism) nature of the ion confirms its dimeric structure. The first zinc(I) compound containing the Zn—Zn bond, [(η5-C5Me5)2Zn2](/wiki/Decamethyldizincocene), is also the first [dimetallocene](/wiki/Metallocene). The [Zn2]2+ ion rapidly [disproportionates](/wiki/Disproportionation) into zinc metal and zinc(II), and has been obtained only a yellow glass only by cooling a solution of metallic zinc in molten ZnCl2.[[34]](#cite_note-34)

### Zinc (II) compounds[[edit](/index.php?title=(none)&action=edit&section=8)]

[thumb|upright|left|Zinc acetate|alt=Sheets of zinc acetate formed by slow evaporation](/wiki/File:Zinc_acetate.JPG) [thumb|upright|Zinc chloride|alt=White lumped powder on a glass plate](/wiki/File:Zinc_chloride.jpg) [Binary compounds](/wiki/Binary_compound) of zinc are known for most of the [metalloids](/wiki/Metalloid) and all the [nonmetals](/wiki/Nonmetal) except the [noble gases](/wiki/Noble_gas). The oxide [ZnO](/wiki/Zinc_oxide) is a white powder that is nearly insoluble in neutral aqueous solutions, but is [amphoteric](/wiki/Amphoteric), dissolving in both strong basic and acidic solutions.[[26]](#cite_note-26) The other [chalcogenides](/wiki/Chalcogen) ([ZnS](/wiki/Zinc_sulfide), [ZnSe](/wiki/Zinc_selenide), and [ZnTe](/wiki/Zinc_telluride)) have varied applications in electronics and optics.[[35]](#cite_note-35) [Pnictogenides](/wiki/Pnictogenide) ([Template:Chem](/wiki/Template:Chem), [Template:Chem](/wiki/Template:Chem), [Template:Chem](/wiki/Template:Chem) and [Template:Chem](/wiki/Template:Chem)),[[36]](#cite_note-36)[[37]](#cite_note-37) the peroxide ([Template:Chem](/wiki/Template:Chem)), the hydride ([Template:Chem](/wiki/Template:Chem)), and the carbide ([Template:Chem](/wiki/Template:Chem)) are also known.[[38]](#cite_note-38) Of the four [halides](/wiki/Halide), [Template:Chem](/wiki/Template:Chem) has the most ionic character, while the others ([Template:Chem](/wiki/Template:Chem), [Template:Chem](/wiki/Template:Chem), and [Template:Chem](/wiki/Template:Chem)) have relatively low melting points and are considered to have more covalent character.[[39]](#cite_note-39) In weak basic solutions containing [Template:Chem](/wiki/Template:Chem) ions, the hydroxide [Template:Chem](/wiki/Template:Chem) forms as a white [precipitate](/wiki/Precipitate). In stronger alkaline solutions, this hydroxide is dissolved to form zincates ([Template:Chem](/wiki/Template:Chem)).[[26]](#cite_note-26) The nitrate [Template:Chem](/wiki/Template:Chem), chlorate [Template:Chem](/wiki/Template:Chem), sulfate [Template:Chem](/wiki/Template:Chem), phosphate [Template:Chem](/wiki/Template:Chem), molybdate [Template:Chem](/wiki/Template:Chem), cyanide [Template:Chem](/wiki/Template:Chem), arsenite [Template:Chem](/wiki/Template:Chem), arsenate [Template:Chem](/wiki/Template:Chem) and the chromate [Template:Chem](/wiki/Template:Chem) (one of the few colored zinc compounds) are a few examples of other common inorganic compounds of zinc.[[40]](#cite_note-40)[[41]](#cite_note-41) One of the simplest examples of an [organic compound](/wiki/Organic_compound) of zinc is the acetate ([Template:Chem](/wiki/Template:Chem)).

[Organozinc compounds](/wiki/Organozinc_compound) are those that contain zinc–carbon covalent bonds. Diethylzinc ([Template:Chem](/wiki/Template:Chem)) is a reagent in synthetic chemistry. It was first reported in 1848 from the reaction of zinc and [ethyl iodide](/wiki/Ethyl_iodide), and was the first compound known to contain a metal–carbon [sigma bond](/wiki/Sigma_bond).[[42]](#cite_note-42) **Tests for Zinc**

Cobalticyanide paper (Rinnmann's test for Zn) can be used as a chemical indicator for zinc. 4g of K3Co(CN)6 and 1g of KClO3 is dissolved on 100ml of water. Paper is dipped in the solution and dried at 100\*C. One drop of the sample is dropped onto the dry paper and heated. A green disc indicates the presence of zinc.[[43]](#cite_note-43) [Template:Clear](/wiki/Template:Clear)

## History[[edit](/index.php?title=(none)&action=edit&section=9)]

### Ancient use[[edit](/index.php?title=(none)&action=edit&section=10)]

[upright|thumb|Late Roman brass bucket – the](/wiki/File:Hemmoorer_Eimer.jpg) [Hemmoorer](/wiki/Hemmoor) Eimer from Warstade, Germany, second to third century AD|alt=Large black bowl-shaped bucket on a stand. The bucket has incrustation around its top. Various isolated examples of the use of impure zinc in ancient times have been discovered. Zinc ores were used to make the zinc–copper alloy [brass](/wiki/Brass) thousands of years prior to the discovery of zinc as a separate element. Judean brass from the 14th to 10th centuries BC contains 23% zinc.[[2]](#cite_note-2) Knowledge of how to produce brass spread to [Ancient Greece](/wiki/Ancient_Greece) by the 7th century BC, but few varieties were made.<ref name=jas5>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> Ornaments made of [alloys](/wiki/Alloy) containing 80–90% zinc, with lead, iron, [antimony](/wiki/Antimony), and other metals making up the remainder, have been found that are 2,500 years old.[[13]](#cite_note-13) A possibly prehistoric statuette containing 87.5% zinc was found in a [Dacian](/wiki/Dacia) archaeological site.[[44]](#cite_note-44) The oldest known pills were made of the zinc carbonates hydrozincite and smithsonite. The pills were used for sore eyes and were found aboard the Roman ship [Relitto del Pozzino](/wiki/Relitto_del_Pozzino), wrecked in 140 BC.[[45]](#cite_note-45)[[46]](#cite_note-46) The manufacture of brass was known to the [Romans](/wiki/Ancient_Rome) by about 30 BC.[[47]](#cite_note-47) They made brass by heating powdered [calamine](/wiki/Calamine_(mineral)) (zinc [silicate](/wiki/Silicate) or carbonate), charcoal and copper together in a crucible.[[47]](#cite_note-47) The resulting [calamine brass](/wiki/Calamine_brass) was then either cast or hammered into shape for use in weaponry.[[48]](#cite_note-48) Some coins struck by Romans in the Christian era are made of what is probably calamine brass.[[49]](#cite_note-49) [Strabo](/wiki/Strabo) writing in the 1st century BC (but quoting a now lost work of the 4th century BC historian [Theopompus](/wiki/Theopompus)) mentions "drops of false silver" which when mixed with copper make brass. This may refer to small quantities of zinc that is a by-product of smelting [sulfide](/wiki/Sulfide) ores.[[50]](#cite_note-50) Zinc in such remnants in smelting ovens was usually discarded as it was thought to be worthless.[[51]](#cite_note-51) The [Berne zinc tablet](/wiki/Berne_zinc_tablet) is a votive plaque dating to [Roman Gaul](/wiki/Roman_Gaul) made of an alloy that is mostly zinc.[[52]](#cite_note-52) The [Charaka Samhita](/wiki/Charaka_Samhita), thought to have been written between 300 and 500 AD,[[53]](#cite_note-53) mentions a metal which, when oxidized, produces *pushpanjan*, thought to be zinc oxide.[[54]](#cite_note-54) Zinc mines at Zawar, near [Udaipur](/wiki/Udaipur) in India, have been active since the [Mauryan period](/wiki/Mauryan_period). The smelting of metallic zinc here, however, appears to have begun around the 12th century AD.<ref name=ammraja>p. 46, Ancient mining and metallurgy in Rajasthan, S. M. Gandhi, chapter 2 in *Crustal Evolution and Metallogeny in the Northwestern Indian Shield: A Festschrift for Asoke Mookherjee*, M. Deb, ed., Alpha Science Int'l Ltd., 2000, ISBN 1-84265-001-7.</ref>[[55]](#cite_note-55) One estimate is that this location produced an estimated million tonnes of metallic zinc and zinc oxide from the 12th to 16th centuries.[[15]](#cite_note-15) Another estimate gives a total production of 60,000 tonnes of metallic zinc over this period.[[56]](#cite_note-56) The [Rasaratna Samuccaya](/wiki/Rasaratna_Samuccaya), written in approximately the 13th century AD, mentions two types of zinc-containing ores: one used for metal extraction and another used for medicinal purposes.[[55]](#cite_note-55)

