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**Chromium**

From Wikipedia, the free encyclopedia

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

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| --- | --- |
| Chromium,  24Cr | |
| [Chromium crystals and 1cm3 cube.jpg](https://en.wikipedia.org/wiki/File:Chromium_crystals_and_1cm3_cube.jpg) | |
| **General properties** | |
| **Appearance** | silvery metallic |
| [**Standard atomic weight**](https://en.wikipedia.org/wiki/Standard_atomic_weight) **(*A*r, standard)** | 51.9961(6)[[1]](https://en.wikipedia.org/wiki/Chromium#cite_note-CIAAW2016-1) |
| **Chromium in the** [**periodic table**](https://en.wikipedia.org/wiki/Periodic_table) | |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 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[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 | [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](https://en.wikipedia.org/wiki/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) | | – ↑ **Cr** ↓ [Mo](https://en.wikipedia.org/wiki/Molybdenum) | | [vanadium](https://en.wikipedia.org/wiki/Vanadium) ← **chromium** → [manganese](https://en.wikipedia.org/wiki/Manganese) | | | | |
| [**Atomic number**](https://en.wikipedia.org/wiki/Atomic_number)(*Z*) | 24 |
| [**Group**](https://en.wikipedia.org/wiki/Group_(periodic_table)) | [group 6](https://en.wikipedia.org/wiki/Group_6_element) |
| [**Period**](https://en.wikipedia.org/wiki/Period_(periodic_table)) | [period 4](https://en.wikipedia.org/wiki/Period_(periodic_table)#Period_4) |
| [**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) | [[Ar](https://en.wikipedia.org/wiki/Argon)] 3d5 4s1 |
| Electrons per shell | 2, 8, 13, 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) | 2180 [K](https://en.wikipedia.org/wiki/Kelvin) ​(1907 °C, ​3465 °F) |
| [**Boiling point**](https://en.wikipedia.org/wiki/Boiling_point) | 2944 K ​(2671 °C, ​4840 °F) |
| [**Density**](https://en.wikipedia.org/wiki/Density)(near r.t.) | 7.19 g/cm3 |
| when liquid (at m.p.) | 6.3 g/cm3 |
| [**Heat of fusion**](https://en.wikipedia.org/wiki/Enthalpy_of_fusion) | 21.0 [kJ/mol](https://en.wikipedia.org/wiki/Kilojoule_per_mole) |
| [**Heat of vaporization**](https://en.wikipedia.org/wiki/Enthalpy_of_vaporization) | 347 kJ/mol |
| [**Molar heat capacity**](https://en.wikipedia.org/wiki/Molar_heat_capacity) | 23.35 J/(mol·K) |
| [**Vapor pressure**](https://en.wikipedia.org/wiki/Vapor_pressure)   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ***P***(Pa) | **1** | **10** | **100** | **1 k** | **10 k** | **100 k** | | **at *T***(K) | 1656 | 1807 | 1991 | 2223 | 2530 | 2942 | | |
| **Atomic properties** | |
| [**Oxidation states**](https://en.wikipedia.org/wiki/Oxidation_state) | −4, −2, −1, +1, +2, **+3**, +4, +5, **+6** (depending on the oxidation state, an acidic, basic, or [amphoteric](https://en.wikipedia.org/wiki/Amphoterism) oxide) |
| [**Electronegativity**](https://en.wikipedia.org/wiki/Electronegativity) | Pauling scale: 1.66 |
| [**Ionization energies**](https://en.wikipedia.org/wiki/Ionization_energy) | * 1st: 652.9 kJ/mol * 2nd: 1590.6 kJ/mol * 3rd: 2987 kJ/mol * ([more](https://en.wikipedia.org/wiki/Molar_ionization_energies_of_the_elements#chromium)) |
| [**Atomic radius**](https://en.wikipedia.org/wiki/Atomic_radius) | empirical: 128 [pm](https://en.wikipedia.org/wiki/Picometre) |
| [**Covalent radius**](https://en.wikipedia.org/wiki/Covalent_radius) | 139±5 pm |
| [Color lines in a spectral range](https://en.wikipedia.org/wiki/File:Chromium_spectrum_visible.png)  [**Spectral lines**](https://en.wikipedia.org/wiki/Spectral_line) **of chromium** | |
| **Other properties** | |
| [**Crystal structure**](https://en.wikipedia.org/wiki/Crystal_structure) | ​[body-centered cubic](https://en.wikipedia.org/wiki/Cubic_crystal_system) (bcc)  [Body-centered cubic crystal structure for chromium](https://en.wikipedia.org/wiki/File:Cubic-body-centered.svg) |
| [**Speed of sound**](https://en.wikipedia.org/wiki/Speed_of_sound)thin rod | 5940 m/s (at 20 °C) |
| [**Thermal expansion**](https://en.wikipedia.org/wiki/Coefficient_of_thermal_expansion) | 4.9 µm/(m·K) (at 25 °C) |
| [**Thermal conductivity**](https://en.wikipedia.org/wiki/Thermal_conductivity) | 93.9 W/(m·K) |
| [**Electrical resistivity**](https://en.wikipedia.org/wiki/Electrical_resistivity_and_conductivity) | 125 nΩ·m (at 20 °C) |
| [**Magnetic ordering**](https://en.wikipedia.org/wiki/Magnetism) | [antiferromagnetic](https://en.wikipedia.org/wiki/Antiferromagnetism) (rather: [SDW](https://en.wikipedia.org/wiki/Spin_density_wave))[[2]](https://en.wikipedia.org/wiki/Chromium#cite_note-fawcett-2) |
| [**Magnetic susceptibility**](https://en.wikipedia.org/wiki/Magnetic_susceptibility) | +280.0·10−6 cm3/mol (273 K)[[3]](https://en.wikipedia.org/wiki/Chromium#cite_note-3) |
| [**Young's modulus**](https://en.wikipedia.org/wiki/Young%27s_modulus) | 279 GPa |
| [**Shear modulus**](https://en.wikipedia.org/wiki/Shear_modulus) | 115 GPa |
| [**Bulk modulus**](https://en.wikipedia.org/wiki/Bulk_modulus) | 160 GPa |
| [**Poisson ratio**](https://en.wikipedia.org/wiki/Poisson%27s_ratio) | 0.21 |
| [**Mohs hardness**](https://en.wikipedia.org/wiki/Mohs_scale_of_mineral_hardness) | 8.5 |
| [**Vickers hardness**](https://en.wikipedia.org/wiki/Vickers_hardness_test) | 1060 MPa |
| [**Brinell hardness**](https://en.wikipedia.org/wiki/Brinell_hardness_test) | 687–6500 MPa |
| [**CAS Number**](https://en.wikipedia.org/wiki/CAS_Registry_Number) | 7440-47-3 |
| **History** | |
| [**Discovery**](https://en.wikipedia.org/wiki/Timeline_of_chemical_element_discoveries) **and first isolation** | [Louis Nicolas Vauquelin](https://en.wikipedia.org/wiki/Louis_Nicolas_Vauquelin) (1794, 1797) |
| **Main** [**isotopes of chromium**](https://en.wikipedia.org/wiki/Isotopes_of_chromium) | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | [**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) | | **50Cr** | 4.345% | [stable](https://en.wikipedia.org/wiki/Stable_isotope) | | | | **51Cr** | [syn](https://en.wikipedia.org/wiki/Synthetic_radioisotope) | 27.7025 d | [ε](https://en.wikipedia.org/wiki/Electron_capture) | [51V](https://en.wikipedia.org/wiki/Vanadium-51) | | [γ](https://en.wikipedia.org/wiki/Gamma_ray) | – | | **52Cr** | 83.789% | stable | | | | **53Cr** | 9.501% | stable | | | | **54Cr** | 2.365% | stable | | | | |
| * [view](https://en.wikipedia.org/wiki/Template:Infobox_chromium) * [talk](https://en.wikipedia.org/wiki/Template_talk:Infobox_chromium) * [edit](https://en.wikipedia.org/w/index.php?title=Template:Infobox_chromium&action=edit)   | [references](https://en.wikipedia.org/wiki/List_of_data_references_for_chemical_elements) | |

**Chromium** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Cr** and [atomic number](https://en.wikipedia.org/wiki/Atomic_number) 24. It is the first element in [group 6](https://en.wikipedia.org/wiki/Group_6_element). It is a steely-grey, [lustrous](https://en.wikipedia.org/wiki/Luster_(mineralogy)), hard and brittle [transition metal](https://en.wikipedia.org/wiki/Transition_metal).[[4]](https://en.wikipedia.org/wiki/Chromium#cite_note-4) Chromium boasts a high usage rate as a [metal](https://en.wikipedia.org/wiki/Metal) that is able to be highly [polished](https://en.wikipedia.org/wiki/Polishing) while resisting [tarnishing](https://en.wikipedia.org/wiki/Tarnish). Chromium is also the main component of [stainless steel](https://en.wikipedia.org/wiki/Stainless_steel), a popular steel alloy due to its uncommonly high [specular reflection](https://en.wikipedia.org/wiki/Specular_reflection). Simple polished chromium reflects almost 70% of the [visible spectrum](https://en.wikipedia.org/wiki/Visible_spectrum), with almost 90% of [infrared light](https://en.wikipedia.org/wiki/Infrared) waves being reflected.[[5]](https://en.wikipedia.org/wiki/Chromium#cite_note-NIST_specular_reflection-5) The name of the element is derived from the [Greek](https://en.wikipedia.org/wiki/Ancient_Greek) word χρῶμα, *chrōma*, meaning [color](https://en.wikipedia.org/wiki/Color),[[6]](https://en.wikipedia.org/wiki/Chromium#cite_note-6) because many chromium compounds are intensely colored.

[Ferrochromium](https://en.wikipedia.org/wiki/Ferrochromium) alloy is commercially produced from [chromite](https://en.wikipedia.org/wiki/Chromite) by [silicothermic](https://en.wikipedia.org/wiki/Silicothermic) or [aluminothermic reactions](https://en.wikipedia.org/wiki/Aluminothermic_reaction) and chromium metal by [roasting](https://en.wikipedia.org/wiki/Roasting_(metallurgy)) and [leaching](https://en.wikipedia.org/wiki/Leaching_(metallurgy)) processes followed by reduction with [carbon](https://en.wikipedia.org/wiki/Carbon) and then [aluminium](https://en.wikipedia.org/wiki/Aluminium). Chromium metal is of high value for its high [corrosion](https://en.wikipedia.org/wiki/Corrosion) resistance and [hardness](https://en.wikipedia.org/wiki/Hardness). A major development in steel production was the discovery that steel could be made highly resistant to corrosion and discoloration by adding metallic chromium to form [stainless steel](https://en.wikipedia.org/wiki/Stainless_steel). Stainless steel and [chrome plating](https://en.wikipedia.org/wiki/Chrome_plating) ([electroplating](https://en.wikipedia.org/wiki/Electroplating) with chromium) together comprise 85% of the commercial use.

