[This is a good article. Follow the link for more information.](https://en.wikipedia.org/wiki/Wikipedia:Good_articles)

[Listen to this article](https://en.wikipedia.org/wiki/File:Silver.ogg)

**Silver**

From Wikipedia, the free encyclopedia

[Jump to navigation](https://en.wikipedia.org/wiki/Silver#mw-head) [Jump to search](https://en.wikipedia.org/wiki/Silver#p-search)

This article is about the chemical element. For other uses, see [Silver (disambiguation)](https://en.wikipedia.org/wiki/Silver_(disambiguation)).

|  |  |
| --- | --- |
| Silver,  47Ag | |
| [Silver crystal.jpg](https://en.wikipedia.org/wiki/File:Silver_crystal.jpg) | |
| **General properties** | |
| **Appearance** | lustrous white metal |
| [**Standard atomic weight**](https://en.wikipedia.org/wiki/Standard_atomic_weight) **(*A*r, standard)** | 107.8682(2)[[1]](https://en.wikipedia.org/wiki/Silver#cite_note-CIAAW2016-1) |
| **Silver in the** [**periodic table**](https://en.wikipedia.org/wiki/Periodic_table) | |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | [Hydrogen](https://en.wikipedia.org/wiki/Hydrogen) |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | [Helium](https://en.wikipedia.org/wiki/Helium) | | [Lithium](https://en.wikipedia.org/wiki/Lithium) | [Beryllium](https://en.wikipedia.org/wiki/Beryllium) |  | | | | | | | | | | | | | | | | | | | | | | | | [Boron](https://en.wikipedia.org/wiki/Boron) | [Carbon](https://en.wikipedia.org/wiki/Carbon) | [Nitrogen](https://en.wikipedia.org/wiki/Nitrogen) | [Oxygen](https://en.wikipedia.org/wiki/Oxygen) | [Fluorine](https://en.wikipedia.org/wiki/Fluorine) | [Neon](https://en.wikipedia.org/wiki/Neon) | | [Sodium](https://en.wikipedia.org/wiki/Sodium) | [Magnesium](https://en.wikipedia.org/wiki/Magnesium) |  | | | | | | | | | | | | | | | | | | | | | | | | [Aluminium](https://en.wikipedia.org/wiki/Aluminium) | [Silicon](https://en.wikipedia.org/wiki/Silicon) | [Phosphorus](https://en.wikipedia.org/wiki/Phosphorus) | [Sulfur](https://en.wikipedia.org/wiki/Sulfur) | [Chlorine](https://en.wikipedia.org/wiki/Chlorine) | [Argon](https://en.wikipedia.org/wiki/Argon) | | [Potassium](https://en.wikipedia.org/wiki/Potassium) | [Calcium](https://en.wikipedia.org/wiki/Calcium) | [Scandium](https://en.wikipedia.org/wiki/Scandium) |  | | | | | | | | | | | | | | [Titanium](https://en.wikipedia.org/wiki/Titanium) | [Vanadium](https://en.wikipedia.org/wiki/Vanadium) | [Chromium](https://en.wikipedia.org/wiki/Chromium) | [Manganese](https://en.wikipedia.org/wiki/Manganese) | [Iron](https://en.wikipedia.org/wiki/Iron) | [Cobalt](https://en.wikipedia.org/wiki/Cobalt) | [Nickel](https://en.wikipedia.org/wiki/Nickel) | [Copper](https://en.wikipedia.org/wiki/Copper) | [Zinc](https://en.wikipedia.org/wiki/Zinc) | [Gallium](https://en.wikipedia.org/wiki/Gallium) | [Germanium](https://en.wikipedia.org/wiki/Germanium) | [Arsenic](https://en.wikipedia.org/wiki/Arsenic) | [Selenium](https://en.wikipedia.org/wiki/Selenium) | [Bromine](https://en.wikipedia.org/wiki/Bromine) | [Krypton](https://en.wikipedia.org/wiki/Krypton) | | [Rubidium](https://en.wikipedia.org/wiki/Rubidium) | [Strontium](https://en.wikipedia.org/wiki/Strontium) | [Yttrium](https://en.wikipedia.org/wiki/Yttrium) |  |  | | | | | | | | | | | | | [Zirconium](https://en.wikipedia.org/wiki/Zirconium) | [Niobium](https://en.wikipedia.org/wiki/Niobium) | [Molybdenum](https://en.wikipedia.org/wiki/Molybdenum) | [Technetium](https://en.wikipedia.org/wiki/Technetium) | [Ruthenium](https://en.wikipedia.org/wiki/Ruthenium) | [Rhodium](https://en.wikipedia.org/wiki/Rhodium) | [Palladium](https://en.wikipedia.org/wiki/Palladium) | Silver | [Cadmium](https://en.wikipedia.org/wiki/Cadmium) | [Indium](https://en.wikipedia.org/wiki/Indium) | [Tin](https://en.wikipedia.org/wiki/Tin) | [Antimony](https://en.wikipedia.org/wiki/Antimony) | [Tellurium](https://en.wikipedia.org/wiki/Tellurium) | [Iodine](https://en.wikipedia.org/wiki/Iodine) | [Xenon](https://en.wikipedia.org/wiki/Xenon) | | [Caesium](https://en.wikipedia.org/wiki/Caesium) | [Barium](https://en.wikipedia.org/wiki/Barium) | [Lanthanum](https://en.wikipedia.org/wiki/Lanthanum) | [Cerium](https://en.wikipedia.org/wiki/Cerium) | [Praseodymium](https://en.wikipedia.org/wiki/Praseodymium) | [Neodymium](https://en.wikipedia.org/wiki/Neodymium) | [Promethium](https://en.wikipedia.org/wiki/Promethium) | [Samarium](https://en.wikipedia.org/wiki/Samarium) | [Europium](https://en.wikipedia.org/wiki/Europium) | [Gadolinium](https://en.wikipedia.org/wiki/Gadolinium) | [Terbium](https://en.wikipedia.org/wiki/Terbium) | [Dysprosium](https://en.wikipedia.org/wiki/Dysprosium) | [Holmium](https://en.wikipedia.org/wiki/Holmium) | [Erbium](https://en.wikipedia.org/wiki/Erbium) | [Thulium](https://en.wikipedia.org/wiki/Thulium) | [Ytterbium](https://en.wikipedia.org/wiki/Ytterbium) | [Lutetium](https://en.wikipedia.org/wiki/Lutetium) | [Hafnium](https://en.wikipedia.org/wiki/Hafnium) | [Tantalum](https://en.wikipedia.org/wiki/Tantalum) | [Tungsten](https://en.wikipedia.org/wiki/Tungsten) | [Rhenium](https://en.wikipedia.org/wiki/Rhenium) | [Osmium](https://en.wikipedia.org/wiki/Osmium) | [Iridium](https://en.wikipedia.org/wiki/Iridium) | [Platinum](https://en.wikipedia.org/wiki/Platinum) | [Gold](https://en.wikipedia.org/wiki/Gold) | [Mercury (element)](https://en.wikipedia.org/wiki/Mercury_(element)) | [Thallium](https://en.wikipedia.org/wiki/Thallium) | [Lead](https://en.wikipedia.org/wiki/Lead) | [Bismuth](https://en.wikipedia.org/wiki/Bismuth) | [Polonium](https://en.wikipedia.org/wiki/Polonium) | [Astatine](https://en.wikipedia.org/wiki/Astatine) | [Radon](https://en.wikipedia.org/wiki/Radon) | | [Francium](https://en.wikipedia.org/wiki/Francium) | [Radium](https://en.wikipedia.org/wiki/Radium) | [Actinium](https://en.wikipedia.org/wiki/Actinium) | [Thorium](https://en.wikipedia.org/wiki/Thorium) | [Protactinium](https://en.wikipedia.org/wiki/Protactinium) | [Uranium](https://en.wikipedia.org/wiki/Uranium) | [Neptunium](https://en.wikipedia.org/wiki/Neptunium) | [Plutonium](https://en.wikipedia.org/wiki/Plutonium) | [Americium](https://en.wikipedia.org/wiki/Americium) | [Curium](https://en.wikipedia.org/wiki/Curium) | [Berkelium](https://en.wikipedia.org/wiki/Berkelium) | [Californium](https://en.wikipedia.org/wiki/Californium) | [Einsteinium](https://en.wikipedia.org/wiki/Einsteinium) | [Fermium](https://en.wikipedia.org/wiki/Fermium) | [Mendelevium](https://en.wikipedia.org/wiki/Mendelevium) | [Nobelium](https://en.wikipedia.org/wiki/Nobelium) | [Lawrencium](https://en.wikipedia.org/wiki/Lawrencium) | [Rutherfordium](https://en.wikipedia.org/wiki/Rutherfordium) | [Dubnium](https://en.wikipedia.org/wiki/Dubnium) | [Seaborgium](https://en.wikipedia.org/wiki/Seaborgium) | [Bohrium](https://en.wikipedia.org/wiki/Bohrium) | [Hassium](https://en.wikipedia.org/wiki/Hassium) | [Meitnerium](https://en.wikipedia.org/wiki/Meitnerium) | [Darmstadtium](https://en.wikipedia.org/wiki/Darmstadtium) | [Roentgenium](https://en.wikipedia.org/wiki/Roentgenium) | [Copernicium](https://en.wikipedia.org/wiki/Copernicium) | [Nihonium](https://en.wikipedia.org/wiki/Nihonium) | [Flerovium](https://en.wikipedia.org/wiki/Flerovium) | [Moscovium](https://en.wikipedia.org/wiki/Moscovium) | [Livermorium](https://en.wikipedia.org/wiki/Livermorium) | [Tennessine](https://en.wikipedia.org/wiki/Tennessine) | [Oganesson](https://en.wikipedia.org/wiki/Oganesson) | | [Cu](https://en.wikipedia.org/wiki/Copper) ↑ **Ag** ↓ [Au](https://en.wikipedia.org/wiki/Gold) | | [palladium](https://en.wikipedia.org/wiki/Palladium) ← **silver** → [cadmium](https://en.wikipedia.org/wiki/Cadmium) | | | | |
| [**Atomic number**](https://en.wikipedia.org/wiki/Atomic_number)(*Z*) | 47 |
| [**Group**](https://en.wikipedia.org/wiki/Group_(periodic_table)) | [group 11](https://en.wikipedia.org/wiki/Group_11_element) |
| [**Period**](https://en.wikipedia.org/wiki/Period_(periodic_table)) | [period 5](https://en.wikipedia.org/wiki/Period_(periodic_table)#Period_5) |
| [**Block**](https://en.wikipedia.org/wiki/Block_(periodic_table)) | [d-block](https://en.wikipedia.org/wiki/D-block) |
| [**Element category**](https://en.wikipedia.org/wiki/Names_for_sets_of_chemical_elements#Category) | [transition metal](https://en.wikipedia.org/wiki/Transition_metal) |
| [**Electron configuration**](https://en.wikipedia.org/wiki/Electron_configuration) | [[Kr](https://en.wikipedia.org/wiki/Krypton)] 4d10 5s1 |
| Electrons per shell | 2, 8, 18, 18, 1 |
| **Physical properties** | |
| [**Phase**](https://en.wikipedia.org/wiki/Phase_(matter)) **at**[**STP**](https://en.wikipedia.org/wiki/Standard_conditions_for_temperature_and_pressure) | [solid](https://en.wikipedia.org/wiki/Solid) |
| [**Melting point**](https://en.wikipedia.org/wiki/Melting_point) | 1234.93 [K](https://en.wikipedia.org/wiki/Kelvin) ​(961.78 °C, ​1763.2 °F) |
| [**Boiling point**](https://en.wikipedia.org/wiki/Boiling_point) | 2435 K ​(2162 °C, ​3924 °F) |
| [**Density**](https://en.wikipedia.org/wiki/Density)(near r.t.) | 10.49 g/cm3 |
| when liquid (at m.p.) | 9.320 g/cm3 |
| [**Heat of fusion**](https://en.wikipedia.org/wiki/Enthalpy_of_fusion) | 11.28 [kJ/mol](https://en.wikipedia.org/wiki/Kilojoule_per_mole) |
| [**Heat of vaporisation**](https://en.wikipedia.org/wiki/Enthalpy_of_vaporization) | 254 kJ/mol |
| [**Molar heat capacity**](https://en.wikipedia.org/wiki/Molar_heat_capacity) | 25.350 J/(mol·K) |
| [**Vapour pressure**](https://en.wikipedia.org/wiki/Vapor_pressure)   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ***P***(Pa) | **1** | **10** | **100** | **1 k** | **10 k** | **100 k** | | **at *T***(K) | 1283 | 1413 | 1575 | 1782 | 2055 | 2433 | | |
| **Atomic properties** | |
| [**Oxidation states**](https://en.wikipedia.org/wiki/Oxidation_state) | −2, −1, **+1**, +2, +3 (an [amphoteric](https://en.wikipedia.org/wiki/Amphoterism) oxide) |
| [**Electronegativity**](https://en.wikipedia.org/wiki/Electronegativity) | Pauling scale: 1.93 |
| [**Ionisation energies**](https://en.wikipedia.org/wiki/Ionization_energy) | * 1st: 731.0 kJ/mol * 2nd: 2070 kJ/mol * 3rd: 3361 kJ/mol |
| [**Atomic radius**](https://en.wikipedia.org/wiki/Atomic_radius) | empirical: 144 [pm](https://en.wikipedia.org/wiki/Picometre) |
| [**Covalent radius**](https://en.wikipedia.org/wiki/Covalent_radius) | 145±5 pm |
| [**Van der Waals radius**](https://en.wikipedia.org/wiki/Van_der_Waals_radius) | 172 pm |
| [Color lines in a spectral range](https://en.wikipedia.org/wiki/File:Silver_spectrum_visible.png)  [**Spectral lines**](https://en.wikipedia.org/wiki/Spectral_line) **of silver** | |
| **Other properties** | |
| [**Crystal structure**](https://en.wikipedia.org/wiki/Crystal_structure) | ​[face-centred cubic](https://en.wikipedia.org/wiki/Cubic_crystal_system) (fcc)  [Face-centered cubic crystal structure for silver](https://en.wikipedia.org/wiki/File:Cubic-face-centered.svg) |
| [**Speed of sound**](https://en.wikipedia.org/wiki/Speed_of_sound)thin rod | 2680 m/s (at r.t.) |
| [**Thermal expansion**](https://en.wikipedia.org/wiki/Coefficient_of_thermal_expansion) | 18.9 µm/(m·K) (at 25 °C) |
| [**Thermal conductivity**](https://en.wikipedia.org/wiki/Thermal_conductivity) | 429 W/(m·K) |
| [**Thermal diffusivity**](https://en.wikipedia.org/wiki/Thermal_diffusivity) | 174 mm2/s (at 300 K) |
| [**Electrical resistivity**](https://en.wikipedia.org/wiki/Electrical_resistivity_and_conductivity) | 15.87 nΩ·m (at 20 °C) |
| [**Magnetic ordering**](https://en.wikipedia.org/wiki/Magnetism) | [diamagnetic](https://en.wikipedia.org/wiki/Diamagnetism)[[2]](https://en.wikipedia.org/wiki/Silver#cite_note-2) |
| [**Magnetic susceptibility**](https://en.wikipedia.org/wiki/Magnetic_susceptibility) | −19.5·10−6 cm3/mol (296 K)[[3]](https://en.wikipedia.org/wiki/Silver#cite_note-3) |
| [**Young's modulus**](https://en.wikipedia.org/wiki/Young%27s_modulus) | 83 GPa |
| [**Shear modulus**](https://en.wikipedia.org/wiki/Shear_modulus) | 30 GPa |
| [**Bulk modulus**](https://en.wikipedia.org/wiki/Bulk_modulus) | 100 GPa |
| [**Poisson ratio**](https://en.wikipedia.org/wiki/Poisson%27s_ratio) | 0.37 |
| [**Mohs hardness**](https://en.wikipedia.org/wiki/Mohs_scale_of_mineral_hardness) | 2.5 |
| [**Vickers hardness**](https://en.wikipedia.org/wiki/Vickers_hardness_test) | 251 MPa |
| [**Brinell hardness**](https://en.wikipedia.org/wiki/Brinell_hardness_test) | 206–250 MPa |
| [**CAS Number**](https://en.wikipedia.org/wiki/CAS_Registry_Number) | 7440-22-4 |
| **History** | |
| [**Discovery**](https://en.wikipedia.org/wiki/Timeline_of_chemical_element_discoveries) | before [5000 BC](https://en.wikipedia.org/wiki/5000_BC) |
| **Main** [**isotopes of silver**](https://en.wikipedia.org/wiki/Isotopes_of_silver) | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | [**Iso­tope**](https://en.wikipedia.org/wiki/Isotope) | [**Abun­dance**](https://en.wikipedia.org/wiki/Natural_abundance) | [**Half-life**](https://en.wikipedia.org/wiki/Half-life) **(*t*1/2)** | [**Decay mode**](https://en.wikipedia.org/wiki/Radioactive_decay) | [**Pro­duct**](https://en.wikipedia.org/wiki/Decay_product) | | **105Ag** | [syn](https://en.wikipedia.org/wiki/Synthetic_radioisotope) | 41.2 d | [ε](https://en.wikipedia.org/wiki/Electron_capture) | [105Pd](https://en.wikipedia.org/wiki/Palladium-105) | | [γ](https://en.wikipedia.org/wiki/Gamma_radiation) | – | | **106**[**m**](https://en.wikipedia.org/wiki/Nuclear_isomer)**Ag** | syn | 8.28 d | ε | [106Pd](https://en.wikipedia.org/wiki/Palladium-106) | | γ | – | | **107Ag** | 51.839% | [stable](https://en.wikipedia.org/wiki/Stable_isotope) | | | | **108mAg** | syn | 418 y | ε | [108Pd](https://en.wikipedia.org/wiki/Palladium-108) | | [IT](https://en.wikipedia.org/wiki/Isomeric_transition) | [108Ag](https://en.wikipedia.org/wiki/Silver-108) | | γ | – | | **109Ag** | 48.161% | stable | | | | **111Ag** | syn | 7.45 d | [β−](https://en.wikipedia.org/wiki/Beta_decay) | [111Cd](https://en.wikipedia.org/wiki/Cadmium-111) | | γ | – | | |
| * [view](https://en.wikipedia.org/wiki/Template:Infobox_silver) * [talk](https://en.wikipedia.org/wiki/Template_talk:Infobox_silver) * [edit](https://en.wikipedia.org/w/index.php?title=Template:Infobox_silver&action=edit)   | [references](https://en.wikipedia.org/wiki/List_of_data_references_for_chemical_elements) | |

**Silver** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Ag** (from the [Latin](https://en.wikipedia.org/wiki/Latin) *argentum*, derived from the [Proto-Indo-European](https://en.wikipedia.org/wiki/Proto-Indo-European) [*h₂erǵ*](https://en.wiktionary.org/wiki/Reconstruction:Proto-Indo-European/h%E2%82%82er%C7%B5-): "shiny" or "white") and [atomic number](https://en.wikipedia.org/wiki/Atomic_number) 47. A soft, white, lustrous [transition metal](https://en.wikipedia.org/wiki/Transition_metal), it exhibits the highest [electrical conductivity](https://en.wikipedia.org/wiki/Electrical_conductivity), [thermal conductivity](https://en.wikipedia.org/wiki/Thermal_conductivity), and [reflectivity](https://en.wikipedia.org/wiki/Reflectivity) of any [metal](https://en.wikipedia.org/wiki/Metal). The metal is found in the Earth's crust in the pure, free elemental form ("native silver"), as an [alloy](https://en.wikipedia.org/wiki/Alloy) with [gold](https://en.wikipedia.org/wiki/Gold) and other metals, and in minerals such as [argentite](https://en.wikipedia.org/wiki/Argentite) and [chlorargyrite](https://en.wikipedia.org/wiki/Chlorargyrite). Most silver is produced as a byproduct of [copper](https://en.wikipedia.org/wiki/Copper), gold, [lead](https://en.wikipedia.org/wiki/Lead), and [zinc](https://en.wikipedia.org/wiki/Zinc) [refining](https://en.wikipedia.org/wiki/Refining).

