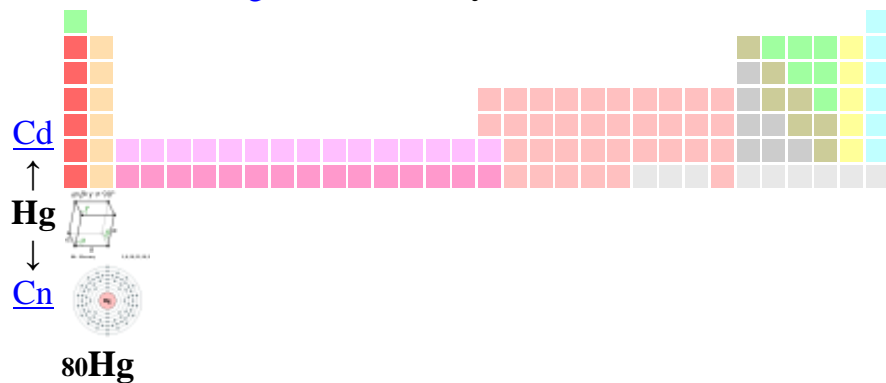


Mercury (element)

From Wikipedia, the free encyclopedia

[gold](#) ← **mercury** → [thallium](#)



[Periodic table](#)

Appearance

silvery



Spectral lines of mercury (UV not seen)

General properties

Name, symbol , number	mercury, Hg, 80
Pronunciation	/ˈmɜrkjəri/ or /ˈmɜrkəri/ <i>MER-k(y)ə-ree</i> alternatively /ˈkwɪksɪlvər/ or /haɪˈdrɑrdʒɪrəm/ <i>hye-DRAR-ji-rəm</i>
Element category	transition metal
Group, period, block	12 , 6 , d
Standard atomic weight	200.59(2)
Electron configuration	[Xe] 4f ¹⁴ 5d ¹⁰ 6s ²

Electrons per [shell](#) 2, 8, 18, 32, 18, 2 ([Image](#))

Physical properties

Phase	liquid
Density (near r.t.)	13.534 g·cm ⁻³
Melting point	234.32 K , -38.83 °C, -37.89 °F
Boiling point	629.88 K, 356.73 °C, 674.11 °F
Critical point	1750 K, 172.00 MPa
Heat of fusion	2.29 kJ·mol⁻¹
Heat of vaporization	59.11 kJ·mol⁻¹
Molar heat capacity	27.983 J·mol⁻¹·K⁻¹
Vapor pressure	
P (Pa)	1 10 100 1 k 10 k 100 k
at T (K)	315 350 393 449 523 629

Atomic properties

Oxidation states	4, 2 (mercuric), 1 (mercurous) (mildly basic oxide)
Electronegativity	2.00 (Pauling scale)
Ionization energies	1st: 1007.1 kJ·mol⁻¹ 2nd: 1810 kJ·mol⁻¹ 3rd: 3300 kJ·mol⁻¹
Atomic radius	151 pm
Covalent radius	132±5 pm
Van der Waals radius	155 pm

Miscellanea

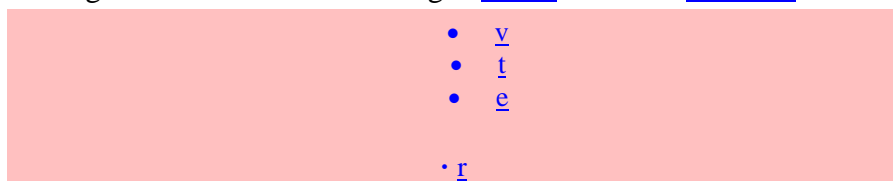
Crystal structure	rhombohedral
Magnetic ordering	diamagnetic ^[1]
Electrical resistivity	(25 °C) 961 nΩ·m
Thermal conductivity	8.30 W·m⁻¹·K⁻¹
Thermal expansion	(25 °C) 60.4 μm·m⁻¹·K⁻¹
Speed of sound	(liquid, 20 °C) 1451.4 m·s⁻¹
CAS registry number	7439-97-6

Most stable isotopes

Main article: [Isotopes of mercury](#)

iso	NA	half-life	DM	DE (MeV)	DP
¹⁹⁴ Hg	syn	444 y	ε	0.040	¹⁹⁴ Au
¹⁹⁵ Hg	syn	9.9 h	ε	1.510	¹⁹⁵ Au
¹⁹⁶ Hg	0.15%	¹⁹⁶ Hg is stable with 116 neutrons			
¹⁹⁷ Hg	syn	64.14 h	ε	0.600	¹⁹⁷ Au
¹⁹⁸ Hg	9.97%	¹⁹⁸ Hg is stable with 118 neutrons			
¹⁹⁹ Hg	16.87%	¹⁹⁹ Hg is stable with 119 neutrons			
²⁰⁰ Hg	23.1%	²⁰⁰ Hg is stable with 120 neutrons			
²⁰¹ Hg	13.18%	²⁰¹ Hg is stable with 121 neutrons			

²⁰² Hg	29.86%	²⁰² Hg is stable with 122 neutrons	
²⁰³ Hg	syn	46.612 d	β^- 0.492 ²⁰³ Tl
²⁰⁴ Hg	6.87%	²⁰⁴ Hg is stable with 124 neutrons	



Mercury is a [chemical element](#) with the symbol **Hg** and [atomic number](#) 80. It is also known as **quicksilver** or **hydrargyrum** (from "[hydr-](#)" *water* and "[argyros](#)" *silver*). A heavy, silvery [d-block](#) element, mercury is the only metal that is liquid at [standard conditions for temperature and pressure](#); the only other element that is liquid under these conditions is [bromine](#), and metals such as [caesium](#), [francium](#), [gallium](#), and [rubidium](#) melt just above room temperature. With a [freezing point](#) of -38.83 °C and [boiling point](#) of 356.73 °C , mercury has one of the narrowest ranges of its liquid state of any metal.^{[2][3][4]}

Mercury occurs in deposits throughout the world mostly as [cinnabar](#) ([mercuric sulfide](#)). The red pigment [vermilion](#) is mostly obtained by reduction from cinnabar. Cinnabar is highly toxic by ingestion or inhalation of the dust. [Mercury poisoning](#) can also result from exposure to water-soluble forms of mercury (such as [mercuric chloride](#) or [methylmercury](#)), inhalation of mercury vapor, or eating seafood contaminated with mercury.