In the United States, [trivalent](https://en.wikipedia.org/wiki/Trivalent) chromium (Cr(III)) [ion](https://en.wikipedia.org/wiki/Ion) is considered an [essential nutrient](https://en.wikipedia.org/wiki/Essential_nutrient) in humans for [insulin](https://en.wikipedia.org/wiki/Insulin), [sugar](https://en.wikipedia.org/wiki/Sugar) and [lipid](https://en.wikipedia.org/wiki/Lipid) [metabolism](https://en.wikipedia.org/wiki/Metabolism).[[7]](https://en.wikipedia.org/wiki/Chromium#cite_note-ods-7) However, in 2014, the [European Food Safety Authority](https://en.wikipedia.org/wiki/European_Food_Safety_Authority), acting for the European Union, concluded that there was not sufficient evidence for chromium to be recognized as essential.[[8]](https://en.wikipedia.org/wiki/Chromium#cite_note-8)

While chromium metal and Cr(III) ions are not considered toxic, [hexavalent chromium](https://en.wikipedia.org/wiki/Hexavalent_chromium) (Cr(VI)) is both toxic and [carcinogenic](https://en.wikipedia.org/wiki/Carcinogenic). Abandoned chromium production sites often require [environmental cleanup](https://en.wikipedia.org/wiki/Environmental_remediation).



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**Physical properties**

**Atomic**

Chromium is the fourth [transition metal](https://en.wikipedia.org/wiki/Transition_metal) found on the periodic table, and has an electron configuration of [[Ar](https://en.wikipedia.org/wiki/Argon)] 3d5 4s1. It is also the first element in the periodic table whose ground-state electron configuration violates the [Aufbau principle](https://en.wikipedia.org/wiki/Aufbau_principle). This occurs again later in the periodic table with other elements and their electron configurations, such as [copper](https://en.wikipedia.org/wiki/Copper), [niobium](https://en.wikipedia.org/wiki/Niobium), and [molybdenum](https://en.wikipedia.org/wiki/Molybdenum).[[9]](https://en.wikipedia.org/wiki/Chromium#cite_note-CasaXPS-9) This occurs because electrons in the same orbital repel each other due to their like charges. In the previous elements, the energetic cost of promoting an electron to the next higher energy level is too great to compensate for that released by lessening inter-electronic repulsion. However, in the 3d transition metals, the energy gap between the 3d and the next-higher 4s subshell is very small, and because the 3d subshell is more compact than the 4s subshell, inter-electron repulsion is smaller between 4s electrons than between 3d electrons. This lowers the energetic cost of promotion and increases the energy released by it, so that the promotion becomes energetically feasible and one or even two electrons are always promoted to the 4s subshell. (Similar promotions happen for every transition metal atom but one, [palladium](https://en.wikipedia.org/wiki/Palladium).)[[10]](https://en.wikipedia.org/wiki/Chromium#cite_note-10)

Chromium is the first element in the 3d series where the 3d electrons are starting to sink into the inert core; they thus contribute less to [metallic bonding](https://en.wikipedia.org/wiki/Metallic_bonding), and hence the melting and boiling points and the [enthalpy of atomisation](https://en.wikipedia.org/wiki/Enthalpy_of_atomisation) of chromium are lower than those of the preceding element [vanadium](https://en.wikipedia.org/wiki/Vanadium). Chromium(VI) is a strong [oxidising agent](https://en.wikipedia.org/wiki/Oxidising_agent) in contrast to the [molybdenum](https://en.wikipedia.org/wiki/Molybdenum)(VI) and [tungsten](https://en.wikipedia.org/wiki/Tungsten)(VI) oxides.[[11]](https://en.wikipedia.org/wiki/Chromium#cite_note-Greenwood1004-11)

Chromium has an unusually high [specular reflection](https://en.wikipedia.org/wiki/Specular_reflection) in comparison to that of other transitional metals. At 425 [μm](https://en.wikipedia.org/wiki/Micrometer), chromium was found to have a relative maximum reflection of about 72% reflectance, before entering a depression in reflectivity, reaching a minimum of 62% reflectance at 750 [μm](https://en.wikipedia.org/wiki/Micrometer) before rising again to reflecting roughly 90% of 4000 [μm](https://en.wikipedia.org/wiki/Micrometer) of [infrared](https://en.wikipedia.org/wiki/Infrared) [waves](https://en.wikipedia.org/wiki/Light).[[5]](https://en.wikipedia.org/wiki/Chromium#cite_note-NIST_specular_reflection-5). When chromium is formed into a [stainless steel](https://en.wikipedia.org/wiki/Stainless_steel) alloy and [polished](https://en.wikipedia.org/wiki/Polishing), the specular reflection decreases with the inclusion of additional metals, yet is still rather high in comparison with other alloys. Between 40% and 60% of the visible spectrum is reflected off of polished stainless steel.[[5]](https://en.wikipedia.org/wiki/Chromium#cite_note-NIST_specular_reflection-5) The explanation on why chromium displays such a high turnout of reflected [photon](https://en.wikipedia.org/wiki/Photon) waves in general, especially the 90% of infrared waves that were reflected, can be attributed to chromium's magnetic properties.[[12]](https://en.wikipedia.org/wiki/Chromium#cite_note-ISU_infrared-12) Chromium has unique magnetic properties in the sense that chromium is the only elemental solid which shows [antiferromagnetic](https://en.wikipedia.org/wiki/Antiferromagnetic) ordering at room temperature (and below). Above 38 °C, its magnetic ordering changes to [paramagnetic](https://en.wikipedia.org/wiki/Paramagnetic).[[2]](https://en.wikipedia.org/wiki/Chromium#cite_note-fawcett-2). The antiferromagnetic properties, which cause the chromium atoms to temporarily [ionize](https://en.wikipedia.org/wiki/Ionization) and bond with themselves because the body-centric cubic's magnetic properties are disproportionate to the [lattice periodicity](https://en.wikipedia.org/wiki/Crystal_structure). This is due to the fact that the magnetic moments at the cube's corners and the cube centers are not equal, but still antiparallel.[[12]](https://en.wikipedia.org/wiki/Chromium#cite_note-ISU_infrared-12) From here, the frequency-dependent [relative permittivity](https://en.wikipedia.org/wiki/Relative_permittivity) of chromium, deriving from [Maxwell's equations](https://en.wikipedia.org/wiki/Maxwell%27s_equations) in conjunction with its [antiferromagnetivity](https://en.wikipedia.org/wiki/Antiferromagnetism), leave chromium with one of the highest infrared and visible light reflectance out of the known chemical elements.[[13]](https://en.wikipedia.org/wiki/Chromium#cite_note-ISU_optical-13)

**Bulk**

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

Sample of pure chromium metal

**Passivation**

Chromium metal left standing in air is [passivated](https://en.wikipedia.org/wiki/Passivation_(chemistry)) by oxidation, forming a thin, protective, surface layer. This layer is a [spinel](https://en.wikipedia.org/wiki/Spinel) structure only a few molecules thick. It is very dense, and prevents the diffusion of oxygen into the underlying metal. This is different from the oxide that forms on iron and carbon steel, through which elemental oxygen continues to migrate, reaching the underlying material to cause incessant [rusting](https://en.wikipedia.org/wiki/Rust).[[14]](https://en.wikipedia.org/wiki/Chromium#cite_note-14) Passivation can be enhanced by short contact with [oxidizing acids](https://en.wikipedia.org/wiki/Oxidizing_acid) like [nitric acid](https://en.wikipedia.org/wiki/Nitric_acid). Passivated chromium is stable against acids. Passivation can be removed with a strong [reducing agent](https://en.wikipedia.org/wiki/Reducing_agent) that destroys the protective oxide layer on the metal. Chromium metal treated in this way readily dissolves in weak acids.[[15]](https://en.wikipedia.org/wiki/Chromium#cite_note-HollemanAF-15)

Chromium, unlike such metals as iron and nickel, does not suffer from [hydrogen embrittlement](https://en.wikipedia.org/wiki/Hydrogen_embrittlement). However, it does suffer from nitrogen [embrittlement](https://en.wikipedia.org/wiki/Embrittlement), reacting with nitrogen from air and forming brittle nitrides at the high temperatures necessary to work the metal parts.[[16]](https://en.wikipedia.org/wiki/Chromium#cite_note-16)

**Isotopes**

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

Naturally occurring chromium is composed of three stable [isotopes](https://en.wikipedia.org/wiki/Isotope); 52Cr, 53Cr and 54Cr, with 52Cr being the most abundant (83.789% [natural abundance](https://en.wikipedia.org/wiki/Natural_abundance)). 19 [radioisotopes](https://en.wikipedia.org/wiki/Radioisotope) have been characterized, with the most stable being 50Cr with a [half-life](https://en.wikipedia.org/wiki/Half-life) of (more than) 1.8×1017 years, and 51Cr with a half-life of 27.7 days. All of the remaining [radioactive](https://en.wikipedia.org/wiki/Radioactive) isotopes have half-lives that are less than 24 hours and the majority less than 1 minute. This element also has 2 [meta states](https://en.wikipedia.org/wiki/Meta_state).[[17]](https://en.wikipedia.org/wiki/Chromium#cite_note-NUBASE-17)

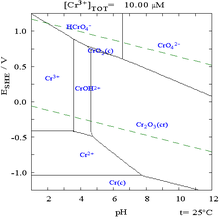
53Cr is the [radiogenic](https://en.wikipedia.org/wiki/Radiogenic) decay product of 53[Mn](https://en.wikipedia.org/wiki/Manganese) (half-life = 3.74 million years).[[18]](https://en.wikipedia.org/wiki/Chromium#cite_note-18) Chromium isotopes are typically collocated (and compounded) with [manganese](https://en.wikipedia.org/wiki/Manganese) isotopes. This circumstance is useful in [isotope geology](https://en.wikipedia.org/wiki/Isotope_geology). Manganese-chromium isotope ratios reinforce the evidence from 26[Al](https://en.wikipedia.org/wiki/Aluminium) and 107[Pd](https://en.wikipedia.org/wiki/Palladium) concerning the early history of the [solar system](https://en.wikipedia.org/wiki/Solar_system). Variations in 53Cr/52Cr and Mn/Cr ratios from several meteorites indicate an initial 53Mn/55Mn ratio that suggests Mn-Cr isotopic composition must result from in-situ decay of 53Mn in differentiated planetary bodies. Hence 53Cr provides additional evidence for [nucleosynthetic](https://en.wikipedia.org/wiki/Nucleosynthesis) processes immediately before coalescence of the solar system.[[19]](https://en.wikipedia.org/wiki/Chromium#cite_note-53Mn53Cr-19)

The isotopes of chromium range in [atomic mass](https://en.wikipedia.org/wiki/Atomic_mass) from 43 [u](https://en.wikipedia.org/wiki/Atomic_mass_unit) (43Cr) to 67 u (67Cr). The primary [decay mode](https://en.wikipedia.org/wiki/Decay_mode) before the most abundant stable isotope, 52Cr, 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).[[17]](https://en.wikipedia.org/wiki/Chromium#cite_note-NUBASE-17) 53Cr has been posited as a proxy for atmospheric oxygen concentration.[[20]](https://en.wikipedia.org/wiki/Chromium#cite_note-20)

**Chemistry and compounds**

See also: [Category:Chromium compounds](https://en.wikipedia.org/wiki/Category:Chromium_compounds).

