

= Copper =

Copper is a chemical element with symbol Cu (from Latin : cuprum) and atomic number 29 . It is a soft , malleable and ductile metal with very high thermal and electrical conductivity . A freshly exposed surface of pure copper has a reddish @-@ orange color . It is used as a conductor of heat and electricity , as a building material and as a constituent of various metal alloys , such as Sterling silver used in jewelry , cupronickel used to make marine hardware and coins and constantan used in strain gauges and thermocouples for temperature measurement .

Copper is found as a pure metal in nature , and this was the first source of the metal to be used by humans , ca . 8 @,@ 000 BC . It was the first metal to be smelted from its ore , ca . 5 @,@ 000 BC , the first metal to be cast into a shape in a mold , ca . 4 @,@ 000 BC and the first metal to be purposefully alloyed with another metal , tin , to create bronze , ca . 3 @,@ 500 BC .

In the Roman era , copper was principally mined on Cyprus , the origin of the name of the metal , from aes ?yprium (metal of Cyprus) , later corrupted to ?uprum , from which the words copper (English) , cuivre (French) , Koper (Dutch) and Kupfer (German) are all derived . The commonly encountered compounds are copper (II) salts , which often impart blue or green colors to such minerals as azurite , malachite , and turquoise , and have been used widely and historically as pigments . Architectural structures built with copper (usually roofing elements) corrode to give green verdigris (or patina) . Decorative art prominently features copper , both in the elemental metal and in compounds as pigments . Copper compounds are also used as bacteriostatic agents , fungicides , and wood preservatives .

Copper is essential to all living organisms as a trace dietary mineral because it is a key constituent of the respiratory enzyme complex cytochrome c oxidase . In molluscs and crustacea copper is a constituent of the blood pigment hemocyanin , replaced by the iron @-@ complexed hemoglobin in fish and other vertebrates . In humans , copper is found mainly in the liver , muscle , and bone . The adult body contains between 1 @.@ 4 and 2 @.@ 1 mg of copper per kilogram of body weight . Hence a healthy human weighing 60 kilogram contains approximately 0 @.@ 1 g of copper . However , this small amount is essential to the overall human well @-@ being .

= = Characteristics = =

= = = Physical = = =

Copper , silver and gold are in group 11 of the periodic table , and they share certain attributes : they have one s @-@ orbital electron on top of a filled d @-@ electron shell and are characterized by high ductility and electrical and thermal conductivity . The filled d @-@ shells in these elements contribute little to interatomic interactions , which are dominated by the s @-@ electrons through metallic bonds . Unlike metals with incomplete d @-@ shells , metallic bonds in copper are lacking a covalent character and are relatively weak . This observation explains the low hardness and high ductility of single crystals of copper . At the macroscopic scale , introduction of extended defects to the crystal lattice , such as grain boundaries , hinders flow of the material under applied stress , thereby increasing its hardness . For this reason , copper is usually supplied in a fine @-@ grained polycrystalline form , which has greater strength than monocrystalline forms .

The softness of copper partly explains its high electrical conductivity (59 @.@ 6×10^6 S / m) and high thermal conductivity , the second highest (second only to silver) among pure metals at room temperature . This is because the resistivity to electron transport in metals at room temperature originates primarily from scattering of electrons on thermal vibrations of the lattice , which are relatively weak in a soft metal . The maximum permissible current density of copper in open air is approximately 3 @.@ 1×10^6 A / m² of cross @-@ sectional area , above which it begins to heat excessively .

Copper is one of four metallic elements with a natural color other than gray or silver , the others being caesium (yellow) , gold (yellow) , and osmium (bluish) . Pure copper is orange @-@ red

and acquires a reddish tarnish when exposed to air . The characteristic color of copper results from the electronic transitions between the filled 3d and half @-@ empty 4s atomic shells ? the energy difference between these shells corresponds to orange light . The same mechanism causes the yellow color of gold and caesium .

As with other metals , if copper is put in contact with another metal , galvanic corrosion will occur .

= = = Chemical = = =

Copper does not react with water but it does slowly react with atmospheric oxygen to form a layer of brown @-@ black copper oxide which , unlike the rust that forms on iron in moist air , protects the underlying metal from further corrosion (passivation) . A green layer of verdigris (copper carbonate) can often be seen on old copper structures , such as the roofing of many older buildings and the Statue of Liberty . Copper tarnishes when exposed to some sulfur compounds , with which it reacts to form various copper sulfides .