Silver has long been valued as a [precious metal](https://en.wikipedia.org/wiki/Precious_metal). Silver metal is used in many [bullion coins](https://en.wikipedia.org/wiki/Bullion_coin), sometimes [alongside gold](https://en.wikipedia.org/wiki/Bimetallism):[[4]](https://en.wikipedia.org/wiki/Silver#cite_note-4) while it is more abundant than gold, it is much less abundant as a [native metal](https://en.wikipedia.org/wiki/Native_metal).[[5]](https://en.wikipedia.org/wiki/Silver#cite_note-5) Its purity is typically measured on a [per-mille](https://en.wikipedia.org/wiki/Per-mille) basis; a 94%-pure alloy is described as "0.940 fine". As one of the seven [metals of antiquity](https://en.wikipedia.org/wiki/Metals_of_antiquity), silver has had an enduring role in most human cultures.

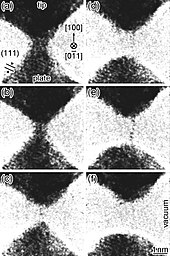
Other than in [currency](https://en.wikipedia.org/wiki/Currency) and as an [investment](https://en.wikipedia.org/wiki/Investment) medium ([coins](https://en.wikipedia.org/wiki/Coins) and [bullion](https://en.wikipedia.org/wiki/Bullion)),[[6]](https://en.wikipedia.org/wiki/Silver#cite_note-6) silver is used in [solar panels](https://en.wikipedia.org/wiki/Solar_panels), [water filtration](https://en.wikipedia.org/wiki/Water_filtration), [jewellery](https://en.wikipedia.org/wiki/Jewellery), ornaments, high-value tableware and utensils (hence the term [silverware](https://en.wikipedia.org/wiki/Silver_(household))), in [electrical contacts](https://en.wikipedia.org/wiki/Electrical_contact) and [conductors](https://en.wikipedia.org/wiki/Electrical_conductor), in specialized mirrors, window coatings, in [catalysis](https://en.wikipedia.org/wiki/Catalysis) of chemical reactions, as a colorant in [stained glass](https://en.wikipedia.org/wiki/Stained_glass) and in specialised confectionery. Its compounds are used in [photographic](https://en.wikipedia.org/wiki/Photographic_film) and [X-ray](https://en.wikipedia.org/wiki/X-ray) film. Dilute solutions of [silver nitrate](https://en.wikipedia.org/wiki/Silver_nitrate) and other silver compounds are used as [disinfectants](https://en.wikipedia.org/wiki/Disinfectant) and microbiocides ([oligodynamic effect](https://en.wikipedia.org/wiki/Oligodynamic_effect)), added to [bandages](https://en.wikipedia.org/wiki/Bandage) and wound-dressings, [catheters](https://en.wikipedia.org/wiki/Catheter), and other [medical instruments](https://en.wikipedia.org/wiki/Medical_instrument).



**Contents**

* [1 Characteristics](https://en.wikipedia.org/wiki/Silver#Characteristics)
  + [1.1 Isotopes](https://en.wikipedia.org/wiki/Silver#Isotopes)
* [2 Chemistry](https://en.wikipedia.org/wiki/Silver#Chemistry)
* [3 Compounds](https://en.wikipedia.org/wiki/Silver#Compounds)
  + [3.1 Oxides and chalcogenides](https://en.wikipedia.org/wiki/Silver#Oxides_and_chalcogenides)
  + [3.2 Halides](https://en.wikipedia.org/wiki/Silver#Halides)
  + [3.3 Other inorganic compounds](https://en.wikipedia.org/wiki/Silver#Other_inorganic_compounds)
  + [3.4 Coordination compounds](https://en.wikipedia.org/wiki/Silver#Coordination_compounds)
  + [3.5 Organometallic](https://en.wikipedia.org/wiki/Silver#Organometallic)
  + [3.6 Intermetallic](https://en.wikipedia.org/wiki/Silver#Intermetallic)
* [4 Etymology](https://en.wikipedia.org/wiki/Silver#Etymology)
* [5 History](https://en.wikipedia.org/wiki/Silver#History)
* [6 Symbolic role](https://en.wikipedia.org/wiki/Silver#Symbolic_role)
* [7 Occurrence and production](https://en.wikipedia.org/wiki/Silver#Occurrence_and_production)
* [8 Monetary use](https://en.wikipedia.org/wiki/Silver#Monetary_use)
  + [8.1 Price](https://en.wikipedia.org/wiki/Silver#Price)
* [9 Applications](https://en.wikipedia.org/wiki/Silver#Applications)
  + [9.1 Jewellery and silverware](https://en.wikipedia.org/wiki/Silver#Jewellery_and_silverware)
  + [9.2 Medicine](https://en.wikipedia.org/wiki/Silver#Medicine)
  + [9.3 Electronics](https://en.wikipedia.org/wiki/Silver#Electronics)
  + [9.4 Brazing alloys](https://en.wikipedia.org/wiki/Silver#Brazing_alloys)
  + [9.5 Chemical equipment](https://en.wikipedia.org/wiki/Silver#Chemical_equipment)
  + [9.6 Catalysis](https://en.wikipedia.org/wiki/Silver#Catalysis)
  + [9.7 Photography](https://en.wikipedia.org/wiki/Silver#Photography)
  + [9.8 Nanoparticles](https://en.wikipedia.org/wiki/Silver#Nanoparticles)
  + [9.9 Miscellanea](https://en.wikipedia.org/wiki/Silver#Miscellanea)
* [10 Precautions](https://en.wikipedia.org/wiki/Silver#Precautions)
* [11 See also](https://en.wikipedia.org/wiki/Silver#See_also)
* [12 References](https://en.wikipedia.org/wiki/Silver#References)
* [13 Bibliography](https://en.wikipedia.org/wiki/Silver#Bibliography)
* [14 External links](https://en.wikipedia.org/wiki/Silver#External_links)

**Characteristics**

[](https://en.wikipedia.org/wiki/File:Ag_atomic_wire.jpg)

Silver is extremely ductile, and can be drawn into a wire one atom wide.[[7]](https://en.wikipedia.org/wiki/Silver#cite_note-7)

Silver is similar in its physical and chemical properties to its two vertical neighbours in [group 11](https://en.wikipedia.org/wiki/Group_11_element) of the [periodic table](https://en.wikipedia.org/wiki/Periodic_table), [copper](https://en.wikipedia.org/wiki/Copper) and [gold](https://en.wikipedia.org/wiki/Gold). Its 47 electrons are arranged in the [configuration](https://en.wikipedia.org/wiki/Electron_configuration) [Kr]4d105s1, similarly to copper ([Ar]3d104s1) and gold ([Xe]4f145d106s1); group 11 is one of the few groups in the [d-block](https://en.wikipedia.org/wiki/D-block) which has a completely consistent set of electron configurations.[[8]](https://en.wikipedia.org/wiki/Silver#cite_note-CRC-8) This distinctive electron configuration, with a single electron in the highest occupied s subshell over a filled d subshell, accounts for many of the singular properties of metallic silver.[[9]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1177-9)

Silver is an extremely soft, [ductile](https://en.wikipedia.org/wiki/Ductility) and [malleable](https://en.wikipedia.org/wiki/Malleability) [transition metal](https://en.wikipedia.org/wiki/Transition_metal), though it is slightly less malleable than gold. Silver crystallizes in a [face-centered cubic](https://en.wikipedia.org/wiki/Face-centered_cubic) lattice with bulk coordination number 12, where only the single 5s electron is delocalized, similarly to copper and gold.[[10]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1178-10) Unlike metals with incomplete d-shells, metallic bonds in silver are lacking a [covalent](https://en.wikipedia.org/wiki/Covalent_bond) character and are relatively weak. This observation explains the low [hardness](https://en.wikipedia.org/wiki/Hardness) and high ductility of [single crystals](https://en.wikipedia.org/wiki/Monocrystalline) of silver.[[11]](https://en.wikipedia.org/wiki/Silver#cite_note-b1-11)

Silver has a brilliant white metallic luster that can take a high [polish](https://en.wikipedia.org/wiki/Polishing),[[12]](https://en.wikipedia.org/wiki/Silver#cite_note-reflective-12) and which is so characteristic that the name of the metal itself has become a [colour name](https://en.wikipedia.org/wiki/Silver_(colour)).[[9]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1177-9) Unlike copper and gold, the energy required to excite an electron from the filled d band to the s-p conduction band in silver is large enough (around 385 kJ/mol) that it no longer corresponds to absorption in the visible region of the spectrum, but rather in the [ultraviolet](https://en.wikipedia.org/wiki/Ultraviolet); hence silver is not a coloured metal.[[9]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1177-9) Protected silver has greater optical [reflectivity](https://en.wikipedia.org/wiki/Reflectivity) than [aluminium](https://en.wikipedia.org/wiki/Aluminium) at all wavelengths longer than ~450 nm.[[13]](https://en.wikipedia.org/wiki/Silver#cite_note-edwards-13) At wavelengths shorter than 450 nm, silver's reflectivity is inferior to that of aluminium and drops to zero near 310 nm.[[14]](https://en.wikipedia.org/wiki/Silver#cite_note-gemin-14)

Very high electrical and thermal conductivity is common to the elements in group 11, because their single s electron is free and does not interact with the filled d subshell, as such interactions (which occur in the preceding transition metals) lower electron mobility.[[15]](https://en.wikipedia.org/wiki/Silver#cite_note-15) The [electrical conductivity](https://en.wikipedia.org/wiki/Electrical_conductivity) of silver is the greatest of all metals, greater even than copper, but it is not widely used for this property because of the higher cost. An exception is in [radio-frequency engineering](https://en.wikipedia.org/wiki/Radio-frequency_engineering), particularly at [VHF](https://en.wikipedia.org/wiki/VHF) and higher frequencies where silver plating improves electrical conductivity because those [currents tend to flow on the surface of conductors](https://en.wikipedia.org/wiki/Skin_effect) rather than through the interior. During [World War II](https://en.wikipedia.org/wiki/World_War_II) in the US, 13540 tons of silver were used in [electromagnets](https://en.wikipedia.org/wiki/Electromagnets) for enriching [uranium](https://en.wikipedia.org/wiki/Uranium), mainly because of the wartime shortage of copper.[[16]](https://en.wikipedia.org/wiki/Silver#cite_note-16)[[17]](https://en.wikipedia.org/wiki/Silver#cite_note-17)[[18]](https://en.wikipedia.org/wiki/Silver#cite_note-18) Pure silver has the highest [thermal conductivity](https://en.wikipedia.org/wiki/Thermal_conductivity) of any metal, although the conductivity of [carbon](https://en.wikipedia.org/wiki/Carbon) (in the [diamond](https://en.wikipedia.org/wiki/Diamond) [allotrope](https://en.wikipedia.org/wiki/Allotropy)) and [superfluid helium-4](https://en.wikipedia.org/wiki/Superfluid_helium-4) are even higher.[[8]](https://en.wikipedia.org/wiki/Silver#cite_note-CRC-8) Silver also has the lowest [contact resistance](https://en.wikipedia.org/wiki/Contact_resistance) of any metal.[[8]](https://en.wikipedia.org/wiki/Silver#cite_note-CRC-8)

Silver readily forms [alloys](https://en.wikipedia.org/wiki/Alloy) with copper and gold, as well as [zinc](https://en.wikipedia.org/wiki/Zinc). Zinc-silver alloys with low zinc concentration may be considered as face-centred cubic solid solutions of zinc in silver, as the structure of the silver is largely unchanged while the electron concentration rises as more zinc is added. Increasing the electron concentration further leads to [body-centred cubic](https://en.wikipedia.org/wiki/Body-centred_cubic) (electron concentration 1.5), [complex cubic](https://en.wikipedia.org/wiki/Cubic_crystal_system) (1.615), and [hexagonal close-packed](https://en.wikipedia.org/wiki/Hexagonal_close-packed) phases (1.75).[[10]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1178-10)

**Isotopes**

Main article: [Isotopes of silver](https://en.wikipedia.org/wiki/Isotopes_of_silver)

Naturally occurring silver is composed of two stable [isotopes](https://en.wikipedia.org/wiki/Isotope), 107Ag and 109Ag, with 107Ag being slightly more abundant (51.839% [natural abundance](https://en.wikipedia.org/wiki/Natural_abundance)). This almost equal abundance is rare in the periodic table. The [atomic weight](https://en.wikipedia.org/wiki/Atomic_weight) is 107.8682(2) [u](https://en.wikipedia.org/wiki/Atomic_mass_unit);[[19]](https://en.wikipedia.org/wiki/Silver#cite_note-IUPAC-19)[[20]](https://en.wikipedia.org/wiki/Silver#cite_note-20) this value is very important because of the importance of silver compounds, particularly halides, in [gravimetric analysis](https://en.wikipedia.org/wiki/Gravimetric_analysis).[[19]](https://en.wikipedia.org/wiki/Silver#cite_note-IUPAC-19) Both isotopes of silver are produced in stars via the [s-process](https://en.wikipedia.org/wiki/S-process) (slow neutron capture), as well as in supernovas via the [r-process](https://en.wikipedia.org/wiki/R-process) (rapid neutron capture).[[21]](https://en.wikipedia.org/wiki/Silver#cite_note-Cameron-21)

Twenty-eight [radioisotopes](https://en.wikipedia.org/wiki/Radioisotope) have been characterized, the most stable being 105Ag with a [half-life](https://en.wikipedia.org/wiki/Half-life) of 41.29 days, 111Ag with a half-life of 7.45 days, and 112Ag with a half-life of 3.13 hours. Silver has numerous [nuclear isomers](https://en.wikipedia.org/wiki/Nuclear_isomer), the most stable being 108mAg (*t*1/2 = 418 years), 110mAg (*t*1/2 = 249.79 days) and 106mAg (*t*1/2 = 8.28 days). All of the remaining [radioactive](https://en.wikipedia.org/wiki/Radioactive) isotopes have half-lives of less than an hour, and the majority of these have half-lives of less than three minutes.[[22]](https://en.wikipedia.org/wiki/Silver#cite_note-Audi-22)

Isotopes of silver range in [relative atomic mass](https://en.wikipedia.org/wiki/Atomic_weight) from 92.950 u (93Ag) to 129.950 u (130Ag);[[23]](https://en.wikipedia.org/wiki/Silver#cite_note-23) the primary [decay mode](https://en.wikipedia.org/wiki/Decay_mode) before the most abundant stable isotope, 107Ag, is [electron capture](https://en.wikipedia.org/wiki/Electron_capture) and the primary mode after is [beta decay](https://en.wikipedia.org/wiki/Beta_decay). The primary [decay products](https://en.wikipedia.org/wiki/Decay_product) before 107Ag are [palladium](https://en.wikipedia.org/wiki/Palladium) (element 46) isotopes, and the primary products after are [cadmium](https://en.wikipedia.org/wiki/Cadmium) (element 48) isotopes.[[22]](https://en.wikipedia.org/wiki/Silver#cite_note-Audi-22)

The palladium [isotope](https://en.wikipedia.org/wiki/Isotope) 107Pd decays by beta emission to 107Ag with a half-life of 6.5 million years. [Iron meteorites](https://en.wikipedia.org/wiki/Iron_meteorite) are the only objects with a high-enough palladium-to-silver ratio to yield measurable variations in 107Ag abundance. [Radiogenic](https://en.wikipedia.org/wiki/Radiogenic) 107Ag was first discovered in the [Santa Clara](https://en.wikipedia.org/wiki/Santa_Clara,_Durango) meteorite in 1978.[[24]](https://en.wikipedia.org/wiki/Silver#cite_note-24) The discoverers suggest the coalescence and differentiation of iron-cored small [planets](https://en.wikipedia.org/wiki/Planet) may have occurred 10 million years after a [nucleosynthetic](https://en.wikipedia.org/wiki/Nucleosynthetic) event. 107Pd–107Ag correlations observed in bodies that have clearly been melted since the [accretion](https://en.wikipedia.org/wiki/Accretion_(astrophysics)) of the [solar system](https://en.wikipedia.org/wiki/Solar_system) must reflect the presence of unstable nuclides in the early solar system.[[25]](https://en.wikipedia.org/wiki/Silver#cite_note-25)

**Chemistry**

|  |  |  |  |
| --- | --- | --- | --- |
| Oxidation states and stereochemistries of silver[[26]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1179-26) | | | |
| **Oxidation  state** | **Coordination  number** | **Stereochemistry** | **Representative compound** |
| 0 (d10s1) | 3 | Planar | Ag(CO)3 |
| 1 (d10) | 2 | Linear | [Ag(CN)2]− |
| 3 | Trigonal planar | AgI(PEt2Ar)2 |
| 4 | Tetrahedral | [Ag(diars)2]+ |
| 6 | Octahedral | AgF, AgCl, AgBr |
| 2 (d9) | 4 | Square planar | [Ag(py)4]2+ |
| 3 (d8) | 4 | Square planar | [AgF4]− |
| 6 | Octahedral | [AgF6]3− |

Silver is a rather unreactive metal. This is because its filled 4d shell is not very effective in shielding the electrostatic forces of attraction from the nucleus to the outermost 5s electron, and hence silver is near the bottom of the [electrochemical series](https://en.wikipedia.org/wiki/Electrochemical_series) (*E*0(Ag+/Ag) = +0.799 V).[[9]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1177-9) In group 11, silver has the lowest first ionization energy (showing the instability of the 5s orbital), but has higher second and third ionization energies than copper and gold (showing the stability of the 4d orbitals), so that the chemistry of silver is predominantly that of the +1 oxidation state, reflecting the increasingly limited range of oxidation states along the transition series as the d-orbitals fill and stabilize.[[27]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1180-27) Unlike copper, for which the larger [hydration energy](https://en.wikipedia.org/wiki/Hydration_energy) of Cu2+ as compared to Cu+ is the reason why the former is the more stable in aqueous solution and solids despite lacking the stable filled d-subshell of the latter, with silver this effect is swamped by its larger second ionisation energy. Hence, Ag+ is the stable species in aqueous solution and solids, with Ag2+ being much less stable as it oxidizes water.[[27]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1180-27)

Most silver compounds have significant [covalent](https://en.wikipedia.org/wiki/Covalent_bond) character due to the small size and high first ionization energy (730.8 kJ/mol) of silver.[[9]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1177-9) Furthermore, silver's Pauling [electronegativity](https://en.wikipedia.org/wiki/Electronegativity) of 1.93 is higher than that of [lead](https://en.wikipedia.org/wiki/Lead) (1.87), and its [electron affinity](https://en.wikipedia.org/wiki/Electron_affinity) of 125.6 kJ/mol is much higher than that of [hydrogen](https://en.wikipedia.org/wiki/Hydrogen) (72.8 kJ/mol) and not much less than that of [oxygen](https://en.wikipedia.org/wiki/Oxygen) (141.0 kJ/mol).[[28]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1176-28) Due to its full d-subshell, silver in its main +1 oxidation state exhibits relatively few properties of the transition metals proper from groups 4 to 10, forming rather unstable [organometallic compounds](https://en.wikipedia.org/wiki/Organometallic_compound), forming linear complexes showing very low [coordination numbers](https://en.wikipedia.org/wiki/Coordination_number) like 2, and forming an amphoteric oxide[[29]](https://en.wikipedia.org/wiki/Silver#cite_note-29) as well as [Zintl phases](https://en.wikipedia.org/wiki/Zintl_phase) like the [post-transition metals](https://en.wikipedia.org/wiki/Post-transition_metal).[[30]](https://en.wikipedia.org/wiki/Silver#cite_note-30) Unlike the preceding transition metals, the +1 oxidation state of silver is stable even in the absence of [π-acceptor ligands](https://en.wikipedia.org/wiki/Pi_backbonding).[[27]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1180-27)