**Chemical properties**

[](https://en.wikipedia.org/wiki/File:Chromium_in_water_pourbiax_diagram.png)

The [Pourbaix diagram](https://en.wikipedia.org/wiki/Pourbaix_diagram) for chromium in pure water, perchloric acid, or sodium hydroxide[[21]](https://en.wikipedia.org/wiki/Chromium#cite_note-Crspeci-21)[[22]](https://en.wikipedia.org/wiki/Chromium#cite_note-medusa-22)

Chromium is a member of [group 6](https://en.wikipedia.org/wiki/Group_6_element), of the [transition metals](https://en.wikipedia.org/wiki/Transition_metal). Chromium(0) has an electron configuration of [Ar]3d54s1, owing to the lower energy of the [high spin configuration](https://en.wikipedia.org/wiki/Spin_states_(d_electrons)). Chromium exhibits a wide range of [oxidation states](https://en.wikipedia.org/wiki/Oxidation_state), but chromium being ionized into a cation with a positive 3 charge serves as chromium's most stable ionic state.[[23]](https://en.wikipedia.org/wiki/Chromium#cite_note-23) The +3 and +6 states occur the most commonly within chromium compounds; charges of +1, +4 and +5 for chromium are rare, but nevertheless due occasionally exist for chromium.[[24]](https://en.wikipedia.org/wiki/Chromium#cite_note-Greenwood-24)

**Primary oxidation states**

|  |  |
| --- | --- |
| **Oxidation  states**[**[note 1]**](https://en.wikipedia.org/wiki/Chromium#cite_note-25)[**[24]**](https://en.wikipedia.org/wiki/Chromium#cite_note-Greenwood-24) | |
| −2 | Na 2[Cr(CO) 5] |
| −1 | Na 2[Cr 2(CO) 10] |
| 0 | [Cr(C 6H 6) 2](https://en.wikipedia.org/wiki/Bis(benzene)chromium) |
| +1 | K 3[Cr(CN) 5NO] |
| +2 | [CrCl 2](https://en.wikipedia.org/wiki/Chromium(II)_chloride) |
| **+3** | [CrCl 3](https://en.wikipedia.org/wiki/Chromium(III)_chloride) |
| +4 | K 2CrF 6 |
| +5 | [K 3CrO 8](https://en.wikipedia.org/wiki/Potassium_tetraperoxochromate(V)) |
| **+6** | [K 2CrO 4](https://en.wikipedia.org/wiki/Potassium_chromate) |

**Chromium(III)**

[](https://en.wikipedia.org/wiki/File:Chromium(III)-chloride-purple-anhydrous-sunlight.jpg)

Anhydrous chromium(III) chloride (CrCl3)

A large number of chromium(III) compounds are known, such as [chromium(III) nitrate](https://en.wikipedia.org/wiki/Chromium_nitrate), [chromium(III) acetate](https://en.wikipedia.org/wiki/Chromium(III)_acetate), and [chromium(III) oxide](https://en.wikipedia.org/wiki/Chromium(III)_oxide).[[25]](https://en.wikipedia.org/wiki/Chromium#cite_note-26) Chromium(III) can be obtained by dissolving elemental chromium in acids like [hydrochloric acid](https://en.wikipedia.org/wiki/Hydrochloric_acid) or [sulfuric acid](https://en.wikipedia.org/wiki/Sulfuric_acid), but it can also be formed through the reduction of chromium(VI) by [cytochrome](https://en.wikipedia.org/wiki/Cytochrome) [c7](https://en.wikipedia.org/wiki/Cytochrome_c).[[26]](https://en.wikipedia.org/wiki/Chromium#cite_note-27) The Cr3+  
ion has a similar radius (63 [pm](https://en.wikipedia.org/wiki/Picometer)) to Al3+  
(radius 50 pm), and they can replace each other in some compounds, such as in [chrome alum](https://en.wikipedia.org/wiki/Chrome_alum) and [alum](https://en.wikipedia.org/wiki/Alum). When a trace amount of Cr3+  
replaces Al3+  
in [corundum](https://en.wikipedia.org/wiki/Corundum) (aluminium oxide, Al2O3), [pink sapphire](https://en.wikipedia.org/wiki/Pink_sapphire) or red-colored [ruby](https://en.wikipedia.org/wiki/Ruby) is formed, depending on the amount of chromium.

Chromium(III) tends to form [octahedral](https://en.wikipedia.org/wiki/Octahedral_molecular_geometry) complexes. Commercially available [chromium(III) chloride](https://en.wikipedia.org/wiki/Chromium(III)_chloride) hydrate is the dark green complex [CrCl2(H2O)4]Cl. Closely related compounds are the pale green [CrCl(H2O)5]Cl2 and violet [Cr(H2O)6]Cl3. If water-free green[[*citation needed*](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] [chromium(III) chloride](https://en.wikipedia.org/wiki/Chromium(III)_chloride) is dissolved in water, the green solution turns violet after some time as the chloride in the inner [coordination sphere](https://en.wikipedia.org/wiki/Coordination_sphere) is replaced by water. This kind of reaction is also observed with solutions of [chrome alum](https://en.wikipedia.org/wiki/Chrome_alum) and other water-soluble chromium(III) salts.

[Chromium(III) hydroxide](https://en.wikipedia.org/wiki/Chromium(III)_hydroxide) (Cr(OH)3) is [amphoteric](https://en.wikipedia.org/wiki/Amphoterism), dissolving in acidic solutions to form [Cr(H2O)6]3+, and in basic solutions to form [Cr(OH)  
6]3−  
. It is dehydrated by heating to form the green [chromium(III) oxide](https://en.wikipedia.org/wiki/Chromium(III)_oxide) (Cr2O3), a stable oxide with a crystal structure identical to that of [corundum](https://en.wikipedia.org/wiki/Corundum).[[15]](https://en.wikipedia.org/wiki/Chromium#cite_note-HollemanAF-15)

**Chromium(VI)**

[Chromium(VI) compounds](https://en.wikipedia.org/wiki/Hexavalent_chromium) are oxidants at low or neutral pH. [Chromate](https://en.wikipedia.org/wiki/Chromate_and_dichromate) anions (CrO2−  
4) and [dichromate](https://en.wikipedia.org/wiki/Chromate_and_dichromate) (Cr2O72−) anions are the principal ions at this oxidation state. They exist at an equilibrium, determined by pH:

2 [CrO4]2− + 2 H+ ⇌ [Cr2O7]2− + H2O

Chromium(VI) halides are known also and include the [hexafluoride](https://en.wikipedia.org/wiki/Hexafluoride) [CrF6](https://en.wikipedia.org/wiki/Chromium_hexafluoride) and [chromyl chloride](https://en.wikipedia.org/wiki/Chromyl_chloride) (CrO  
2Cl  
2).[[15]](https://en.wikipedia.org/wiki/Chromium#cite_note-HollemanAF-15)

[](https://en.wikipedia.org/wiki/File:Chrom(VI)-oxid.jpg)

Chromium(VI) oxide

[Sodium chromate](https://en.wikipedia.org/wiki/Sodium_chromate) is produced industrially by the oxidative roasting of [chromite](https://en.wikipedia.org/wiki/Chromite) ore with [calcium](https://en.wikipedia.org/wiki/Calcium_carbonate) or [sodium carbonate](https://en.wikipedia.org/wiki/Sodium_carbonate). The change in equilibrium is visible by a change from yellow (chromate) to orange (dichromate), such as when an acid is added to a neutral solution of [potassium chromate](https://en.wikipedia.org/wiki/Potassium_chromate). At yet lower pH values, further condensation to more complex [oxyanions](https://en.wikipedia.org/wiki/Oxyanion) of chromium is possible.

Both the [chromate and dichromate](https://en.wikipedia.org/wiki/Chromate_and_dichromate) anions are strong oxidizing reagents at low pH:[[15]](https://en.wikipedia.org/wiki/Chromium#cite_note-HollemanAF-15)

Cr  
2O2−  
7 + 14 H  
3O+  
+ 6 e− → 2 Cr3+  
+ 21 H  
2O (ε0 = 1.33 V)

They are, however, only moderately oxidizing at high pH:[[15]](https://en.wikipedia.org/wiki/Chromium#cite_note-HollemanAF-15)

CrO2−  
4 + 4 H  
2O + 3 e− → Cr(OH)  
3 + 5 OH−  
(ε0 = −0.13 V)

[](https://en.wikipedia.org/wiki/File:Chroman_sodn%C3%BD.JPG)

[Sodium chromate](https://en.wikipedia.org/wiki/Sodium_chromate) (Na2CrO4)

Chromium(VI) compounds in solution can be detected by adding an acidic [hydrogen peroxide](https://en.wikipedia.org/wiki/Hydrogen_peroxide) solution. The unstable dark blue [chromium(VI) peroxide](https://en.wikipedia.org/wiki/Chromium(VI)_peroxide) (CrO5) is formed, which can be stabilized as an ether adduct CrO  
5·OR  
2.[[15]](https://en.wikipedia.org/wiki/Chromium#cite_note-HollemanAF-15)

[Chromic acid](https://en.wikipedia.org/wiki/Chromic_acid) has the hypothetical formula H  
2CrO  
4. It is a vaguely described chemical, despite many well-defined chromates and dichromates being known. The dark red [chromium(VI) oxide](https://en.wikipedia.org/wiki/Chromium(VI)_oxide) CrO  
3, the acid [anhydride](https://en.wikipedia.org/wiki/Anhydride) of chromic acid, is sold industrially as "chromic acid".[[15]](https://en.wikipedia.org/wiki/Chromium#cite_note-HollemanAF-15) It can be produced by mixing sulfuric acid with dichromate, and is a strong oxidizing agent.

**Other oxidation states**

**Chromium(V) and chromium(IV)**

The oxidation state +5 is only realized in few compounds but are intermediates in many reactions involving oxidations by chromate. The only binary compound is the volatile [chromium(V) fluoride](https://en.wikipedia.org/wiki/Chromium(V)_fluoride) (CrF5). This red solid has a melting point of 30 °C and a boiling point of 117 °C. It can be prepared by treating chromium metal with fluorine at 400 °C and 200 bar pressure. The peroxochromate(V) is another example of the +5 oxidation state. [Potassium peroxochromate](https://en.wikipedia.org/wiki/Potassium_tetraperoxochromate(V)) (K3[Cr(O2)4]) is made by reacting potassium chromate with hydrogen peroxide at low temperatures. This red brown compound is stable at room temperature but decomposes spontaneously at 150–170 °C.[[27]](https://en.wikipedia.org/wiki/Chromium#cite_note-28)

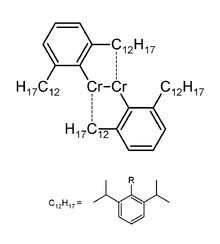
Compounds of chromium(IV) (in the +4 oxidation state) are slightly more common than those of chromium(V). The tetrahalides, [CrF4](https://en.wikipedia.org/wiki/Chromium(IV)_fluoride), [CrCl4](https://en.wikipedia.org/wiki/Chromium(IV)_chloride), and CrBr4, can be produced by treating the trihalides (CrX  
3) with the corresponding halogen at elevated temperatures. Such compounds are susceptible to disproportionation reactions and are not stable in water.

**Chromium(II)**

Many chromium(II) compounds are known, such as the water-stable [chromium(II) chloride](https://en.wikipedia.org/wiki/Chromium(II)_chloride) CrCl  
2 that can be made by reducing chromium(III) chloride with zinc. The resulting bright blue solution created from dissolving chromium(II) chloride is only stable at neutral [pH](https://en.wikipedia.org/wiki/PH).[[15]](https://en.wikipedia.org/wiki/Chromium#cite_note-HollemanAF-15) Some other notable chromium(II) compounds include [chromium(II) oxide](https://en.wikipedia.org/wiki/Chromium(II)_oxide) CrO, and [chromium(II) sulfate](https://en.wikipedia.org/wiki/Chromium(II)_sulfate) CrSO  
4. Many chromous carboxylates are known as well, the most famous of these being the red [chromium(II) acetate](https://en.wikipedia.org/wiki/Chromium(II)_acetate) (Cr2(O2CCH3)4) that features a quadruple bond.[[28]](https://en.wikipedia.org/wiki/Chromium#cite_note-29)

**Chromium(I)**

Most chromium(I) compounds are obtained solely by oxidation of electron-rich, [octahedral](https://en.wikipedia.org/wiki/Octahedral_molecular_geometry) chromium(0) complexes. Other chromium(I) complexes contain [cyclopentadienyl](https://en.wikipedia.org/wiki/Cyclopentadienyl) ligands. As verified by [X-ray diffraction](https://en.wikipedia.org/wiki/X-ray_diffraction), a Cr-Cr [quintuple bond](https://en.wikipedia.org/wiki/Quintuple_bond) (length 183.51(4)  pm) has also been described.[[29]](https://en.wikipedia.org/wiki/Chromium#cite_note-30) Extremely bulky monodentate ligands stabilize this compound by shielding the quintuple bond from further reactions.