= = = Isotopes = = =

There are 29 isotopes of copper . ^{63}Cu and ^{65}Cu are stable , with ^{63}Cu comprising approximately 69 % of naturally occurring copper ; both have a spin of $3/2$. The other isotopes are radioactive , with the most stable being ^{67}Cu with a half @-@ life of 61 @. @ 83 hours . Seven metastable isotopes have been characterized ; $^{68\text{m}}\text{Cu}$ is the longest @-@ lived with a half @-@ life of 3 @. @ 8 minutes . Isotopes with a mass number above 64 decay by ? ? , whereas those with a mass number below 64 decay by ? + . ^{64}Cu , which has a half @-@ life of 12 @. @ 7 hours , decays both ways .

^{62}Cu and ^{64}Cu have significant applications . ^{62}Cu is used in ^{62}Cu @-@ PTSM as a radioactive tracer for positron emission tomography .

= = = Occurrence = = =

Copper is produced in massive stars and is present in the Earth 's crust in a proportion of about 50 parts per million (ppm) . It occurs as native copper , in the copper sulfides chalcopyrite and chalcocite , in the copper carbonates azurite and malachite , and in the copper (I) oxide mineral cuprite . The largest mass of elemental copper discovered weighed 420 tonnes and was found in 1857 on the Keweenaw Peninsula in Michigan , US . Native copper is a polycrystal , with the largest single crystal ever described measuring $4 @. @ 4 \times 3 @. @ 2 \times 3 @. @ 2$ cm .

= = = Production = = =

Most copper is mined or extracted as copper sulfides from large open pit mines in porphyry copper deposits that contain 0 @. @ 4 to 1 @. @ 0 % copper . Sites include Chuquibambilla in Chile , Bingham Canyon Mine in Utah , United States and El Chino Mine in New Mexico , United States . According to the British Geological Survey in 2005 , Chile was the top producer of copper with at least one @-@ third world share followed by the United States , Indonesia and Peru . Copper can also be recovered through the in @-@ situ leach process . Several sites in the state of Arizona are considered prime candidates for this method . The amount of copper in use is increasing and the quantity available is barely sufficient to allow all countries to reach developed world levels of usage .

= = = Reserves = = =

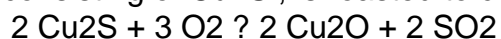
Copper has been in use at least 10 @, @ 000 years , but more than 95 % of all copper ever mined and smelted has been extracted since 1900 , and more than half was extracted the last 24 years . As with many natural resources , the total amount of copper on Earth is vast , with around 10¹⁴ tons

in the top kilometer of Earth 's crust , which is about 5 million years ' worth at the current rate of extraction . However , only a tiny fraction of these reserves is economically viable with present @-@ day prices and technologies . Estimates of copper reserves available for mining vary from 25 years to 60 years , depending on core assumptions such as the growth rate . Recycling is a major source of copper in the modern world . Because of these and other factors , the future of copper production and supply is the subject of much debate , including the concept of peak copper , analogous to peak oil .

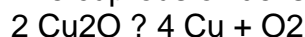
The price of copper has historically been unstable , and it sextupled from the 60 @-@ year low of US \$ 0 @-@ 60 / lb (US \$ 1 @-@ 32 / kg) in June 1999 to US \$ 3 @-@ 75 per pound (US \$ 8 @-@ 27 / kg) in May 2006 . It dropped to US \$ 2 @-@ 40 / lb (US \$ 5 @-@ 29 / kg) in February 2007 , then rebounded to US \$ 3 @-@ 50 / lb (US \$ 7 @-@ 71 / kg) in April 2007 . In February 2009 , weakening global demand and a steep fall in commodity prices since the previous year 's highs left copper prices at US \$ 1 @-@ 51 / lb (US \$ 3 @-@ 32 / kg) .