### Early studies and naming[[edit](/index.php?title=(none)&action=edit&section=11)]

Zinc was distinctly recognized as a metal under the designation of *Yasada* or Jasada in the medical Lexicon ascribed to the Hindu king [Madanapala](/wiki/Madanapala) and written about the year 1374.[[57]](#cite_note-57) Smelting and extraction of impure zinc by reducing calamine with wool and other organic substances was accomplished in the 13th century in India.[[6]](#cite_note-6)[[58]](#cite_note-58) The Chinese did not learn of the technique until the 17th century.[[58]](#cite_note-58) [thumb|left|Various](/wiki/File:Zinc-alchemy_symbols.png) [alchemical](/wiki/Alchemy) symbols for the element zinc [Alchemists](/wiki/Alchemy) burned zinc metal in air and collected the resulting zinc oxide on a [condenser](/wiki/Condenser_(heat_transfer)). Some alchemists called this zinc oxide *lana philosophica*, Latin for "philosopher's wool", because it collected in wooly tufts, whereas others thought it looked like white snow and named it *nix album*.[[59]](#cite_note-59) The name of the metal was probably first documented by [Paracelsus](/wiki/Paracelsus), a Swiss-born German alchemist, who referred to the metal as "zincum" or "zinken" in his book *Liber Mineralium II*, in the 16th century.[[58]](#cite_note-58)[[60]](#cite_note-60) The word is probably derived from the German [Template:Lang](/wiki/Template:Lang), and supposedly meant "tooth-like, pointed or jagged" (metallic zinc crystals have a needle-like appearance).[[61]](#cite_note-61) *Zink* could also imply "tin-like" because of its relation to German *zinn* meaning tin.[[62]](#cite_note-62) Yet another possibility is that the word is derived from the [Persian](/wiki/Persian_language) word [Template:Lang](/wiki/Template:Lang) *seng* meaning stone.[[63]](#cite_note-63) The metal was also called Indian tin, tutanego, calamine, and spinter.[[13]](#cite_note-13) German metallurgist [Andreas Libavius](/wiki/Andreas_Libavius) received a quantity of what he called "calay" of Malabar from a cargo ship captured from the Portuguese in 1596.[[64]](#cite_note-64) Libavius described the properties of the sample, which may have been zinc. Zinc was regularly imported to Europe from the Orient in the 17th and early 18th centuries,[[58]](#cite_note-58) but was at times very expensive.<ref group=note>An [East India Company](/wiki/East_India_Company) ship carrying a cargo of nearly pure zinc metal from the Orient sank off the coast [Sweden](/wiki/Sweden) in 1745.[Template:Harv](/wiki/Template:Harv)</ref>

### Isolation[[edit](/index.php?title=(none)&action=edit&section=12)]

[thumb|upright|](/wiki/File:Andreas_Sigismund_Marggraf-flip.jpg)[Andreas Sigismund Marggraf](/wiki/Andreas_Sigismund_Marggraf) is given credit for first isolating pure zinc|alt=Picture of an old man head (profile). The man has a long face, short hair and tall forehead. Metallic zinc was isolated in India by 1300 AD,[[65]](#cite_note-65)[[66]](#cite_note-66)[[67]](#cite_note-67) much earlier than in the West. Before it was isolated in Europe, it was imported from India in about 1600 CE.<ref name=zinc-eng/> [Postlewayt's](/wiki/Postlewayt) *Universal Dictionary*, a contemporary source giving technological information in Europe, did not mention zinc before 1751 but the element was studied before then.[[55]](#cite_note-55)[[68]](#cite_note-68) Flemish [metallurgist](/wiki/Metallurgist) and [alchemist](/wiki/Alchemist) [P. M. de Respour](/wiki/P._M._de_Respour) reported that he had extracted metallic zinc from zinc oxide in 1668.[[15]](#cite_note-15) By the start of the 18th century, [Étienne François Geoffroy](/wiki/Étienne_François_Geoffroy) described how zinc oxide condenses as yellow crystals on bars of iron placed above zinc ore that is being smelted.[[15]](#cite_note-15) In Britain, [John Lane](/wiki/John_Lane_(metallurgist)) is said to have carried out experiments to smelt zinc, probably at [Landore](/wiki/Landore), prior to his bankruptcy in 1726.[[69]](#cite_note-69) In 1738 in Great Britain, [William Champion](/wiki/William_Champion_(metallurgist)) patented a process to extract zinc from calamine in a vertical [retort](/wiki/Retort) style smelter.[[70]](#cite_note-70) His technique resembled that used at Zawar zinc mines in [Rajasthan](/wiki/Rajasthan), but no evidence suggests he visited the Orient.<ref name=zinc-eng>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> Champion's process was used through 1851.[[58]](#cite_note-58) German chemist [Andreas Marggraf](/wiki/Andreas_Sigismund_Marggraf) normally gets credit for discovering pure metallic zinc, even though Swedish chemist Anton von Swab had distilled zinc from calamine four years previously.[[58]](#cite_note-58) In his 1746 experiment, Marggraf heated a mixture of calamine and charcoal in a closed vessel without copper to obtain a metal.[[51]](#cite_note-51) This procedure became commercially practical by 1752.[[71]](#cite_note-71)

### Later work[[edit](/index.php?title=(none)&action=edit&section=13)]

[thumb|upright|left|](/wiki/File:Luigi_Galvani,_oil-painting.jpg)[Galvanization](/wiki/Galvanization) was named after [Luigi Galvani](/wiki/Luigi_Galvani).|alt=Painting of a middle-aged man sitting by the table, wearing a wig, black jacket, white shirt and white scarf. William Champion's brother, John, patented a process in 1758 for [calcining](/wiki/Calcining) zinc sulfide into an oxide usable in the retort process.[[13]](#cite_note-13) Prior to this, only calamine could be used to produce zinc. In 1798, [Johann Christian Ruberg](/wiki/Johann_Christian_Ruberg) improved on the smelting process by building the first horizontal retort smelter.[[72]](#cite_note-72) [Jean-Jacques Daniel Dony](/wiki/Jean-Jacques_Daniel_Dony) built a different kind of horizontal zinc smelter in Belgium that processed even more zinc.[[58]](#cite_note-58)Italian doctor [Luigi Galvani](/wiki/Luigi_Galvani) discovered in 1780 that connecting the [spinal cord](/wiki/Spinal_cord) of a freshly dissected frog to an iron rail attached by a brass hook caused the frog's leg to twitch.[[73]](#cite_note-73) He incorrectly thought he had discovered an ability of nerves and muscles to create [electricity](/wiki/Electricity) and called the effect "[animal electricity](/wiki/Bioelectricity)".<ref name=IntEncyl>[Template:Cite book](/wiki/Template:Cite_book)</ref> The galvanic cell and the process of galvanization were both named for Luigi Galvani, and his discoveries paved the way for [electrical batteries](/wiki/Battery_(electricity)), galvanization, and [cathodic protection](/wiki/Cathodic_protection).<ref name=IntEncyl/>

Galvani's friend, [Alessandro Volta](/wiki/Alessandro_Volta), continued researching the effect and invented the [Voltaic pile](/wiki/Voltaic_pile) in 1800.[[73]](#cite_note-73) The basic unit of Volta's pile was a simplified [galvanic cell](/wiki/Galvanic_cell), made of plates of copper and zinc separated by an [electrolyte](/wiki/Electrolyte) and connected by a conductor externally. The units were stacked in series to make the Voltaic cell, which produced electricity by directing [electrons](/wiki/Electron) from the zinc to the copper and allowing the zinc to corrode.[[73]](#cite_note-73) The non-magnetic character of zinc and its lack of color in solution delayed discovery of its importance to biochemistry and nutrition.<ref name=Cotton1999p626/> This changed in 1940 when [carbonic anhydrase](/wiki/Carbonic_anhydrase), an enzyme that scrubs carbon dioxide from blood, was shown to have zinc in its [active site](/wiki/Active_site).<ref name=Cotton1999p626/> The digestive enzyme [carboxypeptidase](/wiki/Carboxypeptidase) became the second known zinc-containing enzyme in 1955.<ref name=Cotton1999p626>[Template:Harvnb](/wiki/Template:Harvnb)</ref>