Silver does not react with air, even at red heat, and thus was considered by [alchemists](https://en.wikipedia.org/wiki/Alchemist) as a [noble metal](https://en.wikipedia.org/wiki/Noble_metal) along with gold. Its reactivity is intermediate between that of copper (which forms [copper(I) oxide](https://en.wikipedia.org/wiki/Copper(I)_oxide) when heated in air to red heat) and gold. Like copper, silver reacts with [sulfur](https://en.wikipedia.org/wiki/Sulfur) and its compounds; in their presence, silver tarnishes in air to form the black [silver sulfide](https://en.wikipedia.org/wiki/Silver_sulfide) (copper forms the green [sulfate](https://en.wikipedia.org/wiki/Sulfate) instead, while gold does not react). Unlike copper, silver will not react with the halogens, with the exception of [fluorine](https://en.wikipedia.org/wiki/Fluorine) gas, with which it forms the [difluoride](https://en.wikipedia.org/wiki/Silver(II)_fluoride). While silver is not attacked by non-oxidizing acids, the metal dissolves readily in hot concentrated [sulfuric acid](https://en.wikipedia.org/wiki/Sulfuric_acid), as well as dilute or concentrated [nitric acid](https://en.wikipedia.org/wiki/Nitric_acid). In the presence of air, and especially in the presence of [hydrogen peroxide](https://en.wikipedia.org/wiki/Hydrogen_peroxide), silver dissolves readily in aqueous solutions of [cyanide](https://en.wikipedia.org/wiki/Cyanide).[[26]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1179-26)

The three main forms of deterioration in historical silver artifacts are tarnishing, formation of [silver chloride](https://en.wikipedia.org/wiki/Silver_chloride) due to long-term immersion in salt water, as well as reaction with [nitrate](https://en.wikipedia.org/wiki/Nitrate) ions or oxygen. Fresh silver chloride is pale yellow, becoming purplish on exposure to light; it projects slightly from the surface of the artifact or coin. The precipitation of copper in ancient silver can be used to date artifacts, as copper is nearly always a constituent of silver alloys.[[31]](https://en.wikipedia.org/wiki/Silver#cite_note-31)

Silver metal is attacked by strong oxidizers such as [potassium permanganate](https://en.wikipedia.org/wiki/Potassium_permanganate) (KMnO  
4) and [potassium dichromate](https://en.wikipedia.org/wiki/Potassium_dichromate) (K  
2Cr  
2O  
7), and in the presence of [potassium bromide](https://en.wikipedia.org/wiki/Potassium_bromide) (KBr). These compounds are used in photography to [bleach](https://en.wikipedia.org/wiki/Bleach) silver images, converting them to silver bromide that can either be fixed with [thiosulfate](https://en.wikipedia.org/wiki/Thiosulfate) or redeveloped to [intensify](https://en.wikipedia.org/wiki/Potassium_dichromate#photography) the original image. Silver forms [cyanide](https://en.wikipedia.org/wiki/Cyanide) complexes ([silver cyanide](https://en.wikipedia.org/wiki/Silver_cyanide)) that are soluble in water in the presence of an excess of cyanide ions. Silver cyanide solutions are used in [electroplating](https://en.wikipedia.org/wiki/Electroplating) of silver.[[32]](https://en.wikipedia.org/wiki/Silver#cite_note-photo-32)

The common [oxidation states](https://en.wikipedia.org/wiki/Oxidation_state) of silver are (in order of commonness): +1 (the most stable state; for example, [silver nitrate](https://en.wikipedia.org/wiki/Silver_nitrate), AgNO3); +2 (highly oxidising; for example, [silver(II) fluoride](https://en.wikipedia.org/wiki/Silver(II)_fluoride), AgF2); and even very rarely +3 (extreme oxidising; for example, potassium tetrafluoroargentate(III), KAgF4).[[33]](https://en.wikipedia.org/wiki/Silver#cite_note-33) The +1 state is by far the most common, followed by the easily reducible +2 state. The +3 state requires very strong oxidising agents to attain, such as [fluorine](https://en.wikipedia.org/wiki/Fluorine) or [peroxodisulfate](https://en.wikipedia.org/wiki/Peroxodisulfate), and some silver(III) compounds react with atmospheric moisture and attack glass.[[34]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1188-34) Indeed, silver(III) fluoride is usually obtained by reacting silver or silver monofluoride with the strongest known oxidizing agent, [krypton difluoride](https://en.wikipedia.org/wiki/Krypton_difluoride).[[35]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood903-35)

**Compounds**

**Oxides and chalcogenides**

[](https://en.wikipedia.org/wiki/File:Sulfid_st%C5%99%C3%ADbrn%C3%BD.PNG)

Silver(I) sulfide

Silver and gold have rather low [chemical affinities](https://en.wikipedia.org/wiki/Chemical_affinity) for oxygen, lower than copper, and it is therefore expected that silver oxides are thermally quite unstable. Soluble silver(I) salts precipitate dark-brown [silver(I) oxide](https://en.wikipedia.org/wiki/Silver(I)_oxide), Ag2O, upon the addition of alkali. (The hydroxide AgOH exists only in solution; otherwise it spontaneously decomposes to the oxide.) Silver(I) oxide is very easily reduced to metallic silver, and decomposes to silver and oxygen above 160 °C.[[36]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1181-36) This and other silver(I) compounds may be oxidized by the strong oxidizing agent [peroxodisulfate](https://en.wikipedia.org/wiki/Peroxodisulfate) to black AgO, a mixed [silver(I,III) oxide](https://en.wikipedia.org/wiki/Silver(I,III)_oxide) of formula AgIAgIIIO2. Some other mixed oxides with silver in non-integral oxidation states, namely Ag2O3 and Ag3O4, are also known, as is Ag3O which behaves as a metallic conductor.[[36]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1181-36)

[Silver(I) sulfide](https://en.wikipedia.org/wiki/Silver(I)_sulfide), Ag2S, is very readily formed from its constituent elements and is the cause of the black tarnish on some old silver objects. It may also be formed from the reaction of [hydrogen sulfide](https://en.wikipedia.org/wiki/Hydrogen_sulfide) with silver metal or aqueous Ag+ ions. Many non-stoichiometric [selenides](https://en.wikipedia.org/wiki/Selenide) and [tellurides](https://en.wikipedia.org/wiki/Telluride_(chemistry)) are known; in particular, AgTe~3 is a low-temperature [superconductor](https://en.wikipedia.org/wiki/Superconductor).[[36]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1181-36)

**Halides**

Main article: [Silver halide](https://en.wikipedia.org/wiki/Silver_halide)

[](https://en.wikipedia.org/wiki/File:Common_Silver_Halide_Precipitates.jpg)

The three common silver halide precipitates: from left to right, [silver iodide](https://en.wikipedia.org/wiki/Silver_iodide), [silver bromide](https://en.wikipedia.org/wiki/Silver_bromide), and [silver chloride](https://en.wikipedia.org/wiki/Silver_chloride).

The only known dihalide of silver is [the difluoride](https://en.wikipedia.org/wiki/Silver(II)_fluoride), AgF2, which can be obtained from the elements under heat. A strong yet thermally stable and therefore safe fluorinating agent, silver(II) fluoride is often used to synthesize [hydrofluorocarbons](https://en.wikipedia.org/wiki/Hydrofluorocarbon).[[37]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1183-37)

In stark contrast to this, all four silver(I) halides are known. The [fluoride](https://en.wikipedia.org/wiki/Silver(I)_fluoride), [chloride](https://en.wikipedia.org/wiki/Silver_chloride), and [bromide](https://en.wikipedia.org/wiki/Silver_bromide) have the sodium chloride structure, but the [iodide](https://en.wikipedia.org/wiki/Silver_iodide) has three known stable forms at different temperatures; that at room temperature is the cubic [zinc blende](https://en.wikipedia.org/wiki/Zinc_blende) structure. They can all be obtained by the direct reaction of their respective elements.[[37]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1183-37) As the halogen group is descended, the silver halide gains more and more covalent character, solubility decreases, and the color changes from the white chloride to the yellow iodide as the energy required for [ligand-metal charge transfer](https://en.wikipedia.org/wiki/Charge-transfer_complex) (X−Ag+ → XAg) decreases.[[37]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1183-37) The fluoride is anomalous, as the fluoride ion is so small that it has a considerable [solvation](https://en.wikipedia.org/wiki/Solvation) energy and hence is highly water-soluble and forms di- and tetrahydrates.[[37]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1183-37) The other three silver halides are highly insoluble in aqueous solutions and are very commonly used in gravimetric [analytical](https://en.wikipedia.org/wiki/Wet_chemistry) methods.[[19]](https://en.wikipedia.org/wiki/Silver#cite_note-IUPAC-19) All four are [photosensitive](https://en.wikipedia.org/wiki/Photosensitive) (though the monofluoride is so only to [ultraviolet](https://en.wikipedia.org/wiki/Ultraviolet) light), especially the bromide and iodide which photodecompose to silver metal, and thus were used in traditional photography.[[37]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1183-37) The reaction involved is:[[38]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1185-38)

X− + *hν* → X + e− (excitation of the halide ion, which gives up its extra electron into the conduction band)

Ag+ + e− → Ag (liberation of a silver ion, which gains an electron to become a silver atom)

The process is not reversible because the silver atom liberated is typically found at a [crystal defect](https://en.wikipedia.org/wiki/Crystal_defect) or an impurity site, so that the electron's energy is lowered enough that it is "trapped".[[38]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1185-38)

**Other inorganic compounds**

[](https://en.wikipedia.org/wiki/File:Silver_nitrate_crystals.jpg)

Crystals of silver nitrate

White [silver nitrate](https://en.wikipedia.org/wiki/Silver_nitrate), AgNO3, is a versatile precursor to many other silver compounds, especially the halides, and is much less sensitive to light. It was once called *lunar caustic* because silver was called *luna* by the ancient alchemists, who believed that silver was associated with the moon.[[39]](https://en.wikipedia.org/wiki/Silver#cite_note-39) It is often used for gravimetric analysis, exploiting the insolubility of the heavier silver halides which it is a common precursor to.[[19]](https://en.wikipedia.org/wiki/Silver#cite_note-IUPAC-19) Silver nitrate is used in many ways in [organic synthesis](https://en.wikipedia.org/wiki/Organic_synthesis), e.g. for [deprotection](https://en.wikipedia.org/wiki/Deprotection) and oxidations. Ag+ binds [alkenes](https://en.wikipedia.org/wiki/Alkene) reversibly, and silver nitrate has been used to separate mixtures of alkenes by selective absorption. The resulting [adduct](https://en.wikipedia.org/wiki/Adduct) can be decomposed with [ammonia](https://en.wikipedia.org/wiki/Ammonia) to release the free alkene.[[40]](https://en.wikipedia.org/wiki/Silver#cite_note-40)

Yellow [silver carbonate](https://en.wikipedia.org/wiki/Silver_carbonate), Ag2CO3 can be easily prepared by reacting aqueous solutions of [sodium carbonate](https://en.wikipedia.org/wiki/Sodium_carbonate) with a deficiency of silver nitrate.[[41]](https://en.wikipedia.org/wiki/Silver#cite_note-OS-41) Its principal use is for the production of silver powder for use in microelectronics. It is reduced with [formaldehyde](https://en.wikipedia.org/wiki/Formaldehyde), producing silver free of alkali metals:[[42]](https://en.wikipedia.org/wiki/Silver#cite_note-Ull-42)

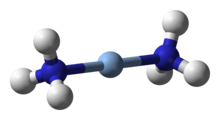
Ag2CO3 + CH2O → 2 Ag + 2 CO2 + H2

Silver carbonate is also used as a [reagent](https://en.wikipedia.org/wiki/Reagent) in organic synthesis such as the [Koenigs-Knorr reaction](https://en.wikipedia.org/wiki/Koenigs-Knorr_reaction). In the [Fétizon oxidation](https://en.wikipedia.org/wiki/F%C3%A9tizon_oxidation), silver carbonate on [celite](https://en.wikipedia.org/wiki/Celite) acts as an [oxidising agent](https://en.wikipedia.org/wiki/Oxidising_agent) to form [lactones](https://en.wikipedia.org/wiki/Lactone) from [diols](https://en.wikipedia.org/wiki/Diols). It is also employed to convert [alkyl](https://en.wikipedia.org/wiki/Alkyl) bromides into [alcohols](https://en.wikipedia.org/wiki/Alcohol).[[41]](https://en.wikipedia.org/wiki/Silver#cite_note-OS-41)

[Silver fulminate](https://en.wikipedia.org/wiki/Silver_fulminate), AgCNO, a powerful, touch-sensitive [explosive](https://en.wikipedia.org/wiki/Explosive) used in [percussion caps](https://en.wikipedia.org/wiki/Percussion_cap), is made by reaction of silver metal with nitric acid in the presence of [ethanol](https://en.wikipedia.org/wiki/Ethanol). Other dangerously explosive silver compounds are [silver azide](https://en.wikipedia.org/wiki/Silver_azide), AgN3, formed by reaction of [silver nitrate](https://en.wikipedia.org/wiki/Silver_nitrate) with [sodium azide](https://en.wikipedia.org/wiki/Sodium_azide),[[43]](https://en.wikipedia.org/wiki/Silver#cite_note-43) and [silver acetylide](https://en.wikipedia.org/wiki/Silver_acetylide), Ag2C2, formed when silver reacts with [acetylene](https://en.wikipedia.org/wiki/Acetylene) gas in [ammonia](https://en.wikipedia.org/wiki/Ammonia) solution.[[27]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1180-27) In its most characteristic reaction, silver azide decomposes explosively, releasing nitrogen gas: given the photosensitivity of silver salts, this behaviour may be induced by shining a light on its crystals.[[27]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1180-27)

2 AgN  
3 (s) → 3 N  
2 (g) + 2 Ag (s)

**Coordination compounds**

[](https://en.wikipedia.org/wiki/File:Diamminesilver(I)-3D-balls.png)

Structure of the diamminesilver(I) complex, [Ag(NH3)2]+

Silver complexes tend to be similar to those of its lighter homologue copper. Silver(III) complexes tend to be rare and very easily reduced to the more stable lower oxidation states, though they are slightly more stable than those of copper(III). For instance, the square planar periodate [Ag(IO5OH)2]5− and tellurate [Ag{TeO4(OH)2}2]5− complexes may be prepared by oxidising silver(I) with alkaline [peroxodisulfate](https://en.wikipedia.org/wiki/Peroxodisulfate). The yellow diamagnetic [AgF4]− is much less stable, fuming in moist air and reacting with glass.[[34]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1188-34)

Silver(II) complexes are more common. Like the valence isoelectronic copper(II) complexes, they are usually square planar and paramagnetic, which is increased by the greater field splitting for 4d electrons than for 3d electrons. Aqueous Ag2+, produced by oxidation of Ag+ by ozone, is a very strong oxidising agent, even in acidic solutions: it is stabilized in [phosphoric acid](https://en.wikipedia.org/wiki/Phosphoric_acid) due to complex formation. Peroxodisulfate oxidation is generally necessary to give the more stable complexes with heterocyclic [amines](https://en.wikipedia.org/wiki/Amine), such as [Ag(py)4]2+ and [Ag(bipy)2]2+: these are stable provided the counterion cannot reduce the silver back to the +1 oxidation state. [AgF4]2− is also known in its violet barium salt, as are some silver(II) complexes with *N*- or *O*-donor ligands such as pyridine carboxylates.[[44]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1189-44)

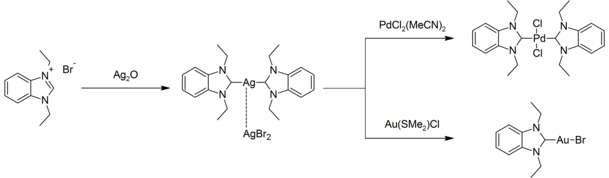
By far the most important oxidation state for silver in complexes is +1. The Ag+ cation is diamagnetic, like its homologues Cu+ and Au+, as all three have closed-shell electron configurations with no unpaired electrons: its complexes are colourless provided the ligands are not too easily polarized such as I−. Ag+ forms salts with most anions, but it is reluctant to coordinate to oxygen and thus most of these salts are insoluble in water: the exceptions are the nitrate, perchlorate, and fluoride. The tetracoordinate tetrahedral aqueous ion [Ag(H2O)4]+ is known, but the characteristic geometry for the Ag+ cation is 2-coordinate linear. For example, silver chloride dissolves readily in excess aqueous ammonia to form [Ag(NH3)2]+; silver salts are dissolved in photography due to the formation of the thiosulfate complex [Ag(S2O3)2]3−; and [cyanide](https://en.wikipedia.org/wiki/Cyanide) extraction for silver (and gold) works by the formation of the complex [Ag(CN)2]−. Silver cyanide forms the linear polymer {Ag–C≡N→Ag–C≡N→}; silver [thiocyanate](https://en.wikipedia.org/wiki/Thiocyanate) has a similar structure, but forms a zigzag instead because of the sp3-[hybridized](https://en.wikipedia.org/wiki/Orbital_hybridization) sulfur atom. [Chelating ligands](https://en.wikipedia.org/wiki/Chelating_ligand) are unable to form linear complexes and thus silver(I) complexes with them tend to form polymers; a few exceptions exist, such as the near-tetrahedral [diphosphine](https://en.wikipedia.org/wiki/Diphosphine) and [diarsine](https://en.wikipedia.org/wiki/Diarsine) complexes [Ag(L–L)2]+.[[45]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1195-45)

**Organometallic**

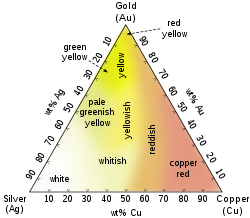
Main article: [Organosilver chemistry](https://en.wikipedia.org/wiki/Organosilver_chemistry)

Under standard conditions, silver does not form simple carbonyls, due to the weakness of the Ag–C bond. A few are known at very low temperatures around 6–15 K, such as the green, planar paramagnetic Ag(CO)3, which dimerizes at 25–30 K, probably by forming Ag–Ag bonds. Additionally, the silver carbonyl [Ag(CO)] [B(OTeF5)4] is known. Polymeric AgLX complexes with [alkenes](https://en.wikipedia.org/wiki/Alkene) and [alkynes](https://en.wikipedia.org/wiki/Alkyne) are known, but their bonds are thermodynamically weaker than even those of the [platinum](https://en.wikipedia.org/wiki/Platinum) complexes (though they are formed more readily than those of the analogous gold complexes): they are also quite unsymmetrical, showing the weak *π* bonding in group 11. Ag–C *σ* bonds may also be formed by silver(I), like copper(I) and gold(I), but the simple alkyls and aryls of silver(I) are even less stable than those of copper(I) (which tend to explode under ambient conditions). For example, poor thermal stability is reflected in the relative decomposition temperatures of AgMe (−50 °C) and CuMe (−15 °C) as well as those of PhAg (74 °C) and PhCu (100 °C).[[46]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1199-46)

The C–Ag bond is stabilized by [perfluoroalkyl](https://en.wikipedia.org/wiki/Perfluoroalkane) ligands, for example in AgCF(CF3)2.[[47]](https://en.wikipedia.org/wiki/Silver#cite_note-Miller1968-47) Alkenylsilver compounds are also more stable than their alkylsilver counterparts.[[48]](https://en.wikipedia.org/wiki/Silver#cite_note-48) Silver-[NHC complexes](https://en.wikipedia.org/wiki/Transition_metal_carbene_complex) are easily prepared, and are commonly used to prepare other NHC complexes by displacing labile ligands. For example, the reaction of the bis(NHC)silver(I) complex with [bis(acetonitrile)palladium dichloride](https://en.wikipedia.org/wiki/Bis(acetonitrile)palladium_dichloride) or [chlorido(dimethyl sulfide)gold(I)](https://en.wikipedia.org/wiki/Chlorido(dimethyl_sulfide)gold(I)):[[49]](https://en.wikipedia.org/wiki/Silver#cite_note-49)