== Methods ==

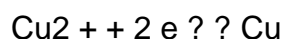
The concentration of copper in ores averages only 0 @-@ 6 % , and most commercial ores are sulfides , especially chalcopyrite (CuFeS_2) and to a lesser extent chalcocite (Cu_2S) . These minerals are concentrated from crushed ores to the level of 10 ? 15 % copper by froth flotation or bioleaching . Heating this material with silica in flash smelting removes much of the iron as slag . The process exploits the greater ease of converting iron sulfides into oxides , which in turn react with the silica to form the silicate slag that floats on top of the heated mass . The resulting copper matte , consisting of Cu_2S , is roasted to convert all sulfides into oxides :



The cuprous oxide is converted to blister copper upon heating :



The Sudbury matte process converted only half the sulfide to oxide and then used this oxide to remove the rest of the sulfur as oxide . It was then electrolytically refined and the anode mud exploited for the platinum and gold it contained . This step exploits the relatively easy reduction of copper oxides to copper metal . Natural gas is blown across the blister to remove most of the remaining oxygen and electrorefining is performed on the resulting material to produce pure copper :



== Recycling ==

Like aluminium , copper is 100 % recyclable without any loss of quality , both from raw state and from manufactured products . In volume , copper is the third most recycled metal after iron and aluminium . An estimated 80 % of all copper ever mined is still in use today . According to the International Resource Panel 's Metal Stocks in Society report , the global per capita stock of copper in use in society is 35 ? 55 kg . Much of this is in more @-@ developed countries (140 ? 300 kg per capita) rather than less @-@ developed countries (30 ? 40 kg per capita) .

The process of recycling copper is roughly the same as is used to extract copper but requires fewer steps . High @-@ purity scrap copper is melted in a furnace and then reduced and cast into billets and ingots ; lower @-@ purity scrap is refined by electroplating in a bath of sulfuric acid .

== Alloys ==

Numerous copper alloys have been formulated , many with important uses . Brass is an alloy of copper and zinc . Bronze usually refers to copper @-@ tin alloys , but can refer to any alloy of copper such as aluminium bronze . Copper is one of the most important constituents of silver and carat gold and carat solders used in the jewelry industry , modifying the color , hardness and melting point of the resulting alloys . Some lead @-@ free solders consist of tin alloyed with a small

proportion of copper and other metals .

The alloy of copper and nickel , called cupronickel , is used in low @-@ denomination coins , often for the outer cladding . The US 5 @-@ cent coin (currently called a nickel) consists of 75 % copper and 25 % nickel in homogeneous composition . The alloy of 90 % copper and 10 % nickel , remarkable for its resistance to corrosion , is used for various objects exposed to seawater , though it is vulnerable to the sulfides sometimes found in polluted harbors and estuaries . Alloys of copper with aluminium (about 7 %) have a pleasant golden color and are used in decorations . Shakud? is a Japanese decorative alloy of copper containing a low percentage of gold , typically 4 @-@ 10 % , that can be patinated to a dark blue or black colour .

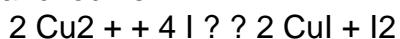
= = Compounds = =

Copper forms a rich variety of compounds , usually with oxidation states + 1 and + 2 , which are often called cuprous and cupric , respectively .

= = = Binary compounds = = =

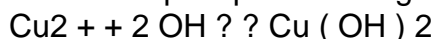
As with other elements , the simplest compounds of copper are binary compounds , i.e. those containing only two elements , the principal examples being oxides , sulfides , and halides . Both cuprous and cupric oxides are known . Among the numerous copper sulfides , important examples include copper (I) sulfide and copper (II) sulfide .

Cuprous halides (with chlorine , bromine , and iodine) are known , as are cupric halides with fluorine , chlorine , and bromine . Attempts to prepare copper (II) iodide yield only cuprous iodide and iodine .

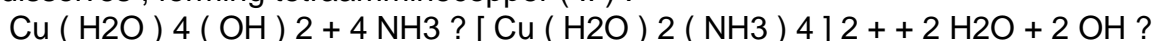


= = = Coordination chemistry = = =

Copper forms coordination complexes with ligands . In aqueous solution , copper (II) exists as $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$. This complex exhibits the fastest water exchange rate (speed of water ligands attaching and detaching) for any transition metal aquo complex . Adding aqueous sodium hydroxide causes the precipitation of light blue solid copper (II) hydroxide . A simplified equation is :



Aqueous ammonia results in the same precipitate . Upon adding excess ammonia , the precipitate dissolves , forming tetraamminecopper (II) :



Many other oxyanions form complexes ; these include copper (II) acetate , copper (II) nitrate , and copper (II) carbonate . Copper (II) sulfate forms a blue crystalline pentahydrate , the most familiar copper compound in the laboratory . It is used in a fungicide called the Bordeaux mixture .