[Template:Clear](/wiki/Template:Clear)

## Production[[edit](/index.php?title=(none)&action=edit&section=14)]

### Mining and processing[[edit](/index.php?title=(none)&action=edit&section=15)]

|  |  |  |
| --- | --- | --- |
| Top zinc output countries 2014<ref name=USGSMCS2015/> | | |
| [**Rank**](/wiki/Ranking) | [**Country**](/wiki/Country) | [**Tonnes**](/wiki/Tonne) |
| **1** | [Template:Flagicon](/wiki/Template:Flagicon) [**China**](/wiki/China) | **5,000,000** |
| **2** | [Template:Flagicon](/wiki/Template:Flagicon) [**Australia**](/wiki/Australia) | **1,500,000** |
| **3** | [Template:Flagicon](/wiki/Template:Flagicon) [**Peru**](/wiki/Peru) | **1,300,000** |
| **4** | [Template:Flagicon](/wiki/Template:Flagicon) [**India**](/wiki/India) | **820,000** |
| **5** | [Template:Flagicon](/wiki/Template:Flagicon) [**United States**](/wiki/United_States) | **700,000** |
| **6** | [Template:Flagicon](/wiki/Template:Flagicon) [**Mexico**](/wiki/Mexico) | **700,000** |

[Template:Main article](/wiki/Template:Main_article) [Template:See also](/wiki/Template:See_also) [thumb|350px|Percentage of zinc output in 2006 by countries](/wiki/File:World_Zinc_Production_2006.svg)[[74]](#cite_note-74)|alt=World map revealing that about 40% of zinc is produced in China, 20% in Australia, 20% in Peru, and 5% in US, Canada and Kazakhstan each.

[thumb|lang=en|World production trend](/wiki/File:Zinc_world_production.svg)

Zinc is the fourth most common metal in use, trailing only iron, aluminium, and copper with an annual production of about 13 million tonnes.<ref name=USGSMCS2015/> The world's largest zinc producer is [Nyrstar](/wiki/Nyrstar), a merger of the Australian [OZ Minerals](/wiki/OZ_Minerals) and the Belgian [Umicore](/wiki/Umicore).[[75]](#cite_note-75) About 70% of the world's zinc originates from mining, while the remaining 30% comes from recycling secondary zinc.[[76]](#cite_note-76) Commercially pure zinc is known as Special High Grade, often abbreviated *SHG*, and is 99.995% pure.[[77]](#cite_note-77) Worldwide, 95% of new zinc is mined from [sulfidic](/wiki/Sulfide) ore deposits, in which sphalerite (ZnS) is nearly always mixed with the sulfides of copper, lead and iron.[[78]](#cite_note-78) Zinc mines are scattered throughout the world, with the main areas being China, Australia, and Peru. China produced 38% of the global zinc output in 2014.<ref name=USGSMCS2015/>

Zinc metal is produced using [extractive metallurgy](/wiki/Extractive_metallurgy).[[79]](#cite_note-79) The ore is finely ground, then put through [froth flotation](/wiki/Froth_flotation) to separate minerals from [gangue](/wiki/Gangue) (on the property of [hydrophobicity](/wiki/Hydrophobicity)), to get a zinc sulfide ore concentrate[[79]](#cite_note-79) consisting of about 50% zinc, 32% sulfur, 13% iron, and 5% [Template:Chem](/wiki/Template:Chem).[[79]](#cite_note-79) [Roasting](/wiki/Roasting_(metallurgy)) converts the zinc sulfide concentrate to zinc oxide:[[78]](#cite_note-78):2 ZnS + 3 [Template:Chem](/wiki/Template:Chem) → 2 ZnO + 2 [Template:Chem](/wiki/Template:Chem)

The sulfur dioxide is used for the production of sulfuric acid, which is necessary for the leaching process. If deposits of zinc carbonate, zinc silicate, or zinc spinel (like the [Skorpion Deposit](/wiki/Skorpion_Zinc) in Namibia) are used for zinc production, the roasting can be omitted.[[80]](#cite_note-80) For further processing two basic methods are used: [pyrometallurgy](/wiki/Pyrometallurgy) or [electrowinning](/wiki/Electrowinning). Pyrometallurgy reduces zinc oxide with [carbon](/wiki/Carbon) or [carbon monoxide](/wiki/Carbon_monoxide) at [Template:Convert](/wiki/Template:Convert) into the metal, which is distilled as zinc vapor to separate it from other metals, which are not volatile at those temperatures.[[81]](#cite_note-81) The zinc vapor is collected in a condenser.[[78]](#cite_note-78) The equations below describe this process:[[78]](#cite_note-78)

2 ZnO + C → 2 Zn + [Template:Chem](/wiki/Template:Chem)

ZnO + CO → Zn + [Template:Chem](/wiki/Template:Chem)

In [electrowinning](/wiki/Electrowinning), zinc is leached from the ore concentrate by [sulfuric acid](/wiki/Sulfuric_acid):[[82]](#cite_note-82)

ZnO + [Template:Chem](/wiki/Template:Chem) → [Template:Chem](/wiki/Template:Chem) + [Template:Chem](/wiki/Template:Chem)

Finally, the zinc is reduced by [electrolysis](/wiki/Electrolysis).[[78]](#cite_note-78)

2 [Template:Chem](/wiki/Template:Chem) + 2 [Template:Chem](/wiki/Template:Chem) → 2 Zn + 2 [Template:Chem](/wiki/Template:Chem) + [Template:Chem](/wiki/Template:Chem)

The sulfuric acid is regenerated and recycled to the leaching step.

When galvanised feedstock is fed to an [electric arc furnace](/wiki/Electric_arc_furnace), the zinc is recovered from the dust by a number of processes, predominately the [Waelz process](/wiki/Waelz_process) (90% as of 2014).[[83]](#cite_note-83)

### Environmental impact[[edit](/index.php?title=(none)&action=edit&section=16)]

Refinement of sulfidic zinc ores produces large volumes of sulfur dioxide and [cadmium](/wiki/Cadmium) vapor. Smelter [slag](/wiki/Slag) and other residues contain significant quantities of heavy metals. About 1.1 million tonnes of metallic zinc and 130 thousand tonnes of lead were mined and smelted in the Belgian towns of [La Calamine](/wiki/Kelmis) and [Plombières](/wiki/Plombières) between 1806 and 1882.[[84]](#cite_note-84) The dumps of the past mining operations leach zinc and cadmium, and the sediments of the [Geul River](/wiki/Geul_River) contain non-trivial amounts of heavy metals.[[84]](#cite_note-84) About two thousand years ago, emissions of zinc from mining and smelting totaled 10 thousand tonnes a year. After increasing 10-fold from 1850, zinc emissions peaked at 3.4 million tonnes per year in the 1980s and declined to 2.7 million tonnes in the 1990s, although a 2005 study of the Arctic troposphere found that the concentrations there did not reflect the decline. Anthropogenic and natural emissions occur at a ratio of 20 to 1.<ref name=Broadley2007/>

Zinc in rivers flowing through industrial and mining areas can be as high as 20 ppm.[[85]](#cite_note-85) Effective [sewage treatment](/wiki/Sewage_treatment) greatly reduces this; treatment along the [Rhine](/wiki/Rhine), for example, has decreased zinc levels to 50 ppb.[[85]](#cite_note-85) Concentrations of zinc as low as 2 ppm adversely affects the amount of oxygen that fish can carry in their blood.[[86]](#cite_note-86) [Template:Wide image](/wiki/Template:Wide_image)

[Soils contaminated](/wiki/Soil_contamination) with zinc from mining, refining, or fertilizing with zinc-bearing sludge can contain several grams of zinc per kilogram of dry soil. Levels of zinc in excess of 500 ppm in soil interfere with the ability of plants to absorb other [essential metals](/wiki/Dietary_mineral), such as iron and [manganese](/wiki/Manganese). Zinc levels of 2000 ppm to 180,000 ppm (18%) have been recorded in some soil samples.[[85]](#cite_note-85)

## Applications[[edit](/index.php?title=(none)&action=edit&section=17)]

Major applications of zinc include (numbers are given for the US)[[87]](#cite_note-87)# [Galvanizing](/wiki/Galvanization) (55%)