Mercury is used in [thermometers](#), [barometers](#), [manometers](#), [sphygmomanometers](#), [float valves](#), some electrical switches, and other scientific apparatus, though concerns about the element's toxicity have led to mercury thermometers and sphygmomanometers being largely phased out in clinical environments in favor of [alcohol](#)-filled, [galinstan](#)-filled, digital, or [thermistor](#)-based instruments. It remains in use in scientific research applications and in [amalgam](#) material for [dental restoration](#). It is used in lighting: electricity passed through mercury vapor in a phosphor tube produces short-wave [ultraviolet light](#) which then causes the phosphor to [fluoresce](#), making visible light.

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Properties

Physical properties



A [pound coin](#) (density $\sim 7.6 \text{ g/cm}^3$) floats in mercury due to the combination of the [buoyant force](#) and [surface tension](#).

Mercury is a heavy, silvery-white metal. As compared to other metals, it is a poor conductor of heat, but a fair conductor of electricity.^[5] Mercury has an exceptionally low melting temperature for a d-block metal. A complete explanation of this fact requires a deep excursion into [quantum physics](#), but it can be summarized as follows: mercury has a unique electronic configuration where electrons fill up all the available 1s, 2s, 2p, 3s, 3p, 3d, 4s, 4p, 4d, 4f, 5s, 5p, 5d and 6s subshells. As such configuration strongly resists removal of an electron, mercury behaves similarly to [noble gas](#) elements, which form weak bonds and thus easily melting solids. The

stability of the 6s shell is due to the presence of a filled 4f shell. An f shell poorly screens the nuclear charge that increases the attractive [Coulomb interaction](#) of the 6s shell and the nucleus (see [lanthanide contraction](#)). The absence of a filled inner *f* shell is the reason for the somewhat higher melting temperature of [cadmium](#) and [zinc](#), although both these metals still melt easily and, in addition, have unusually low boiling points. Metals such as [gold](#) have atoms with one less 6s electron than mercury. Those electrons are more easily removed and are shared between the gold atoms forming relatively strong [metallic bonds](#).^{[3][6]}

Chemical properties

Mercury does not react with most acids, such as dilute [sulfuric acid](#), although [oxidizing acids](#) such as concentrated [sulfuric acid](#) and [nitric acid](#) or [aqua regia](#) dissolve it to give [sulfate](#), [nitrate](#), and [chloride](#) salts. Like silver, mercury reacts with atmospheric [hydrogen sulfide](#). Mercury even reacts with solid sulfur flakes, which are used in mercury spill kits to absorb mercury vapors (spill kits also use [activated carbon](#) and powdered zinc).^[7]

Amalgams



Mercury-discharge spectral calibration lamp

Mercury dissolves to form [amalgams](#) with gold, zinc and many other metals. Because iron is an exception, iron flasks have been traditionally used to trade mercury. Other metals that do not form amalgams with mercury include tantalum, tungsten and platinum. [Sodium amalgam](#) is a common reducing agent in [organic synthesis](#), and is also used in [high-pressure sodium](#) lamps.

Mercury readily combines with [aluminium](#) to form a [mercury-aluminium amalgam](#) when the two pure metals come into contact. Since the amalgam reacts with air to give aluminium oxide, small amounts of mercury corrode aluminium. For this reason, mercury is not allowed aboard an aircraft under most circumstances because of the risk of it forming an amalgam with exposed aluminium parts in the aircraft.^[8]

Isotopes

Main article: [Isotopes of mercury](#)

There are seven stable [isotopes](#) of mercury with ²⁰²Hg being the most abundant (29.86%). The longest-lived [radioisotopes](#) are ¹⁹⁴Hg with a [half-life](#) of 444 years, and ²⁰³Hg with a half-life of 46.612 days. Most of the remaining radioisotopes have half-lives that are less than a day. ¹⁹⁹Hg and ²⁰¹Hg are the most often studied [NMR](#)-active nuclei, having spins of 1/2 and 3/2 respectively.^[5]

History



The symbol for [the planet Mercury](#) (♿) has been used since ancient times to represent the element

Mercury was found in [Egyptian](#) tombs that date from 1500 BC.^[9]

In [China](#) and [Tibet](#), mercury use was thought to prolong life, heal fractures, and maintain generally good health, although it is now known that exposure to mercury leads to serious adverse health effects.^[10] One of China's emperors, [Qín Shǐ Huáng Dì](#) — allegedly buried in a tomb that contained rivers of flowing mercury on a model of the land he ruled, representative of the rivers of China — was killed by drinking a mercury and powdered [jade](#) mixture formulated by [Qin](#) alchemists (causing [liver failure](#), [mercury poisoning](#), and [brain death](#)) who intended to give him eternal life.^{[11][12]}

The [ancient Greeks](#) used mercury in ointments; the [ancient Egyptians](#) and the [Romans](#) used it in [cosmetics](#) which sometimes deformed the face. In [Lamanai](#), once a major city of the [Maya civilization](#), a pool of mercury was found under a marker in a [Mesoamerican ballcourt](#).^{[13][14]} By 500 BC mercury was used to make [amalgams](#) (Medieval Latin *amalgama*, "alloy of mercury") with other metals.^[15]