[](https://en.wikipedia.org/wiki/File:Silver-NHC_as_carbene_transmetallation_agent.png)

**Intermetallic**

[](https://en.wikipedia.org/wiki/File:Ag-Au-Cu-colours-english.svg)

Different colors of silver–copper–gold alloys

Silver forms [alloys](https://en.wikipedia.org/wiki/Alloy) with most other elements on the periodic table. The elements from groups 1–3, except for [hydrogen](https://en.wikipedia.org/wiki/Hydrogen), [lithium](https://en.wikipedia.org/wiki/Lithium), and [beryllium](https://en.wikipedia.org/wiki/Beryllium), are very miscible with silver in the condensed phase and form intermetallic compounds; those from groups 4–9 are only poorly miscible; the elements in groups 10–14 (except [boron](https://en.wikipedia.org/wiki/Boron) and [carbon](https://en.wikipedia.org/wiki/Carbon)) have very complex Ag–M phase diagrams and form the most commercially important alloys; and the remaining elements on the periodic table have no consistency in their Ag–M phase diagrams. By far the most important such alloys are those with copper: most silver used for coinage and jewellery is in reality a silver–copper alloy, and the [eutectic mixture](https://en.wikipedia.org/wiki/Eutectic_mixture) is used in vacuum [brazing](https://en.wikipedia.org/wiki/Brazing). The two metals are completely miscible as liquids but not as solids; their importance in industry comes from the fact that their properties tend to be suitable over a wide range of variation in silver and copper concentration, although most useful alloys tend to be richer in silver than the eutectic mixture (71.9% silver and 28.1% copper by weight, and 60.1% silver and 28.1% copper by atom).[[50]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann54-50)

Most other binary alloys are of little use: for example, silver–gold alloys are too soft and silver–[cadmium](https://en.wikipedia.org/wiki/Cadmium) alloys too toxic. Ternary alloys have much greater importance: dental [amalgams](https://en.wikipedia.org/wiki/Amalgam_(dentistry)) are usually silver–tin–mercury alloys, silver–copper–gold alloys are very important in jewellery (usually on the gold-rich side) and have a vast range of hardnesses and colours, silver–copper–zinc alloys are useful as low-melting brazing alloys, and silver–cadmium–[indium](https://en.wikipedia.org/wiki/Indium) (involving three adjacent elements on the periodic table) is useful in [nuclear reactors](https://en.wikipedia.org/wiki/Nuclear_reactor) because of its high thermal neutron capture [cross-section](https://en.wikipedia.org/wiki/Cross_section_(physics)), good conduction of heat, mechanical stability, and resistance to corrosion in hot water.[[50]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann54-50)

**Etymology**

The word "silver" appears in [Anglo-Saxon](https://en.wikipedia.org/wiki/Old_English_language) in various spellings, such as *seolfor* and *siolfor*. A similar form is seen throughout the [Germanic languages](https://en.wikipedia.org/wiki/Germanic_languages) (compare [Old High German](https://en.wikipedia.org/wiki/Old_High_German) *silabar* and *silbir*). The chemical symbol Ag is from the [Latin](https://en.wikipedia.org/wiki/Latin) word for "silver", *argentum* (compare [Ancient Greek](https://en.wikipedia.org/wiki/Ancient_Greek) ἄργυρος, *árgyros*), from the [Proto-Indo-European](https://en.wikipedia.org/wiki/Proto-Indo-European) root \**h₂erǵ-* (formerly reconstructed as *\*arǵ-*), meaning "white" or "shining": this was the usual Proto-Indo-European word for the metal, whose reflexes are missing in Germanic and [Balto-Slavic](https://en.wikipedia.org/wiki/Balto-Slavic). The Balto-Slavic words for silver are quite similar to the Germanic ones (e.g. [Russian](https://en.wikipedia.org/wiki/Russian_language) *серебро* [*serebro*], [Polish](https://en.wikipedia.org/wiki/Polish_language) *srebro*, [Lithuanian](https://en.wikipedia.org/wiki/Lithuanian_language) *sidabras*) and they may have a common origin, although this is uncertain: some scholars have suggested the [Akkadian](https://en.wikipedia.org/wiki/Akkadian_language) *sarpu* "refined silver" as this origin, related to the word *sarapu* "to refine or smelt".[[51]](https://en.wikipedia.org/wiki/Silver#cite_note-51)[[52]](https://en.wikipedia.org/wiki/Silver#cite_note-52)

**History**

[](https://en.wikipedia.org/wiki/File:Vad%C3%A1szt%C3%A1l_(2).jpg)

Silver plate from the 4th century

Silver was one of the seven [metals of antiquity](https://en.wikipedia.org/wiki/Metals_of_antiquity) that were known to prehistoric humans and whose discovery is thus lost to history.[[53]](https://en.wikipedia.org/wiki/Silver#cite_note-Weeks4-53) In particular, the three metals of group 11, copper, silver, and gold, occur in the [elemental form](https://en.wikipedia.org/wiki/Native_metal) in nature and were probably used as the first primitive forms of [money](https://en.wikipedia.org/wiki/Money) as opposed to simple bartering.[[54]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1173-54) However, unlike copper, silver did not lead to the growth of [metallurgy](https://en.wikipedia.org/wiki/Metallurgy) on account of its low structural strength, and was more often used ornamentally or as money.[[55]](https://en.wikipedia.org/wiki/Silver#cite_note-metallurgy-55) Since silver is more reactive than gold, supplies of native silver were much more limited than those of gold.[[54]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1173-54) For example, silver was more expensive than gold in Egypt until around the fifteenth century BC:[[56]](https://en.wikipedia.org/wiki/Silver#cite_note-Weeks14-56) the Egyptians are thought to have separated gold from silver by heating the metals with salt, and then reducing the [silver chloride](https://en.wikipedia.org/wiki/Silver_chloride) produced to the metal.[[57]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann16-57)

The situation changed with the discovery of [cupellation](https://en.wikipedia.org/wiki/Cupellation), a technique that allowed silver metal to be extracted from its ores. While [slag](https://en.wikipedia.org/wiki/Slag) heaps found in [Asia Minor](https://en.wikipedia.org/wiki/Asia_Minor) and on the islands of the [Aegean Sea](https://en.wikipedia.org/wiki/Aegean_Sea) indicate that silver was being separated from [lead](https://en.wikipedia.org/wiki/Lead) as early as the [4th millennium BC](https://en.wikipedia.org/wiki/4th_millennium_BC),[[8]](https://en.wikipedia.org/wiki/Silver#cite_note-CRC-8) and one of the earliest silver extraction centres in Europe was [Sardinia](https://en.wikipedia.org/wiki/Sardinia) in early the [Chalcolithic period](https://en.wikipedia.org/wiki/Chalcolithic_period),[[58]](https://en.wikipedia.org/wiki/Silver#cite_note-58) these techniques did not spread widely until later, when it spread throughout the region and beyond.[[56]](https://en.wikipedia.org/wiki/Silver#cite_note-Weeks14-56) The origins of silver production in [India](https://en.wikipedia.org/wiki/India), [China](https://en.wikipedia.org/wiki/China), and [Japan](https://en.wikipedia.org/wiki/Japan) were almost certainly equally ancient, but are not well-documented due to their great age.[[57]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann16-57)

[](https://en.wikipedia.org/wiki/File:Silver_mining_in_Kutn%C3%A1_Hora_1490s.jpg)

Silver mining and processing in [Kutná Hora](https://en.wikipedia.org/wiki/Kutn%C3%A1_Hora), Bohemia, 1490s

When the [Phoenicians](https://en.wikipedia.org/wiki/Phoenicia) first came to what is now [Spain](https://en.wikipedia.org/wiki/Spain), they obtained so much silver that they could not fit it all on their ships, and as a result used silver to weight their anchors instead of lead.[[56]](https://en.wikipedia.org/wiki/Silver#cite_note-Weeks14-56) By the time of the Greek and Roman civilizations, silver coins were a staple of the economy:[[54]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1173-54) the Greeks were already extracting silver from [galena](https://en.wikipedia.org/wiki/Galena) by the 7th century BC,[[56]](https://en.wikipedia.org/wiki/Silver#cite_note-Weeks14-56) and the rise of [Athens](https://en.wikipedia.org/wiki/Athens) was partly made possible by the nearby silver mines at [Laurium](https://en.wikipedia.org/wiki/Laurium), from which they extracted about 30 tonnes a year from 600 to 300 BC.[[59]](https://en.wikipedia.org/wiki/Silver#cite_note-nbb-59) The stability of the [Roman currency](https://en.wikipedia.org/wiki/Roman_currency) relied to a high degree on the supply of silver bullion, mostly from Spain, which [Roman miners](https://en.wikipedia.org/wiki/Roman_metallurgy) produced on a scale unparalleled before the [discovery of the New World](https://en.wikipedia.org/wiki/Discovery_of_the_New_World). Reaching a peak production of 200 tonnes per year, an estimated silver stock of 10000 tonnes circulated in the [Roman economy](https://en.wikipedia.org/wiki/Roman_economy) in the middle of the second century AD, five to ten times larger than the combined amount of silver available to [medieval Europe](https://en.wikipedia.org/wiki/Early_Middle_Ages) and the [Abbasid Caliphate](https://en.wikipedia.org/wiki/Abbasid_Caliphate) around AD 800.[[60]](https://en.wikipedia.org/wiki/Silver#cite_note-60)[[61]](https://en.wikipedia.org/wiki/Silver#cite_note-61) The Romans also recorded the extraction of silver in central and northern Europe in the same time period. This production came to a nearly complete halt with the fall of the Roman Empire, not to resume until the time of [Charlemagne](https://en.wikipedia.org/wiki/Charlemagne): by then, tens of thousands of tonnes of silver had already been extracted.[[57]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann16-57)

Central Europe became the centre of silver production during the [Middle Ages](https://en.wikipedia.org/wiki/Middle_Ages), as the Mediterranean deposits exploited by the ancient civilisations had been exhausted. Silver mines were opened in [Bohemia](https://en.wikipedia.org/wiki/Bohemia), [Saxony](https://en.wikipedia.org/wiki/Saxony), [Erzgebirge](https://en.wikipedia.org/wiki/Erzgebirge), [Alsace](https://en.wikipedia.org/wiki/Alsace), the [Lahn](https://en.wikipedia.org/wiki/Lahn) region, [Siegerland](https://en.wikipedia.org/wiki/Siegerland), [Silesia](https://en.wikipedia.org/wiki/Silesia), [Hungary](https://en.wikipedia.org/wiki/Hungary), [Norway](https://en.wikipedia.org/wiki/Norway), [Steiermark](https://en.wikipedia.org/wiki/Steiermark), [Salzburg](https://en.wikipedia.org/wiki/Salzburg), and the southern [Black Forest](https://en.wikipedia.org/wiki/Black_Forest). Most of these ores were quite rich in silver and could simply be separated by hand from the remaining rock and then smelted; some deposits of native silver were also encountered. Many of these mines were soon exhausted, but a few of them remained active until the [Industrial Revolution](https://en.wikipedia.org/wiki/Industrial_Revolution), before which the world production of silver was around a meagre 50 tonnes per year.[[57]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann16-57) In the Americas, high temperature silver-lead [cupellation](https://en.wikipedia.org/wiki/Cupellation) technology was developed by pre-Inca civilizations as early as AD 60–120; silver deposits in India, China, Japan, and pre-Columbian America continued to be mined during this time.[[57]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann16-57)[[62]](https://en.wikipedia.org/wiki/Silver#cite_note-62)

With the discovery of America and the plundering of silver by the Spanish conquistadors, Central and South America became the dominant producers of silver until around the beginning of the 18th century, particularly [Peru](https://en.wikipedia.org/wiki/Peru), [Bolivia](https://en.wikipedia.org/wiki/Bolivia), [Chile](https://en.wikipedia.org/wiki/Chile), and [Argentina](https://en.wikipedia.org/wiki/Argentina):[[57]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann16-57) the last of these countries later took its name from that of the metal that composed so much of its mineral wealth.[[59]](https://en.wikipedia.org/wiki/Silver#cite_note-nbb-59) The silver trade this was a part of gave way to a global network of exchange. As one historian put it, silver "went round the world and made the world go round."[[63]](https://en.wikipedia.org/wiki/Silver#cite_note-63) Much of this silver ended up in the hands of the Chinese. A Portuguese merchant in 1621 noted that silver "wanders throughout all the world... before flocking to China, where it remains as if at its natural center."[[64]](https://en.wikipedia.org/wiki/Silver#cite_note-64) Still, much of it went to Spain, allowing Spanish rulers to pursue military and political ambitions in both Europe and the Americas. "New World mines," concluded several historians, "supported the Spanish empire."[[65]](https://en.wikipedia.org/wiki/Silver#cite_note-65)

In the 19th century, primary production of silver moved to North America, particularly [Canada](https://en.wikipedia.org/wiki/Canada), [Mexico](https://en.wikipedia.org/wiki/Mexico), and [Nevada](https://en.wikipedia.org/wiki/Nevada) in the [United States](https://en.wikipedia.org/wiki/United_States): some secondary production from lead and zinc ores also took place in Europe, and deposits in [Siberia](https://en.wikipedia.org/wiki/Siberia) and the [Russian Far East](https://en.wikipedia.org/wiki/Russian_Far_East) as well as in [Australia](https://en.wikipedia.org/wiki/Australia) were mined.[[57]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann16-57) [Poland](https://en.wikipedia.org/wiki/Poland) emerged as an important producer during the 1970s after the discovery of copper deposits that were rich in silver, before the centre of production returned to the Americas the following decade. Today, Peru and Mexico are still among the primary silver producers, but the distribution of silver production around the world is quite balanced and about one-fifth of the silver supply comes from recycling instead of new production.[[57]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann16-57)

**Symbolic role**

[](https://en.wikipedia.org/wiki/File:6852_les_deniers_de_judas.JPG)

16th-century fresco painting of Judas being paid thirty pieces of silver for his betrayal of Jesus

Silver plays a certain role in mythology and has found various usage as a metaphor and in folklore. The Greek poet [Hesiod](https://en.wikipedia.org/wiki/Hesiod)'s [*Works and Days*](https://en.wikipedia.org/wiki/Works_and_Days) (lines 109–201) lists different [ages of man](https://en.wikipedia.org/wiki/Ages_of_man) named after metals like gold, silver, bronze and iron to account for successive ages of humanity.[[66]](https://en.wikipedia.org/wiki/Silver#cite_note-66) [Ovid](https://en.wikipedia.org/wiki/Ovid)'s [*Metamorphoses*](https://en.wikipedia.org/wiki/Metamorphoses) contains another retelling of the story, containing an illustration of silver's metaphorical use of signifying the second-best in a series, better than bronze but worse than gold:

But when good [Saturn](https://en.wikipedia.org/wiki/Saturn_(mythology)), banish'd from above,  
Was driv'n to Hell, the world was under [Jove](https://en.wikipedia.org/wiki/Jupiter_(mythology)).  
Succeeding times a silver age behold,  
Excelling brass, but more excell'd by gold.

— *Ovid,* [*Metamorphoses*](https://en.wikipedia.org/wiki/Metamorphoses)*, Book I, trans.* [*John Dryden*](https://en.wikipedia.org/wiki/John_Dryden)

In folklore, silver was commonly thought to have mystic powers: for example, a [bullet](https://en.wikipedia.org/wiki/Bullet) cast from silver is often supposed in such folklore the only weapon that is effective against a [werewolf](https://en.wikipedia.org/wiki/Werewolf), [witch](https://en.wikipedia.org/wiki/Witch), or other [monsters](https://en.wikipedia.org/wiki/Monster).[[67]](https://en.wikipedia.org/wiki/Silver#cite_note-67)[[68]](https://en.wikipedia.org/wiki/Silver#cite_note-narodna-68) From this the idiom of a [silver bullet](https://en.wikipedia.org/wiki/Silver_bullet) developed into figuratively referring to any simple solution with very high effectiveness or almost miraculous results, as in the widely discussed [software engineering](https://en.wikipedia.org/wiki/Software_engineering) paper [*No Silver Bullet*](https://en.wikipedia.org/wiki/No_Silver_Bullet).[[69]](https://en.wikipedia.org/wiki/Silver#cite_note-69)

Silver production has also inspired figurative language. Clear references to cupellation occur throughout the [Old Testament](https://en.wikipedia.org/wiki/Old_Testament) of the [Bible](https://en.wikipedia.org/wiki/Bible), such as in [Jeremiah](https://en.wikipedia.org/wiki/Jeremiah)'s rebuke to Judah: "The bellows are burned, the lead is consumed of the fire; the founder melteth in vain: for the wicked are not plucked away. Reprobate silver shall men call them, because the Lord hath rejected them." (Jeremiah 6:19–20) Jeremiah was also aware of sheet silver, exemplifying the malleability and ductility of the metal: "Silver spread into plates is brought from Tarshish, and gold from Uphaz, the work of the workman, and of the hands of the founder: blue and purple is their clothing: they are all the work of cunning men." (Jeremiah 10:9)[[56]](https://en.wikipedia.org/wiki/Silver#cite_note-Weeks14-56)

Silver also has more negative cultural meanings: the idiom [thirty pieces of silver](https://en.wiktionary.org/wiki/thirty_pieces_of_silver), referring to a reward for betrayal, references the bribe [Judas Iscariot](https://en.wikipedia.org/wiki/Judas_Iscariot) is said in the [New Testament](https://en.wikipedia.org/wiki/New_Testament) to have taken from Jewish leaders in [Jerusalem](https://en.wikipedia.org/wiki/Jerusalem) to turn [Jesus of Nazareth](https://en.wikipedia.org/wiki/Jesus) over to soldiers of the high priest Caiaphas.[[70]](https://en.wikipedia.org/wiki/Silver#cite_note-70) Ethically, silver also symbolizes greed and degradation of consciousness; this is the negative aspect, the perverting of its value.[[71]](https://en.wikipedia.org/wiki/Silver#cite_note-71)

**Occurrence and production**

Further information: [Silver mining](https://en.wikipedia.org/wiki/Silver_mining)

[](https://en.wikipedia.org/wiki/File:Acanthite_-_Chispas_Mine,_Arizpe,_Sonora,_Mexico.jpg)

Acanthite sample from the Chispas Mine in [Sonora](https://en.wikipedia.org/wiki/Sonora), [Mexico](https://en.wikipedia.org/wiki/Mexico); scale at bottom of image as one inch with a rule at one centimetre

The abundance of silver in the Earth's crust is 0.08 [parts per million](https://en.wikipedia.org/wiki/Parts_per_million), almost exactly the same as that of [mercury](https://en.wikipedia.org/wiki/Mercury_(element)). It mostly occurs in [sulfide](https://en.wikipedia.org/wiki/Sulfide) ores, especially [acanthite](https://en.wikipedia.org/wiki/Acanthite) and [argentite](https://en.wikipedia.org/wiki/Argentite), Ag2S. Argentite deposits sometimes also contain [native](https://en.wikipedia.org/wiki/Native_metal) silver when they occur in reducing environments, and when in contact with salt water they are converted to [chlorargyrite](https://en.wikipedia.org/wiki/Chlorargyrite) (including [horn silver](https://en.wikipedia.org/wiki/Horn_silver)), AgCl, which is prevalent in [Chile](https://en.wikipedia.org/wiki/Chile) and [New South Wales](https://en.wikipedia.org/wiki/New_South_Wales).[[72]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1174-72) Most other silver minerals are silver [pnictides](https://en.wikipedia.org/wiki/Pnictide) or [chalcogenides](https://en.wikipedia.org/wiki/Chalcogenide); they are generally lustrous semiconductors. Most true silver deposits, as opposed to argentiferous deposits of other metals, came from [Tertiary period](https://en.wikipedia.org/wiki/Tertiary_period) vulcanism.[[73]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann21-73)