1. [Brass](/wiki/Brass) and [bronze](/wiki/Bronze) (16%)
2. Other alloys (21%)
3. Miscellaneous (8%)

### Anti-corrosion and batteries[[edit](/index.php?title=(none)&action=edit&section=18)]

[thumb|Hot-dip handrail](/wiki/File:Feuerverzinkte_Oberfläche.jpg) [galvanized](/wiki/Galvanization) crystalline surface|alt=Merged elongated crystals of various shades of gray. Zinc is most commonly used as an anti-[corrosion](/wiki/Corrosion) agent,[[88]](#cite_note-88) and galvanization (coating of [iron](/wiki/Iron) or [steel](/wiki/Steel)) is the most familiar form. In 2009 in the United States, 55% or 893 thousand tonnes of the zinc metal was used for galvanization.[[87]](#cite_note-87) Zinc is more reactive than iron or steel and thus will attract almost all local oxidation until it completely corrodes away.<ref name=Stwertka1998p99>[Template:Harvnb](/wiki/Template:Harvnb)</ref> A protective surface layer of oxide and carbonate ([Template:Chem](/wiki/Template:Chem) forms as the zinc corrodes.[[89]](#cite_note-89) This protection lasts even after the zinc layer is scratched but degrades through time as the zinc corrodes away.[[89]](#cite_note-89) The zinc is applied electrochemically or as molten zinc by [hot-dip galvanizing](/wiki/Hot-dip_galvanizing) or spraying. Galvanization is used on chain-link fencing, guard rails, suspension bridges, lightposts, metal roofs, heat exchangers, and car bodies.[[12]](#cite_note-12) The relative reactivity of zinc and its ability to attract oxidation to itself makes it an efficient [sacrificial anode](/wiki/Sacrificial_anode) in [cathodic protection](/wiki/Cathodic_protection) (CP). For example, cathodic protection of a buried pipeline can be achieved by connecting anodes made from zinc to the pipe.[[89]](#cite_note-89) Zinc acts as the [anode](/wiki/Anode) (negative terminus) by slowly corroding away as it passes electric current to the steel pipeline.[[89]](#cite_note-89)<ref group=note>Electric current will naturally flow between zinc and steel but in some circumstances inert anodes are used with an external DC source.</ref> Zinc is also used to cathodically protect metals that are exposed to sea water.[[90]](#cite_note-90) A zinc disc attached to a ship's iron rudder will slowly corrode while the rudder stays intact.<ref name=Stwertka1998p99/> Similarly, a zinc plug attached to a propeller or the metal protective guard for the keel of the ship provides temporary protection.

With a [standard electrode potential](/wiki/Standard_electrode_potential) (SEP) of −0.76 [volts](/wiki/Volt), zinc is used as an anode material for batteries. (More reactive lithium (SEP −3.04 V) is used for anodes in [lithium batteries](/wiki/Lithium_battery) ). Powdered zinc is used in this way in [alkaline batteries](/wiki/Alkaline_battery) and the case (which also serves as the anode) of [zinc–carbon batteries](/wiki/Zinc-carbon_battery) is formed from sheet zinc.[[91]](#cite_note-91)[[92]](#cite_note-92) Zinc is used as the anode or fuel of the [zinc-air battery](/wiki/Zinc-air_battery)/fuel cell.[[93]](#cite_note-93)[[94]](#cite_note-94)[[95]](#cite_note-95) The [zinc-cerium](/wiki/Zinc–cerium_battery) [redox flow battery](/wiki/Redox_flow_battery) also relies on a zinc-based negative half-cell.<ref name=Xie1>[Template:Cite journal](/wiki/Template:Cite_journal)</ref>

### Alloys[[edit](/index.php?title=(none)&action=edit&section=19)]

A widely used zinc alloy is brass, in which copper is alloyed with anywhere from 3% to 45% zinc, depending upon the type of brass.[[89]](#cite_note-89) Brass is generally more [ductile](/wiki/Ductile) and stronger than copper, and has superior [corrosion resistance](/wiki/Corrosion_resistance).[[89]](#cite_note-89) These properties make it useful in communication equipment, hardware, musical instruments, and water valves.[[89]](#cite_note-89) [thumb|left|Cast brass microstructure at magnification 400x|alt=A mosaica pattern composed of components having various shapes and shades of brown.](/wiki/File:Microstructure_of_rolled_and_annealed_brass;_magnification_400X.jpg) Other widely used zinc alloys include [nickel silver](/wiki/Nickel_silver), typewriter metal, soft and aluminium [solder](/wiki/Solder), and commercial [bronze](/wiki/Bronze).[[6]](#cite_note-6) Zinc is also used in contemporary pipe organs as a substitute for the traditional lead/tin alloy in pipes.[[96]](#cite_note-96) Alloys of 85–88% zinc, 4–10% copper, and 2–8% aluminium find limited use in certain types of machine bearings. Zinc is the primary metal in [American one cent coins](/wiki/Lincoln_cent) (pennies) since 1982.[[97]](#cite_note-97) The zinc core is coated with a thin layer of copper to give the appearance of a copper coin. In 1994, [Template:Convert](/wiki/Template:Convert) of zinc were used to produce 13.6 billion pennies in the United States.[[98]](#cite_note-98) Alloys of zinc with small amounts of copper, aluminium, and magnesium are useful in [die casting](/wiki/Die_casting) as well as [spin casting](/wiki/Spin_casting), especially in the automotive, electrical, and hardware industries.[[6]](#cite_note-6) These alloys are marketed under the name [Zamak](/wiki/Zamak).[[99]](#cite_note-99) An example of this is [zinc aluminium](/wiki/Zinc_aluminium). The low melting point together with the low [viscosity](/wiki/Viscosity) of the alloy makes possible the production of small and intricate shapes. The low working temperature leads to rapid cooling of the cast products and fast production for assembly.[[6]](#cite_note-6)[[100]](#cite_note-100) Another alloy, marketed under the brand name Prestal, contains 78% zinc and 22% aluminium, and is reported to be nearly as strong as steel but as malleable as plastic.[[6]](#cite_note-6)[[101]](#cite_note-101) This [superplasticity](/wiki/Superplasticity) of the alloy allows it to be molded using die casts made of ceramics and cement.[[6]](#cite_note-6) Similar alloys with the addition of a small amount of lead can be cold-rolled into sheets. An alloy of 96% zinc and 4% aluminium is used to make stamping dies for low production run applications for which ferrous metal dies would be too expensive.[[102]](#cite_note-102) For building facades, roofing, and other applications for [sheet metal](/wiki/Sheet_metal) formed by [deep drawing](/wiki/Deep_drawing), [roll forming](/wiki/Roll_forming), or [bending](/wiki/Bending_(metalworking)), zinc alloys with [titanium](/wiki/Titanium) and copper are used.[[103]](#cite_note-103) Unalloyed zinc is too brittle for these manufacturing processes.[[103]](#cite_note-103) As a dense, inexpensive, easily worked material, zinc is used as a [lead](/wiki/Lead) replacement. In the wake of [lead concerns](/wiki/Lead_poisoning), zinc appears in weights for various applications ranging from fishing[[104]](#cite_note-104) to [tire balances](/wiki/Tire_balance) and flywheels.[[105]](#cite_note-105) [Cadmium zinc telluride](/wiki/Cadmium_zinc_telluride) (CZT) is a [semiconductive](/wiki/Semiconductor) alloy that can be divided into an array of small sensing devices.[[106]](#cite_note-106) These devices are similar to an [integrated circuit](/wiki/Integrated_circuit) and can detect the energy of incoming [gamma ray](/wiki/Gamma_ray) photons.[[106]](#cite_note-106) When behind an absorbing mask, the CZT sensor array can determine the direction of the rays.[[106]](#cite_note-106)