[Alchemists](#) thought of mercury as the [First Matter](#) from which all metals were formed. They believed that different [metals](#) could be produced by varying the quality and quantity of [sulfur](#) contained within the mercury. The purest of these was gold, and mercury was called for in attempts at the [transmutation](#) of base (or impure) metals into gold, which was the goal of many alchemists.^[16]

Hg is the modern [chemical symbol](#) for mercury. It comes from *hydrargyrum*, a [Latinized](#) form of the [Greek](#) word ὕδραργυρος (*hydrargyros*), which is a compound word meaning "water-silver" (hydr- = water, argyros = silver) — since it is liquid like water and shiny like silver. The element was named after the Roman god [Mercury](#), known for speed and mobility. It is associated with the planet [Mercury](#); the astrological symbol for the planet is also one of the [alchemical symbols](#) for the metal; the Indian word for alchemy is [Rasavātam](#) which means "the way of mercury".^[17] Mercury is the only metal for which the alchemical planetary name became the common name.^[16]

The mines in [Almadén](#) (Spain), [Monte Amiata](#) (Italy), and [Idrija](#) (now Slovenia) dominated the mercury production from the opening of the mine in Almadén 2500 years ago until new deposits were found at the end of the 19th century.^[18]

Occurrence

See also: [Category:Mercury minerals](#) and [Category:Mercury mines](#)



Mercury output in 2005

Mercury is an extremely rare element in the Earth's [crust](#), having an average crustal abundance by mass of only 0.08 parts per million (ppm).^[19] However, because it does not blend [geochemically](#) with those elements that constitute the majority of the crustal mass, mercury ores can be extraordinarily concentrated considering the element's abundance in ordinary rock. The richest mercury ores contain up to 2.5% mercury by mass, and even the leanest concentrated deposits are at least 0.1% mercury (12,000 times average crustal abundance). It is found either as a native metal (rare) or in [cinnabar](#), [corderoite](#), [livingstonite](#) and other [minerals](#), with cinnabar (HgS) being the most common ore.^[20] Mercury ores usually occur in very young orogenic belts where rock of high density are forced to the crust of the Earth, often in hot springs or other [volcanic](#) regions.^[21]

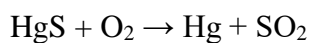
Beginning in 1558, with the invention of the [patio process](#) to extract silver from ore using mercury, mercury became an essential resource in the economy of Spain and its American colonies. Mercury was used to extract silver from the lucrative mines in [New Spain](#) and [Peru](#). Initially, the Spanish Crown's mines in Almaden in Southern Spain supplied all the mercury for the colonies.^[22] Mercury deposits were discovered in the New World, and more than 100,000 tons of mercury were mined from the region of [Huancavelica](#), Peru, over the course of three centuries following the discovery of deposits there in 1563. The patio process and later [pan amalgamation](#) process continued to create great demand for mercury to treat silver ores until the late 19th century.^[23]



Native mercury with [cinnabar](#), Socrates mine, [Sonoma County, California](#). Cinnabar sometimes alters to native mercury in the oxidized zone of mercury deposits.

Former mines in [Italy](#), the [United States](#) and [Mexico](#) which once produced a large proportion of the world supply have now been completely mined out or, in the case of [Slovenia \(Idrija\)](#) and Spain ([Almadén](#)), shut down due to the fall of the price of mercury. [Nevada's McDermitt Mine](#), the last mercury mine in the United States, closed in 1992. The price of mercury has been highly volatile over the years and in 2006 was \$650 per 76-pound (34.46 kg) flask.^[24]

Mercury is extracted by heating cinnabar in a current of air and condensing the vapor. The equation for this extraction is



In 2005, China was the top producer of mercury with almost two-thirds global share followed by [Kyrgyzstan](#).^[25] Several other countries are believed to have unrecorded production of mercury from copper [electrowinning](#) processes and by recovery from effluents.

Because of the high toxicity of mercury, both the mining of cinnabar and refining for mercury are hazardous and historic causes of mercury poisoning.^[26] In China, prison labor was used by a private mining company as recently as the 1950s to create new cinnabar mercury mines. Thousands of prisoners were used by the Luo Xi mining company to establish new tunnels.^[27] In addition, worker health in functioning mines is at high risk.

The [European Union](#) directive calling for compact [fluorescent bulbs](#) to be made mandatory by 2012 has encouraged China to re-open deadly cinnabar mines to obtain the mercury required for CFL bulb manufacture. As a result, environmental dangers have been a concern, particularly in the southern cities of [Foshan](#) and [Guangzhou](#), and in the [Guizhou](#) province in the south west.^[27]

Abandoned mercury mine processing sites often contain very hazardous waste piles of roasted cinnabar calcines. Water run-off from such sites is a recognized source of ecological damage. Former mercury mines may be suited for constructive re-use. For example, in 1976 [Santa Clara County, California](#) purchased the historic [Almaden Quicksilver Mine](#) and created a county park on the site, after conducting extensive safety and environmental analysis of the property.^[28]

Chemistry

See also: [Category:Mercury compounds](#)

Mercury exists in two main oxidation states, I and II. Higher oxidation states are unimportant, but have been detected, e.g., [mercury\(IV\) fluoride](#) (HgF₄) but only under extraordinary conditions.^[29]

Compounds of mercury(I)

Different from its lighter neighbors, cadmium and zinc, mercury forms simple stable compounds with metal-metal bonds. The mercury(I) compounds are [diamagnetic](#) and feature the dimeric cation, Hg₂²⁺

2. Stable derivatives include the chloride and nitrate. Treatment of Hg(I) compounds complexation with strong ligands such as sulfide, cyanide, etc. induces disproportionation to Hg²⁺ and elemental mercury.^[30] [Mercury\(I\) chloride](#), a colorless solid also known as [calomel](#), is really the compound with the formula Hg₂Cl₂, with the connectivity Cl-Hg-Hg-Cl. It is a standard in electrochemistry. It reacts with chlorine to give mercuric chloride, which resists further oxidation.