[](https://en.wikipedia.org/wiki/File:5-fold_chromium.png)

Chromium compound determined experimentally to contain a Cr-Cr quintuple bond

**Chromium(0)**

Main article: [Organochromium chemistry](https://en.wikipedia.org/wiki/Organochromium_chemistry)

Many chromium(0) compounds are currently known; however, most of these compounds are derivatives of the compounds [chromium hexacarbonyl](https://en.wikipedia.org/wiki/Chromium_hexacarbonyl) or [bis(benzene)chromium](https://en.wikipedia.org/wiki/Bis(benzene)chromium).[[30]](https://en.wikipedia.org/wiki/Chromium#cite_note-31)

**Occurrence**

See also: [Category:Chromium minerals](https://en.wikipedia.org/wiki/Category:Chromium_minerals).

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

[Crocoite](https://en.wikipedia.org/wiki/Crocoite) (PbCrO4)

[](https://en.wikipedia.org/wiki/File:Chromit_1.jpg)

[Chromite](https://en.wikipedia.org/wiki/Chromite) ore

Chromium is the 13th most [abundant element in Earth's crust](https://en.wikipedia.org/wiki/Abundance_of_elements_in_Earth%27s_crust) with an average concentration of 100 ppm.[[31]](https://en.wikipedia.org/wiki/Chromium#cite_note-Emsley-32) Chromium compounds are found in the environment from the [erosion](https://en.wikipedia.org/wiki/Erosion) of chromium-containing rocks, and can be redistributed by volcanic eruptions. Typical background concentrations of chromium in environmental media are: atmosphere <10 ng m−3; soil <500 mg kg−1; vegetation <0.5 mg kg−1; freshwater <10 ug L−1; seawater <1 ug L−1; sediment <80 mg kg−1.[[32]](https://en.wikipedia.org/wiki/Chromium#cite_note-Rieuwerts-33)

Chromium is mined as [chromite](https://en.wikipedia.org/wiki/Chromite) (FeCr2O4) ore.[[33]](https://en.wikipedia.org/wiki/Chromium#cite_note-NRC-34) About two-fifths of the chromite ores and concentrates in the world are produced in South Africa, about a third in [Kazakhstan](https://en.wikipedia.org/wiki/Kazakhstan),[[34]](https://en.wikipedia.org/wiki/Chromium#cite_note-Trump-SoHo-Bayrock-35) while [India](https://en.wikipedia.org/wiki/India), [Russia](https://en.wikipedia.org/wiki/Russia), and [Turkey](https://en.wikipedia.org/wiki/Turkey) are also substantial producers. Untapped chromite deposits are plentiful, but geographically concentrated in Kazakhstan and southern [Africa](https://en.wikipedia.org/wiki/Africa).[[35]](https://en.wikipedia.org/wiki/Chromium#cite_note-USGS2015Yb-36)

Although rare, deposits of [native](https://en.wikipedia.org/wiki/Native_metal) chromium exist.[[36]](https://en.wikipedia.org/wiki/Chromium#cite_note-37)[[37]](https://en.wikipedia.org/wiki/Chromium#cite_note-38) The [Udachnaya Pipe](https://en.wikipedia.org/wiki/Udachnaya_Pipe) in Russia produces samples of the native metal. This mine is a [kimberlite](https://en.wikipedia.org/wiki/Kimberlite) pipe, rich in [diamonds](https://en.wikipedia.org/wiki/Diamond), and the [reducing environment](https://en.wikipedia.org/wiki/Redox) helped produce both elemental chromium and [diamond](https://en.wikipedia.org/wiki/Diamond).[[38]](https://en.wikipedia.org/wiki/Chromium#cite_note-39)

The relation between Cr(III) and Cr(VI) strongly depends on [pH](https://en.wikipedia.org/wiki/PH) and [oxidative](https://en.wikipedia.org/wiki/Oxidative) properties of the location. In most cases, Cr(III) is the dominating species,[[21]](https://en.wikipedia.org/wiki/Chromium#cite_note-Crspeci-21) but in some areas, the ground water can contain up to 39 µg/liter of total chromium of which 30 µg/liter is Cr(VI).[[39]](https://en.wikipedia.org/wiki/Chromium#cite_note-40)

**History**

**Ancient uses**

Chromium was first discovered as an element after it came to the attention of the Western world in the red crystalline mineral [crocoite](https://en.wikipedia.org/wiki/Crocoite) (which is [lead(II) chromate](https://en.wikipedia.org/wiki/Lead(II)_chromate)). This mineral was discovered in 1761 and was initially used as a [pigment](https://en.wikipedia.org/wiki/Pigment); the distinctive color was attributed to the chromium from within the crocoite. In present day, nearly all chromium is commercially extracted from the only viable ore for extensiveness and predicted long term use, being [chromite](https://en.wikipedia.org/wiki/Chromite), which is iron chromium oxide (FeCr2O4); chromite is now the principal source of chromium for use in pigments.[[40]](https://en.wikipedia.org/wiki/Chromium#cite_note-41)

**Terracotta Army weapons**

Weapons found in burial pits dating from the late 3rd century B.C. [Qin Dynasty](https://en.wikipedia.org/wiki/Qin_Dynasty) of the [Terracotta Army](https://en.wikipedia.org/wiki/Terracotta_Army) near [Xi'an](https://en.wikipedia.org/wiki/Xi%27an), [China](https://en.wikipedia.org/wiki/China), have been analyzed by archaeologists. Although these weapons were presumably buried more than two millennia ago, the ancient [bronze](https://en.wikipedia.org/wiki/Bronze) tips of both the swords and [crossbow](https://en.wikipedia.org/wiki/Crossbow) bolts found at the site showed unexpectedly little corrosion, possibly because the bronze was deliberately coated with a thin layer of chromium oxide.[[41]](https://en.wikipedia.org/wiki/Chromium#cite_note-42) Still, this oxide layer that was found on the weapons was not pure chromium metal or chrome plating as it is commonly produced today, but a mere 10-15 [μm](https://en.wikipedia.org/wiki/Micrometer) layer of chromium oxide molecules at up to 2% chromium was discovered, which turned out to be enough to protect the bronze from corroding.[[42]](https://en.wikipedia.org/wiki/Chromium#cite_note-Lorch2016-43)

**Chromium as pigment**

Chromium minerals as pigments came to the attention of the west in the 18th century. On 26 July 1761, [Johann Gottlob Lehmann](https://en.wikipedia.org/wiki/Johann_Gottlob_Lehmann_(scientist)) found an orange-red mineral in the [Beryozovskoye mines](https://en.wikipedia.org/wiki/Beryozovskoye_deposit) in the [Ural Mountains](https://en.wikipedia.org/wiki/Ural_Mountains) which he named *Siberian red lead*.[[43]](https://en.wikipedia.org/wiki/Chromium#cite_note-Meyer_1962_p.-44)[[44]](https://en.wikipedia.org/wiki/Chromium#cite_note-45) Though misidentified as a [lead](https://en.wikipedia.org/wiki/Lead) compound with [selenium](https://en.wikipedia.org/wiki/Selenium) and [iron](https://en.wikipedia.org/wiki/Iron) components, the mineral was in fact [crocoite](https://en.wikipedia.org/wiki/Crocoite) (or [lead(II) chromate](https://en.wikipedia.org/wiki/Lead(II)_chromate)) with a formula of PbCrO4.[[45]](https://en.wikipedia.org/wiki/Chromium#cite_note-ChromiumVI-46) In 1770, [Peter Simon Pallas](https://en.wikipedia.org/wiki/Peter_Simon_Pallas) visited the same site as Lehmann and found a red lead mineral that was discovered to possess useful properties as a [pigment](https://en.wikipedia.org/wiki/Pigment) in [paints](https://en.wikipedia.org/wiki/Paint). After Pallas, the use of Siberian red lead as a paint pigment began to develop rapidly throughout the region.[[46]](https://en.wikipedia.org/wiki/Chromium#cite_note-Weeks1932-47)

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

The red color of rubies is from a trace amount of chromium.

In 1794, [Louis Nicolas Vauquelin](https://en.wikipedia.org/wiki/Louis_Nicolas_Vauquelin) received samples of crocoite [ore](https://en.wikipedia.org/wiki/Ore). He produced [chromium trioxide](https://en.wikipedia.org/wiki/Chromium(VI)_oxide) (CrO3) by mixing crocoite with [hydrochloric acid](https://en.wikipedia.org/wiki/Hydrochloric_acid).[[45]](https://en.wikipedia.org/wiki/Chromium#cite_note-ChromiumVI-46) In 1797, Vauquelin discovered that he could isolate metallic chromium by heating the oxide in a charcoal oven, for which he is credited as the one who truly discovered the element.[[47]](https://en.wikipedia.org/wiki/Chromium#cite_note-48)[[48]](https://en.wikipedia.org/wiki/Chromium#cite_note-49) Vauquelin was also able to detect traces of chromium in precious [gemstones](https://en.wikipedia.org/wiki/Gemstone), such as [ruby](https://en.wikipedia.org/wiki/Ruby) or [emerald](https://en.wikipedia.org/wiki/Emerald).[[45]](https://en.wikipedia.org/wiki/Chromium#cite_note-ChromiumVI-46)[[49]](https://en.wikipedia.org/wiki/Chromium#cite_note-50)

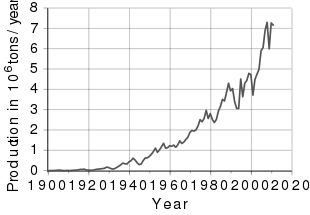
During the 19th century, chromium was primarily used not only as a component of paints, but in [tanning](https://en.wikipedia.org/wiki/Tanning_(leather)) salts as well. For quite some time, the crocoite found in Russia was the main source for such tanning materials. In 1827, a larger chromite deposit was discovered near [Baltimore](https://en.wikipedia.org/wiki/Baltimore), United States, which quickly met the demand for tanning salts much more adequately than the crocoite that had been used previously. This made the United States the largest producer of chromium products until the year 1848, when larger deposits of chromite were uncovered near the city of [Bursa](https://en.wikipedia.org/wiki/Bursa), Turkey.[[33]](https://en.wikipedia.org/wiki/Chromium#cite_note-NRC-34)

Chromium is also famous for its reflective, metallic luster when polished. It is used as a protective and decorative coating on car parts, plumbing fixtures, furniture parts and many other items, usually applied by [electroplating](https://en.wikipedia.org/wiki/Electroplating). Chromium was used for electroplating as early as 1848, but this use only became widespread with the development of an improved process in 1924.[[50]](https://en.wikipedia.org/wiki/Chromium#cite_note-Crplating-51)

**Production**

[](https://en.wikipedia.org/wiki/File:Chrom_1.jpg)

Piece of chromium produced with [aluminothermic reaction](https://en.wikipedia.org/wiki/Aluminothermic_reaction)