### Other industrial uses[[edit](/index.php?title=(none)&action=edit&section=20)]

[thumb|Zinc oxide is used as a white](/wiki/File:Zinc_oxide.jpg) [pigment](/wiki/Pigment) in [paints](/wiki/Paint).|alt=White powder on a glass plate Roughly one quarter of all zinc output in the United States in 2009 was consumed in zinc compounds;[[87]](#cite_note-87) a variety of which are used industrially. Zinc oxide is widely used as a white pigment in paints and as a [catalyst](/wiki/Catalyst) in the manufacture of rubber to disburse heat. Zinc oxide is used to protect rubber polymers and plastics from [ultraviolet radiation](/wiki/Ultraviolet_radiation) (UV).[[12]](#cite_note-12) The [semiconductor](/wiki/Semiconductor) properties of zinc oxide make it useful in [varistors](/wiki/Varistor) and photocopying products.[[107]](#cite_note-107) The [zinc zinc-oxide cycle](/wiki/Zinc_zinc-oxide_cycle) is a two step [thermochemical](/wiki/Thermochemistry) process based on zinc and zinc oxide for [hydrogen production](/wiki/Hydrogen_production).[[108]](#cite_note-108) [Zinc chloride](/wiki/Zinc_chloride) is often added to lumber as a [fire retardant](/wiki/Fire_retardant)[[109]](#cite_note-109) and sometimes as a wood [preservative](/wiki/Preservative).[[110]](#cite_note-110) It is used in the manufacture of other chemicals.[[109]](#cite_note-109) [Zinc methyl](/wiki/Zinc_methyl) ([Template:Chem](/wiki/Template:Chem)) is used in a number of organic [syntheses](/wiki/Organic_synthesis).[[111]](#cite_note-111) [Zinc sulfide](/wiki/Zinc_sulfide) (ZnS) is used in [luminescent](/wiki/Luminescence) pigments such as on the hands of clocks, [X-ray](/wiki/X-ray) and television screens, and [luminous paints](/wiki/Luminous_paint).[[112]](#cite_note-112) Crystals of ZnS are used in [lasers](/wiki/Laser) that operate in the mid-[infrared](/wiki/Infrared) part of the spectrum.[[113]](#cite_note-113) [Zinc sulfate](/wiki/Zinc_sulfate) is a chemical in [dyes](/wiki/Dye) and pigments.[[109]](#cite_note-109) [Zinc pyrithione](/wiki/Zinc_pyrithione) is used in [antifouling](/wiki/Antifouling) paints.[[114]](#cite_note-114) Zinc powder is sometimes used as a [propellant](/wiki/Propellant) in [model rockets](/wiki/Model_rocket).[[115]](#cite_note-115) When a compressed mixture of 70% zinc and 30% [sulfur](/wiki/Sulfur) powder is ignited there is a violent chemical reaction.[[115]](#cite_note-115) This produces zinc sulfide, together with large amounts of hot gas, heat, and light.[[115]](#cite_note-115) Zinc sheet metal is used to make zinc [bars](/wiki/Bar_(counter)).[[116]](#cite_note-116) [Template:Chem](/wiki/Template:Chem), the most abundant isotope of zinc, is very susceptible to [neutron activation](/wiki/Neutron_activation), being [transmuted](/wiki/Nuclear_transmutation) into the highly radioactive [Template:Chem](/wiki/Template:Chem), which has a half-life of 244 days and produces intense [gamma radiation](/wiki/Gamma_ray). Because of this, zinc oxide used in nuclear reactors as an anti-corrosion agent is depleted of [Template:Chem](/wiki/Template:Chem) before use, this is called [depleted zinc oxide](/wiki/Depleted_zinc_oxide). For the same reason, zinc has been proposed as a [salting](/wiki/Salted_bomb) material for [nuclear weapons](/wiki/Nuclear_weapon) ([cobalt](/wiki/Cobalt) is another, better-known salting material).[[117]](#cite_note-117) A jacket of [isotopically enriched](/wiki/Isotope_separation) [Template:Chem](/wiki/Template:Chem) would be irradiated by the intense high-energy neutron flux from an exploding thermonuclear weapon, forming a large amount of [Template:Chem](/wiki/Template:Chem) significantly increasing the radioactivity of the weapon's [fallout](/wiki/Nuclear_fallout).[[117]](#cite_note-117) Such a weapon is not known to have ever been built, tested, or used.[[117]](#cite_note-117) [Template:Chem](/wiki/Template:Chem) is used as a [tracer](/wiki/Isotopic_tracer) to study how alloys that contain zinc wear out, or the path and the role of zinc in organisms.[[118]](#cite_note-118) Zinc dithiocarbamate complexes are used as agricultural [fungicides](/wiki/Fungicide); these include [Zineb](/wiki/Zineb), Metiram, Propineb and Ziram.[[119]](#cite_note-119) Zinc naphthenate is used as wood preservative.[[120]](#cite_note-120) Zinc in the form of [ZDDP](/wiki/Zinc_dithiophosphate), is used as an anti-wear additive for metal parts in engine oil.[[121]](#cite_note-121)

### Dietary supplement[[edit](/index.php?title=(none)&action=edit&section=21)]

[thumb|175px|](/wiki/File:Zinc_50_mg.jpg)[GNC](/wiki/General_Nutrition_Centers) zinc 50 mg tablets ([AU](/wiki/Australia))

In most single-tablet, over-the-counter, daily vitamin and [mineral](/wiki/Dietary_mineral) supplements, zinc is included in such forms as zinc oxide, zinc acetate, or [zinc gluconate](/wiki/Zinc_gluconate).[[122]](#cite_note-122) Zinc is believed to be an [antioxidant](/wiki/Antioxidant) that may protect against accelerated aging of the skin and muscles of the body; studies differ as to its effectiveness.[[123]](#cite_note-123) Zinc also helps speed up the healing process after an injury.[[123]](#cite_note-123) It is also suspected of being beneficial to the human [immune system](/wiki/Immune_system), and deficiency may be deleterious to virtually all parts of the system.[[124]](#cite_note-124) Zinc deficiency has been associated with [major depressive disorder](/wiki/Major_depressive_disorder) (MDD), and zinc supplements may be an effective treatment.[[125]](#cite_note-125) Zinc serves as a simple, inexpensive, and critical tool for treating diarrheal episodes among children in the developing world. Zinc becomes depleted in the body during [diarrhea](/wiki/Diarrhea), but recent studies suggest that replenishing zinc with a 10- to 14-day course of treatment can reduce the duration and severity of diarrheal episodes and may also prevent future episodes for as long as three months.[[126]](#cite_note-126) [thumb|left|](/wiki/File:Zinc_gluconate_structure.svg)[Zinc gluconate](/wiki/Zinc_gluconate) is one compound used for the delivery of zinc as a [dietary supplement](/wiki/Dietary_supplement).|alt=Skeletal chemical formula of a planar compound featuring a Zn atom in the center, symmetrically bonded to four oxygens. Those oxygens are further connected to linear COH chains.

The [Age-Related Eye Disease Study](/wiki/Age-Related_Eye_Disease_Study) determined that zinc can be part of an effective treatment for [age-related macular degeneration](/wiki/Age-related_macular_degeneration).[[127]](#cite_note-127) Zinc supplement is an effective treatment for [acrodermatitis enteropathica](/wiki/Acrodermatitis_enteropathica), a genetic disorder affecting zinc absorption that was previously fatal to affected infants.[[47]](#cite_note-47) [Gastroenteritis](/wiki/Gastroenteritis) is strongly attenuated by ingestion of zinc, possibly by direct antimicrobial action of the ions in the [gastrointestinal tract](/wiki/Gastrointestinal_tract), or by the absorption of the zinc and re-release from immune cells (all [granulocytes](/wiki/Granulocyte) secrete zinc), or both.[[128]](#cite_note-128)[[129]](#cite_note-129) In 2011, researchers at [John Jay College of Criminal Justice](/wiki/John_Jay_College_of_Criminal_Justice) reported that dietary zinc supplements can mask the presence of drugs in urine. Similar claims appear in web forums.[[130]](#cite_note-130) Although not yet tested as a therapy in humans, a growing body of evidence indicates that zinc may preferentially kill prostate cancer cells. Because zinc naturally homes to the prostate and because the prostate is accessible with relatively non-invasive procedures, its potential as a chemotherapeutic agent in this type of cancer has shown promise.[[131]](#cite_note-131) However, other studies have demonstrated that chronic use of zinc supplements in excess of the recommended dosage may actually increase the chance of developing prostate cancer, also likely due to the natural buildup of this heavy metal in the prostate.[[132]](#cite_note-132)

### Zinc lozenges and the common cold[[edit](/index.php?title=(none)&action=edit&section=22)]

[Template:Main article](/wiki/Template:Main_article) In studies of zinc supplements and the common cold, [zinc acetate](/wiki/Zinc_acetate) produced the most positive results, apparently because acetate does not bind zinc ions.[[133]](#cite_note-133)