The principal sources of silver are the ores of copper, copper-nickel, lead, and lead-zinc obtained from [Peru](https://en.wikipedia.org/wiki/Peru), [Bolivia](https://en.wikipedia.org/wiki/Bolivia), [Mexico](https://en.wikipedia.org/wiki/Mexico), [China](https://en.wikipedia.org/wiki/China), [Australia](https://en.wikipedia.org/wiki/Australia), [Chile](https://en.wikipedia.org/wiki/Chile), [Poland](https://en.wikipedia.org/wiki/Poland) and [Serbia](https://en.wikipedia.org/wiki/Serbia).[[8]](https://en.wikipedia.org/wiki/Silver#cite_note-CRC-8) Peru, Bolivia and Mexico have been mining silver since 1546, and are still major world producers. Top silver-producing mines are [Cannington](https://en.wikipedia.org/wiki/Cannington_Mine) (Australia), [Fresnillo](https://en.wikipedia.org/wiki/Mina_Proa%C3%B1o) (Mexico), [San Cristóbal](https://en.wikipedia.org/wiki/San_Crist%C3%B3bal_mine_(Bolivia)) (Bolivia), [Antamina](https://en.wikipedia.org/wiki/Antamina_mine) (Peru), [Rudna](https://en.wikipedia.org/wiki/Rudna_mine) (Poland), and [Penasquito](https://en.wikipedia.org/wiki/Pe%C3%B1asquito_Polymetallic_Mine) (Mexico).[[74]](https://en.wikipedia.org/wiki/Silver#cite_note-CPM_Group-74) Top near-term mine development projects through 2015 are Pascua Lama (Chile), Navidad (Argentina), Jaunicipio (Mexico), Malku Khota (Bolivia),[[75]](https://en.wikipedia.org/wiki/Silver#cite_note-75) and Hackett River (Canada).[[74]](https://en.wikipedia.org/wiki/Silver#cite_note-CPM_Group-74) In [Central Asia](https://en.wikipedia.org/wiki/Central_Asia), [Tajikistan](https://en.wikipedia.org/wiki/Mining_in_Tajikistan#Silver) is known to have some of the largest silver deposits in the world.[[76]](https://en.wikipedia.org/wiki/Silver#cite_note-76)

Silver is usually found in nature combined with other metals, or in minerals that contain silver compounds, generally in the form of [sulfides](https://en.wikipedia.org/wiki/Sulfides) such as [galena](https://en.wikipedia.org/wiki/Galena) (lead sulfide) or [cerussite](https://en.wikipedia.org/wiki/Cerussite) (lead carbonate). So the primary production of silver requires the smelting and then [cupellation](https://en.wikipedia.org/wiki/Cupellation) of argentiferous lead ores, a historically important process.[[77]](https://en.wikipedia.org/wiki/Silver#cite_note-Kassianidou-77) Lead melts at 327 °C, lead oxide at 888 °C and silver melts at 960 °C. To separate the silver, the alloy is melted again at the high temperature of 960 °C to 1000 °C in an oxidizing environment. The lead oxidises to [lead monoxide](https://en.wikipedia.org/wiki/Lead(II)_oxide), then known as [litharge](https://en.wikipedia.org/wiki/Litharge), which captures the oxygen from the other metals present. The liquid lead oxide is removed or absorbed by [capillary action](https://en.wikipedia.org/wiki/Capillary_action) into the hearth linings.[[78]](https://en.wikipedia.org/wiki/Silver#cite_note-78)[[79]](https://en.wikipedia.org/wiki/Silver#cite_note-BayleyCrossleyPonting-79)[[80]](https://en.wikipedia.org/wiki/Silver#cite_note-80)

Ag(s) + 2Pb(s) + O  
2(g) → 2PbO(absorbed) + Ag(l)

Today, silver metal is primarily produced instead as a secondary byproduct of [electrolytic](https://en.wikipedia.org/wiki/Electrolysis) refining of copper, lead, and zinc, and by application of the [Parkes process](https://en.wikipedia.org/wiki/Parkes_process) on lead bullion from ore that also contains silver.[[81]](https://en.wikipedia.org/wiki/Silver#cite_note-usgs-81) In such processes, silver follows the non-ferrous metal in question through its concentration and smelting, and is later purified out. For example, in copper production, purified copper is [electrolytically](https://en.wikipedia.org/wiki/Electrolysis) deposited on the cathode, while the less reactive precious metals such as silver and gold collect under the anode as the so-called "anode slime". This is then separated and purified of base metals by treatment with hot aerated dilute [sulfuric](https://en.wikipedia.org/wiki/Sulfuric) acid and heating with lime or silica flux, before the silver is purified to over 99.9% purity via electrolysis in [nitrate](https://en.wikipedia.org/wiki/Nitrate) solution.[[72]](https://en.wikipedia.org/wiki/Silver#cite_note-Greenwood1174-72)

Commercial-grade fine silver is at least 99.9% pure, and purities greater than 99.999% are available. In 2014, Mexico was the top producer of silver (5,000 [tonnes](https://en.wikipedia.org/wiki/Tonne) or 18.7% of the world's total of 26,800 t), followed by China (4,060 t) and Peru (3,780 t).[[81]](https://en.wikipedia.org/wiki/Silver#cite_note-usgs-81)

**Monetary use**

[](https://en.wikipedia.org/wiki/File:1000oz.silver.bullion.bar.top.jpg)

1,000 oz silver bar

The earliest known coins were minted in the kingdom of [Lydia](https://en.wikipedia.org/wiki/Lydia) in [Asia Minor](https://en.wikipedia.org/wiki/Anatolia) around 600 BC.[[82]](https://en.wikipedia.org/wiki/Silver#cite_note-coins-82) The coins of Lydia were made of [electrum](https://en.wikipedia.org/wiki/Electrum), which is a naturally occurring [alloy](https://en.wikipedia.org/wiki/Alloy) of gold and silver, that was available within the territory of Lydia.[[82]](https://en.wikipedia.org/wiki/Silver#cite_note-coins-82) Since that time, [silver standards](https://en.wikipedia.org/wiki/Silver_standard), in which the standard economic [unit of account](https://en.wikipedia.org/wiki/Unit_of_account) is a fixed weight of silver, have been widespread throughout the world until the 20th century. Notable [silver coins](https://en.wikipedia.org/wiki/Silver_coin) through the centuries include the [Greek drachma](https://en.wikipedia.org/wiki/Greek_drachma),[[83]](https://en.wikipedia.org/wiki/Silver#cite_note-83) the Roman [denarius](https://en.wikipedia.org/wiki/Denarius),[[84]](https://en.wikipedia.org/wiki/Silver#cite_note-84) the Islamic [dirham](https://en.wikipedia.org/wiki/Dirham),[[85]](https://en.wikipedia.org/wiki/Silver#cite_note-oeddirhem-85) the [karshapana](https://en.wikipedia.org/wiki/Karshapana) from ancient India and [rupee](https://en.wikipedia.org/wiki/Rupee) from the time of the [Mughal Empire](https://en.wikipedia.org/wiki/Mughal_Empire) (grouped with copper and gold coins to create a trimetallic standard),[[86]](https://en.wikipedia.org/wiki/Silver#cite_note-86) and the [Spanish dollar](https://en.wikipedia.org/wiki/Spanish_dollar).[[87]](https://en.wikipedia.org/wiki/Silver#cite_note-Woodcock2009-87)[[88]](https://en.wikipedia.org/wiki/Silver#cite_note-Osborne2012-88)

The ratio between the amount of silver used for coinage and that used for other purposes has fluctuated greatly over time; for example, in wartime, more silver tends to have been used for coinage to finance the war.[[89]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann63-89)

Today, silver bullion has the [ISO 4217](https://en.wikipedia.org/wiki/ISO_4217) currency code XAG, one of only four [precious metals](https://en.wikipedia.org/wiki/Precious_metal) to have one (the others being [palladium](https://en.wikipedia.org/wiki/Palladium), [platinum](https://en.wikipedia.org/wiki/Platinum), and gold).[[90]](https://en.wikipedia.org/wiki/Silver#cite_note-90) Silver coins are produced from cast rods or ingots, rolled to the correct thickness, heat-treated, and then used to cut [blanks](https://en.wikipedia.org/wiki/Planchet) from. These blanks are then milled and minted in a coining press; modern coining presses can produce 8000 silver coins per hour.[[89]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann63-89)

**Price**

As of July 2018, silver is valued at around $495 per kilogram, or about $15.5 per ounce.[[91]](https://en.wikipedia.org/wiki/Silver#cite_note-91)

Silver prices are normally quoted in [Troy ounces](https://en.wikipedia.org/wiki/Troy_Weight). One troy ounce is equal to 31.1034 grams. In 2015 China reverted to the metric system and currently prices silver (and gold) in grams.[[92]](https://en.wikipedia.org/wiki/Silver#cite_note-92)[[93]](https://en.wikipedia.org/wiki/Silver#cite_note-93) The London silver fix is published once daily at noon London time. This price is determined by several major international banks and is used by [London bullion market](https://en.wikipedia.org/wiki/London_bullion_market) members for trading that day. Prices are most commonly shown as the [United States dollar](https://en.wikipedia.org/wiki/United_States_dollar) (USD), the [Pound sterling](https://en.wikipedia.org/wiki/Pound_sterling) (GBP), and the [Euro](https://en.wikipedia.org/wiki/Euro) (EUR).

**Applications**

**Jewellery and silverware**

[](https://en.wikipedia.org/wiki/File:Alexandra_Nikolaevna%27s_toilet_set_(Fasanierie_castle)_02_by_shako.JPG)

Silver toilet set of [Grand Duchess Alexandra Nikolaevna of Russia](https://en.wikipedia.org/wiki/Grand_Duchess_Alexandra_Nikolaevna_of_Russia)

The major use of silver besides coinage throughout most of history was in the manufacture of [jewellery](https://en.wikipedia.org/wiki/Jewellery) and other general-use items, and this continues to be a major use today. Examples include [table silver](https://en.wikipedia.org/wiki/Household_silver) for cutlery, for which silver is highly suited due to its antibacterial properties. [Western concert flutes](https://en.wikipedia.org/wiki/Western_concert_flute) are usually plated with or made out of [sterling silver](https://en.wikipedia.org/wiki/Sterling_silver);[[94]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann65-94) in fact, most silverware is only silver-plated rather than made out of pure silver; the silver is normally put in place by [electroplating](https://en.wikipedia.org/wiki/Electroplating). Silver-plated glass (as opposed to metal) is used for mirrors, [vacuum flasks](https://en.wikipedia.org/wiki/Vacuum_flask), and Christmas tree decorations.[[95]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann67-95)

Because pure silver is very soft, most silver used for these purposes is alloyed with copper, with finenesses of 925/1000, 835/1000, and 800/1000 being common. One drawback is the easy tarnishing of silver in the presence of [hydrogen sulfide](https://en.wikipedia.org/wiki/Hydrogen_sulfide) and its derivatives. Including precious metals such as palladium, platinum, and gold gives resistance to tarnishing but is quite costly; [base metals](https://en.wikipedia.org/wiki/Base_metal) like [zinc](https://en.wikipedia.org/wiki/Zinc), [cadmium](https://en.wikipedia.org/wiki/Cadmium), [silicon](https://en.wikipedia.org/wiki/Silicon), and [germanium](https://en.wikipedia.org/wiki/Germanium) do not totally prevent corrosion and tend to affect the lustre and colour of the alloy. Electrolytically refined pure silver plating is effective at increasing resistance to tarnishing. The usual solutions for restoring the lustre of tarnished silver are dipping baths that reduce the silver sulfide surface to metallic silver, and cleaning off the layer of tarnish with a paste; the latter approach also has the welcome side effect of polishing the silver concurrently.[[94]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann65-94) A simple chemical approach to removal of the sulfide tarnish is to bring silver items into contact with aluminium foil whilst immersed in water containing a conducting salt, such as sodium chloride.[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)]

**Medicine**

Main article: [Medical uses of silver](https://en.wikipedia.org/wiki/Medical_uses_of_silver)

In medicine, silver is incorporated into wound dressings and used as an antibiotic coating in medical devices. Wound dressings containing [silver sulfadiazine](https://en.wikipedia.org/wiki/Silver_sulfadiazine) or [silver nanomaterials](https://en.wikipedia.org/wiki/Silver_nanoparticles) are used to treat external infections. Silver is also used in some medical applications, such as [urinary catheters](https://en.wikipedia.org/wiki/Urinary_catheter) (where tentative evidence indicates it reduces catheter-related [urinary tract infections](https://en.wikipedia.org/wiki/Urinary_tract_infections)) and in [endotracheal breathing tubes](https://en.wikipedia.org/wiki/Endotracheal_tube) (where evidence suggests it reduces ventilator-associated [pneumonia](https://en.wikipedia.org/wiki/Pneumonia)).[[96]](https://en.wikipedia.org/wiki/Silver#cite_note-96)[[97]](https://en.wikipedia.org/wiki/Silver#cite_note-Bou2012-97) The silver [ion](https://en.wikipedia.org/wiki/Ion) is [bioactive](https://en.wikipedia.org/wiki/Biological_activity) and in sufficient [concentration](https://en.wikipedia.org/wiki/Concentration) readily kills [bacteria](https://en.wikipedia.org/wiki/Bacteria) [*in vitro*](https://en.wikipedia.org/wiki/In_vitro). They interfere with enzymes in the bacteria that transport nutrients, form structures, synthesise cell walls, and bond with the bacteria's genetic material. Microbes cannot develop resistance to silver as they can to antibiotics, and hence silver and silver nanoparticles are used as an antimicrobial in a variety of industrial, healthcare, and domestic application: for example, infusing clothing with nanosilver particles thus allows them to stay odourless for longer.[[98]](https://en.wikipedia.org/wiki/Silver#cite_note-98)[[99]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann83-99) Silver compounds are taken up by the body like [mercury](https://en.wikipedia.org/wiki/Mercury_(element)) compounds, but lack the toxicity of the latter. Silver and its alloys are used in cranial surgery to replace bone, and silver–tin–mercury amalgams are used in dentistry.[[95]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann67-95) [Silver diammine fluoride](https://en.wikipedia.org/wiki/Silver_diammine_fluoride), the fluoride salt of a [coordination complex](https://en.wikipedia.org/wiki/Coordination_complex) with the formula [Ag(NH3)2]F, is a topical [medicament](https://en.wikipedia.org/wiki/Medicament) (drug) used to treat and prevent [dental caries](https://en.wikipedia.org/wiki/Dental_caries) (cavities) and relieve dentinal hypersensitivity.[[100]](https://en.wikipedia.org/wiki/Silver#cite_note-100)

**Electronics**

Silver is very important in electronics for conductors and electrodes on account of its high electrical conductivity even when tarnished. Bulk silver and silver foils were used to make vacuum tubes, and continue to be used today in the manufacture of semiconductor devices, circuits, and their components. For example, silver is used in high quality connectors for [RF](https://en.wikipedia.org/wiki/Radio_frequency), [VHF](https://en.wikipedia.org/wiki/Very_high_frequency), and higher frequencies, particularly in tuned circuits such as [cavity filters](https://en.wikipedia.org/wiki/RF_and_microwave_filter#Cavity_filters) where conductors cannot be scaled by more than 6%. [Printed circuits](https://en.wikipedia.org/wiki/Printed_circuit_board) and [RFID](https://en.wikipedia.org/wiki/RFID) antennas are made with silver paints,[[8]](https://en.wikipedia.org/wiki/Silver#cite_note-CRC-8)[[101]](https://en.wikipedia.org/wiki/Silver#cite_note-101) Powdered silver and its alloys are used in paste preparations for conductor layers and electrodes, ceramic capacitors, and other ceramic components.[[102]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann71-102)

**Brazing alloys**

Silver-containing [brazing](https://en.wikipedia.org/wiki/Brazing) alloys are used for brazing metallic materials, mostly [cobalt](https://en.wikipedia.org/wiki/Cobalt), [nickel](https://en.wikipedia.org/wiki/Nickel), and copper-based alloys, tool steels, and precious metals. The basic components are silver and copper, with other elements selected according to the specific application desired: examples include zinc, tin, cadmium, palladium, [manganese](https://en.wikipedia.org/wiki/Manganese), and [phosphorus](https://en.wikipedia.org/wiki/Phosphorus). Silver provides increased workability and corrosion resistance during usage.[[103]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann78-103)

**Chemical equipment**

Silver is useful in the manufacture of chemical equipment on account of its low chemical reactivity, high thermal conductivity, and being easily workable. Silver [crucibles](https://en.wikipedia.org/wiki/Crucible) (alloyed with 0.15% nickel to avoid recrystallisation of the metal at red heat) are used for carrying out alkaline fusion. Copper and silver are also used when doing chemistry with [fluorine](https://en.wikipedia.org/wiki/Fluorine). Equipment made to work at high temperatures is often silver-plated. Silver and its alloys with gold are used as wire or ring seals for oxygen compressors and vacuum equipment.[[104]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann81-104)

**Catalysis**

Silver metal is a good catalyst for [oxidation](https://en.wikipedia.org/wiki/Oxidation) reactions; in fact it is somewhat too good for most purposes, as finely divided silver tends to result in complete oxidation of organic substances to [carbon dioxide](https://en.wikipedia.org/wiki/Carbon_dioxide) and water, and hence coarser-grained silver tends to be used instead. For instance, 15% silver supported on α-Al2O3 or silicates is a catalyst for the oxidation of [ethylene](https://en.wikipedia.org/wiki/Ethylene) to [ethylene oxide](https://en.wikipedia.org/wiki/Ethylene_oxide) at 230–270 °C. Dehydrogenation of [methanol](https://en.wikipedia.org/wiki/Methanol) to [formaldehyde](https://en.wikipedia.org/wiki/Formaldehyde) is conducted at 600–720 °C over silver gauze or crystals as the catalyst, as is dehydrogenation of [isopropanol](https://en.wikipedia.org/wiki/Isopropanol) to [acetone](https://en.wikipedia.org/wiki/Acetone). In the gas phase, [glycol](https://en.wikipedia.org/wiki/Glycol) yields [glyoxal](https://en.wikipedia.org/wiki/Glyoxal) and [ethanol](https://en.wikipedia.org/wiki/Ethanol) yields [acetaldehyde](https://en.wikipedia.org/wiki/Acetaldehyde), while organic [amines](https://en.wikipedia.org/wiki/Amine) are dehydrated to [nitriles](https://en.wikipedia.org/wiki/Nitrile).[[104]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann81-104)

**Photography**

The photosensitivity of the silver halides allowed for their use in traditional photography, although digital photography, which does not use silver, is now dominant. The photosensitive emulsion used in black-and-white photography is a suspension of silver halide crystals in gelatin, possibly mixed in with some noble metal compounds for improved photosensitivity, developing, and tuning. Colour photography requires the addition of special dye components and sensitisers, so that the initial black-and-white silver image couples with a different dye component. The original silver images are bleached off and the silver is then recovered and recycled. Silver nitrate is the starting material in all cases.[[105]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann82-105)

The use of silver nitrate and silver halides in photography has rapidly declined with the advent of digital technology. From the peak global demand for photographic silver in 1999 (267,000,000 [troy ounces](https://en.wikipedia.org/wiki/Troy_ounce) or 8304.6 [metric tonnes](https://en.wikipedia.org/wiki/Metric_tonne)) the market contracted almost 70% by 2013.[[106]](https://en.wikipedia.org/wiki/Silver#cite_note-photosdemand-106)

**Nanoparticles**

Main article: [Silver nanoparticle](https://en.wikipedia.org/wiki/Silver_nanoparticle)

Nanosilver particles, between 10 and 100 nanometres in size, are used in many applications. They are used in conductive inks for printed electronics, and have a much lower melting point than larger silver particles of micrometre size. They are also used medicinally in antibacterials and antifungals in much the same way as larger silver particles.[[99]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann83-99) In addition, according to the [European Union Observatory for Nanomaterials (EUON)](https://euon.echa.europa.eu/), silver nanoparticles are used both in pigments, as well as cosmetics. [[107]](https://en.wikipedia.org/wiki/Silver#cite_note-107)[[108]](https://en.wikipedia.org/wiki/Silver#cite_note-108)