[](https://en.wikipedia.org/wiki/File:Chromium_-_world_production_trend.svg)

World production trend of chromium

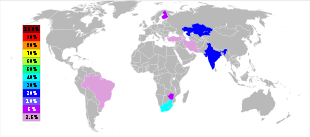
[](https://en.wikipedia.org/wiki/File:Chromium_zone_refined_and_1cm3_cube.jpg)

Chromium, remelted in a horizontal arc zone-refiner, showing large visible crystal grains

Approximately 28.8 million metric tons (Mt) of marketable chromite ore was produced in 2013, and converted into 7.5 Mt of ferrochromium.[[35]](https://en.wikipedia.org/wiki/Chromium#cite_note-USGS2015Yb-36) According to John F. Papp, writing for the USGS, "Ferrochromium is the leading end use of chromite ore, [and] stainless steel is the leading end use of ferrochromium."[[35]](https://en.wikipedia.org/wiki/Chromium#cite_note-USGS2015Yb-36)

The largest producers of chromium ore in 2013 have been South Africa (48%), Kazakhstan (13%), Turkey (11%), India (10%) with several other countries producing the rest of about 18% of the world production.[[35]](https://en.wikipedia.org/wiki/Chromium#cite_note-USGS2015Yb-36)

The two main products of chromium ore refining are [ferrochromium](https://en.wikipedia.org/wiki/Ferrochromium) and metallic chromium. For those products the ore smelter process differs considerably. For the production of ferrochromium, the chromite ore (FeCr2O4) is reduced in large scale in [electric arc furnace](https://en.wikipedia.org/wiki/Electric_arc_furnace) or in smaller smelters with either [aluminium](https://en.wikipedia.org/wiki/Aluminium) or [silicon](https://en.wikipedia.org/wiki/Silicon) in an [aluminothermic reaction](https://en.wikipedia.org/wiki/Aluminothermic_reaction).[[51]](https://en.wikipedia.org/wiki/Chromium#cite_note-IndMin-52)

[](https://en.wikipedia.org/wiki/File:World_Chromium_Production_2002.svg)

Chromium ore output in 2002[[52]](https://en.wikipedia.org/wiki/Chromium#cite_note-USGS2002Yb-53)

For the production of pure chromium, the iron must be separated from the chromium in a two step roasting and leaching process. The chromite ore is heated with a mixture of [calcium carbonate](https://en.wikipedia.org/wiki/Calcium_carbonate) and [sodium carbonate](https://en.wikipedia.org/wiki/Sodium_carbonate) in the presence of air. The chromium is oxidized to the hexavalent form, while the iron forms the stable Fe2O3. The subsequent leaching at higher elevated temperatures dissolves the [chromates](https://en.wikipedia.org/wiki/Chromate) and leaves the insoluble iron oxide. The chromate is converted by [sulfuric acid](https://en.wikipedia.org/wiki/Sulfuric_acid) into the dichromate.[[51]](https://en.wikipedia.org/wiki/Chromium#cite_note-IndMin-52)

4 FeCr2O4 + 8 Na2CO3 + 7 O2 → 8 Na2CrO4 + 2 Fe2O3 + 8 CO2

2 Na2CrO4 + H2SO4 → Na2Cr2O7 + Na2SO4 + H2O

The dichromate is converted to the chromium(III) oxide by reduction with carbon and then reduced in an aluminothermic reaction to chromium.[[51]](https://en.wikipedia.org/wiki/Chromium#cite_note-IndMin-52)

Na2Cr2O7 + 2 C → Cr2O3 + Na2CO3 + CO

Cr2O3 + 2 Al → Al2O3 + 2 Cr

**Applications**

The creation of metal alloys account for 85% of the available chromium's usage.[[53]](https://en.wikipedia.org/wiki/Chromium#cite_note-54) The remainder of chromium is used in the [chemical](https://en.wikipedia.org/wiki/Chemical_industry), [refractory](https://en.wikipedia.org/wiki/Refractory), and [foundry](https://en.wikipedia.org/wiki/Foundry) industries.

**Metallurgy**

[](https://en.wikipedia.org/wiki/File:Besteck_WMF_Stockholm_ca_1960er.jpg)

Stainless steel cutlery made from Cromargan 18/10, containing 18% Chromium.

Main articles: [Chrome plating](https://en.wikipedia.org/wiki/Chrome_plating) and [Stainless steel](https://en.wikipedia.org/wiki/Stainless_steel)

The strengthening effect of forming stable metal carbides at the grain boundaries and the strong increase in corrosion resistance made chromium an important alloying material for steel. The [high-speed tool steels](https://en.wikipedia.org/wiki/High_speed_steel) contain between 3 and 5% chromium. [Stainless steel](https://en.wikipedia.org/wiki/Stainless_steel), the primary corrosion-resistant metal alloy, is formed when chromium is introduced to [iron](https://en.wikipedia.org/wiki/Iron) in sufficient concentrations, usually where the chromium concentration is above 11%.[[54]](https://en.wikipedia.org/wiki/Chromium#cite_note-Davis_2000_p.-55) For stainless steel's formation, ferrochromium is added to the molten iron. Also, nickel-based alloys increase in strength due to the formation of discrete, stable metal carbide particles at the grain boundaries. For example, [Inconel](https://en.wikipedia.org/wiki/Inconel) 718 contains 18.6% chromium. Because of the excellent high-temperature properties of these nickel [superalloys](https://en.wikipedia.org/wiki/Superalloy), they are used in [jet engines](https://en.wikipedia.org/wiki/Jet_engine) and [gas turbines](https://en.wikipedia.org/wiki/Gas_turbine) in lieu of common structural materials.[[55]](https://en.wikipedia.org/wiki/Chromium#cite_note-superal-56)

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

Decorative chrome plating on a motorcycle.

The relative high hardness and corrosion resistance of unalloyed chromium makes chrome a reliable metal for surface coating; it is still the most popular metal concerning sheet coating with its above average durability compared to other coating metals.[[56]](https://en.wikipedia.org/wiki/Chromium#cite_note-57) A layer of chromium is deposited on pretreated metallic surfaces by [electroplating](https://en.wikipedia.org/wiki/Electroplating) techniques. There are two deposition methods: thin and thick. Thin deposition involves a layer of chromium below 1 µm thickness deposited by [chrome plating](https://en.wikipedia.org/wiki/Chrome_plating), and are used for decorative surfaces. Thicker chromium layers are deposited if wear-resistant surfaces are needed. Both methods use acidic chromate or [dichromate](https://en.wikipedia.org/wiki/Dichromate) solutions. To prevent the energy-consuming change in oxidation state, the use of chromium(III) sulfate is under development; for most applications of chromium, the previously established process is used.[[50]](https://en.wikipedia.org/wiki/Chromium#cite_note-Crplating-51)

In the [chromate conversion coating](https://en.wikipedia.org/wiki/Chromate_conversion_coating) process, the strong oxidative properties of chromates are used to deposit a protective oxide layer on metals like aluminium, zinc and cadmium. This [passivation](https://en.wikipedia.org/wiki/Passivation_(chemistry)) and the self-healing properties by the chromate stored in the chromate conversion coating, which is able to migrate to local defects, are the benefits of this coating method.[[57]](https://en.wikipedia.org/wiki/Chromium#cite_note-Edwards-58) Because of environmental and health regulations on chromates, alternative coating methods are under development.[[58]](https://en.wikipedia.org/wiki/Chromium#cite_note-59)

Chromic acid [anodizing](https://en.wikipedia.org/wiki/Anodizing) (or Type I anodizing) of aluminium is another electrochemical process, which does not lead to the deposition of chromium, but uses [chromic acid](https://en.wikipedia.org/wiki/Chromic_acid) as electrolyte in the solution. During anodization, an oxide layer is formed on the aluminium. The use of chromic acid, instead of the normally used sulfuric acid, leads to a slight difference of these oxide layers.[[59]](https://en.wikipedia.org/wiki/Chromium#cite_note-surface-60) The high toxicity of Cr(VI) compounds, used in the established chromium electroplating process, and the strengthening of safety and environmental regulations demand a search for substitutes for chromium or at least a change to less toxic chromium(III) compounds.[[50]](https://en.wikipedia.org/wiki/Chromium#cite_note-Crplating-51)

**Dye and pigment**

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

School bus painted in [chrome yellow](https://en.wikipedia.org/wiki/Chrome_yellow)[[60]](https://en.wikipedia.org/wiki/Chromium#cite_note-61)

The mineral [crocoite](https://en.wikipedia.org/wiki/Crocoite) (which is also [lead chromate](https://en.wikipedia.org/wiki/Lead_chromate) PbCrO4) was used as a yellow pigment shortly after its discovery. After a synthesis method became available starting from the more abundant chromite, [chrome yellow](https://en.wikipedia.org/wiki/Chrome_yellow) was, together with [cadmium yellow](https://en.wikipedia.org/wiki/Cadmium_yellow), one of the most used yellow pigments. The pigment does not photodegrade, but it tends to darken due to the formation of chromium(III) oxide. It has a strong color, and was used for school buses in the [United States](https://en.wikipedia.org/wiki/United_States) and for the Postal Service (for example, the [Deutsche Post](https://en.wikipedia.org/wiki/Deutsche_Post)) in Europe. The use of chrome yellow has since declined due to environmental and safety concerns and was replaced by organic pigments or other alternatives that are free from lead and chromium. Other pigments that are based around chromium are, for example, the deep shade of red pigment [chrome red](https://en.wikipedia.org/wiki/Chrome_red), which is simply lead chromate with [lead(II) hydroxide](https://en.wikipedia.org/wiki/Lead(II)_hydroxide) (PbCrO4·Pb(OH)2). A very important chromate pigment, which was used widely in metal primer formulations, was zinc chromate, now replaced by zinc phosphate. A wash primer was formulated to replace the dangerous practice of pre-treating aluminium aircraft bodies with a phosphoric acid solution. This used zinc tetroxychromate dispersed in a solution of [polyvinyl butyral](https://en.wikipedia.org/wiki/Polyvinyl_butyral). An 8% solution of phosphoric acid in solvent was added just before application. It was found that an easily oxidized alcohol was an essential ingredient. A thin layer of about 10–15 µm was applied, which turned from yellow to dark green when it was cured. There is still a question as to the correct mechanism. Chrome green is a mixture of [Prussian blue](https://en.wikipedia.org/wiki/Prussian_blue) and [chrome yellow](https://en.wikipedia.org/wiki/Chrome_yellow), while the chrome oxide green is [chromium(III) oxide](https://en.wikipedia.org/wiki/Chromium(III)_oxide).[[61]](https://en.wikipedia.org/wiki/Chromium#cite_note-Cryel-62)

Chromium oxides are also used as a green pigment in the field of glassmaking and also as a glaze for ceramics.[[62]](https://en.wikipedia.org/wiki/Chromium#cite_note-63) Green chromium oxide is extremely [lightfast](https://en.wikipedia.org/wiki/Lightfastness) and as such is used in cladding coatings. It is also the main ingredient in [infrared](https://en.wikipedia.org/wiki/Infrared) reflecting paints, used by the armed forces to paint vehicles and to give them the same infrared reflectance as green leaves.[[63]](https://en.wikipedia.org/wiki/Chromium#cite_note-64)

**Synthetic ruby and the first laser**

[](https://en.wikipedia.org/wiki/File:5_Maiman_Laser_Components.jpg)