### Topical use[[edit](/index.php?title=(none)&action=edit&section=23)]

[Template:Further](/wiki/Template:Further) [Topical preparations](/wiki/Topical_administration) of zinc include those used on the skin, often in the form of [zinc oxide](/wiki/Zinc_oxide). Zinc preparations can protect against [sunburn](/wiki/Sunburn) in the summer and [windburn](/wiki/Windburn) in the winter.[[47]](#cite_note-47) Applied thinly to a baby's diaper area ([perineum](/wiki/Perineum)) with each diaper change, it can protect against [diaper rash](/wiki/Diaper_rash).[[47]](#cite_note-47) Chelated zinc is used in toothpastes and mouthwashes to prevent [bad breath](/wiki/Halitosis).[[134]](#cite_note-134) [Zinc pyrithione](/wiki/Zinc_pyrithione) is widely included in shampoos to prevent dandruff.[[135]](#cite_note-135) Zinc ions are effective [antimicrobial agents](/wiki/Antimicrobial_agent) even at low concentrations.[[136]](#cite_note-136)

### Organic chemistry[[edit](/index.php?title=(none)&action=edit&section=24)]

[thumb|350px|Addition of diphenylzinc to an aldehyde](/wiki/Image:DiphenylzincCarbonylAddition.png) [Organozinc](/wiki/Organozinc_compound) chemistry is the science of copounds that contain carbon-zinc bonds, describing the physical properties, synthesis, and chemical reactions.Many organozinc compounds are important.[[137]](#cite_note-137)[[138]](#cite_note-138)[[139]](#cite_note-139)[[140]](#cite_note-140) Among important applications are

* The Frankland-Duppa Reaction in which an [oxalate](/wiki/Oxalate) [ester](/wiki/Ester)(ROCOCOOR) reacts with an [alkyl halide](/wiki/Alkyl_halide) R'X, zinc and [hydrochloric acid](/wiki/Hydrochloric_acid) to form the α-hydroxycarboxylic esters RR'COHCOOR[[141]](#cite_note-141)\* The [Reformatskii reaction](/wiki/Reformatskii_reaction) in which α-halo-esters and aldehydes are converted to β-hydroxy-esters
* The [Simmons–Smith reaction](/wiki/Simmons–Smith_reaction) in which the carbenoid (iodomethyl)zinc iodide reacts with alkene(or alkyne) and converts them to cyclopropane
* The [Addition reaction](/wiki/Addition_reaction) of organozinc compounds to form [carbonyl](/wiki/Carbonyl) compounds
* The [Barbier reaction](/wiki/Barbier_reaction) (1899), which is the zinc equivalent of the magnesium [Grignard reaction](/wiki/Grignard_reaction) and is the better of the two. In presence of water, formation of the organomagnesium halide will fail, whereas the Barbier reaction can take place in water.
* On the downside, organozincs are much less nucleophilic than Grignards, and they are expensive and difficult to handle. Commercially available diorganozinc compounds are [dimethylzinc](/wiki/Dimethylzinc), [diethylzinc](/wiki/Diethylzinc) and diphenylzinc. In one study,[[142]](#cite_note-142)[[143]](#cite_note-143) the active organozinc compound is obtained from much cheaper [organobromine](/wiki/Organobromine_compound) precursors
* The [Negishi coupling](/wiki/Negishi_coupling) is also an important reaction for the formation of new carbon-carbon bonds between unsaturated carbon atoms in alkenes, arenes and alkynes. The catalysts are nickel and palladium. A key step in the [catalytic cycle](/wiki/Catalytic_cycle) is a [transmetalation](/wiki/Transmetalation) in which a zinc halide exchanges its organic substituent for another halogen with the palladium (nickel) metal center.
* The [Fukuyama coupling](/wiki/Fukuyama_coupling) is another coupling reaction, but it uses a thioester as reactant and produces a ketone.

Zinc has found many applications as catalyst in organic synthesis including asymmetric synthesis, being cheap and easily available alternative to precious metal complexes. The results (yield and [ee](/wiki/Enantiomeric_excess)) obtained with chiral zinc catalysts are comparable to those achieved with palladium, ruthenium, iridium and others, and zinc becomes metal catalyst of choice.[[144]](#cite_note-144)

## Biological role[[edit](/index.php?title=(none)&action=edit&section=25)]

Zinc is an essential [trace element](/wiki/Trace_element) for humans[[145]](#cite_note-145) and other animals,[[146]](#cite_note-146) for plants<ref name=Broadley2007>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> and for [microorganisms](/wiki/Microorganism).[[147]](#cite_note-147) Zinc is found in nearly 100 specific [enzymes](/wiki/Enzyme)[[148]](#cite_note-148) (other sources[[149]](#cite_note-149) say 300), serves as structural ions in [transcription factors](/wiki/Transcription_factor) and is stored and transferred in [metallothioneins](/wiki/Metallothionein).[[150]](#cite_note-150) It is "typically the second most abundant transition metal in organisms" after iron and it is the only metal which appears in all [enzyme classes](/wiki/Enzyme#Naming_conventions).<ref name=Broadley2007/>

In proteins, Zinc ions are often coordinated to the amino acid side chains of [aspartic acid](/wiki/Aspartic_acid_(data_page)), [glutamic acid](/wiki/Glutamic_acid), [cysteine](/wiki/Cysteine) and [histidine](/wiki/Histidine). The theoretical and computational description of this zinc binding in proteins (as well as that of other transition metals) is difficult.[[151]](#cite_note-151) Between 2 and 4 grams of zinc<ref name=Rink2000>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> are distributed throughout the human body. Most zinc is in the brain, muscle, bones, kidney, and liver, with the highest concentrations in the prostate and parts of the eye.[[152]](#cite_note-152) Semen is particularly rich in zinc, a key factor in [prostate gland](/wiki/Prostate_gland) function and [reproductive organ](/wiki/Reproductive_organ) growth.<ref name=Berdanier2007>[Template:Cite book](/wiki/Template:Cite_book)</ref>

In humans, zinc plays "ubiquitous biological roles".<ref name=Hambridge2007/> It interacts with "a wide range of organic [ligands](/wiki/Ligand)",<ref name=Hambridge2007/> and has roles in the metabolism of RNA and DNA, [signal transduction](/wiki/Signal_transduction), and [gene expression](/wiki/Gene_expression). It also regulates [apoptosis](/wiki/Apoptosis). A 2006 study estimated that about 10% of human proteins (2800) potentially bind zinc, in addition to hundreds more that transport and traffic zinc; a similar [*in silico*](/wiki/In_silico) study in the plant *Arabidopsis thaliana* found 2367 zinc-related proteins.<ref name=Broadley2007/>

In the brain, zinc is stored in specific [synaptic vesicles](/wiki/Synaptic_vesicles) by [glutamatergic](/wiki/Glutamatergic) neurons[[153]](#cite_note-153) and can "modulate brain excitability".<ref name=Hambridge2007/> It plays a key role in [synaptic plasticity](/wiki/Synaptic_plasticity) and so in learning.[[154]](#cite_note-154) However, it has been called "the brain's dark horse"[[153]](#cite_note-153) because it also can be a [neurotoxin](/wiki/Neurotoxin), suggesting zinc [homeostasis](/wiki/Homeostasis) plays a critical role in normal functioning of the brain and [central nervous system](/wiki/Central_nervous_system).[[153]](#cite_note-153)