Polyols , compounds containing more than one alcohol functional group , generally interact with cupric salts . For example , copper salts are used to test for reducing sugars . Specifically , using Benedict 's reagent and Fehling 's solution the presence of the sugar is signaled by a color change from blue $\text{Cu}(\text{II})$ to reddish copper (I) oxide . Schweizer 's reagent and related complexes with ethylenediamine and other amines dissolve cellulose . Amino acids form very stable chelate complexes with copper (II) . Many wet @-@ chemical tests for copper ions exist , one involving potassium ferrocyanide , which gives a brown precipitate with copper (II) salts .

= = = Organocopper chemistry = = =

Compounds that contain a carbon @-@ copper bond are known as organocopper compounds . They are very reactive towards oxygen to form copper (I) oxide and have many uses in chemistry . They are synthesized by treating copper (I) compounds with Grignard reagents , terminal alkynes or organolithium reagents ; in particular , the last reaction described produces a Gilman reagent .

These can undergo substitution with alkyl halides to form coupling products ; as such , they are important in the field of organic synthesis . Copper (I) acetylide is highly shock @-@ sensitive but is an intermediate in reactions such as the Cadiot @-@ Chodkiewicz coupling and the Sonogashira coupling . Conjugate addition to enones and carbocupration of alkynes can also be achieved with organocopper compounds . Copper (I) forms a variety of weak complexes with alkenes and carbon monoxide , especially in the presence of amine ligands .

= = = Copper (III) and copper (IV) = = =

Copper (III) is most often found in oxides . A simple example is potassium cuprate , KCuO_2 , a blue @-@ black solid . The most extensively studied copper (III) compounds are the cuprate superconductors . Yttrium barium copper oxide ($\text{YBa}_2\text{Cu}_3\text{O}_7$) consists of both Cu (II) and Cu (III) centres . Like oxide , fluoride is a highly basic anion and is known to stabilize metal ions in high oxidation states . Both copper (III) and even copper (IV) fluorides are known , K_3CuF_6 and Cs_2CuF_6 , respectively .

Some copper proteins form oxo complexes , which also feature copper (III) . With tetrapeptides , purple @-@ colored copper (III) complexes are stabilized by the deprotonated amide ligands .

Complexes of copper (III) are also found as intermediates in reactions of organocopper compounds .

= = History = =

= = = Copper Age = = =

Copper occurs naturally as native metallic copper and was known to some of the oldest civilizations on record . The history of copper use is at least 11 @,@ 000 years old , estimated to have begun in 9000 BC in the Middle East ; a copper pendant was found in northern Iraq that dates to 8700 BC . Evidence suggests that gold and meteoric iron (but not iron smelting) were the only metals used by humans before copper . The history of copper metallurgy is thought to follow this sequence : 1) cold working of native copper , 2) annealing , 3) smelting , and 4) the lost wax casting . In southeastern Anatolia , all four of these techniques appear more or less simultaneously at the beginning of the Neolithic c . 7500 BC .

Just as agriculture was independently invented in several parts of the world , copper smelting was independently invented in different places . It was probably discovered in China before 2800 BC , in Central America perhaps around 600 AD , and in West Africa about the 9th or 10th century AD . Investment casting was invented in 4500 ? 4000 BC in Southeast Asia and carbon dating has established mining at Alderley Edge in Cheshire , UK at 2280 to 1890 BC . Ötzi the Iceman , a male dated from 3300 ? 3200 BC , was found with an axe with a copper head 99 @.@ 7 % pure ; high levels of arsenic in his hair suggest his involvement in copper smelting . Experience with copper has assisted the development of other metals ; in particular , copper smelting led to the discovery of iron smelting . Production in the Old Copper Complex in Michigan and Wisconsin is dated between 6000 and 3000 BC . Natural bronze , a type of copper made from ores rich in silicon , arsenic , and (rarely) tin , came into general use in the Balkans around 5500 BC .

= = = Bronze Age = = =

Alloying copper with tin to make bronze was first practiced about 4000 years after the discovery of copper smelting , and about 2000 years after " natural bronze " had come into general use . Bronze artifacts from the Vin?a culture date to 4500 BC . Sumerian and Egyptian artifacts of copper and bronze alloys date to 3000 BC . The Bronze Age began in Southeastern Europe around 3700 ? 3300 BC , in Northwestern Europe about 2500 BC . It ended with the beginning of the Iron Age , 2000 ? 1000 BC in the Near East , and 600 BC in Northern Europe . The transition between the

Neolithic period and the Bronze Age was formerly termed the Chalcolithic period (copper @-@ stone) , when copper tools were used with stone tools . The term has gradually fallen out of favor because in some parts of the world , the Chalcolithic and Neolithic are coterminous at both ends . Brass , an alloy of copper and zinc , is of much more recent origin . It was known to the Greeks , but became a significant supplement to bronze during the Roman Empire .