Red crystal of an ruby laser

Natural [rubies](https://en.wikipedia.org/wiki/Ruby) are [corundum](https://en.wikipedia.org/wiki/Corundum) (aluminum oxide) crystals that are colored red (the rarest type) due to chromium (III) ions (other colors of corundum gems are termed [sapphires](https://en.wikipedia.org/wiki/Sapphire)). A red-colored artificial ruby may also be achieved by doping chromium(III) into artificial corundum crystals, thus making chromium a requirement for making synthetic rubies.[[64]](https://en.wikipedia.org/wiki/Chromium#cite_note-65) Such a synthetic ruby crystal was the basis for the first [laser](https://en.wikipedia.org/wiki/Laser), produced in 1960, which relied on [stimulated emission](https://en.wikipedia.org/wiki/Stimulated_emission) of light from the chromium atoms in such a crystal. A ruby laser is lasing at 694.3 nanometers, in a deep red color.[[65]](https://en.wikipedia.org/wiki/Chromium#cite_note-WebbJones2004-66)

**Wood preservative**

Because of their toxicity, chromium(VI) salts are used for the preservation of wood. For example, [chromated copper arsenate](https://en.wikipedia.org/wiki/Chromated_copper_arsenate) (CCA) is used in [timber treatment](https://en.wikipedia.org/wiki/Timber_treatment) to protect wood from decay fungi, wood-attacking insects, including [termites](https://en.wikipedia.org/wiki/Termites), and marine borers.[[66]](https://en.wikipedia.org/wiki/Chromium#cite_note-Hings-67) The formulations contain chromium based on the oxide CrO3 between 35.3% and 65.5%. In the United States, 65,300 metric tons of CCA solution were used in 1996.[[66]](https://en.wikipedia.org/wiki/Chromium#cite_note-Hings-67)

**Tanning**

Main article: [Tanning (leather)](https://en.wikipedia.org/wiki/Tanning_(leather))

Chromium(III) salts, especially [chrome alum](https://en.wikipedia.org/wiki/Chrome_alum) and [chromium(III) sulfate](https://en.wikipedia.org/wiki/Chromium(III)_sulfate), are used in the tanning of [leather](https://en.wikipedia.org/wiki/Leather). The chromium(III) stabilizes the leather by cross linking the [collagen](https://en.wikipedia.org/wiki/Collagen) fibers.[[67]](https://en.wikipedia.org/wiki/Chromium#cite_note-68) Chromium tanned leather can contain between 4 and 5% of chromium, which is tightly bound to the proteins.[[33]](https://en.wikipedia.org/wiki/Chromium#cite_note-NRC-34) Although the form of chromium used for tanning is not the toxic hexavalent variety, there remains interest in management of chromium in the tanning industry such as recovery and reuse, direct/indirect recycling,[[68]](https://en.wikipedia.org/wiki/Chromium#cite_note-69) use of less chromium or "chrome-less" tanning are practiced to better manage chromium in tanning.

**Refractory material**

The high heat resistivity and high melting point makes [chromite](https://en.wikipedia.org/wiki/Chromite) and chromium(III) oxide a material for high temperature refractory applications, like [blast furnaces](https://en.wikipedia.org/wiki/Blast_furnace), cement [kilns](https://en.wikipedia.org/wiki/Kiln), molds for the firing of [bricks](https://en.wikipedia.org/wiki/Brick) and as foundry sands for the [casting](https://en.wikipedia.org/wiki/Casting_(metalworking)) of metals. In these applications, the refractory materials are made from mixtures of chromite and magnesite. The use is declining because of the environmental regulations due to the possibility of the formation of chromium(VI).[[51]](https://en.wikipedia.org/wiki/Chromium#cite_note-IndMin-52) [[69]](https://en.wikipedia.org/wiki/Chromium#cite_note-Barnhart1997-70)

**Catalysts**

Several chromium compounds are used as [catalysts](https://en.wikipedia.org/wiki/Catalyst) for processing hydrocarbons. For example, the [Phillips catalyst](https://en.wikipedia.org/wiki/Phillips_catalyst), prepared from chromium oxides, is used for the production of about half the world's [polyethylene](https://en.wikipedia.org/wiki/Polyethylene).[[70]](https://en.wikipedia.org/wiki/Chromium#cite_note-71) Fe-Cr mixed oxides are employed as high-temperature catalysts for the [water gas shift reaction](https://en.wikipedia.org/wiki/Water_gas_shift_reaction).[[71]](https://en.wikipedia.org/wiki/Chromium#cite_note-72)[[72]](https://en.wikipedia.org/wiki/Chromium#cite_note-73) [Copper chromite](https://en.wikipedia.org/wiki/Copper_chromite) is a useful [hydrogenation](https://en.wikipedia.org/wiki/Hydrogenation) catalyst.[[73]](https://en.wikipedia.org/wiki/Chromium#cite_note-74)

**Other uses**

* [Chromium(IV) oxide](https://en.wikipedia.org/wiki/Chromium(IV)_oxide) (CrO2) is a [magnetic](https://en.wikipedia.org/wiki/Magnetism) compound. Its ideal shape [anisotropy](https://en.wikipedia.org/wiki/Anisotropy), which imparts high [coercivity](https://en.wikipedia.org/wiki/Coercivity) and remnant magnetization, made it a compound superior to the γ-Fe2O3. Chromium(IV) oxide is used to manufacture [magnetic tape](https://en.wikipedia.org/wiki/Magnetic_tape) used in high-performance audio tape and standard [audio cassettes](https://en.wikipedia.org/wiki/Compact_audio_cassette).[[74]](https://en.wikipedia.org/wiki/Chromium#cite_note-75) Chromates can prevent corrosion of steel under wet conditions, and therefore chromates are added to drilling muds.[[75]](https://en.wikipedia.org/wiki/Chromium#cite_note-76)
* [Chromium(III) oxide](https://en.wikipedia.org/wiki/Chromium(III)_oxide) (Cr2O3) is a metal polish known as green rouge.[[76]](https://en.wikipedia.org/wiki/Chromium#cite_note-DoiMarinescu2011-77)[[77]](https://en.wikipedia.org/wiki/Chromium#cite_note-78)
* [Chromic acid](https://en.wikipedia.org/wiki/Chromic_acid) is a powerful oxidizing agent and is a useful compound for cleaning laboratory glassware of any trace of organic compounds. It is prepared by dissolving [potassium dichromate](https://en.wikipedia.org/wiki/Potassium_dichromate) in concentrated sulfuric acid, which is then used to wash the apparatus. [Sodium dichromate](https://en.wikipedia.org/wiki/Sodium_dichromate) is sometimes used because of its higher solubility (50 g/L versus 200 g/L respectively). The use of dichromate cleaning solutions is now phased out due to the high toxicity and environmental concerns. Modern cleaning solutions are highly effective and chromium free.[[78]](https://en.wikipedia.org/wiki/Chromium#cite_note-Roth1994-79)
* [Potassium dichromate](https://en.wikipedia.org/wiki/Potassium_dichromate) is a chemical [reagent](https://en.wikipedia.org/wiki/Reagent), used as a titrating agent.
* [Chrome alum](https://en.wikipedia.org/wiki/Chrome_alum) is [Chromium(III) potassium sulfate](https://en.wikipedia.org/wiki/Chromium(III)_potassium_sulfate) and is used as a [mordant](https://en.wikipedia.org/wiki/Mordant) (i.e., a fixing agent) for dyes in fabric and in [tanning](https://en.wikipedia.org/wiki/Tanning_(leather)).[[79]](https://en.wikipedia.org/wiki/Chromium#cite_note-Ul-Islam2017-80)

**Biological role**

See also: [Chromium deficiency](https://en.wikipedia.org/wiki/Chromium_deficiency) and [Chromium in glucose metabolism](https://en.wikipedia.org/wiki/Chromium_in_glucose_metabolism)

In the form trivalent chromium, Cr(III), or Cr3+, chromium was tentatively identified as an essential nutrient in the late 1950s and later accepted as a trace element for its roles in the action of [insulin](https://en.wikipedia.org/wiki/Insulin), a hormone critical to the metabolism and storage of carbohydrate, fat and protein.[[7]](https://en.wikipedia.org/wiki/Chromium#cite_note-ods-7)[[80]](https://en.wikipedia.org/wiki/Chromium#cite_note-81) The precise mechanism of its actions in the body, however, have not been fully defined, leaving in question whether chromium is essential for healthy people.[[7]](https://en.wikipedia.org/wiki/Chromium#cite_note-ods-7)[[81]](https://en.wikipedia.org/wiki/Chromium#cite_note-82)[[82]](https://en.wikipedia.org/wiki/Chromium#cite_note-83)[[83]](https://en.wikipedia.org/wiki/Chromium#cite_note-84)

Trivalent chromium occurs in trace amounts in foods, wine and water.[[7]](https://en.wikipedia.org/wiki/Chromium#cite_note-ods-7)[[84]](https://en.wikipedia.org/wiki/Chromium#cite_note-85) In contrast, [hexavalent chromium](https://en.wikipedia.org/wiki/Hexavalent_chromium) (Cr(VI) or Cr6+) is highly toxic and [mutagenic](https://en.wikipedia.org/wiki/Mutagen) when inhaled.[[85]](https://en.wikipedia.org/wiki/Chromium#cite_note-86) Ingestion of chromium(VI) in water has been linked to stomach tumors, and it may also cause allergic [contact dermatitis](https://en.wikipedia.org/wiki/Contact_dermatitis) (ACD).[[86]](https://en.wikipedia.org/wiki/Chromium#cite_note-87)

[Chromium deficiency](https://en.wikipedia.org/wiki/Chromium_deficiency), involving a lack of Cr(III) in the body, or perhaps some complex of it, such as [glucose tolerance factor](https://en.wikipedia.org/wiki/Glucose_tolerance_factor) is controversial.[[7]](https://en.wikipedia.org/wiki/Chromium#cite_note-ods-7) Some studies suggest that the biologically active form of chromium (III) is transported in the body via an oligopeptide called [low-molecular-weight chromium-binding substance](https://en.wikipedia.org/wiki/Low-molecular-weight_chromium-binding_substance) (LMWCr), which might play a role in the insulin signaling pathway.[[87]](https://en.wikipedia.org/wiki/Chromium#cite_note-pharmacological1-88)

Chromium content of common foods is generally low (1-13 micrograms per serving).[[7]](https://en.wikipedia.org/wiki/Chromium#cite_note-ods-7)[[88]](https://en.wikipedia.org/wiki/Chromium#cite_note-database-89) Chromium content of food varies widely due to differences in soil mineral content, growing season, plant [cultivar](https://en.wikipedia.org/wiki/Cultivar), and contamination during processing.[[88]](https://en.wikipedia.org/wiki/Chromium#cite_note-database-89) In addition, chromium (and [nickel](https://en.wikipedia.org/wiki/Nickel)) leach into food cooked in stainless steel, with the effect largest when the cookware is new. Acidic foods such as tomato sauce which are cooked for many hours also exacerbate this effect.[[89]](https://en.wikipedia.org/wiki/Chromium#cite_note-90)[[90]](https://en.wikipedia.org/wiki/Chromium#cite_note-91)

**Dietary recommendations**

There is disagreement on chromium's status as an essential nutrient. Governmental departments from Australia, New Zealand, India, Japan and the United States consider chromium essential[[91]](https://en.wikipedia.org/wiki/Chromium#cite_note-AustraliaNZ-92)[[92]](https://en.wikipedia.org/wiki/Chromium#cite_note-India-93)[[93]](https://en.wikipedia.org/wiki/Chromium#cite_note-Japan-94)[[94]](https://en.wikipedia.org/wiki/Chromium#cite_note-IOM-Chromium-95) while the [European Food Safety Authority](https://en.wikipedia.org/wiki/European_Food_Safety_Authority) (EFSA), representing the European Union, does not.[[95]](https://en.wikipedia.org/wiki/Chromium#cite_note-EFSA-96)