Indicative of its tendency to bond to itself, mercury forms [mercury polycations](#), which consist of linear chains of mercury centers, capped with a positive charge. One example is Hg₃²⁺(AsF₆⁻)₂.^[31]

Compounds of mercury(II)

Mercury(II) is the most common oxidation state and is the main one in nature as well. All four mercuric halides are known. They form tetrahedral complexes with other ligands but the halides adopt linear coordination geometry, somewhat like Ag⁺ does. Best known is [mercury\(II\) chloride](#), an easily [sublimating](#) white solid. HgCl₂ forms [coordination complexes](#) that are typically tetrahedral, e.g. HgCl₄²⁻.

[Mercury\(II\) oxide](#), the main [oxide](#) of mercury, arises when the metal is exposed to air for long periods at elevated temperatures. It reverts to the elements upon heating near 400 °C, as was demonstrated by Priestly in an early synthesis of pure [oxygen](#).^[7] Hydroxides of mercury are poorly characterized, as they are for its neighbors gold and silver.

Being a [soft metal](#), mercury forms very stable derivatives with the heavier chalcogens. Preeminent is [mercury\(II\) sulfide](#), HgS, which occurs in nature as the ore cinnabar and is the brilliant pigment [vermillion](#). Like ZnS, HgS crystallizes in two [forms](#), the reddish cubic form and the black [zinc blende](#) form.^[5] [Mercury\(II\) selenide](#) (HgSe) and [mercury\(II\) telluride](#) (HgTe) are also known, these as well as various derivatives, e.g. [mercury cadmium telluride](#) and [mercury zinc telluride](#) being [semiconductors](#) useful as [infrared detector](#) materials.^[32]

Mercury(II) salts form a variety of complex derivatives with [ammonia](#). These include Millon's base (Hg₂N⁺), the one-dimensional polymer (salts of HgNH₂⁺)_n, and "fusible white precipitate"

or $[\text{Hg}(\text{NH}_3)_2]\text{Cl}_2$. Known as [Nessler's reagent](#), potassium tetraiodomercurate(II) (HgI_4^{2-}) is still occasionally used to test for ammonia owing to its tendency to form the deeply colored iodide salt of Millon's base.

[Mercury fulminate](#), (a [detonator](#) widely used in [explosives](#));^[5]

Compounds of mercury(IV)

Mercury(IV) is the rarest oxidation state of mercury which is known to exist. The only known mercury(IV) compound is [mercury\(IV\) fluoride](#).

Organomercury compounds

Main article: [Organomercury compound](#)

Organic mercury [compounds](#) are historically important but are of little industrial value in the western world. Mercury(II) salts are a rare examples of simple metal complexes that react directly with aromatic rings. Organomercury compounds are always divalent and usually two-coordinate and linear geometry. Unlike organocadmium and organozinc compounds, organomercury compounds do not react with water. They usually have the formula HgR_2 , which are often volatile, or HgRX , which are often solids, where R is [aryl](#) or [alkyl](#) and X is usually halide or acetate. [Methylmercury](#), a generic term for compounds with the formula CH_3HgX is a dangerous family of compounds that is found in some a [polluted](#) water.^[33] They arise by a process known as biomethylation.

Applications



 The bulb of a [mercury-in-glass thermometer](#)

Mercury is used primarily for the manufacture of industrial chemicals or for electrical and electronic applications. It is used in some thermometers, especially ones which are used to measure high temperatures. A still increasing amount is used as gaseous mercury in [fluorescent lamps](#), while most of the other applications are slowly phased out due to health and safety regulations and is in some applications replaced with less toxic but considerably more expensive [Galinstan alloy](#).^[34]

Medicine



☐
Amalgam filling



☐
The deep violet glow of a mercury vapor discharge in a [germicidal lamp](#), whose spectrum is rich in invisible ultraviolet radiation.
See also: [Amalgam \(dentistry\)](#)

Mercury and its compounds have been used in medicine, although they are much less common today than they once were, now that the toxic effects of mercury and its compounds are more widely understood. The element mercury is an ingredient in [dental amalgams](#). [Thiomersal](#) (called *Thimerosal* in the United States) is an [organic compound](#) used as a [preservative](#) in [vaccines](#),

though this use is in decline.^[35] Another mercury compound [Merbromin](#) (Mercurochrome) is a topical antiseptic used for minor cuts and scrapes is still in use in some countries.

Since the 1930s some [vaccines](#) have contained the preservative [thiomersal](#), which is metabolized or degraded to [ethyl mercury](#). Although it was [widely speculated](#) that this mercury-based preservative can cause or trigger [autism](#) in children, scientific studies showed no evidence supporting any such link.^[36] Nevertheless thiomersal has been removed from or reduced to trace amounts in all U.S. vaccines recommended for children 6 years of age and under, with the exception of inactivated influenza vaccine.^[37]

Mercury in the form of one of its common ores, cinnabar, is used in various traditional medicines, especially in [traditional Chinese medicine](#). Review of its safety has found cinnabar can lead to significant mercury intoxication when heated, consumed in [overdose](#) or taken long term, and can have adverse effects at therapeutic doses, though this is typically reversible at therapeutic doses. Although this form of mercury appears less toxic than others, its use in traditional Chinese medicine has not yet been justified as the therapeutic basis for the use of cinnabar is not clear.^[38]

Today, the use of mercury in medicine has greatly declined in all respects, especially in developed countries. [Thermometers](#) and [sphygmomanometers](#) containing mercury were invented in the early 18th and late 19th centuries, respectively. In the early 21st century, their use is declining and has been banned in some countries, states and medical institutions. In 2002, the [U.S. Senate](#) passed legislation to phase out the sale of [non-prescription](#) mercury thermometers. In 2003, [Washington](#) and [Maine](#) became the first states to ban mercury blood pressure devices.^[39] Mercury compounds are found in some [over-the-counter drugs](#), including topical [antiseptics](#), stimulant laxatives, [diaper-rash ointment](#), [eye drops](#), and [nasal sprays](#). The [FDA](#) has "inadequate data to establish general recognition of the safety and effectiveness", of the mercury ingredients in these products.^[40] Mercury is still used in some diuretics, although substitutes now exist for most therapeutic uses.