**Miscellanea**

[](https://en.wikipedia.org/wiki/File:Diwali_sweets_India_2009.jpg)

A tray of [South Asian sweets](https://en.wikipedia.org/wiki/South_Asian_sweets), with some pieces covered with shiny silver *vark*

Pure silver metal is used as a food colouring. It has the [E174](https://en.wikipedia.org/wiki/E_number) designation and is approved in the [European Union](https://en.wikipedia.org/wiki/European_Union).[[109]](https://en.wikipedia.org/wiki/Silver#cite_note-Martínez-AbadOcio2013-109) Traditional Pakistani and Indian dishes sometimes include decorative silver foil known as [*vark*](https://en.wikipedia.org/wiki/Vark),[[110]](https://en.wikipedia.org/wiki/Silver#cite_note-ss-110) and in various other cultures, silver [*dragée*](https://en.wikipedia.org/wiki/Drag%C3%A9e) are used to decorate cakes, cookies, and other dessert items.[[111]](https://en.wikipedia.org/wiki/Silver#cite_note-latimes-111)

[Photochromic lenses](https://en.wikipedia.org/wiki/Photochromic_lens) include silver halides, so that ultraviolet light in natural daylight liberates metallic silver, darkening the lenses. The silver halides are reformed in lower light intensities. Colourless silver chloride films are used in radiation detectors. [Zeolite](https://en.wikipedia.org/wiki/Zeolite) sieves incorporating Ag+ ions are used to desalinate seawater during rescues, using silver ions to precipitate chloride as silver chloride. Silver is also used for its antibacterial properties for water sanitisation, but the application of this is limited by limits on silver consumption. [Colloidal silver](https://en.wikipedia.org/wiki/Colloidal_silver) is similarly used to disinfect closed swimming pools; while it has the advantage of not giving off a smell like [hypochlorite](https://en.wikipedia.org/wiki/Hypochlorite) treatments do, colloidal silver is not effective enough for more contaminated open swimming pools. Small [silver iodide](https://en.wikipedia.org/wiki/Silver_iodide) crystals are used in [cloud seeding](https://en.wikipedia.org/wiki/Cloud_seeding) to cause rain.[[99]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann83-99)

**Precautions**

|  |  |
| --- | --- |
| Silver | |
| **Hazards** | |
| [GHS pictograms](https://en.wikipedia.org/wiki/GHS_hazard_pictograms) | [The environment pictogram in the Globally Harmonized System of Classification and Labelling of Chemicals (GHS)](https://en.wikipedia.org/wiki/File:GHS-pictogram-pollu.svg) |
| [GHS signal word](https://en.wikipedia.org/wiki/Globally_Harmonized_System_of_Classification_and_Labelling_of_Chemicals) | Warning |
| [GHS hazard statements](https://en.wikipedia.org/wiki/GHS_hazard_statement) | H410 |
| [GHS precautionary statements](https://en.wikipedia.org/wiki/GHS_precautionary_statements) | P273, P391, P501[[112]](https://en.wikipedia.org/wiki/Silver#cite_note-112) |
| [NFPA 704](https://en.wikipedia.org/wiki/NFPA_704) | NFPA 704 four-colored diamond  [0](https://en.wikipedia.org/wiki/NFPA_704#Red)  [0](https://en.wikipedia.org/wiki/NFPA_704#Blue)  [0](https://en.wikipedia.org/wiki/NFPA_704#Yellow) |

Silver compounds have low toxicity compared to those of most other [heavy metals](https://en.wikipedia.org/wiki/Heavy_metals), as they are poorly absorbed by the human body when digested, and that which does get absorbed is rapidly converted to insoluble silver compounds or complexed by [metallothionein](https://en.wikipedia.org/wiki/Metallothionein). However, silver fluoride and silver nitrate are caustic and can cause tissue damage, resulting in [gastroenteritis](https://en.wikipedia.org/wiki/Gastroenteritis), [diarrhoea](https://en.wikipedia.org/wiki/Diarrhoea), falling [blood pressure](https://en.wikipedia.org/wiki/Blood_pressure), cramps, paralysis, and [respiratory arrest](https://en.wikipedia.org/wiki/Respiratory_arrest). Animals repeatedly dosed with silver salts have been observed to experience [anaemia](https://en.wikipedia.org/wiki/Anaemia), slowed growth, necrosis of the liver, and fatty degeneration of the liver and kidneys; rats implanted with silver foil or injected with [colloidal silver](https://en.wikipedia.org/wiki/Colloidal_silver) have been observed to develop localised tumours. [Parenterally](https://en.wikipedia.org/wiki/Route_of_administration) admistered colloidal silver causes acute silver poisoning.[[113]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann88-113) Some waterborne species are particularly sensitive to silver salts and those of the other precious metals; in most situations, however, silver does not pose serious environmental hazards.[[113]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann88-113)

In large doses, silver and compounds containing it can be absorbed into the [circulatory system](https://en.wikipedia.org/wiki/Circulatory_system) and become deposited in various body tissues, leading to [argyria](https://en.wikipedia.org/wiki/Argyria), which results in a blue-grayish pigmentation of the skin, eyes, and [mucous membranes](https://en.wikipedia.org/wiki/Mucous_membrane). Argyria is rare, and so far as is known, does not otherwise harm a person's health, though it is disfiguring and usually permanent. Mild forms of argyria are sometimes mistaken for [cyanosis](https://en.wikipedia.org/wiki/Cyanosis).[[113]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann88-113)[[8]](https://en.wikipedia.org/wiki/Silver#cite_note-CRC-8)

Metallic silver, like copper, is an antibacterial agent, which was known to the ancients and first scientifically investigated and named the [oligodynamic effect](https://en.wikipedia.org/wiki/Oligodynamic_effect) by [Carl Nägeli](https://en.wikipedia.org/wiki/Carl_N%C3%A4geli). Silver ions damage the metabolism of bacteria even at such low concentrations as 0.01–0.1 milligrams per litre; metallic silver has a similar effect due to the formation of silver oxide. This effect is lost in the presence of [sulfur](https://en.wikipedia.org/wiki/Sulfur) due to the extreme insolubility of silver sulfide.[[113]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann88-113)

Some silver compounds are very explosive, such as the nitrogen compounds silver azide, silver [amide](https://en.wikipedia.org/wiki/Amide), and silver fulminate, as well as [silver acetylide](https://en.wikipedia.org/wiki/Silver_acetylide), [silver oxalate](https://en.wikipedia.org/wiki/Silver_oxalate), and silver(II) oxide. They can explode on heating, force, drying, illumination, or sometimes spontaneously. To avoid the formation of such compounds, ammonia and [acetylene](https://en.wikipedia.org/wiki/Acetylene) should be kept away from silver equipment. Salts of silver with strongly oxidising acids such as [silver chlorate](https://en.wikipedia.org/wiki/Silver_chlorate) and silver nitrate can explode on contact with materials that can be readily oxidised, such as organic compounds, sulfur and soot.[[113]](https://en.wikipedia.org/wiki/Silver#cite_note-Ullmann88-113)

**See also**

* [Silver medal](https://en.wikipedia.org/wiki/Silver_medal)
* [Free silver](https://en.wikipedia.org/wiki/Free_silver)
* [List of countries by silver production](https://en.wikipedia.org/wiki/List_of_countries_by_silver_production)
* [List of silver compounds](https://en.wikipedia.org/wiki/Category:Silver_compounds)
* [Silver as an investment](https://en.wikipedia.org/wiki/Silver_as_an_investment)
* [Silverpoint](https://en.wikipedia.org/wiki/Silverpoint) drawing

**References**

 *Meija, J.; et al. (2016).* [*"Atomic weights of the elements 2013 (IUPAC Technical Report)"*](https://www.degruyter.com/downloadpdf/j/pac.2016.88.issue-3/pac-2015-0305/pac-2015-0305.xml)*.* [*Pure and Applied Chemistry*](https://en.wikipedia.org/wiki/Pure_and_Applied_Chemistry)*.* ***88*** *(3): 265–91.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1515/pac-2015-0305*](https://doi.org/10.1515%2Fpac-2015-0305)*.*

  *Lide, D. R., ed. (2005). "Magnetic susceptibility of the elements and inorganic compounds".* [*CRC Handbook of Chemistry and Physics*](https://web.archive.org/web/20110303222309/http:/www-d0.fnal.gov/hardware/cal/lvps_info/engineering/elementmagn.pdf) *(PDF) (86th ed.). Boca Raton (FL): CRC Press.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*0-8493-0486-5*](https://en.wikipedia.org/wiki/Special:BookSources/0-8493-0486-5)*.*

  *Weast, Robert (1984). CRC, Handbook of Chemistry and Physics. Boca Raton, Florida: Chemical Rubber Company Publishing. pp. E110.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*0-8493-0464-4*](https://en.wikipedia.org/wiki/Special:BookSources/0-8493-0464-4)*.*

  [*"BULLION VS. NUMISMATIC COINS: Difference between Bullion and Numismatic Coins"*](https://www.providentmetals.com/knowledge-center/precious-metals-resources/bullion-vs-numismatic-coins.html)*. www.providentmetals.com. Retrieved 2017-12-17.*

  [*"'World has 5 times more gold than silver' | Latest News & Updates at Daily News & Analysis"*](http://www.dnaindia.com/money/interview-world-has-5-times-more-gold-than-silver-1235602)*. dna. 2009-03-03. Retrieved 2017-12-17.*

  [*"Lucius Precious Metals | Buy Gold, Silver, Bullion & Coins"*](http://www.lpm.hk)*. www.lpm.hk. Retrieved 2017-10-14.*

  *Masuda, Hideki (2016). "Combined Transmission Electron Microscopy – In situ Observation of the Formation Process and Measurement of Physical Properties for Single Atomic-Sized Metallic Wires". In Janecek, Milos; Kral, Robert. Modern Electron Microscopy in Physical and Life Sciences. InTech.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.5772/62288*](https://doi.org/10.5772%2F62288)*.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-953-51-2252-4*](https://en.wikipedia.org/wiki/Special:BookSources/978-953-51-2252-4)*.*

  *Hammond, C. R. (2004). The Elements, in Handbook of Chemistry and Physics (81st ed.). CRC press.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-0-8493-0485-9*](https://en.wikipedia.org/wiki/Special:BookSources/978-0-8493-0485-9)*.*

  Greenwood and Earnshaw, p. 1177

  Greenwood and Earnshaw, p. 1178

  *George L. Trigg; Edmund H. Immergut (1 November 1992).* [*Encyclopedia of applied physics*](https://books.google.com/books?id=sVQ5RAAACAAJ)*. 4: Combustion to Diamagnetism. VCH Publishers. pp. 267–272.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-3-527-28126-8*](https://en.wikipedia.org/wiki/Special:BookSources/978-3-527-28126-8)*. Retrieved 2 May 2011.*

  *Alex Austin (2007). The Craft of Silversmithing: Techniques, Projects, Inspiration. Sterling Publishing Company, Inc. p. 43.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-1-60059-131-0*](https://en.wikipedia.org/wiki/Special:BookSources/978-1-60059-131-0)*.*

  *Edwards, H. W.; Petersen, R. P. (1936). "Reflectivity of evaporated silver films". Physical Review.* ***50*** *(9): 871.* [*Bibcode*](https://en.wikipedia.org/wiki/Bibcode)*:*[*1936PhRv...50..871E*](http://adsabs.harvard.edu/abs/1936PhRv...50..871E)*.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1103/PhysRev.50.871*](https://doi.org/10.1103%2FPhysRev.50.871)*.*

  [*"Silver vs. Aluminum"*](http://www.gemini.edu/sciops/telescopes-and-sites/optics/silver-vs-aluminum)*. Gemini Observatory. Retrieved 2014-08-01.*

  Russell AM & Lee KL 2005, [*Structure-property relations in nonferrous metals*](https://books.google.com/books?id=fIu58uZTE-gC&printsec=frontcover), Wiley-Interscience, New York, [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [0-471-64952-X](https://en.wikipedia.org/wiki/Special:BookSources/0-471-64952-X). p. 302.

  *Nichols, Kenneth D. (1987). The Road to Trinity. Morrow, New York: Morrow. p. 42.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-0-688-06910-0*](https://en.wikipedia.org/wiki/Special:BookSources/978-0-688-06910-0)*.*

  *Young, Howard (11 September 2002).* [*"Eastman at Oak Ridge During World War II"*](https://web.archive.org/web/20120208054014/http:/www.tnengineering.net/AICHE/eastman-oakridge-young.htm)*. Archived from* [*the original*](http://www.tnengineering.net/AICHE/eastman-oakridge-young.htm) *on 2012-02-08.*

  *Oman, H. (1992). "Not invented here? Check your history". Aerospace and Electronic Systems Magazine.* ***7*** *(1): 51–53.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1109/62.127132*](https://doi.org/10.1109%2F62.127132)*.*

  [*"Atomic Weights of the Elements 2007 (IUPAC)"*](http://www.chem.qmul.ac.uk/iupac/AtWt/index.html)*. Retrieved 11 November 2009.*

  [*"Atomic Weights and Isotopic Compositions for All Elements (NIST)"*](http://physics.nist.gov/cgi-bin/Compositions/stand_alone.pl?ele=&ascii=html&isotype=some)*. Retrieved 11 November 2009.*

  *Cameron, A. G. W. (1973).* [*"Abundance of the Elements in the Solar System"*](https://pubs.giss.nasa.gov/docs/1973/1973_Cameron_ca06310p.pdf) *(PDF). Space Science Reviews.* ***15*** *(1): 121–146.* [*Bibcode*](https://en.wikipedia.org/wiki/Bibcode)*:*[*1973SSRv...15..121C*](http://adsabs.harvard.edu/abs/1973SSRv...15..121C)*.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1007/BF00172440*](https://doi.org/10.1007%2FBF00172440)*.*

  *Audi, Georges; Bersillon, O.; Blachot, J.; Wapstra, A. H. (2003).* [*"The NUBASE Evaluation of Nuclear and Decay Properties"*](http://hal.in2p3.fr/in2p3-00014184)*. Nuclear Physics A.* ***729*** *(1): 3–128.* [*Bibcode*](https://en.wikipedia.org/wiki/Bibcode)*:*[*2003NuPhA.729....3A*](http://adsabs.harvard.edu/abs/2003NuPhA.729....3A)*.* [*CiteSeerX*](https://en.wikipedia.org/wiki/CiteSeerX)[*10.1.1.692.8504*](https://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.692.8504)*.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1016/j.nuclphysa.2003.11.001*](https://doi.org/10.1016%2Fj.nuclphysa.2003.11.001)*.*

  [*"Atomic Weights and Isotopic Compositions for Silver (NIST)"*](http://physics.nist.gov/cgi-bin/Compositions/stand_alone.pl?ele=Ag&ascii=html&isotype=all)*. Retrieved 11 November 2009.*

  *Kelly, William R.; Wasserburg, G. J. (1978).* [*"Evidence for the existence of 107Pd in the early solar system"*](http://authors.library.caltech.edu/43037/1/grl921.pdf) *(PDF). Geophysical Research Letters.* ***5*** *(12): 1079–1082.* [*Bibcode*](https://en.wikipedia.org/wiki/Bibcode)*:*[*1978GeoRL...5.1079K*](http://adsabs.harvard.edu/abs/1978GeoRL...5.1079K)*.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1029/GL005i012p01079*](https://doi.org/10.1029%2FGL005i012p01079)*.*

  *Russell, Sara S.; Gounelle, Matthieu; Hutchison, Robert (2001). "Origin of Short-Lived Radionuclides".* [*Philosophical Transactions of the Royal Society A*](https://en.wikipedia.org/wiki/Philosophical_Transactions_of_the_Royal_Society_A)*.* ***359*** *(1787): 1991–2004.* [*Bibcode*](https://en.wikipedia.org/wiki/Bibcode)*:*[*2001RSPTA.359.1991R*](http://adsabs.harvard.edu/abs/2001RSPTA.359.1991R)*.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1098/rsta.2001.0893*](https://doi.org/10.1098%2Frsta.2001.0893)*.* [*JSTOR*](https://en.wikipedia.org/wiki/JSTOR)[*3066270*](https://www.jstor.org/stable/3066270)*.*

  Greenwood and Earnshaw, p. 1179

  Greenwood and Earnshaw, p. 1180

  Greenwood and Earnshaw, p. 1176

  Lidin RA 1996, *Inorganic substances handbook*, begell house, New York, [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [1-56700-065-7](https://en.wikipedia.org/wiki/Special:BookSources/1-56700-065-7). p. 5

  Goodwin F, Guruswamy S, Kainer KU, Kammer C, Knabl W, Koethe A, Leichtfreid G, Schlamp G, Stickler R & Warlimont H 2005, 'Noble metals and noble metal alloys', in *Springer Handbook of Condensed Matter and Materials Data,* W Martienssen & H Warlimont (eds), Springer, Berlin, pp. 329–406, [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [3-540-44376-2](https://en.wikipedia.org/wiki/Special:BookSources/3-540-44376-2). p. 341

  ["Silver Artifacts"](https://web.archive.org/web/20130509014548/http:/events.nace.org/library/corrosion/Artifacts/silver.asp) in *Corrosion – Artifacts*. NACE Resource Center

  *Bjelkhagen, Hans I. (1995). Silver-halide recording materials: for holography and their processing. Springer. pp. 156–166.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-3-540-58619-7*](https://en.wikipedia.org/wiki/Special:BookSources/978-3-540-58619-7)*.*

  *Riedel, Sebastian; Kaupp, Martin (2009). "The highest oxidation states of the transition metal elements". Coordination Chemistry Reviews.* ***253*** *(5–6): 606–624.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1016/j.ccr.2008.07.014*](https://doi.org/10.1016%2Fj.ccr.2008.07.014)*.*

  Greenwood and Earnshaw, p. 1188

  Greenwood and Earnshaw, p. 903

  Greenwood and Earnshaw, pp. 1181–2

  Greenwood and Earnshaw, pp. 1183–5

  Greenwood and Earnshaw, pp. 1185–7

  [*"Definition of Lunar Caustic"*](https://web.archive.org/web/20120131215637/http:/dictionary.die.net/lunar%20caustic)*. dictionary.die.net. Archived from the original on 31 January 2012.*

  *Cope, A. C.; Bach, R. D. (1973).* [*"trans-Cyclooctene"*](http://www.orgsyn.org/demo.aspx?prep=cv5p0315)*.* [*Organic Syntheses*](https://en.wikipedia.org/wiki/Organic_Syntheses)*.*; *Collective Volume,* ***5****, p. 315*

  *McCloskey C. M.; Coleman, G. H. (1955).* [*"β-d-Glucose-2,3,4,6-Tetraacetate"*](http://www.orgsyn.org/demo.aspx?prep=cv3p0434)*.* [*Organic Syntheses*](https://en.wikipedia.org/wiki/Organic_Syntheses)*.*; *Collective Volume,* ***3****, p. 434*

  Andreas Brumby et al. "Silver, Silver Compounds, and Silver Alloys" in Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, Weinheim, 2008. [doi](https://en.wikipedia.org/wiki/Digital_object_identifier):[10.1002/14356007.a24\_107.pub2](https://doi.org/10.1002%2F14356007.a24_107.pub2)

  *Meyer, Rudolf; Köhler, Josef & Homburg, Axel (2007).* [*Explosives*](https://books.google.com/?id=ATiYCfo1VcEC&pg=PA284)*. Wiley–VCH. p. 284.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-3-527-31656-4*](https://en.wikipedia.org/wiki/Special:BookSources/978-3-527-31656-4)*.*

  Greenwood and Earnshaw, p. 1189

  Greenwood and Earnshaw, pp. 1195–6

  Greenwood and Earnshaw, pp. 1199–200

  *Miller, W. T.; Burnard, R. J. (1968). "Perfluoroalkylsilver compounds".* [*J. Am. Chem. Soc.*](https://en.wikipedia.org/wiki/J._Am._Chem._Soc.)***90*** *(26): 7367–7368.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1021/ja01028a047*](https://doi.org/10.1021%2Fja01028a047)*.*