The [National Academy of Medicine](https://en.wikipedia.org/wiki/National_Academy_of_Medicine) (NAM) updated the [Estimated Average Requirements](https://en.wikipedia.org/wiki/Dietary_Reference_Intake#Parameters) (EARs) and the [Recommended Dietary Allowances](https://en.wikipedia.org/wiki/Dietary_Reference_Intake#Parameters) (RDAs) for chromium in 2001. For chromium, there was not sufficient information to set EARs and RDAs, so its needs are described as estimates for [Adequate Intakes](https://en.wikipedia.org/wiki/Dietary_Reference_Intake#Parameters) (AIs). The current AIs of chromium for women ages 14 through 50 is 25 μg/day, and the AIs for women ages 50 and above is 20 μg/day. The AIs for women who are pregnant are 30 μg/day, and for women who are lactating, the set AIs are 45 μg/day. The AIs for men ages 14 through 50 are 35 μg/day, and the AIs for men ages 50 and above are 30 μg/day. For children ages 1 through 13, the AIs increase with age from 0.2 μg/day up to 25 μg/day. As for safety, the NAM sets [Tolerable Upper Intake Levels](https://en.wikipedia.org/wiki/Dietary_Reference_Intake#Parameters) (ULs) for vitamins and minerals when the evidence is sufficient. In the case of chromium, there is not yet enough information and hence no UL has been established. Collectively, the EARs, RDAs, AIs and ULs are the parameters for the nutrition recommendation system known as [Dietary Reference Intake](https://en.wikipedia.org/wiki/Dietary_Reference_Intake) (DRI).[[94]](https://en.wikipedia.org/wiki/Chromium#cite_note-IOM-Chromium-95) Australia and New Zealand consider chromium to be an essential nutrient, with an AI of 35 μg/day for men, 25 μg/day for women, 30 μg/day for women who are pregnant, and 45 μg/day for women who are lactating. A UL has not been set due to the lack of sufficient data.[[91]](https://en.wikipedia.org/wiki/Chromium#cite_note-AustraliaNZ-92) India considers chromium to be an essential nutrient, with an adult recommended intake of 33 μg/day.[[92]](https://en.wikipedia.org/wiki/Chromium#cite_note-India-93) Japan also considers chromium to be an essential nutrient, with an AI of 10 μg/day for adults, including women who are pregnant or lactating. A UL has not been set.[[93]](https://en.wikipedia.org/wiki/Chromium#cite_note-Japan-94) The EFSA of the [European Union](https://en.wikipedia.org/wiki/European_Union) however, does not consider chromium to be an essential nutrient; chromium is the only mineral for which the United States and the European Union disagree.[[95]](https://en.wikipedia.org/wiki/Chromium#cite_note-EFSA-96)[[96]](https://en.wikipedia.org/wiki/Chromium#cite_note-97)

For the [United States'](https://en.wikipedia.org/wiki/United_States) food and dietary supplement labeling purposes, the amount of the substance in a serving is expressed as a percent of the [Daily Value](https://en.wikipedia.org/wiki/Reference_Daily_Intake) (%DV). For chromium labeling purposes, 100% of the Daily Value was 120 μg. As of May 27, 2016, the percentage of daily value was revised to 35 μg to bring the chromium intake into a consensus with the official [Recommended Dietary Allowance](https://en.wikipedia.org/wiki/Dietary_Reference_Intake).[[97]](https://en.wikipedia.org/wiki/Chromium#cite_note-FedReg-98) The original deadline to be in compliance was July 28, 2018, but on September 29, 2017 the [Food and Drug Administration](https://en.wikipedia.org/wiki/Food_and_Drug_Administration) released a proposed rule that extended the deadline to January 1, 2020 for large companies and January 1, 2021 for small companies.[[98]](https://en.wikipedia.org/wiki/Chromium#cite_note-FDAdelay-99)

**Food sources**

Food composition databases such as the those maintained by the U.S. Department of Agriculture do not contain information on the chromium content of foods.[[99]](https://en.wikipedia.org/wiki/Chromium#cite_note-USDA-Database-100) A wide variety of animal-sourced and vegetable-sourced foods contain chromium.[[94]](https://en.wikipedia.org/wiki/Chromium#cite_note-IOM-Chromium-95) Content per serving is influenced by the chromium content of the soil in which the plants are grown and by feedstuffs fed to animals; also by processing methods, as chromium is leached into foods if processed or cooked in chromium-containing stainless steel equipment.[[100]](https://en.wikipedia.org/wiki/Chromium#cite_note-101) One diet analysis study conducted in Mexico reported an average daily chromium intake of 30 micrograms.[[101]](https://en.wikipedia.org/wiki/Chromium#cite_note-102) An estimated 31% of adults in the United States consume multi-vitamin/mineral dietary supplements[[102]](https://en.wikipedia.org/wiki/Chromium#cite_note-Kantor2016-103) which often contain 25 to 60 micrograms of chromium.

**Supplementation**

Chromium is an ingredient in [total parenteral nutrition](https://en.wikipedia.org/wiki/Total_parenteral_nutrition) (TPN) because deficiency can occur after months of intravenous feeding with chromium-free TPN. For this reason, chromium is added to TPN solutions, along with other trace minerals.[[103]](https://en.wikipedia.org/wiki/Chromium#cite_note-Stehle2016-104) It is also in nutritional products for [preterm infants](https://en.wikipedia.org/wiki/Preterm_infant).[[104]](https://en.wikipedia.org/wiki/Chromium#cite_note-105) Although the mechanism in biological roles for chromium is unclear, in the United States chromium-containing products are sold as non-prescription dietary supplements in amounts ranging from 50 to 1,000 μg. Lower amounts of chromium are also often incorporated into multi-vitamin/mineral supplements consumed by an estimated 31% of adults in the United States.[[102]](https://en.wikipedia.org/wiki/Chromium#cite_note-Kantor2016-103) Chemical compounds used in dietary supplements include chromium chloride, chromium citrate, [chromium(III) picolinate](https://en.wikipedia.org/wiki/Chromium(III)_picolinate), [chromium(III) polynicotinate](https://en.wikipedia.org/wiki/Chromium_polynicotinate), and other chemical compositions.[[7]](https://en.wikipedia.org/wiki/Chromium#cite_note-ods-7) The benefit of supplements has not been proven.[[7]](https://en.wikipedia.org/wiki/Chromium#cite_note-ods-7)[[105]](https://en.wikipedia.org/wiki/Chromium#cite_note-Vincent2010-106)

**Approved and disapproved health claims**

In 2005, the U.S. Food and Drug Administration had approved a Qualified Health Claim for chromium picolinate with a requirement for very specific label wording: "One small study suggests that chromium picolinate may reduce the risk of insulin resistance, and therefore possibly may reduce the risk of type 2 diabetes. FDA concludes, however, that the existence of such a relationship between chromium picolinate and either insulin resistance or type 2 diabetes is highly uncertain." At the same time, in answer to other parts of the petition, the FDA rejected claims for chromium picolinate and cardiovascular disease, retinopathy or kidney disease caused be abnormally high blood sugar levels.[[106]](https://en.wikipedia.org/wiki/Chromium#cite_note-107) In 2010, chromium(III) picolinate was approved by Health Canada to be used in dietary supplements. Approved labeling statements include: a factor in the maintenance of good health, provides support for healthy glucose metabolism, helps the body to metabolize carbohydrates and helps the body to metabolize fats.[[107]](https://en.wikipedia.org/wiki/Chromium#cite_note-108) The [European Food Safety Authority](https://en.wikipedia.org/wiki/European_Food_Safety_Authority) (EFSA) approved claims in 2010 that chromium contributed to normal macronutrient metabolism and maintenance of normal blood glucose concentration, but rejected claims for maintenance or achievement of a normal body weight, or reduction of tiredness or fatigue.[[108]](https://en.wikipedia.org/wiki/Chromium#cite_note-EFSA2010-109)

**Diabetes**

Given the evidence for chromium deficiency causing problems with glucose management in the context of intravenous nutrition products formulated without chromium,[[103]](https://en.wikipedia.org/wiki/Chromium#cite_note-Stehle2016-104) research interest turned to whether chromium supplementation for people who have type 2 diabetes but are not chromium deficient could benefit. Looking at the results from four meta-analyses, one reported a statistically significant decrease in fasting [plasma glucose](https://en.wikipedia.org/wiki/Plasma_glucose) levels (FPG) and a non-significant trend in lower [hemoglobin A1C](https://en.wikipedia.org/wiki/Glycated_hemoglobin).[[109]](https://en.wikipedia.org/wiki/Chromium#cite_note-Mauro-110) A second reported the same,[[110]](https://en.wikipedia.org/wiki/Chromium#cite_note-Abdoll2013-111) a third reported significant decreases for both measures,[[111]](https://en.wikipedia.org/wiki/Chromium#cite_note-Suk2014-112) while a fourth reported no benefit for either.[[112]](https://en.wikipedia.org/wiki/Chromium#cite_note-113) A review published in 2016 listed 53 [randomized clinical trials](https://en.wikipedia.org/wiki/Randomized_clinical_trial) that were included in one or more of six [meta-analyses](https://en.wikipedia.org/wiki/Meta-analysis). It concluded that whereas there may be modest decreases in FPG and/or HbA1C that achieve statistical significance in some of these meta-analyses, few of the trials achieved decreases large enough to be expected to be relevant to clinical outcome.[[113]](https://en.wikipedia.org/wiki/Chromium#cite_note-Costello2016-114)

**Weight management**

Two [systematic reviews](https://en.wikipedia.org/wiki/Systematic_review) looked at chromium supplements as a mean of managing body weight in overweight and obese people. One, limited to [chromium picolinate](https://en.wikipedia.org/wiki/Chromium_picolinate), a popular supplement ingredient, reported a statistically significant -1.1 kg (2.4 lb) weight loss in trials longer than 12 weeks.[[114]](https://en.wikipedia.org/wiki/Chromium#cite_note-Tian2013-115) The other included all chromium compounds and reported a statistically significant -0.50 kg (1.1 lb) weight change.[[115]](https://en.wikipedia.org/wiki/Chromium#cite_note-Onakpoya2013-116) Change in percent body fat did not reach statistical significance. Authors of both reviews considered the clinical relevance of this modest weight loss as uncertain/unreliable.[[114]](https://en.wikipedia.org/wiki/Chromium#cite_note-Tian2013-115)[[115]](https://en.wikipedia.org/wiki/Chromium#cite_note-Onakpoya2013-116) The [European Food Safety Authority](https://en.wikipedia.org/wiki/European_Food_Safety_Authority) reviewed the literature and concluded that there was insufficient evidence to support a claim.[[108]](https://en.wikipedia.org/wiki/Chromium#cite_note-EFSA2010-109)

**Athletic performance**

Chromium is promoted as a sports performance dietary supplement, based on the theory that it potentiated insulin activity, with anticipated results of increased muscle mass, and faster recovery of glycogen storage during post-exercise recovery.[[105]](https://en.wikipedia.org/wiki/Chromium#cite_note-Vincent2010-106)[[116]](https://en.wikipedia.org/wiki/Chromium#cite_note-117)[[117]](https://en.wikipedia.org/wiki/Chromium#cite_note-Vinvent2003-118) A review of clinical trials reported that chromium supplementation did not improve exercise performance or increase muscle strength.[[118]](https://en.wikipedia.org/wiki/Chromium#cite_note-119) The International Olympic Committee reviewed dietary supplements for high-performance athletes in 2018 and concluded there was no need to increase chromium intake for athletes, nor support for claims of losing body fat.[[119]](https://en.wikipedia.org/wiki/Chromium#cite_note-120)