= = = Antiquity and Middle Ages = = =

In Greece , copper was known by the name chalkos (??????) . It was an important resource for the Romans , Greeks and other ancient peoples . In Roman times , it was known as aes Cyprium , aes being the generic Latin term for copper alloys and Cyprium from Cyprus , where much copper was mined . The phrase was simplified to cuprum , hence the English copper . Aphrodite (Venus in Rome) represented copper in mythology and alchemy because of its lustrous beauty and its ancient use in producing mirrors ; Cyprus was sacred to the goddess . The seven heavenly bodies known to the ancients were associated with the seven metals known in antiquity , and Venus was assigned to copper .

Britain first used brass in about the 3rd or 2nd Century BC . In North America , copper mining began with marginal workings by Native Americans . Native copper is known to have been extracted from sites on Isle Royale with primitive stone tools between 800 and 1600 . Copper metallurgy was flourishing in South America , particularly in Peru around 1000 AD . Copper burial ornaments from the 15th century have been uncovered , but the metal 's commercial production did not start until the early 20th century .

The cultural role of copper has been important , particularly in currency . Romans in the 6th through 3rd centuries BC used copper lumps as money . At first , the copper itself was valued , but gradually the shape and look of the copper became more important . Julius Caesar had his own coins made from brass , while Octavianus Augustus Caesar 's coins were made from Cu @-@ Pb @-@ Sn alloys . With an estimated annual output of around 15 @,@ 000 t , Roman copper mining and smelting activities reached a scale unsurpassed until the time of the Industrial Revolution ; the provinces most intensely mined were those of Hispania , Cyprus and in Central Europe .

The gates of the Temple of Jerusalem used Corinthian bronze treated with depletion gilding . The process was most prevalent in Alexandria , where alchemy is thought to have begun . In ancient India , copper was used in the holistic medical science Ayurveda for surgical instruments and other medical equipment . Ancient Egyptians (~ 2400 BC) used copper for sterilizing wounds and drinking water , and later to treat headaches , burns , and itching .

= = = Modern period = = =

The Great Copper Mountain was a mine in Falun , Sweden , that operated from the 10th century to 1992 . It satisfied two thirds of Europe 's copper consumption in the 17th century and helped fund many of Sweden 's wars during that time . It was referred to as the nation 's treasury ; Sweden had a copper backed currency .

Copper was used in roofing , currency , Renaissance sculpture , photographic technology known as the daguerreotype , the Statue of Liberty , and other structures . Copper plating and copper sheathing was widely used in the hulls of ships , of which the ships of Christopher Columbus were among the earliest . The Norddeutsche Affinerie in Hamburg was the first modern electroplating plant starting its production in 1876 . The German scientist Gottfried Osann invented powder metallurgy in 1830 while determining the metal 's atomic mass ; around then it was discovered that the amount and type of alloying element (e.g. , tin) to copper would affect bell tones . Flash smelting was developed by Outokumpu in Finland and first applied at Harjavalta in 1949 ; the energy @-@ efficient process accounts for 50 % of the world 's primary copper production .

The Intergovernmental Council of Copper Exporting Countries , formed in 1967 by Chile , Peru , Zaire and Zambia , operated in the copper market as OPEC does in oil , though it never achieved the same influence , particularly because the second @-@ largest producer , the United States ,

was never a member ; it was dissolved in 1988 .

== Applications ==

The major applications of copper are electrical wire (60 %) , roofing and plumbing (20 %) , and industrial machinery (15 %) . Copper is used mostly as a pure metal , but when greater hardness is required , it is put into such alloys as brass and bronze (5 % of total use) . For more than two centuries , copper paint has been used on boat hulls to control the growth of plants and shellfish . A small part of the copper supply is used for nutritional supplements and fungicides in agriculture . Machining of copper is possible , although alloys are preferred for good machinability in creating intricate parts .