Production of chlorine and caustic soda

[Chlorine](#) is produced from [sodium chloride](#) (common salt, NaCl) using [electrolysis](#) to separate the metallic [sodium](#) from the chlorine gas. Usually the salt is dissolved in water to produce a brine. By-products of any such [chloralkali process](#) are hydrogen (H₂) and [sodium hydroxide](#) (NaOH), which is commonly called caustic soda or [lye](#). By far the largest use of mercury^{[41][42]} in the late 20th century was in the mercury cell process (also called the [Castner-Kellner process](#)) where metallic sodium is formed as an [amalgam](#) at a [cathode](#) made from mercury; this sodium is then reacted with water to produce sodium hydroxide.^[43] Many of the industrial mercury releases of the 20th century came from this process, although modern plants claimed to be safe in this regard.^[42] After about 1985, all new chloralkali production facilities that were built in the United States used either [membrane cell or diaphragm cell technologies](#) to produce chlorine.

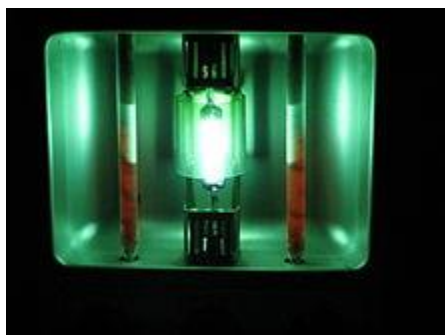
Laboratory uses


Some medical thermometers, especially those for high temperatures, are filled with mercury; however, they are gradually disappearing. In the United States, non-prescription sale of mercury fever thermometers has been banned since 2003.^[44]

Mercury is also found in [liquid mirror telescopes](#). The mirror is formed by rotating liquid mercury on a disk, the parabolic form of the liquid thus formed reflecting and focusing incident light. Such telescopes are cheaper than conventional large mirror telescopes by up to a factor of 100, but the mirror cannot be tilted and always points straight up.^{[45][46][47]}


Liquid mercury is a part of popular secondary reference [electrode](#) (called the [calomel electrode](#)) in [electrochemistry](#) as an alternative to the [standard hydrogen electrode](#). The calomel electrode is used to work out the [electrode potential](#) of [half cells](#).^[48] Last, but not least, the [triple point](#) of mercury, -38.8344 °C , is a fixed point used as a temperature standard for the International Temperature Scale ([ITS-90](#)).^[51]

Niche uses



 Skin tanner containing a low-pressure mercury vapor lamp and two infrared lamps, which act both as light source and [electrical ballast](#)



 Assorted types of fluorescent lamps.

Gaseous mercury is used in [mercury-vapor lamps](#) and some "[neon sign](#)" type advertising signs and [fluorescent lamps](#). Those low-pressure lamps emit very spectrally narrow lines, which are traditionally used in [optical spectroscopy](#) for calibration of spectral position. Commercial calibration lamps are sold for this purpose; however simply reflecting some of the fluorescent-lamp ceiling light into a spectrometer is a common calibration practice.^[49] Gaseous mercury is

also found in some [electron tubes](#), including [ignitrons](#), [thyratrons](#), and [mercury arc rectifiers](#).^[50] It is also used in specialist medical care lamps for skin tanning and disinfection (see pictures).^[51] Gaseous mercury is added to [cold cathode argon](#)-filled lamps to increase the [ionization](#) and [electrical conductivity](#). An argon filled lamp without mercury will have dull spots and will fail to light correctly. Lighting containing mercury can be [bombarded](#)/oven pumped only once. When added to [neon](#) filled tubes the light produced will be inconsistent red/blue spots until the initial burning-in process is completed; eventually it will light a consistent dull off-blue color.^[52]

Cosmetics

Mercury, as [thiomersal](#), is widely used in the manufacture of [mascara](#). In 2008, Minnesota became the first state in the US to ban intentionally added mercury in cosmetics, giving it a tougher standard than the federal government.^[53]

A study in geometric mean urine mercury concentration identified a previously unrecognized source of exposure (skin care products) to inorganic mercury among [New York City](#) residents. Population-based biomonitoring also showed that mercury concentration levels are higher in consumers of seafood and fish meals.^[54]

Historic uses



 Old mercury switches



Mercury [manometer](#) to measure pressure

Many historic applications made use of the peculiar physical properties of mercury, especially as a dense liquid and a liquid metal:

- In [Islamic Spain](#), it was used for filling decorative pools. Later, the American artist [Alexander Calder](#) built a [mercury fountain](#) for the Spanish Pavilion at the [1937 World Exhibition in Paris](#). The fountain is now on display at the [Fundació Joan Miró](#) in [Barcelona](#).^[55]
- Mercury was used inside [wobbler](#) lures. Its heavy, liquid form made it useful since the lures made an attractive irregular movement when the mercury moved inside the plug. Such use was stopped due to environmental concerns, but illegal preparation of modern fishing plugs has occurred.
- The [Fresnel lenses](#) of old [lighthouses](#) used to float and rotate in a bath of mercury which acted like a bearing.^[56]
- Mercury [sphygmomanometers](#) (blood pressure meter), [barometers](#), [diffusion pumps](#), [coulometers](#), and many other laboratory instruments. As an opaque liquid with a high density and a nearly linear thermal expansion, it is ideal for this role.^[57]
- As an electrically conductive liquid, it was used in [mercury switches](#) (including [home mercury light switches](#) installed prior to 1970), tilt switches used in old fire detectors, and tilt switches in many modern home thermostats,^[58]
- Owing to its acoustic properties, mercury was used as the propagation medium in [delay line memory](#) devices used in early digital computers of the mid-20th century.
- Experimental [mercury vapor turbines](#) were installed to increase the efficiency of fossil-fuel electrical power plants.^[59] The South Meadow power plant in Hartford, CT employed mercury as its [working fluid](#), in a [binary](#) configuration with a secondary water circuit, for a number of years starting in the late 1920s in a drive to improve plant efficiency. Several other plants were built, including the Schiller Station in Portsmouth,