**Fresh-water fish**

Chromium is naturally present in the environment in trace amounts, but industrial use in rubber and stainless steel manufacturing, chrome plating, dyes for textiles, tanneries and other uses contaminates aquatic systems. In [Bangladesh](https://en.wikipedia.org/wiki/Bangladesh), rivers in or downstream from industrialized areas exhibit heavy metal contamination. Irrigation water standards for chromium are 0.1 mg/L, but some rivers are more than five times that amount. The standard for fish for human consumption is less than 1 mg/kg, but many tested samples were more than five times that amount.[[120]](https://en.wikipedia.org/wiki/Chromium#cite_note-Islam2018-121) Chromium, especially hexavalent chromium, is highly toxic to fish because it is easily absorbed across the gills, readily enters blood circulation, crosses cell membranes and bioconcentrates up the food chain. In contrast, the toxicity of trivalent chromium is very low, attributed to poor membrane permeability and little biomagnification.[[121]](https://en.wikipedia.org/wiki/Chromium#cite_note-Bakshi2018-122)

Acute and chronic exposure to chromium(VI) affect fish behavior, physiology, reproduction and survival. Hyperactivity and erratic swimming have been reported in contaminated environments. Egg hatching and fingerling survival are affected. In adult fish there are reports of histopathological damage to liver, kidney, muscle, intestines, and gills. Mechanisms include mutagenic gene damage and disruptions of enzyme functions.[[121]](https://en.wikipedia.org/wiki/Chromium#cite_note-Bakshi2018-122)

There is evidence that fish may not require chromium, but benefit from a measured amount in diet. In one study, juvenile fish gained weight on a zero chromium diet, but the addition of 500 μg of chromium in the form of chromium chloride or other supplement types, per kilogram of food (dry weight), increased weight gain. At 2,000 μg/kg the weight gain was no better than with the zero chromium diet, and there were increased DNA strand breaks.[[122]](https://en.wikipedia.org/wiki/Chromium#cite_note-123)

**Precautions**

Main article: [Chromium toxicity](https://en.wikipedia.org/wiki/Chromium_toxicity)

Water-insoluble chromium(III) compounds and chromium metal are not considered a health hazard, while the toxicity and carcinogenic properties of chromium(VI) have been known for a long time.[[123]](https://en.wikipedia.org/wiki/Chromium#cite_note-Barceloux-124) Because of the specific transport mechanisms, only limited amounts of chromium(III) enter the cells. Acute oral toxicity ranges between 1.5 and 3.3 mg/kg.[[124]](https://en.wikipedia.org/wiki/Chromium#cite_note-Katz-125) A 2008 review suggested that moderate uptake of chromium(III) through dietary supplements poses no genetic-toxic risk.[[125]](https://en.wikipedia.org/wiki/Chromium#cite_note-Eastmond-126) In the US, the [Occupational Safety and Health Administration](https://en.wikipedia.org/wiki/Occupational_Safety_and_Health_Administration) (OSHA) has designated an air [permissible exposure limit](https://en.wikipedia.org/wiki/Permissible_exposure_limit) (PEL) in the workplace as a time-weighted average (TWA) of 1 mg/m3. The [National Institute for Occupational Safety and Health](https://en.wikipedia.org/wiki/National_Institute_for_Occupational_Safety_and_Health) (NIOSH) has set a [recommended exposure limit](https://en.wikipedia.org/wiki/Recommended_exposure_limit) (REL) of 0.5 mg/m3, time-weighted average. The [IDLH](https://en.wikipedia.org/wiki/IDLH) (immediately dangerous to life and health) value is 250 mg/m3.[[126]](https://en.wikipedia.org/wiki/Chromium#cite_note-127)

**Chromium(VI) toxicity**

The acute [oral](https://en.wikipedia.org/wiki/Mouth) [toxicity](https://en.wikipedia.org/wiki/Toxicity) for [chromium(VI)](https://en.wikipedia.org/wiki/Hexavalent_chromium) ranges between 50 and 150 mg/kg.[[124]](https://en.wikipedia.org/wiki/Chromium#cite_note-Katz-125) In the body, chromium(VI) is reduced by several mechanisms to chromium(III) already in the blood before it enters the cells. The chromium(III) is excreted from the body, whereas the chromate ion is transferred into the cell by a transport mechanism, by which also [sulfate](https://en.wikipedia.org/wiki/Sulfate) and [phosphate](https://en.wikipedia.org/wiki/Phosphate) ions enter the cell. The acute toxicity of chromium(VI) is due to its strong [oxidational](https://en.wikipedia.org/wiki/Oxidation) properties. After it reaches the blood stream, it damages the kidneys, the liver and blood cells through oxidation reactions. [Hemolysis](https://en.wikipedia.org/wiki/Hemolysis), [renal](https://en.wikipedia.org/wiki/Renal), and liver failure result. Aggressive dialysis can be therapeutic.[[127]](https://en.wikipedia.org/wiki/Chromium#cite_note-Dayan-128)

The [carcinogenity](https://en.wikipedia.org/wiki/Carcinogenity) of chromate dust has been known for a long time, and in 1890 the first publication described the elevated cancer risk of workers in a chromate dye company.[[128]](https://en.wikipedia.org/wiki/Chromium#cite_note-129)[[129]](https://en.wikipedia.org/wiki/Chromium#cite_note-Langard-130) Three mechanisms have been proposed to describe the [genotoxicity](https://en.wikipedia.org/wiki/Genotoxicity) of chromium(VI). The first mechanism includes highly reactive [hydroxyl radicals](https://en.wikipedia.org/wiki/Hydroxyl_radical) and other reactive radicals which are by products of the reduction of chromium(VI) to chromium(III). The second process includes the direct binding of chromium(V), produced by reduction in the cell, and chromium(IV) compounds to the [DNA](https://en.wikipedia.org/wiki/DNA). The last mechanism attributed the genotoxicity to the binding to the DNA of the end product of the chromium(III) reduction.[[130]](https://en.wikipedia.org/wiki/Chromium#cite_note-Cohen-131)[[131]](https://en.wikipedia.org/wiki/Chromium#cite_note-132)

Chromium salts (chromates) are also the cause of [allergic reactions](https://en.wikipedia.org/wiki/Allergic_reaction) in some people. Chromates are often used to manufacture, amongst other things, leather products, paints, cement, mortar and anti-corrosives. Contact with products containing chromates can lead to allergic [contact dermatitis](https://en.wikipedia.org/wiki/Contact_dermatitis) and irritant dermatitis, resulting in ulceration of the skin, sometimes referred to as "chrome ulcers". This condition is often found in workers that have been exposed to strong chromate solutions in electroplating, tanning and chrome-producing manufacturers.[[132]](https://en.wikipedia.org/wiki/Chromium#cite_note-133)[[133]](https://en.wikipedia.org/wiki/Chromium#cite_note-134)

**Environmental issues**

Because chromium compounds were used in [dyes](https://en.wikipedia.org/wiki/Dye), [paints](https://en.wikipedia.org/wiki/Paint), and [leather](https://en.wikipedia.org/wiki/Leather) [tanning](https://en.wikipedia.org/wiki/Tanning_(leather)) compounds, these compounds are often found in soil and [groundwater](https://en.wikipedia.org/wiki/Groundwater) at active and abandoned industrial sites, needing [environmental cleanup](https://en.wikipedia.org/wiki/Environmental_cleanup) and [remediation](https://en.wikipedia.org/wiki/Environmental_remediation). [Primer paint](https://en.wikipedia.org/wiki/Primer_(paint)) containing hexavalent chromium is still widely used for [aerospace](https://en.wikipedia.org/wiki/Aerospace) and [automobile](https://en.wikipedia.org/wiki/Automobile) refinishing applications.[[134]](https://en.wikipedia.org/wiki/Chromium#cite_note-135)

In 2010, the [Environmental Working Group](https://en.wikipedia.org/wiki/Environmental_Working_Group) studied the drinking water in 35 American cities in the first nationwide study. The study found measurable hexavalent chromium in the tap water of 31 of the cities sampled, with [Norman, Oklahoma](https://en.wikipedia.org/wiki/Norman,_Oklahoma), at the top of list; 25 cities had levels that exceeded California's proposed limit.[[135]](https://en.wikipedia.org/wiki/Chromium#cite_note-136)

**See also**

* [Chrome plating](https://en.wikipedia.org/wiki/Chrome_plating)
* [Chromium-vanadium steel](https://en.wikipedia.org/wiki/Chromium-vanadium_steel)
* [Stainless steel](https://en.wikipedia.org/wiki/Stainless_steel)
* [Nichrome](https://en.wikipedia.org/wiki/Nichrome)
* [Chromium toxicity](https://en.wikipedia.org/wiki/Chromium_toxicity)
* [Hexavalent chromium](https://en.wikipedia.org/wiki/Hexavalent_chromium)
* [Chromium deficiency](https://en.wikipedia.org/wiki/Chromium_deficiency)
* [Chromium in glucose metabolism](https://en.wikipedia.org/wiki/Chromium_in_glucose_metabolism)

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|  | |
| [**Portals**](https://en.wikipedia.org/wiki/Portal:Contents/Portals) Access related topics | * [Papapishu-Lab-icon-6.svg](https://en.wikipedia.org/wiki/File:Papapishu-Lab-icon-6.svg)[***Chemistry portal***](https://en.wikipedia.org/wiki/Portal:Chemistry) |

**Notes**

1. Most common oxidation states of chromium are in bold. The right column lists a representative compound for each oxidation state.

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* [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/Chromium)
* [Related changes](https://en.wikipedia.org/wiki/Special:RecentChangesLinked/Chromium)
* [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=Chromium&oldid=874091321)
* [Page information](https://en.wikipedia.org/w/index.php?title=Chromium&action=info)
* [Wikidata item](https://www.wikidata.org/wiki/Special:EntityPage/Q725)
* [Cite this page](https://en.wikipedia.org/w/index.php?title=Special:CiteThisPage&page=Chromium&id=874091321)

**Print/export**

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

**In other projects**

* [Wikimedia Commons](https://commons.wikimedia.org/wiki/Category:Chromium)

**Languages**

* [Deutsch](https://de.wikipedia.org/wiki/Chrom)
* [Español](https://es.wikipedia.org/wiki/Cromo)
* [Français](https://fr.wikipedia.org/wiki/Chrome)
* [한국어](https://ko.wikipedia.org/wiki/%ED%81%AC%EB%A1%9C%EB%AE%B4)
* [Italiano](https://it.wikipedia.org/wiki/Cromo)
* [Русский](https://ru.wikipedia.org/wiki/%D0%A5%D1%80%D0%BE%D0%BC)
* [Tagalog](https://tl.wikipedia.org/wiki/Kromyo)
* [Tiếng Việt](https://vi.wikipedia.org/wiki/Crom)
* [中文](https://zh.wikipedia.org/wiki/%E9%93%AC)

[Edit links](https://www.wikidata.org/wiki/Special:EntityPage/Q725#sitelinks-wikipedia)

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* [Mobile view](https://en.m.wikipedia.org/w/index.php?title=Chromium&mobileaction=toggle_view_mobile)
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