=== Wire and cable ===

Despite competition from other materials , copper remains the preferred electrical conductor in nearly all categories of electrical wiring except overhead electric power transmission where aluminium is often preferred . Copper wire is used in power generation , power transmission , power distribution , telecommunications , electronics circuitry , and countless types of electrical equipment . Electrical wiring is the most important market for the copper industry . This includes structural power wiring , power distribution cable , appliance wire , communications cable , automotive wire and cable , and magnet wire . Roughly half of all copper mined is used for electrical wire and cable conductors . Many electrical devices rely on copper wiring because of its multitude of inherent beneficial properties , such as its high electrical conductivity , tensile strength , ductility , creep (deformation) resistance , corrosion resistance , low thermal expansion , high thermal conductivity , ease of soldering , malleability , and ease of installation .

For a short period from the late 1960s to the late 1970s , copper wiring was replaced by aluminum in many housing construction projects in America (see Aluminum wire for main article) . The new wiring was implicated in a number of house fires and the industry returned to copper .

=== Electronics and related devices ===

Integrated circuits and printed circuit boards increasingly feature copper in place of aluminium because of its superior electrical conductivity (see Copper interconnect for main article) ; heat sinks and heat exchangers use copper because of its superior heat dissipation properties . Electromagnets , vacuum tubes , cathode ray tubes , and magnetrons in microwave ovens use copper , as do wave guides for microwave radiation .

=== Electric motors ===

Copper 's superior conductivity enhances the efficiency of electrical motors . This is important because motors and motor @-@ driven systems account for 43 % -46 % of all global electricity consumption and 69 % of all electricity used by industry . Increasing the mass and cross section of copper in a coil increases the efficiency of the motor . Copper motor rotors , a new technology designed for motor applications where energy savings are prime design objectives , are enabling general @-@ purpose induction motors to meet and exceed National Electrical Manufacturers Association (NEMA) premium efficiency standards .

=== Architecture ===

Copper has been used since ancient times as a durable , corrosion resistant , and weatherproof architectural material . Roofs , flashings , rain gutters , downspouts , domes , spires , vaults , and doors have been made from copper for hundreds or thousands of years . Copper 's architectural use has been expanded in modern times to include interior and exterior wall cladding , building

expansion joints , radio frequency shielding , and antimicrobial and decorative indoor products such as attractive handrails , bathroom fixtures , and counter tops . Some of copper 's other important benefits as an architectural material include low thermal movement , light weight , lightning protection , and recyclability .

The metal 's distinctive natural green patina has long been coveted by architects and designers . The final patina is a particularly durable layer that is highly resistant to atmospheric corrosion , thereby protecting the underlying metal against further weathering . It can be a mixture of carbonate and sulfate compounds in various amounts , depending upon environmental conditions such as sulfur @-@ containing acid rain . Architectural copper and its alloys can also be ' finished ' to embark a particular look , feel , and / or color . Finishes include mechanical surface treatments , chemical coloring , and coatings .

Copper has excellent brazing and soldering properties and can be welded ; the best results are obtained with gas metal arc welding .

= = = Antibiofouling applications = = =

Copper is biostatic , meaning bacteria and many other forms of life will not grow on it . For this reason it has long been used to line parts of ships to protect against barnacles and mussels . It was originally used pure , but has since been superseded by Muntz metal and copper @-@ based paint . Similarly , as discussed in copper alloys in aquaculture , copper alloys have become important netting materials in the aquaculture industry because they are antimicrobial and prevent biofouling , even in extreme conditions and have strong structural and corrosion @-@ resistant properties in marine environments .

= = = Antimicrobial applications = = =

Copper @-@ alloy touch surfaces have natural properties that destroy a wide range of microorganisms (e.g. , E. coli O157 : H7 , methicillin @-@ resistant Staphylococcus aureus (MRSA) , Staphylococcus , Clostridium difficile , influenza A virus , adenovirus , and fungi) . Some 355 copper alloys were proven to kill more than 99 @. @ 9 % of disease @-@ causing bacteria within just two hours when cleaned regularly . The United States Environmental Protection Agency (EPA) has approved the registrations of these copper alloys as " antimicrobial materials with public health benefits " ; that approval allows manufacturers to make legal claims to the public health benefits of products made of registered alloys . In addition , the EPA has approved a long list of antimicrobial copper products made from these alloys , such as bedrails , handrails , over @-@ bed tables , sinks , faucets , door knobs , toilet hardware , computer keyboards , health club equipment , and shopping cart handles (for a comprehensive list , see : Antimicrobial copper @-@ alloy touch surfaces # Approved products) . Copper doorknobs are used by hospitals to reduce the transfer of disease , and Legionnaires ' disease is suppressed by copper tubing in plumbing systems . Antimicrobial copper alloy products are now being installed in healthcare facilities in the U.K. , Ireland , Japan , Korea , France , Denmark , and Brazil and in the subway transit system in Santiago , Chile , where copper @-@ zinc alloy handrails will be installed in some 30 stations between 2011 ? 2014 .