NH, which went online in 1950. The idea did not catch on industry-wide due to the weight and toxicity of mercury, as well as the advent of [supercritical](#) steam plants in later years.^{[60][61]}

- Similarly, liquid mercury was used as a [coolant](#) for some [nuclear reactors](#); however, [sodium](#) is proposed for reactors cooled with liquid metal, because the high density of mercury requires much more energy to circulate as coolant.^[62]
- Mercury was a propellant for early [ion engines](#) in [electric space propulsion](#) systems. Advantages were mercury's high molecular weight, low ionization energy, low dual-ionization energy, high liquid density and liquid storability at [room temperature](#). Disadvantages were concerns regarding environmental impact associated with ground testing and concerns about eventual cooling and condensation of some of the propellant on the spacecraft in long-duration operations. The first spaceflight to use electric propulsion was a mercury-fueled ion thruster developed by [NASA Lewis](#) and flown on the Space Electric Rocket Test "[SERT-1](#)" spacecraft launched by [NASA](#) at its [Wallops Flight Facility](#) in 1964. The SERT-1 flight was followed up by the SERT-2 flight in 1970. Mercury and [caesium](#) were preferred propellants for ion engines until [Hughes Research Laboratory](#) performed studies finding [xenon](#) gas to be a suitable replacement. Xenon is now the preferred propellant for ion engines as it has a high molecular weight, little or no reactivity due to its [noble gas](#) nature, and has a high liquid density under mild cryogenic storage.^{[63][64]}

Others applications made use of the chemical properties of mercury:

- The [mercury battery](#) is a non-rechargeable [electrochemical battery](#), a [primary cell](#), that was common throughout the middle of the 20th century. It was used in a wide variety of applications and was available in various sizes, particularly button sizes. Its constant voltage output and long shelf life gave it a niche use for camera light meters and hearing aids. The mercury cell was effectively banned in most countries in the 1990s due to concerns about the mercury contaminating landfills.
- Mercury was used for preserving wood, developing [daguerreotypes](#), [silvering mirrors](#), anti-fouling paints (discontinued in 1990), [herbicides](#) (discontinued in 1995), handheld maze games, cleaning, and road leveling devices in cars. Mercury compounds have been used in [antiseptics](#), laxatives, [antidepressants](#), and in [antisyphilitics](#).
- It was allegedly used by [allied spies](#) to sabotage Luftwaffe planes: a mercury paste was applied to bare [aluminium](#), causing the metal to rapidly [corrode](#); this would cause structural failures.^[65]
- [Chloralkali process](#): The largest industrial use of mercury during the 20th century was in electrolysis for separating chlorine and sodium from brine; mercury being the [anode](#) of the [Castner-Kellner process](#). The chlorine was used for bleaching paper (hence the location of many of these plants near paper mills) while the sodium was used to make sodium hydroxide for soaps and other cleaning products. This usage has largely been discontinued, replaced with other technologies that utilize membrane cells.^[66]
- As [electrodes](#) in some types of [electrolysis](#), [batteries](#) ([mercury cells](#)), [sodium hydroxide](#) and [chlorine](#) production, handheld games, [catalysts](#), [insecticides](#).
- Mercury was once used as a gun barrel bore cleaner.^{[67][68]}

- From the mid-18th to the mid-19th centuries, a process called "[carroting](#)" was used in the making of [felt](#) hats. Animal skins were rinsed in an orange solution (the term "carroting" arose from this color) of the mercury compound [mercuric nitrate](#), $\text{Hg}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$.^[69] This process separated the fur from the pelt and matted it together. This solution and the vapors it produced were highly toxic. The [United States Public Health Service](#) banned the use of mercury in the felt industry in December 1941. The psychological symptoms associated with mercury poisoning are said by some to have inspired the phrase "mad as a hatter". [Lewis Carroll](#)'s "[Mad Hatter](#)" in his book [Alice's Adventures in Wonderland](#) was a play on words based on the older phrase, but the character himself does not exhibit symptoms of mercury poisoning.^[70]
- Gold and silver mining. Historically, mercury was used extensively in hydraulic gold mining in order to help the gold to sink through the flowing water-gravel mixture. Thin mercury particles may form mercury-gold amalgam and therefore increase the gold recovery rates.^[5] Large-scale use of mercury stopped in the 1960s. However, mercury is still used in small scale, often clandestine, gold prospecting. It is estimated that 45,000 metric tons of mercury used in California for [placer mining](#) have not been recovered.^[71] Mercury was also used in silver mining.^[72]

Historic medicinal uses

Mercury(I) chloride (also known as calomel or mercurous chloride) has been used in [traditional medicine](#) as a [diuretic](#), topical [disinfectant](#), and [laxative](#). [Mercury\(II\) chloride](#) (also known as mercuric chloride or corrosive sublimate) was once used to treat [syphilis](#) (along with other mercury compounds), although it is so toxic that sometimes the symptoms of its toxicity were confused with those of the syphilis it was believed to treat.^[73] It is also used as a disinfectant. [Blue mass](#), a pill or syrup in which mercury is the main ingredient, was prescribed throughout the 19th century for numerous conditions including constipation, depression, child-bearing and toothaches.^[74] In the early 20th century, mercury was administered to children yearly as a laxative and dewormer, and it was used in teething powders for infants. The mercury-containing organohalide [merbromin](#) (sometimes sold as Mercurochrome) is still widely used but has been banned in some countries such as the U.S.^[75]