  *Holliday, A.; Pendlebury, R. E. (1967). "Vinyllead compounds I. Cleavage of vinyl groups from tetravinyllead".* [*J. Organomet. Chem.*](https://en.wikipedia.org/wiki/J._Organomet._Chem.)***7*** *(2): 281–284.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1016/S0022-328X(00)91078-7*](https://doi.org/10.1016%2FS0022-328X%2800%2991078-7)*.*

  *Wang, Harrison M. J.; Lin, Ivan J. B. (1998). "Facile Synthesis of Silver(I)−Carbene Complexes. Useful Carbene Transfer Agents". Organometallics.* ***17*** *(5): 972–975.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1021/om9709704*](https://doi.org/10.1021%2Fom9709704)*.*

  Ullmann, pp. 54–61

  *Harper, Douglas (2001–16).* [*"silver"*](http://www.etymonline.com/index.php?term=silver)*. etymonline.com. Retrieved 2 March 2017.*

  *Harper, Douglas (2001–16).* [*"argent"*](http://www.etymonline.com/index.php?term=argent)*. etymonline.com. Retrieved 2 March 2017.*

  Weeks, p. 4

  Greenwood and Earnshaw, pp. 1173–4

  *Readon, Arthur C. (2011). Metallurgy for the Non-Metallurgist. ASM International. pp. 73–84.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-1-61503-821-3*](https://en.wikipedia.org/wiki/Special:BookSources/978-1-61503-821-3)*.*

  Weeks, pp. 14–19

  Ullmann, pp. 16–9

  *Maria Grazia Melis.* [*"Silver in Neolithic and Eneolithic Sardinia, in H. Meller/R. Risch/E. Pernicka (eds.), Metalle der Macht – Frühes Gold und Silber. 6. Mitteldeutscher Archäologentag vom 17. bis 19. Oktober 2013 in Halle (Saale), Tagungen des Landesmuseums für"*](https://www.academia.edu/9860173)*.*

  *Emsley, John (2011). Nature's building blocks: an A-Z guide to the elements. Oxford University Press. pp. 492–8.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-0-19-960563-7*](https://en.wikipedia.org/wiki/Special:BookSources/978-0-19-960563-7)*.*

  [*Patterson, C. C.*](https://en.wikipedia.org/wiki/Clair_Cameron_Patterson) *(1972). "Silver Stocks and Losses in Ancient and Medieval Times". The Economic History Review.* ***25*** *(2): 205–235 (216, table 2, 228, table 6).* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1111/j.1468-0289.1972.tb02173.x*](https://doi.org/10.1111%2Fj.1468-0289.1972.tb02173.x)*.*

  *de Callataÿ, François (2005). "The Greco-Roman Economy in the Super Long-Run: Lead, Copper, and Shipwrecks". Journal of Roman Archaeology.* ***18****: 361–372 (365f.).* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1017/s104775940000742x*](https://doi.org/10.1017%2Fs104775940000742x)*.*

  *Carol A. Schultze; Charles Stanish; David A. Scott; Thilo Rehren; Scott Kuehner; James K. Feathers (2009).* [*"Direct evidence of 1,900 years of indigenous silver production in the Lake Titicaca Basin of Southern Peru"*](http://www.pnas.org/content/106/41/17280.full)*. Proceedings of the National Academy of Sciences of the United States of America.* ***106*** *(41): 17280–17283.* [*Bibcode*](https://en.wikipedia.org/wiki/Bibcode)*:*[*2009PNAS..10617280S*](http://adsabs.harvard.edu/abs/2009PNAS..10617280S)*.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1073/pnas.0907733106*](https://doi.org/10.1073%2Fpnas.0907733106)*.* [*PMC*](https://en.wikipedia.org/wiki/PubMed_Central)[*2754926*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2754926)*.* [*PMID*](https://en.wikipedia.org/wiki/PubMed_Identifier)[*19805127*](https://www.ncbi.nlm.nih.gov/pubmed/19805127)*. Retrieved 22 May 2013.*

  *Frank, Andre Gunder (1998). ReOrient: Global Economy in the Asian Age. Berkeley: University of California Press. p. 131.*

  *von Glahn, Richard (1996). "Myth and Reality of China's Seventeenth Century Monetary Crisis". Journal of Economic History.* ***2****: 132.*

  *Flynn, Dennis O.; Giraldez, Arturo (1995). "Born with a "Silver Spoon"". Journal of World History.* ***2****: 210.*

  [Joseph Eddy Fontenrose](https://en.wikipedia.org/wiki/Joseph_Eddy_Fontenrose): *Work, Justice, and Hesiod's Five Ages.* In: *Classical Philology.* V. 69, Nr. 1, 1974, p. 1–16.

  *Jackson, Robert (1995). Witchcraft and the Occult. Devizes, Quintet Publishing. p. 25.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-1-85348-888-7*](https://en.wikipedia.org/wiki/Special:BookSources/978-1-85348-888-7)*.*

  *Стойкова, Стефана.* [*"Дельо хайдутин"*](http://liternet.bg/folklor/sbornici/bnpp/haidushki/58.htm)*.* [*Българска народна поезия и проза в седем тома*](http://liternet.bg/folklor/sbornici/bnpp/haidushki/content.htm) *(in Bulgarian). Т. III. Хайдушки и исторически песни. Варна: ЕИ "LiterNet".* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-954-304-232-6*](https://en.wikipedia.org/wiki/Special:BookSources/978-954-304-232-6)*.*

  *Brooks, Frederick. P., Jr. (1987).* [*"No Silver Bullet – Essence and Accident in Software Engineering"*](http://faculty.salisbury.edu/~xswang/Research/Papers/SERelated/no-silver-bullet.pdf) *(PDF). Computer.* ***20*** *(4): 10–19.* [*CiteSeerX*](https://en.wikipedia.org/wiki/CiteSeerX)[*10.1.1.117.315*](https://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.117.315)*.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1109/MC.1987.1663532*](https://doi.org/10.1109%2FMC.1987.1663532)*.*

  [Matthew 26:15](https://www.biblica.com/bible/?osis=niv:Matthew.26:15–26:15)

  *Chevalier, Jean; Gheerbrant, Alain (2009). Dicționar de Simboluri. Mituri, Vise, Obiceiuri, Gesturi, Forme, Figuri, Culori, Numere [Dictionary of Symbols. Myths, Dreams, Habits, Gestures, Shapes, Figures, Colors, Numbers] (in Romanian). Polirom. 105.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-973-46-1286-4*](https://en.wikipedia.org/wiki/Special:BookSources/978-973-46-1286-4)*.*

  Greenwood and Earnshaw, pp. 1174–6

  Ullmann, pp. 21–2

  *CPM Group (2011). CPM Silver Yearbook. New York: Euromoney Books. p. 68.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-0-9826741-4-7*](https://en.wikipedia.org/wiki/Special:BookSources/978-0-9826741-4-7)*.*

  [*"Preliminary Economic Assessment Technical Report 43-101"*](https://web.archive.org/web/20120119090432/http:/www.soamsilver.com/upload/Technical_Reports/Malku_Khota_PEA_Update_11_May_2011.pdf.pdf) *(PDF). South American Silver Corp. Archived from* [*the original*](http://www.soamsilver.com/upload/Technical_Reports/Malku_Khota_PEA_Update_11_May_2011.pdf.pdf) *(PDF) on 19 January 2012.*

  [*"Why Are Kyrgyzstan and Tajikistan So Split on Foreign Mining?"*](http://www.eurasianet.org/node/67365)*. EurasiaNet.org. 7 August 2013. Retrieved 19 August 2013.*

  Kassianidou, V. 2003. Early Extraction of Silver from Complex Polymetallic Ores, in Craddock, P.T. and Lang, J (eds) Mining and Metal production through the Ages. London, British Museum Press: 198–206

  Craddock, P. T. 1995. Early metal mining and production. Edinburgh: Edinburgh University Press. p. 223

  Bayley, J., Crossley, D. and Ponting, M. (eds). 2008. Metals and Metalworking. A research framework for archaeometallurgy. Historical Metallurgy Society 6.

  Pernicka, E., Rehren, Th., Schmitt-Strecker, S. 1998. Late Uruk silver production by cupellation at Habuba Kabira, Syria in Metallurgica Antiqua : in honour of Hans-Gert Bachmann and Robert Maddin by Bachmann, H. G, Maddin, Robert, Rehren, Thilo, Hauptmann, Andreas, Muhly, James David, Deutsches Bergbau-Museum: 123–134.

  *Hilliard, Henry E.* [*"Silver"*](http://minerals.usgs.gov/minerals/pubs/commodity/silver/)*. USGS.*

  [*"The origins of coinage"*](http://www.britishmuseum.org/explore/themes/money/the_origins_of_coinage.aspx)*. britishmuseum.org. Retrieved September 21, 2015.*

  [*"Tetradrachm"*](http://www.merriam-webster.com/dictionary/tetradrachms)*. Merriam-Webster. Retrieved 2008-01-20.*

  Crawford, Michael H. (1974). Roman Republican Coinage, Cambridge University Press, 2 Volumes. [ISBN](https://en.wikipedia.org/wiki/International_Standard_Book_Number) [0-521-07492-4](https://en.wikipedia.org/wiki/Special:BookSources/0-521-07492-4)

  [*Oxford English Dictionary*](https://en.wikipedia.org/wiki/Oxford_English_Dictionary), 1st edition, [s.v. 'dirhem'](http://www.oed.com/view/Entry/53338)

  *etymonline.com (September 20, 2008).* [*"Etymology of rupee"*](http://www.etymonline.com/index.php?search=rupee&searchmode=none)*. Retrieved 2008-09-20.*

  *Ray Woodcock (1 May 2009).* [*Globalization from Genesis to Geneva: A Confluence of Humanity*](https://books.google.com/books?id=N_75TAjONToC)*. Trafford Publishing. pp. 104–105.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-1-4251-8853-5*](https://en.wikipedia.org/wiki/Special:BookSources/978-1-4251-8853-5)*. Retrieved 13 August 2013.*

  *Thomas J. Osborne (29 November 2012).* [*Pacific Eldorado: A History of Greater California*](https://books.google.com/books?id=FvA3jL4CFCMC)*. John Wiley & Sons. p. 31.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-1-118-29217-4*](https://en.wikipedia.org/wiki/Special:BookSources/978-1-118-29217-4)*. Retrieved 13 August 2013.*

  Ullmann, pp. 63–5

  [*"Current currency & funds code list – ISO Currency"*](http://www.currency-iso.org/en/home/tables/table-a1.html)*. SIX.*

  [Current Silver Prices in US Dollars (USD)](http://www.bullion-rates.com/silver/USD/spot-price.htm)

  [*"Buy Silver Bars Online - Silver | LPM"*](https://www.lpm.hk/silver/silver-bars.html)*. www.lpm.hk. Retrieved 2017-10-14.*

  [*"China on gold: "Troy ounce no more" - Marketupdate"*](https://marketupdate.nl/en/china-on-gold-troy-ounce-no-more/)*. 16 October 2015.*

  Ullmann, pp. 65–7

  Ullmann, pp. 67–71

  *Beattie, M.; Taylor, J. (2011). "Silver alloy vs. Uncoated urinary catheters: A systematic review of the literature". Journal of Clinical Nursing.* ***20*** *(15–16): 2098–2108.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1111/j.1365-2702.2010.03561.x*](https://doi.org/10.1111%2Fj.1365-2702.2010.03561.x)*.* [*PMID*](https://en.wikipedia.org/wiki/PubMed_Identifier)[*21418360*](https://www.ncbi.nlm.nih.gov/pubmed/21418360)*.*

  *Bouadma, L.; Wolff, M.; Lucet, J. C. (August 2012). "Ventilator-associated pneumonia and its prevention". Current Opinion in Infectious Diseases.* ***25*** *(4): 395–404.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1097/QCO.0b013e328355a835*](https://doi.org/10.1097%2FQCO.0b013e328355a835)*.* [*PMID*](https://en.wikipedia.org/wiki/PubMed_Identifier)[*22744316*](https://www.ncbi.nlm.nih.gov/pubmed/22744316)*.*

  *Maillard, Jean-Yves; Hartemann, Philippe (2012). "Silver as an antimicrobial: Facts and gaps in knowledge". Critical Reviews in Microbiology.* ***39*** *(4): 373–83.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.3109/1040841X.2012.713323*](https://doi.org/10.3109%2F1040841X.2012.713323)*.* [*PMID*](https://en.wikipedia.org/wiki/PubMed_Identifier)[*22928774*](https://www.ncbi.nlm.nih.gov/pubmed/22928774)*.*

  Ullmann, pp. 83–84

  *Rosenblatt, A.; Stamford, T. C. M.; Niederman, R. (2009). "Silver diamine fluoride: a caries "silver-fluoride bullet"". Journal of Dental Research.* ***88*** *(2): 116–125.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1177/0022034508329406*](https://doi.org/10.1177%2F0022034508329406)*.* [*PMID*](https://en.wikipedia.org/wiki/PubMed_Identifier)[*19278981*](https://www.ncbi.nlm.nih.gov/pubmed/19278981)*.*

  *Nikitin, Pavel V.; Lam, Sander & Rao, K. V. S. (2005). "Low Cost Silver Ink RFID Tag Antennas".* [*2005 IEEE Antennas and Propagation Society International Symposium*](https://web.archive.org/web/20160321212851/http:/www.ee.washington.edu/faculty/nikitin_pavel/papers/APS_2005.pdf) *(PDF).* ***2B****. p. 353.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1109/APS.2005.1552015*](https://doi.org/10.1109%2FAPS.2005.1552015)*.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-0-7803-8883-3*](https://en.wikipedia.org/wiki/Special:BookSources/978-0-7803-8883-3)*. Archived from the original on 21 March 2016.*

  Ullmann, pp. 71–8

  Ullmann, pp. 78–81

  Ullmann, pp. 81–2

  Ullmann, p. 82

  [*"A Big Source of Silver Bullion Demand Has Disappeared"*](http://goldnews.bullionvault.com/silver-bullion-photographic-demand-062120133)*. BullionVault. Retrieved 2014-07-20.*

  [*"European Union Observatory for Nanomaterials pigments inventory"*](https://euon.echa.europa.eu/nano-pigments-inventory)*.*

  [*"European Union Observatory for Nanomaterials catalogue of nano cosmetics ingredients"*](https://euon.echa.europa.eu/catalogue-of-cosmetic-ingredients)*.*

  *Martínez-Abad, A.; Ocio, M. J.; Lagarón, J. M.; Sánchez, G. (2013). "Evaluation of silver-infused polylactide films for inactivation of Salmonella and feline calicivirus in vitro and on fresh-cut vegetables". International Journal of Food Microbiology.* ***162*** *(1): 89–94.* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1016/j.ijfoodmicro.2012.12.024*](https://doi.org/10.1016%2Fj.ijfoodmicro.2012.12.024)*.* [*PMID*](https://en.wikipedia.org/wiki/PubMed_Identifier)[*23376782*](https://www.ncbi.nlm.nih.gov/pubmed/23376782)*.*

  [*Sarvate, Sarita*](https://en.wikipedia.org/wiki/Sarita_Sarvate) *(4 April 2005).* [*"Silver Coating"*](https://web.archive.org/web/20090214002122/http:/indiacurrents.com/news/view_article.html?article_id=b8b860cc0946bef1dbe95caddfe4bcaa)*. India Currents. Archived from the original on 14 February 2009. Retrieved 5 July 2009.*

  *Meisler, Andy (18 December 2005).* [*"A Tempest on a Tea Cart"*](http://articles.latimes.com/2005/dec/18/magazine/tm-dragee51)*. Los Angeles Times.*

  <https://www.sigmaaldrich.com/MSDS/MSDS/DisplayMSDSPage.do?country=US&language=en&productNumber=373249&brand=ALDRICH&PageToGoToURL=https%3A%2F%2Fwww.sigmaaldrich.com%2Fcatalog%2Fproduct%2Faldrich%2F373249%3Flang%3Den>

* 1.  Ullmann, pp. 88–91

**Bibliography**

* [*Greenwood, Norman N.*](https://en.wikipedia.org/wiki/Norman_Greenwood)*; Earnshaw, Alan (1997). Chemistry of the Elements (2nd ed.).* [*Butterworth-Heinemann*](https://en.wikipedia.org/wiki/Butterworth-Heinemann)*.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*0-08-037941-9*](https://en.wikipedia.org/wiki/Special:BookSources/0-08-037941-9)*.*
* [*Weeks, Mary Elvira*](https://en.wikipedia.org/wiki/Mary_Elvira_Weeks)*; Leichester, Henry M. (1968). Discovery of the Elements. Easton, PA: Journal of Chemical Education.* [*ISBN*](https://en.wikipedia.org/wiki/International_Standard_Book_Number)[*978-0-7661-3872-8*](https://en.wikipedia.org/wiki/Special:BookSources/978-0-7661-3872-8)*.* [*LCCN*](https://en.wikipedia.org/wiki/Library_of_Congress_Control_Number)[*68-15217*](https://lccn.loc.gov/68-15217)*.*
* *Andreas Brumby, Peter Braumann, Klaus Zimmermann, Francis Van Den Broeck, Thierry Vandevelde, Dan Goia, Hermann Renner, Günther Schlamp, Klaus Zimmermann, Wolfgang Weise, Peter Tews, Klaus Dermann, Alfons Knödler, Karl-Heinz Schröder, Bernd Kempf, Hans Martin Lüschow, Cartrin Peter, Rainer Schiele, "Silver, Silver Compounds, and Silver Alloys",* [*Ullmann's Encyclopedia of Industrial Chemistry*](https://en.wikipedia.org/wiki/Ullmann%27s_Encyclopedia_of_Industrial_Chemistry)*, Weinheim: Wiley-VCH,* [*doi*](https://en.wikipedia.org/wiki/Digital_object_identifier)*:*[*10.1002/14356007.a24\_107.pub2*](https://doi.org/10.1002%2F14356007.a24_107.pub2)

**External links**

**Silver**at Wikipedia's [sister projects](https://en.wikipedia.org/wiki/Wikipedia:Wikimedia_sister_projects)

* https://upload.wikimedia.org/wikipedia/en/thumb/0/06/Wiktionary-logo-v2.svg/27px-Wiktionary-logo-v2.svg.png[Definitions](https://en.wiktionary.org/wiki/silver) from Wiktionary
* https://upload.wikimedia.org/wikipedia/en/thumb/4/4a/Commons-logo.svg/20px-Commons-logo.svg.png[Media](https://commons.wikimedia.org/wiki/silver) from Wikimedia Commons
* https://upload.wikimedia.org/wikipedia/commons/thumb/f/fa/Wikiquote-logo.svg/23px-Wikiquote-logo.svg.png[Quotations](https://en.wikiquote.org/wiki/silver) from Wikiquote

**Listen to this article** ([info/dl](https://en.wikipedia.org/wiki/File:Silver.ogg))

Menu

0:00

https://upload.wikimedia.org/wikipedia/commons/thumb/4/47/Sound-icon.svg/45px-Sound-icon.svg.png

This audio file was created from a revision of the article "Silver" dated 2005-09-01, and does not reflect subsequent edits to the article. ([Audio help](https://en.wikipedia.org/wiki/Wikipedia:Media_help))

[**More spoken articles**](https://en.wikipedia.org/wiki/Wikipedia:Spoken_articles)