= = = Folk medicine = = =

Copper is commonly used in jewelry , and according to some folklore , copper bracelets relieve arthritis symptoms . In various studies , though , no difference is found between arthritis treated with a copper bracelet , magnetic bracelet , or placebo bracelet . Medical science has not demonstrated any benefits in copper jewelry for any medical condition . A human being can have a dietary copper deficiency , but the condition is very rare because copper is present in many common foods , including legumes (beans) , grains , and nuts .

No evidence shows that copper can be absorbed through the skin . If it were , it might lead to copper poisoning .

=== Compression clothing ===

Recently , some compression clothing with inter @-@ woven copper has been marketed with the same folk medicine claims . Because compression clothing is a valid treatment for some ailments , the clothing may appear to work , but the added copper may have no benefit beyond a placebo effect .

=== Other uses ===

Solutions of copper compounds are used as a wood preservative , particularly in treating the original portion of structures during restoration of dry rot damage . Together with zinc , copper wires may be installed over non @-@ conductive roofing materials to discourage the growth of moss . Textile fibers are blended with copper to create antimicrobial protective fabrics . Copper alloys are used in musical instruments , particularly : the body of brass instruments ; circuitry for all those that are electronically amplified ; the bodies of brass percussion such as gongs , bells , and kettle drums ; the metallic reeds of harmonicas , reed organs , and accordions ; tuning heads on guitars and other string instruments ; string windings on harps , pianos , harpsichords , and string instruments ; and the frame elements of pianos and harps . Copper is commonly used as a base on which other metals such as nickel are electroplated .

Copper is one of three metals , along with lead and silver , used in the museum materials testing procedure called the Oddy test to detect chlorides , oxides , and sulfur compounds .

Copper is used as the printing plate in etching , engraving and other forms of intaglio printmaking .

Copper oxide and carbonate are used add color in stain glass works , in glassmaking , and in ceramic glazes to impart turquoise blue , green , and brown colors .

== Degradation ==

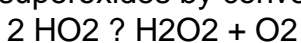
Chromobacterium violaceum and *Pseudomonas fluorescens* can both mobilize solid copper as a cyanide compound . The ericoid mycorrhizal fungi associated with *Calluna* , *Erica* and *Vaccinium* can grow in metalliferous soils containing copper . The ectomycorrhizal fungus *Suillus luteus* protects young pine trees from copper toxicity . A sample of the fungus *Aspergillus niger* was found growing from gold mining solution and was found to contain cyano complexes of such metals as gold , silver , copper , iron , and zinc . The fungus also plays a role in the solubilization of heavy metal sulfides .

== Biological role ==

Copper proteins have diverse roles in biological electron transport and oxygen transportation , processes that exploit the easy interconversion of Cu (I) and Cu (II) . The biological role for copper commenced with the appearance of oxygen in earth 's atmosphere .

Copper is essential in the aerobic respiration of all eukaryotes . In mitochondria it is found in cytochrome c oxidase , which is the last protein in oxidative phosphorylation . Cytochrome c oxidase is the protein that binds the O₂ between a copper and an iron ; the protein transfers 8 electrons to the O₂ molecule to reduce it to two molecules of water .

Copper is also found in many superoxide dismutases , proteins that catalyze the decomposition of superoxides by converting it (by disproportionation) to oxygen and hydrogen peroxide :



The protein hemocyanin is the oxygen carrier in most mollusks and some arthropods such as the horseshoe crab (*Limulus polyphemus*) . Because hemocyanin is blue , these organisms have blue blood rather than the red blood of iron @-@ based hemoglobin . Structurally related to hemocyanin are the laccases and tyrosinases . Instead of reversibly binding oxygen , these proteins hydroxylate substrates , illustrated by their role in the formation of lacquers .

Several copper proteins , such as the " blue copper proteins " , do not interact directly with substrates , hence they are not enzymes . These proteins relay electrons by the process called electron transfer .

A unique tetranuclear copper center has been found in nitrous oxide reductase .