Toxicity and safety

See also: [Mercury poisoning](#)



Mercury and most of its compounds are extremely toxic and must be handled with care; in cases of spills involving mercury (such as from certain [thermometers](#) or [fluorescent light bulbs](#)), specific cleaning procedures are used to avoid exposure and contain the spill.^[76] Protocols call for physically merging smaller droplets on hard surfaces, combining them into a single larger pool for easier removal with an [eyedropper](#), or for gently pushing the spill into a disposable container. Vacuum cleaners and brooms cause greater dispersal of the mercury and should not be

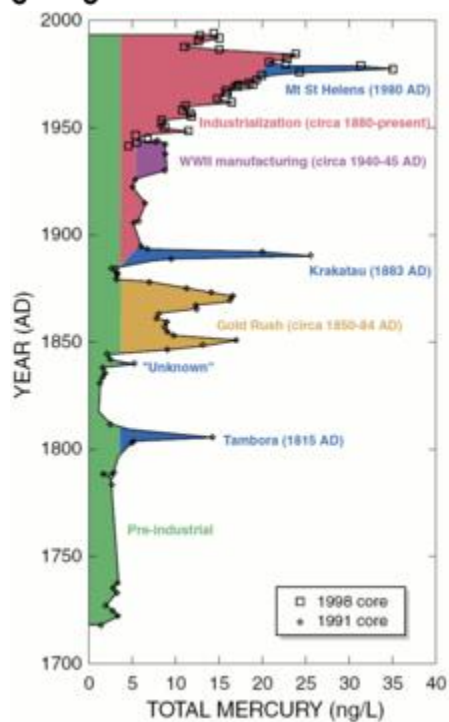
used. Afterwards, fine [sulfur](#), [zinc](#), or some other powder that readily forms an amalgam (alloy) with mercury at ordinary temperatures is sprinkled over the area before itself being collected and properly disposed of. Cleaning porous surfaces and clothing is not effective at removing all traces of mercury and it is therefore advised to discard these kinds of items should they be exposed to a mercury spill.

Mercury can be inhaled and absorbed through the skin and mucous membranes, so containers of mercury are securely sealed to avoid spills and evaporation. Heating of mercury, or of compounds of mercury that may decompose when heated, is always carried out with adequate ventilation in order to avoid exposure to mercury vapor. The most toxic forms of mercury are its [organic compounds](#), such as [dimethylmercury](#) and [methylmercury](#). However, inorganic compounds, such as [cinnabar](#) are also highly toxic by ingestion or inhalation.^[77] Mercury can cause both chronic and acute poisoning.

Releases in the environment



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Amount of atmospheric mercury deposited at Wyoming's Upper Fremont Glacier over the last 270 years

Preindustrial deposition rates of mercury from the atmosphere may be about 4 ng/(1 L of ice deposit). Although that can be considered a natural level of exposure, regional or global sources have significant effects. Volcanic eruptions can increase the atmospheric source by 4–6 times.^[78]

Natural sources, such as [volcanoes](#), are responsible for approximately half of atmospheric mercury emissions. The human-generated half can be divided into the following estimated percentages:^{[79][80][81]}

- 65% from stationary combustion, of which [coal-fired power plants](#) are the largest aggregate source (40% of U.S. mercury emissions in 1999). This includes power plants fueled with gas where the mercury has not been removed. Emissions from coal combustion are between one and two orders of magnitude higher than emissions from oil combustion, depending on the country.^[79]
- 11% from gold production. The three largest point sources for mercury emissions in the U.S. are the three largest gold mines. Hydrogeochemical release of mercury from gold-mine tailings has been accounted as a significant source of atmospheric mercury in eastern Canada.^[82]
- 6.8% from [non-ferrous metal](#) production, typically [smelters](#).
- 6.4% from [cement](#) production.
- 3.0% from [waste disposal](#), including [municipal](#) and [hazardous waste](#), [crematoria](#), and [sewage sludge](#) incineration. This is a significant underestimate due to limited information, and is likely to be off by a factor of two to five.
- 3.0% from [caustic soda](#) production.
- 1.4% from [pig iron](#) and [steel](#) production.
- 1.1% from mercury production, mainly for batteries.
- 2.0% from other sources.

The above percentages are estimates of the global human-caused mercury emissions in 2000, excluding biomass burning, an important source in some regions.^[79]

Current atmospheric mercury contamination in outdoor urban air is (0.01–0.02 $\mu\text{g}/\text{m}^3$) indoor concentrations are significantly elevated over outdoor concentrations, in the range 0.0065–0.523 $\mu\text{g}/\text{m}^3$ (average 0.069 $\mu\text{g}/\text{m}^3$).^[83]

Mercury also enters into the environment through the improper disposal (e.g., land filling, incineration) of certain products. Products containing mercury include: auto parts, [batteries](#), fluorescent bulbs, medical products, thermometers, and thermostats.^[84] Due to health concerns (see below), [toxics use reduction](#) efforts are cutting back or eliminating mercury in such products. For example, most thermometers now use pigmented [alcohol](#) instead of mercury, and [galinstan](#) alloy thermometers are also an option. Mercury thermometers are still occasionally used in the medical field because they are more accurate than alcohol thermometers, though both are commonly being replaced by electronic thermometers and less commonly by galinstan thermometers. Mercury thermometers are still widely used for certain scientific applications because of their greater accuracy and working range.