### Enzymes[[edit](/index.php?title=(none)&action=edit&section=26)]

[thumb|](/wiki/File:Carbonic_anhydrase.png)[Ribbon diagram](/wiki/Ribbon_diagram) of human [carbonic anhydrase](/wiki/Carbonic_anhydrase) II, with zinc atom visible in the center|alt=Interconnected stripes, mostly of yellow and blue color with a few red segments. [thumb|left|](/wiki/File:Zinc_finger_rendered.png)[Zinc fingers](/wiki/Zinc_fingers) help read DNA sequences.|alt=A twisted band, with one side painted blue and another gray. Its two ends are connected through some chemical species to a green atom (zinc). Zinc is an efficient [Lewis acid](/wiki/Lewis_acid), making it a useful catalytic agent in [hydroxylation](/wiki/Hydroxylation) and other enzymatic reactions.<ref name=NRC2000p443>[Template:Harvnb](/wiki/Template:Harvnb)</ref> The metal also has a flexible [coordination geometry](/wiki/Coordination_geometry), which allows proteins using it to rapidly shift [conformations](/wiki/Protein_structure) to perform biological reactions.[[155]](#cite_note-155) Two examples of zinc-containing enzymes are [carbonic anhydrase](/wiki/Carbonic_anhydrase) and [carboxypeptidase](/wiki/Carboxypeptidase), which are vital to the processes of [carbon dioxide](/wiki/Carbon_dioxide) ([Template:Chem](/wiki/Template:Chem)) regulation and digestion of proteins, respectively.[[156]](#cite_note-156) In vertebrate blood, carbonic anhydrase converts [Template:Chem](/wiki/Template:Chem) into bicarbonate and the same enzyme transforms the bicarbonate back into [Template:Chem](/wiki/Template:Chem) for exhalation through the lungs.[[157]](#cite_note-157) Without this enzyme, this conversion would occur about one million times slower[[158]](#cite_note-158) at the normal blood [pH](/wiki/PH) of 7 or would require a pH of 10 or more.[[159]](#cite_note-159) The non-related β-carbonic anhydrase is required in plants for leaf formation, the synthesis of indole [acetic acid](/wiki/Acetic_acid) (auxin) and [alcoholic fermentation](/wiki/Alcoholic_fermentation).[[160]](#cite_note-160) Carboxypeptidase cleaves peptide linkages during digestion of proteins. A [coordinate covalent bond](/wiki/Coordinate_covalent_bond) is formed between the terminal peptide and a C=O group attached to zinc, which gives the carbon a positive charge. This helps to create a [hydrophobic](/wiki/Hydrophobic) pocket on the enzyme near the zinc, which attracts the non-polar part of the protein being digested.[[156]](#cite_note-156)

### Other proteins[[edit](/index.php?title=(none)&action=edit&section=27)]

Zinc serves a purely structural role in [zinc fingers](/wiki/Zinc_finger), twists and clusters.[[161]](#cite_note-161) Zinc fingers form parts of some [transcription factors](/wiki/Transcription_factor), which are proteins that recognize [DNA base sequences](/wiki/DNA_sequence) during the replication and transcription of [DNA](/wiki/DNA). Each of the nine or ten [Template:Chem](/wiki/Template:Chem) ions in a zinc finger helps maintain the finger's structure by coordinately binding to four [amino acids](/wiki/Amino_acid) in the transcription factor.[[158]](#cite_note-158) The transcription factor wraps around the DNA helix and uses its fingers to accurately bind to the DNA sequence.

In [blood plasma](/wiki/Blood_plasma), zinc is bound to and transported by [albumin](/wiki/Albumin) (60%, low-affinity) and [transferrin](/wiki/Transferrin) (10%).<ref name=Rink2000/> Because transferrin also transports iron, excessive iron reduces zinc absorption, and vice versa. A similar antagonism exists with copper.<ref Name=Whitney2005>[Template:Cite book](/wiki/Template:Cite_book)</ref> The concentration of zinc in blood plasma stays relatively constant regardless of zinc intake.<ref name=NRC2000p447>[Template:Harvnb](/wiki/Template:Harvnb)</ref> Cells in the salivary gland, prostate, immune system, and intestine use [zinc signaling](/wiki/Cell_signaling) to communicate with other cells.[[162]](#cite_note-162) Zinc may be held in [metallothionein](/wiki/Metallothionein) reserves within microorganisms or in the intestines or liver of animals.[[163]](#cite_note-163) Metallothionein in intestinal cells is capable of adjusting absorption of zinc by 15–40%.<ref name=Blake2007>[Template:Cite book](/wiki/Template:Cite_book)</ref> However, inadequate or excessive zinc intake can be harmful; excess zinc particularly impairs copper absorption because metallothionein absorbs both metals.<ref name=Fosmire1990/>

### Dietary intake[[edit](/index.php?title=(none)&action=edit&section=28)]

[thumb|upright|](/wiki/File:Foodstuff-containing-Zinc.jpg)[Foods & spices](/wiki/Recommended_Dietary_Allowance) containing zinc|alt=Several plates full of various cereals, fruits and vegetables on a table.

In the U.S., the [Recommended Dietary Allowance](/wiki/Recommended_Dietary_Allowance) (RDA) is 8 mg/day for women and 11 mg/day for men.<ref name=rda>[Template:Cite book](/wiki/Template:Cite_book)</ref> Median intake in the U.S. in 2000 was 9 mg/day for women and 14 mg/day in men.<ref name=NRC2000p442/> Oysters, lobster<ref name=usda> [Template:Cite web](/wiki/Template:Cite_web)</ref> and red meats, especially [beef](/wiki/Beef), [lamb](/wiki/Lamb_and_mutton), and [liver](/wiki/Calves_liver) have some of the highest zinc concentrations.<ref name=Berdanier2007/>

Zinc supplements should be ingested only in cases of zinc deficiency or increased zinc necessity (e.g. after [surgeries](/wiki/Surgery), [traumata](/wiki/Trauma_(medicine)), or [burns](/wiki/Burn)).[[164]](#cite_note-164)[[165]](#cite_note-165) Persistent intake of high doses of zinc can cause copper deficiency.[[164]](#cite_note-164) The concentration of zinc in plants varies with the level in the soil. With adequate zinc in the soil, the food plants that contain the most zinc are wheat (germ and bran) and various seeds ([sesame](/wiki/Sesame), [poppy](/wiki/Poppy), [alfalfa](/wiki/Alfalfa), [celery](/wiki/Celery), [mustard](/wiki/Mustard_(condiment))).<ref name=Ensminger1993>[Template:Cite book](/wiki/Template:Cite_book)</ref> Zinc is also found in [beans](/wiki/Bean), [nuts](/wiki/Nut_(fruit)), [almonds](/wiki/Almond), [whole grains](/wiki/Whole_grain), [pumpkin seeds](/wiki/Pumpkin_seed), [sunflower seeds](/wiki/Sunflower_seed) and [blackcurrant](/wiki/Blackcurrant).[[166]](#cite_note-166) Other sources include [fortified food](/wiki/Food_fortification) and [dietary supplements](/wiki/Dietary_supplement) in various forms. A 1998 review concluded that zinc oxide, one of the most common supplements in the United States, and zinc carbonate are nearly insoluble and poorly absorbed in the body.<ref name=Allen1998/> This review cited studies that found lower plasma zinc concentrations in the subjects who consumed zinc oxide and zinc carbonate than in those who took zinc acetate and sulfate salts.<ref name=Allen1998>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> However, harmful excessive supplementation is a problem among the relatively affluent, and should probably not exceed 20 mg/day in healthy people,[[167]](#cite_note-167) although the U.S. National Research Council set a Tolerable Upper Intake of 40 mg/day.[[168]](#cite_note-168) For fortification, however, a 2003 review recommended cereals (containing zinc oxide) as a cheap, stable source that is as easily absorbed as the more expensive forms.[[169]](#cite_note-169) A 2005 study found that various compounds of zinc, including oxide and sulfate, did not show statistically significant differences in absorption when added as fortificants to maize tortillas.[[170]](#cite_note-170) A 1987 study found that zinc picolinate was better absorbed than zinc gluconate or zinc citrate.[[171]](#cite_note-171) However, a study published in 2008 determined that [zinc glycinate](/wiki/Zinc_glycinate) is the most readily absorbed of the four available dietary supplement compounds.[[172]](#cite_note-172)

### Deficiency[[edit](/index.php?title=(none)&action=edit&section=29)]

[Template:Main article](/wiki/Template:Main_article)

Zinc deficiency is usually due to insufficient dietary intake, but can be associated with [malabsorption](/wiki/Malabsorption), [acrodermatitis enteropathica](/wiki/Acrodermatitis_enteropathica), chronic liver disease, chronic renal disease, sickle cell disease, diabetes, malignancy, and other chronic illnesses.<ref name=Prasad2003/> Groups at risk for zinc deficiency include the elderly, children in developing countries, and those with renal dysfunction.