* [Silver](http://www.periodicvideos.com/videos/047.htm) at [*The Periodic Table of Videos*](https://en.wikipedia.org/wiki/The_Periodic_Table_of_Videos) (University of Nottingham)
* [Society of American Silversmiths](http://www.silversmithing.com/)
* [The Silver Institute](http://www.silverinstitute.org/) A silver industry website
* [A collection of silver items](http://www.theodoregray.com/PeriodicTable/Elements/047/index.html) Samples of silver
* [Transport, Fate and Effects of Silver in the Environment](http://digital.library.wisc.edu/1711.dl/EcoNatRes.Argentum)
* [CDC – NIOSH Pocket Guide to Chemical Hazards – Silver](https://www.cdc.gov/niosh/npg/npgd0557.html)
* [Picture in the Element collection from Heinrich Pniok](http://www.pniok.de/ag.htm)

|  |
| --- |
|  |
| * [**v**](https://en.wikipedia.org/wiki/Template:Periodic_table_(32_columns,_compact)) * [**t**](https://en.wikipedia.org/wiki/Template_talk:Periodic_table_(32_columns,_compact)) * [**e**](https://en.wikipedia.org/w/index.php?title=Template:Periodic_table_(32_columns,_compact)&action=edit)   [**Periodic table**](https://en.wikipedia.org/wiki/Periodic_table)[**(Large cells)**](https://en.wikipedia.org/wiki/Periodic_table_(large_cells)) | |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | [1](https://en.wikipedia.org/wiki/Alkali_metal) | [2](https://en.wikipedia.org/wiki/Alkaline_earth_metal) | [3](https://en.wikipedia.org/wiki/Group_3_element) |  | | | | | | | | | | | | | | [4](https://en.wikipedia.org/wiki/Group_4_element) | [5](https://en.wikipedia.org/wiki/Group_5_element) | [6](https://en.wikipedia.org/wiki/Group_6_element) | [7](https://en.wikipedia.org/wiki/Group_7_element) | [8](https://en.wikipedia.org/wiki/Group_8_element) | [9](https://en.wikipedia.org/wiki/Group_9_element) | [10](https://en.wikipedia.org/wiki/Group_10_element) | [11](https://en.wikipedia.org/wiki/Group_11_element) | [12](https://en.wikipedia.org/wiki/Group_12_element) | [13](https://en.wikipedia.org/wiki/Boron_group) | [14](https://en.wikipedia.org/wiki/Carbon_group) | [15](https://en.wikipedia.org/wiki/Pnictogen) | [16](https://en.wikipedia.org/wiki/Chalcogen) | [17](https://en.wikipedia.org/wiki/Halogen) | [18](https://en.wikipedia.org/wiki/Noble_gas) | | [1](https://en.wikipedia.org/wiki/Period_1_element) | [H](https://en.wikipedia.org/wiki/Hydrogen) |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | [He](https://en.wikipedia.org/wiki/Helium) | | [2](https://en.wikipedia.org/wiki/Period_2_element) | [Li](https://en.wikipedia.org/wiki/Lithium) | [Be](https://en.wikipedia.org/wiki/Beryllium) |  | | | | | | | | | | | | | | | | | | | | | | | | [B](https://en.wikipedia.org/wiki/Boron) | [C](https://en.wikipedia.org/wiki/Carbon) | [N](https://en.wikipedia.org/wiki/Nitrogen) | [O](https://en.wikipedia.org/wiki/Oxygen) | [F](https://en.wikipedia.org/wiki/Fluorine) | [Ne](https://en.wikipedia.org/wiki/Neon) | | [3](https://en.wikipedia.org/wiki/Period_3_element) | [Na](https://en.wikipedia.org/wiki/Sodium) | [Mg](https://en.wikipedia.org/wiki/Magnesium) |  | | | | | | | | | | | | | | | | | | | | | | | | [Al](https://en.wikipedia.org/wiki/Aluminium) | [Si](https://en.wikipedia.org/wiki/Silicon) | [P](https://en.wikipedia.org/wiki/Phosphorus) | [S](https://en.wikipedia.org/wiki/Sulfur) | [Cl](https://en.wikipedia.org/wiki/Chlorine) | [Ar](https://en.wikipedia.org/wiki/Argon) | | [4](https://en.wikipedia.org/wiki/Period_4_element) | [K](https://en.wikipedia.org/wiki/Potassium) | [Ca](https://en.wikipedia.org/wiki/Calcium) | [Sc](https://en.wikipedia.org/wiki/Scandium) |  | | | | | | | | | | | | | | [Ti](https://en.wikipedia.org/wiki/Titanium) | [V](https://en.wikipedia.org/wiki/Vanadium) | [Cr](https://en.wikipedia.org/wiki/Chromium) | [Mn](https://en.wikipedia.org/wiki/Manganese) | [Fe](https://en.wikipedia.org/wiki/Iron) | [Co](https://en.wikipedia.org/wiki/Cobalt) | [Ni](https://en.wikipedia.org/wiki/Nickel) | [Cu](https://en.wikipedia.org/wiki/Copper) | [Zn](https://en.wikipedia.org/wiki/Zinc) | [Ga](https://en.wikipedia.org/wiki/Gallium) | [Ge](https://en.wikipedia.org/wiki/Germanium) | [As](https://en.wikipedia.org/wiki/Arsenic) | [Se](https://en.wikipedia.org/wiki/Selenium) | [Br](https://en.wikipedia.org/wiki/Bromine) | [Kr](https://en.wikipedia.org/wiki/Krypton) | | [5](https://en.wikipedia.org/wiki/Period_5_element) | [Rb](https://en.wikipedia.org/wiki/Rubidium) | [Sr](https://en.wikipedia.org/wiki/Strontium) | [Y](https://en.wikipedia.org/wiki/Yttrium) |  | | | | | | | | | | | | | | [Zr](https://en.wikipedia.org/wiki/Zirconium) | [Nb](https://en.wikipedia.org/wiki/Niobium) | [Mo](https://en.wikipedia.org/wiki/Molybdenum) | [Tc](https://en.wikipedia.org/wiki/Technetium) | [Ru](https://en.wikipedia.org/wiki/Ruthenium) | [Rh](https://en.wikipedia.org/wiki/Rhodium) | [Pd](https://en.wikipedia.org/wiki/Palladium) | Ag | [Cd](https://en.wikipedia.org/wiki/Cadmium) | [In](https://en.wikipedia.org/wiki/Indium) | [Sn](https://en.wikipedia.org/wiki/Tin) | [Sb](https://en.wikipedia.org/wiki/Antimony) | [Te](https://en.wikipedia.org/wiki/Tellurium) | [I](https://en.wikipedia.org/wiki/Iodine) | [Xe](https://en.wikipedia.org/wiki/Xenon) | | [6](https://en.wikipedia.org/wiki/Period_6_element) | [Cs](https://en.wikipedia.org/wiki/Caesium) | [Ba](https://en.wikipedia.org/wiki/Barium) | [La](https://en.wikipedia.org/wiki/Lanthanum) | [Ce](https://en.wikipedia.org/wiki/Cerium) | [Pr](https://en.wikipedia.org/wiki/Praseodymium) | [Nd](https://en.wikipedia.org/wiki/Neodymium) | [Pm](https://en.wikipedia.org/wiki/Promethium) | [Sm](https://en.wikipedia.org/wiki/Samarium) | [Eu](https://en.wikipedia.org/wiki/Europium) | [Gd](https://en.wikipedia.org/wiki/Gadolinium) | [Tb](https://en.wikipedia.org/wiki/Terbium) | [Dy](https://en.wikipedia.org/wiki/Dysprosium) | [Ho](https://en.wikipedia.org/wiki/Holmium) | [Er](https://en.wikipedia.org/wiki/Erbium) | [Tm](https://en.wikipedia.org/wiki/Thulium) | [Yb](https://en.wikipedia.org/wiki/Ytterbium) | [Lu](https://en.wikipedia.org/wiki/Lutetium) | [Hf](https://en.wikipedia.org/wiki/Hafnium) | [Ta](https://en.wikipedia.org/wiki/Tantalum) | [W](https://en.wikipedia.org/wiki/Tungsten) | [Re](https://en.wikipedia.org/wiki/Rhenium) | [Os](https://en.wikipedia.org/wiki/Osmium) | [Ir](https://en.wikipedia.org/wiki/Iridium) | [Pt](https://en.wikipedia.org/wiki/Platinum) | [Au](https://en.wikipedia.org/wiki/Gold) | [Hg](https://en.wikipedia.org/wiki/Mercury_(element)) | [Tl](https://en.wikipedia.org/wiki/Thallium) | [Pb](https://en.wikipedia.org/wiki/Lead) | [Bi](https://en.wikipedia.org/wiki/Bismuth) | [Po](https://en.wikipedia.org/wiki/Polonium) | [At](https://en.wikipedia.org/wiki/Astatine) | [Rn](https://en.wikipedia.org/wiki/Radon) | | [7](https://en.wikipedia.org/wiki/Period_7_element) | [Fr](https://en.wikipedia.org/wiki/Francium) | [Ra](https://en.wikipedia.org/wiki/Radium) | [Ac](https://en.wikipedia.org/wiki/Actinium) | [Th](https://en.wikipedia.org/wiki/Thorium) | [Pa](https://en.wikipedia.org/wiki/Protactinium) | [U](https://en.wikipedia.org/wiki/Uranium) | [Np](https://en.wikipedia.org/wiki/Neptunium) | [Pu](https://en.wikipedia.org/wiki/Plutonium) | [Am](https://en.wikipedia.org/wiki/Americium) | [Cm](https://en.wikipedia.org/wiki/Curium) | [Bk](https://en.wikipedia.org/wiki/Berkelium) | [Cf](https://en.wikipedia.org/wiki/Californium) | [Es](https://en.wikipedia.org/wiki/Einsteinium) | [Fm](https://en.wikipedia.org/wiki/Fermium) | [Md](https://en.wikipedia.org/wiki/Mendelevium) | [No](https://en.wikipedia.org/wiki/Nobelium) | [Lr](https://en.wikipedia.org/wiki/Lawrencium) | [Rf](https://en.wikipedia.org/wiki/Rutherfordium) | [Db](https://en.wikipedia.org/wiki/Dubnium) | [Sg](https://en.wikipedia.org/wiki/Seaborgium) | [Bh](https://en.wikipedia.org/wiki/Bohrium) | [Hs](https://en.wikipedia.org/wiki/Hassium) | [Mt](https://en.wikipedia.org/wiki/Meitnerium) | [Ds](https://en.wikipedia.org/wiki/Darmstadtium) | [Rg](https://en.wikipedia.org/wiki/Roentgenium) | [Cn](https://en.wikipedia.org/wiki/Copernicium) | [Nh](https://en.wikipedia.org/wiki/Nihonium) | [Fl](https://en.wikipedia.org/wiki/Flerovium) | [Mc](https://en.wikipedia.org/wiki/Moscovium) | [Lv](https://en.wikipedia.org/wiki/Livermorium) | [Ts](https://en.wikipedia.org/wiki/Tennessine) | [Og](https://en.wikipedia.org/wiki/Oganesson) | | |
| |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | [Alkali metal](https://en.wikipedia.org/wiki/Alkali_metal) | [Alkaline earth metal](https://en.wikipedia.org/wiki/Alkaline_earth_metal) | [Lan­thanide](https://en.wikipedia.org/wiki/Lanthanide) | [Actinide](https://en.wikipedia.org/wiki/Actinide) | [Transition metal](https://en.wikipedia.org/wiki/Transition_metal) | [Post-​transition metal](https://en.wikipedia.org/wiki/Post-transition_metal) | [Metalloid](https://en.wikipedia.org/wiki/Metalloid) | [Reactive nonmetal](https://en.wikipedia.org/wiki/Reactive_nonmetal) | [Noble gas](https://en.wikipedia.org/wiki/Noble_gas) | Unknown chemical properties | | |

|  |
| --- |
|  |
| * [**v**](https://en.wikipedia.org/wiki/Template:Silver_compounds) * [**t**](https://en.wikipedia.org/wiki/Template_talk:Silver_compounds) * [**e**](https://en.wikipedia.org/w/index.php?title=Template:Silver_compounds&action=edit)   **Silver compounds** | |

|  |
| --- |
|  |
| * [**v**](https://en.wikipedia.org/wiki/Template:Jewellery) * [**t**](https://en.wikipedia.org/wiki/Template_talk:Jewellery) * [**e**](https://en.wikipedia.org/w/index.php?title=Template:Jewellery&action=edit)   [**Jewellery**](https://en.wikipedia.org/wiki/Jewellery) | |

|  |  |
| --- | --- |
| [**Authority control**](https://en.wikipedia.org/wiki/Help:Authority_control) **[Edit this at Wikidata](https://www.wikidata.org/wiki/Q1090)** | * [BNE](https://en.wikipedia.org/wiki/Biblioteca_Nacional_de_Espa%C3%B1a): [XX526371](http://catalogo.bne.es/uhtbin/authoritybrowse.cgi?action=display&authority_id=XX526371) * [BNF](https://en.wikipedia.org/wiki/Biblioth%C3%A8que_nationale_de_France): [cb11959564p](https://catalogue.bnf.fr/ark:/12148/cb11959564p) [(data)](http://data.bnf.fr/ark:/12148/cb11959564p) * [GND](https://en.wikipedia.org/wiki/Integrated_Authority_File): [4133759-1](https://d-nb.info/gnd/4133759-1) * [LCCN](https://en.wikipedia.org/wiki/Library_of_Congress_Control_Number): [sh85122588](https://id.loc.gov/authorities/subjects/sh85122588) * [NARA](https://en.wikipedia.org/wiki/National_Archives_and_Records_Administration): [10641526](https://catalog.archives.gov/id/10641526) * [NDL](https://en.wikipedia.org/wiki/National_Diet_Library): [00562453](https://id.ndl.go.jp/auth/ndlna/00562453) |

[Categories](https://en.wikipedia.org/wiki/Help:Category):

* [Silver](https://en.wikipedia.org/wiki/Category:Silver)
* [Chemical elements](https://en.wikipedia.org/wiki/Category:Chemical_elements)
* [Transition metals](https://en.wikipedia.org/wiki/Category:Transition_metals)
* [Noble metals](https://en.wikipedia.org/wiki/Category:Noble_metals)
* [Precious metals](https://en.wikipedia.org/wiki/Category:Precious_metals)
* [Cubic minerals](https://en.wikipedia.org/wiki/Category:Cubic_minerals)
* [Electrical conductors](https://en.wikipedia.org/wiki/Category:Electrical_conductors)
* [Native element minerals](https://en.wikipedia.org/wiki/Category:Native_element_minerals)
* [E-number additives](https://en.wikipedia.org/wiki/Category:E-number_additives)

**Navigation menu**

* Not logged in
* [Talk](https://en.wikipedia.org/wiki/Special:MyTalk)
* [Contributions](https://en.wikipedia.org/wiki/Special:MyContributions)
* [Create account](https://en.wikipedia.org/w/index.php?title=Special:CreateAccount&returnto=Silver)
* [Log in](https://en.wikipedia.org/w/index.php?title=Special:UserLogin&returnto=Silver)
* [Article](https://en.wikipedia.org/wiki/Silver)
* [Talk](https://en.wikipedia.org/wiki/Talk:Silver)
* [Read](https://en.wikipedia.org/wiki/Silver)
* [Edit](https://en.wikipedia.org/w/index.php?title=Silver&action=edit)
* [View history](https://en.wikipedia.org/w/index.php?title=Silver&action=history)

**Search**

Top of Form

Bottom of Form

* [Main page](https://en.wikipedia.org/wiki/Main_Page)
* [Contents](https://en.wikipedia.org/wiki/Portal:Contents)
* [Featured content](https://en.wikipedia.org/wiki/Portal:Featured_content)
* [Current events](https://en.wikipedia.org/wiki/Portal:Current_events)
* [Random article](https://en.wikipedia.org/wiki/Special:Random)
* [Donate to Wikipedia](https://donate.wikimedia.org/wiki/Special:FundraiserRedirector?utm_source=donate&utm_medium=sidebar&utm_campaign=C13_en.wikipedia.org&uselang=en)
* [Wikipedia store](https://shop.wikimedia.org)

**Interaction**

* [Help](https://en.wikipedia.org/wiki/Help:Contents)
* [About Wikipedia](https://en.wikipedia.org/wiki/Wikipedia:About)
* [Community portal](https://en.wikipedia.org/wiki/Wikipedia:Community_portal)
* [Recent changes](https://en.wikipedia.org/wiki/Special:RecentChanges)
* [Contact page](https://en.wikipedia.org/wiki/Wikipedia:Contact_us)

**Tools**

* [What links here](https://en.wikipedia.org/wiki/Special:WhatLinksHere/Silver)
* [Related changes](https://en.wikipedia.org/wiki/Special:RecentChangesLinked/Silver)
* [Upload file](https://en.wikipedia.org/wiki/Wikipedia:File_Upload_Wizard)
* [Special pages](https://en.wikipedia.org/wiki/Special:SpecialPages)
* [Permanent link](https://en.wikipedia.org/w/index.php?title=Silver&oldid=873194337)
* [Page information](https://en.wikipedia.org/w/index.php?title=Silver&action=info)
* [Wikidata item](https://www.wikidata.org/wiki/Special:EntityPage/Q1090)
* [Cite this page](https://en.wikipedia.org/w/index.php?title=Special:CiteThisPage&page=Silver&id=873194337)

**Print/export**

* [Create a book](https://en.wikipedia.org/w/index.php?title=Special:Book&bookcmd=book_creator&referer=Silver)
* [Download as PDF](https://en.wikipedia.org/w/index.php?title=Special:ElectronPdf&page=Silver&action=show-download-screen)
* [Printable version](https://en.wikipedia.org/w/index.php?title=Silver&printable=yes)

**In other projects**

* [Wikimedia Commons](https://commons.wikimedia.org/wiki/Category:Silver)
* [Wikiquote](https://en.wikiquote.org/wiki/Silver)

**Languages**

* [Deutsch](https://de.wikipedia.org/wiki/Silber)
* [Español](https://es.wikipedia.org/wiki/Plata)
* [Français](https://fr.wikipedia.org/wiki/Argent)
* [한국어](https://ko.wikipedia.org/wiki/%EC%9D%80)
* [Italiano](https://it.wikipedia.org/wiki/Argento)
* [Русский](https://ru.wikipedia.org/wiki/%D0%A1%D0%B5%D1%80%D0%B5%D0%B1%D1%80%D0%BE)
* [Tagalog](https://tl.wikipedia.org/wiki/Pilak)
* [Tiếng Việt](https://vi.wikipedia.org/wiki/B%E1%BA%A1c)
* [中文](https://zh.wikipedia.org/wiki/%E9%8A%80)

[Edit links](https://www.wikidata.org/wiki/Special:EntityPage/Q1090#sitelinks-wikipedia)

* This page was last edited on 11 December 2018, at 17:55 (UTC).
* Text is available under the [Creative Commons Attribution-ShareAlike License](https://en.wikipedia.org/wiki/Wikipedia:Text_of_Creative_Commons_Attribution-ShareAlike_3.0_Unported_License); additional terms may apply. By using this site, you agree to the [Terms of Use](https://foundation.wikimedia.org/wiki/Terms_of_Use) and [Privacy Policy](https://foundation.wikimedia.org/wiki/Privacy_policy). Wikipedia® is a registered trademark of the [Wikimedia Foundation, Inc.](https://www.wikimediafoundation.org/), a non-profit organization.
* [Privacy policy](https://foundation.wikimedia.org/wiki/Privacy_policy)
* [About Wikipedia](https://en.wikipedia.org/wiki/Wikipedia:About)
* [Disclaimers](https://en.wikipedia.org/wiki/Wikipedia:General_disclaimer)
* [Contact Wikipedia](https://en.wikipedia.org/wiki/Wikipedia:Contact_us)
* [Developers](https://www.mediawiki.org/wiki/Special:MyLanguage/How_to_contribute)
* [Cookie statement](https://foundation.wikimedia.org/wiki/Cookie_statement)
* [Mobile view](https://en.m.wikipedia.org/w/index.php?title=Silver&mobileaction=toggle_view_mobile)
* [Wikimedia Foundation](https://wikimediafoundation.org/)
* [Powered by MediaWiki](https://www.mediawiki.org/)