The United States [Clean Air Act](#), passed in 1990, put mercury on a list of toxic pollutants that need to be controlled to the greatest possible extent. Thus, industries that release high concentrations of mercury into the environment agreed to install maximum achievable control technologies (MACT). In March 2005 EPA rule^[85] added power plants to the list of sources that should be controlled and a national [cap and trade](#) rule was issued. States were given until

November 2006 to impose stricter controls, and several States are doing so. The rule was being subjected to legal challenges from several States in 2005 and decision was made in 2008. The Clean Air Mercury Rule was struck down by a Federal Appeals Court on February 8, 2008. The rule was deemed not sufficient to protect the health of persons living near coal-fired power plants. The court opinion cited the negative impact on human health from coal-fired power plants' mercury emissions documented in the EPA Study Report to Congress of 1998.^[86]

The EPA announced new rules for coal-fired power plants on December 22, 2011.^[87] Cement kilns that burn hazardous waste are held to a looser standard than are standard [hazardous waste incinerators](#) in the United States, and as a result are a disproportionate source of mercury pollution.^[88]

Historically, one of the largest releases was from the Colex plant, a lithium-isotope separation plant at Oak Ridge. The plant operated in the 1950s and 1960s. Records are incomplete and unclear, but government commissions have estimated that some two million pounds of mercury are unaccounted for.^[89]

A serious [industrial disasters](#) was the dumping of mercury compounds into [Minamata Bay](#), Japan. It is estimated that over 3,000 people suffered various deformities, severe mercury poisoning symptoms or death from what became known as [Minamata disease](#).^[90]

Occupational exposure

Due to the health effects of mercury exposure, industrial and commercial uses are regulated in many countries. The [World Health Organization](#), [OSHA](#), and [NIOSH](#) all treat mercury as an occupational hazard, and have established specific occupational exposure limits. Environmental releases and disposal of mercury are regulated in the U.S. primarily by the [United States Environmental Protection Agency](#).

[Case control studies](#) have shown effects such as tremors, impaired [cognitive](#) skills, and sleep disturbance in workers with chronic exposure to mercury vapor even at low concentrations in the range 0.7–42 $\mu\text{g}/\text{m}^3$.^{[91][92]} A study has shown that acute exposure (4 – 8 hours) to calculated elemental mercury levels of 1.1 to 44 mg/m^3 resulted in chest pain, [dyspnea](#), cough, [hemoptysis](#), impairment of pulmonary function, and evidence of interstitial [pneumonitis](#).^[93] Acute exposure to mercury vapor has been shown to result in profound central nervous system effects, including psychotic reactions characterized by delirium, hallucinations, and suicidal tendency. Occupational exposure has resulted in broad-ranging functional disturbance, including [erethism](#), irritability, excitability, excessive shyness, and insomnia. With continuing exposure, a fine tremor develops and may escalate to violent muscular spasms. Tremor initially involves the hands and later spreads to the eyelids, lips, and tongue. Long-term, low-level exposure has been associated with more subtle symptoms of erethism, including fatigue, irritability, loss of memory, vivid dreams and depression.^{[94][95]}

Treatment

Research on the treatment of mercury poisoning is limited. Currently available drugs for acute mercurial poisoning include chelators N-acetyl-D, L-[penicillamine](#) (NAP), [British Anti-Lewisite](#) (BAL), [2,3-dimercapto-1-propanesulfonic acid](#) (DMPS), and [dimercaptosuccinic acid](#) (DMSA). In one small study including 11 construction workers exposed to elemental mercury, patients were treated with DMSA and NAP.^[96] [Chelation therapy](#) with both drugs resulted in the mobilization of a small fraction of the total estimated body mercury. DMSA was able to increase the excretion of mercury to a greater extent than NAP.^[97]

Fish

Main article: [Mercury in fish](#)

[Fish](#) and [shellfish](#) have a natural tendency to concentrate mercury in their bodies, often in the form of [methylmercury](#), a highly toxic organic compound of mercury. Species of fish that are high on the [food chain](#), such as [shark](#), [swordfish](#), [king mackerel](#), [albacore tuna](#), and [tilefish](#) contain higher concentrations of mercury than others. As mercury and methylmercury are fat soluble, they primarily accumulate in the [viscera](#), although they are also found throughout the muscle tissue.^[98] When this fish is consumed by a predator, the mercury level is accumulated. Since fish are less efficient at depurating than accumulating methylmercury, fish-tissue concentrations increase over time. Thus species that are high on the [food chain](#) amass body burdens of mercury that can be ten times higher than the species they consume. This process is called [biomagnification](#). [Mercury poisoning](#) happened this way in [Minamata, Japan](#), now called [Minamata disease](#).

Regulations

In the United States, the [Environmental Protection Agency](#) is charged with regulating and managing mercury contamination. Several laws give the EPA this authority, including the [Clean Air Act](#), the [Clean Water Act](#), the [Resource Conservation and Recovery Act](#), and the [Safe Drinking Water Act](#). Additionally, the [Mercury-Containing and Rechargeable Battery Management Act](#), passed in 1996, phases out the use of mercury in batteries, and provides for the efficient and cost-effective disposal of many types of used batteries.^[99] North America contributed approximately 11% of the total global anthropogenic mercury emissions in 1995.^[100]

In the [European Union](#), the directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (see [RoHS](#)) bans mercury from certain electrical and electronic products, and limits the amount of mercury in other products to less than 1000 [ppm](#).^[101] There are restrictions for mercury concentration in packaging (the limit is 100 ppm for sum of mercury, [lead](#), [hexavalent chromium](#) and [cadmium](#)) and batteries (the limit is 5 ppm).^[102] In July 2007, the European Union also banned mercury in non-electrical measuring devices, such as thermometers and barometers. The ban applies to new devices only, and contains exemptions for the health care sector and a two-year grace period for manufacturers of barometers.^[103]

[Norway](#) enacted a total ban on the use of mercury in the manufacturing and import/export of mercury products, effective January 1, 2008.^[104] In 2002, several lakes in Norway were found to

have a poor state of mercury pollution, with an excess of 1 mg/g of mercury in their sediment.^[105]

References