=== Dietary needs ===

Copper is an essential trace element in plants and animals , but not all microorganisms . The human body contains copper at a level of about 1 to 2 mg per kg of body mass . Copper is absorbed in the gut , then transported to the liver bound to albumin . After processing in the liver , copper is distributed to other tissues in a second phase , which involves the protein ceruloplasmin , carrying the majority of copper in blood . Ceruloplasmin also carries the copper that is excreted in milk , and is particularly well absorbed as a copper source . Copper in the body normally undergoes enterohepatic circulation (about 5 mg a day , vs. about 1 mg per day absorbed in the diet and excreted from the body) , and the body is able to excrete some excess copper , if needed , via bile , which carries some copper out of the liver that is not then reabsorbed by the intestine .

=== Dietary reference intake ===

The Food and Nutrition Board of the U.S. Institute of Medicine updated Estimated Average Requirements (EARs) and Recommended Dietary Allowances (RDAs) for copper in 2001 . The current EAR for copper for people ages 14 and up is 0.7 mg / day . The RDA is 0.9 mg / day . RDAs are higher than EARs so as to identify amounts that will cover people with higher than average requirements . RDA for pregnancy equals 1.0 mg / day . RDA for lactation equals 1.3 mg / day . For infants up to 12 months the AI is 0.22 mg / day and for children ages 1 to 13 years the RDA increases with age from 0.34 to 0.7 mg / day . As for safety , the Food and Nutrition Board also sets Tolerable Upper Intake Levels (known as ULs) for vitamins and minerals when evidence is sufficient . In the case of copper the UL is set at 10 mg / day . Collectively the EARs , RDAs , AIs and ULs are referred to as Dietary Reference Intakes . The European Food Safety Authority reviewed the same safety question and set its UL at 5 mg / day .

For U.S. food and dietary supplement labeling purposes the amount in a serving is expressed as a percent of Daily Value (% DV) . For copper labeling purposes 100 % of the Daily Value was 2.0 mg , but as of May 2016 it has been revised to 0.9 mg . Food and supplement companies have until July 28 , 2018 to comply with the change . A table of the pre and post change adult Daily Values is provided at Reference Daily Intake .

In the United States , copper deficiency is not common . A federal survey of food consumption determined that for women and men over the age of 19 , average consumption from foods and beverages was 1.1 and 1.54 mg / day , respectively . For women , 10 % consumed less than the EAR , for men < 3 % .

=== Copper based disorders ===

Because of its role in facilitating iron uptake , copper deficiency can produce anemia like symptoms , neutropenia , bone abnormalities , hypopigmentation , impaired growth , increased incidence of infections , osteoporosis , hyperthyroidism , and abnormalities in glucose and cholesterol metabolism . Conversely , Wilson 's disease causes an accumulation of copper in body tissues .

Severe deficiency can be found by testing for low plasma or serum copper levels , low ceruloplasmin , and low red blood cell superoxide dismutase levels ; these are not sensitive to marginal copper status . The " cytochrome c oxidase activity of leucocytes and platelets " has been stated as another factor in deficiency , but the results have not been confirmed by replication .

Gram quantities of various copper salts have been taken in suicide attempts and produced acute

copper toxicity in humans , possibly due to redox cycling and the generation of reactive oxygen species that damage DNA . Corresponding amounts of copper salts (30 mg / kg) are toxic in animals . A minimum dietary value for healthy growth in rabbits has been reported to be at least 3 ppm in the diet . However , higher concentrations of copper (100 ppm , 200 ppm , or 500 ppm) in the diet of rabbits may favorably influence feed conversion efficiency , growth rates , and carcass dressing percentages .

Chronic copper toxicity does not normally occur in humans because of transport systems that regulate absorption and excretion . Autosomal recessive mutations in copper transport proteins can disable these systems , leading to Wilson 's disease with copper accumulation and cirrhosis of the liver in persons who have inherited two defective genes .

Elevated copper levels have also been linked to worsening symptoms of Alzheimer 's disease .

= = = Occupational exposure = = =

In the US , the Occupational Safety and Health Administration (OSHA) has designated a permissible exposure limit (PEL) for copper dust and fumes in the workplace as a time @-@ weighted average (TWA) of 1 mg / m³ . The National Institute for Occupational Safety and Health (NIOSH) has set a Recommended exposure limit (REL) of 1 mg / m³ , time @-@ weighted average . The IDLH (immediately dangerous to life and health) value is 100 mg / m³ .