Symptoms of mild zinc deficiency are diverse.<ref name=NRC2000p442>[Template:Harvnb](/wiki/Template:Harvnb)</ref> Clinical outcomes include depressed growth, diarrhea, impotence and delayed sexual maturation, [alopecia](/wiki/Alopecia), eye and skin lesions, impaired appetite, altered cognition, impaired host defense properties, defects in carbohydrate utilization, and reproductive [teratogenesis](/wiki/Teratogenesis).[[173]](#cite_note-173) Mild zinc deficiency depresses immunity,[[174]](#cite_note-174) although excessive zinc does also.<ref name=Rink2000/> Animals with a zinc deficiency require twice as much food to attain the same weight gain as animals with sufficient zinc.[[112]](#cite_note-112) Despite some concerns,[[175]](#cite_note-175) western vegetarians and vegans do not suffer any more from overt zinc deficiency than meat-eaters.[[176]](#cite_note-176) Major plant sources of zinc include cooked dried beans, sea vegetables, fortified cereals, soy foods, nuts, peas, and seeds.[[175]](#cite_note-175) However, [phytates](/wiki/Phytates) in many whole-grains and fibers may interfere with zinc absorption and marginal zinc intake has poorly understood effects. The zinc [chelator](/wiki/Chelation) [phytate](/wiki/Phytic_acid), found in seeds and [cereal](/wiki/Cereal) [bran](/wiki/Bran), can contribute to zinc malabsorption.<ref name=Prasad2003/> Some evidence suggests that more than the US RDA (15 mg) of zinc daily may be needed in those whose diet is high in phytates, such as some vegetarians.[[175]](#cite_note-175) These considerations must be balanced against the paucity of adequate zinc [biomarkers](/wiki/Biomarker), and the most widely used indicator, plasma zinc, has poor [sensitivity and specificity](/wiki/Sensitivity_and_specificity).[[177]](#cite_note-177) Diagnosing zinc deficiency is a persistent challenge.<ref name=Hambridge2007/>

Nearly two billion people in the developing world are deficient in zinc.<ref name=Prasad2003>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> In children, it causes an increase in infection and diarrhea and contributes to the death of about 800,000 children worldwide per year.<ref name=Hambridge2007/> The World Health Organization advocates zinc supplementation for severe malnutrition and diarrhea.<ref name=WHO2007>[Template:Cite web](/wiki/Template:Cite_web)</ref> Zinc supplements help prevent disease and reduce mortality, especially among children with low birth weight or stunted growth.<ref name=WHO2007/> However, zinc supplements should not be administered alone, because many in the developing world have several deficiencies, and zinc interacts with other micronutrients.[[178]](#cite_note-178)

## Soil remediation[[edit](/index.php?title=(none)&action=edit&section=30)]

The Ericoid Mycorrhizal Fungi Calluna, Erica and Vaccinium can grow in zinc metalliferous soils.[[179]](#cite_note-179)

### Agriculture[[edit](/index.php?title=(none)&action=edit&section=31)]

Zinc deficiency appears to be the most common micronutrient deficiency in crop plants; it is particularly common in high-pH soils.[[180]](#cite_note-180) Zinc-deficient [soil](/wiki/Soil) is [cultivated](/wiki/Tillage) in the cropland of about half of Turkey and India, a third of China, and most of Western Australia. Substantial responses to zinc fertilization have been reported in these areas.<ref name=Broadley2007/> Plants that grow in soils that are zinc-deficient are more susceptible to disease. Zinc is added to the soil primarily through the weathering of rocks, but humans have added zinc through fossil fuel combustion, mine waste, phosphate fertilizers, pesticide ([zinc phosphide](/wiki/Zinc_phosphide)), limestone, manure, sewage sludge, and particles from galvanized surfaces. Excess zinc is toxic to plants, although zinc toxicity is far less widespread.<ref name=Broadley2007/>

## Precautions[[edit](/index.php?title=(none)&action=edit&section=32)]

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### Toxicity[[edit](/index.php?title=(none)&action=edit&section=33)]

Although zinc is an essential requirement for good health, excess zinc can be harmful. Excessive absorption of zinc suppresses copper and iron absorption.<ref name=Fosmire1990/> The free zinc ion in solution is highly toxic to plants, invertebrates, and even vertebrate fish.[[181]](#cite_note-181) The Free Ion Activity Model is well-established in the literature, and shows that just [micromolar](/wiki/Mole_(unit)) amounts of the free ion kills some organisms. A recent example showed 6 micromolar killing 93% of all [*Daphnia*](/wiki/Daphnia) in water.[[182]](#cite_note-182) The free zinc ion is a powerful [Lewis acid](/wiki/Lewis_acid) up to the point of being [corrosive](/wiki/Corrosive). Stomach acid contains [hydrochloric acid](/wiki/Hydrochloric_acid), in which metallic zinc dissolves readily to give corrosive zinc chloride. Swallowing a post-1982 American one [cent](/wiki/Cent_(United_States_coin)) piece (97.5% zinc) can cause damage to the stomach lining through the high solubility of the zinc ion in the acidic stomach.[[183]](#cite_note-183) Evidence shows that people taking 100–300 mg of zinc daily may suffer induced [copper deficiency](/wiki/Copper_deficiency). A 2007 trial observed that elderly men taking 80 mg daily were hospitalized for urinary complications more often than those taking a placebo.[[184]](#cite_note-184) The [USDA](/wiki/USDA) [RDA](/wiki/Recommended_Dietary_Allowance) is 11 and 8 mg Zn/day for men and women, respectively.<ref name=rda/> Levels of 100–300 mg may interfere with the utilization of copper and iron or adversely affect cholesterol.<ref name=Fosmire1990>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> Zinc in excess of 500 ppm in soil interferes with the plant absorption of other essential metals, such as iron and manganese.[[85]](#cite_note-85) A condition called the [zinc shakes](/wiki/Zinc_shakes) or "zinc chills" can be induced by inhalation of zinc fumes while [brazing](/wiki/Brazing) or welding galvanized materials.[[112]](#cite_note-112) Zinc is a common ingredient of [denture](/wiki/Denture) cream which may contain between 17 and 38 mg of zinc per gram. Disability and even deaths from excessive use of these products have been claimed.[[185]](#cite_note-185) The U.S. [Food and Drug Administration](/wiki/Food_and_Drug_Administration) (FDA) states that zinc damages nerve receptors in the nose, causing [anosmia](/wiki/Anosmia). Reports of anosmia were also observed in the 1930s when zinc preparations were used in a failed attempt to prevent [polio](/wiki/Polio) infections.[[186]](#cite_note-186) On June 16, 2009, the FDA ordered removal of zinc-based intranasal cold products from store shelves. The FDA said the loss of smell can be life-threatening because people with impaired smell cannot detect leaking gas or smoke, and cannot tell if food has spoiled before they eat it.[[187]](#cite_note-187) Recent research suggests that the topical antimicrobial zinc pyrithione is a potent [heat shock](/wiki/Heat_shock) response inducer that may impair genomic integrity with induction of [PARP](/wiki/Poly_ADP_ribose_polymerase)-dependent energy crisis in cultured human [keratinocytes](/wiki/Keratinocytes) and [melanocytes](/wiki/Melanocytes).[[188]](#cite_note-188)

### Poisoning[[edit](/index.php?title=(none)&action=edit&section=34)]

In 1982, the [US Mint](/wiki/United_States_Mint) began minting [pennies](/wiki/Cent_(United_States_coin)) coated in copper but containing primarily zinc. The new zinc pennies pose a risk of zinc toxicosis, which can be fatal. One reported case of chronic ingestion of 425 pennies (over 1 kg of zinc) resulted in death due to gastrointestinal bacterial and fungal [sepsis](/wiki/Sepsis). Another patient who ingested 12 grams of zinc showed only [lethargy](/wiki/Lethargy) and [ataxia](/wiki/Ataxia) (gross lack of coordination of muscle movements).[[189]](#cite_note-189) Several other cases have been reported of humans suffering zinc intoxication by the ingestion of zinc coins.[[190]](#cite_note-190)[[191]](#cite_note-191) Pennies and other small coins are sometimes ingested by dogs, requiring veterinary removal of the foreign objects. The zinc content of some coins can cause zinc toxicity, commonly fatal in dogs through severe [hemolytic anemia](/wiki/Hemolytic_anemia) and liver or kidney damage; vomiting and diarrhea are possible symptoms.[[192]](#cite_note-192) Zinc is highly toxic in [parrots](/wiki/Parrots) and poisoning can often be fatal.[[193]](#cite_note-193) The consumption of fruit juices stored in galvanized cans has resulted in mass parrot poisonings with zinc.[[47]](#cite_note-47)

## See also[[edit](/index.php?title=(none)&action=edit&section=35)]

[Template:Spoken Wikipedia](/wiki/Template:Spoken_Wikipedia)

* [List of countries by zinc production](/wiki/List_of_countries_by_zinc_production)
* [Spelter](/wiki/Spelter)
* [Wet storage stain](/wiki/Wet_storage_stain)
* [Zinc alloy electroplating](/wiki/Zinc_alloy_electroplating)

## Notes[[edit](/index.php?title=(none)&action=edit&section=36)]