

Copper: Essential for Human Health

Copper is an essential trace element vital to the health of all living organisms. Although the amount of copper found in the human body (50–120 milligrams) would fit on the head of a pin, this tiny quantity is essential. Research has revealed that copper is vital for the optimal health of the human body, along with other mineral micronutrients such as iron, calcium and zinc.

This e-source explores copper's essentiality and uses in the human body. Below are different sections, for quick navigation.

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The human body contains around 2 mg of copper per kilogram of body mass. While copper is found throughout the body, it is concentrated in organs with high metabolic activity, such as the liver, kidneys, heart and brain. This tiny amount is enough to provide copper ions for billions of protein molecules, in particular enzymes, where the copper ions are essential cofactors. Without cofactors, the enzymes could not work.

Copper is an essential trace mineral that cannot be formed by the human body so must be ingested from dietary sources every day. According to the World Health Organisation, 1–3 milligrams per day of copper are required to prevent any symptoms of deficit. Various health and nutrition organisations around the world have set dietary reference values, highlighting the importance of copper as part of a balanced diet.

Adequate Copper Intakes (mg/day)

Age	Females	Males
7 – 11 months	0.4	0.4
1 – <3 years	0.7	0.7
3 – <10 years	1.0	1.0
10 – <18 years	1.1	1.3
≥18 years	1.3	1.6
Pregnancy/lactation	1.5	

Did You Know?

Natural foods such as cereals, meat and fish generally contain sufficient copper to provide up to 50% of required copper intake. Also, there are some unexpected and delightful sources such as cocoa, providing one valid, scientific reason to eat (dark) chocolate!

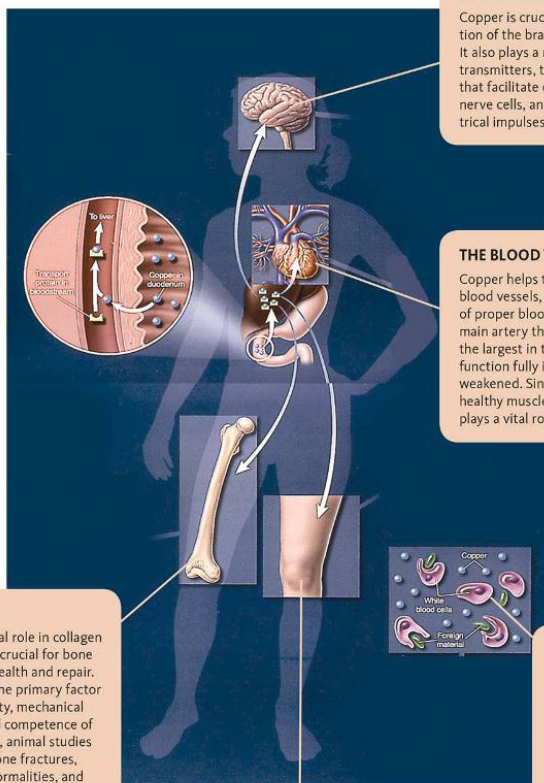


*Copper is crucial for the development of the brain and nervous system.
(Courtesy of Gida.de.)*

Copper is Used Throughout the Body

Virtually every cell in the body utilises copper and, together with iron and zinc, is one of the trio of minerals essential to good health. Copper is vital to the health of the body from foetal development through to old age. Quite simply, without copper our brains, nervous systems and cardiovascular systems could not function normally. Copper is essential for:

- Brain development during foetal and post-natal growth, and maintenance of brain health throughout life, including effective anti-oxidative defence and efficient communication between nerve cells.
- Maintenance of healthy skin and connective tissue.
- Wound healing.
- Structural integrity and function of heart and blood vessels.
- Growth of new blood vessels.
- Proper structure and function of circulating blood cells.
- Formation of the cells of our immune system (white blood cells).
- Maintenance of a healthy and effective immune response.
- Generation and storage of energy in the 'power plants' of our cells, the mitochondria.



THE BRAIN:

Copper is crucial for the normal formation of the brain and nervous system. It also plays a role in making neurotransmitters, the chemical messengers that facilitate communication between nerve cells, and the movement of electrical impulses along nerves.

THE BLOOD VESSELS AND HEART:

Copper helps to sustain the elasticity of blood vessels, which allows maintenance of proper blood pressure. The aorta - the main artery that runs from the heart, and the largest in the human body - cannot function fully if its elastic framework is weakened. Since copper is needed for the healthy muscle tone and function, it also plays a vital role in the heart.

THE BONE:

Copper's vital role in collagen formation is crucial for bone formation, health and repair. Collagen is the primary factor for the rigidity, mechanical strength and competence of bone. In fact, animal studies show that bone fractures, skeletal abnormalities, and osteoporosis occur with copper deficiency.

THE SKIN:

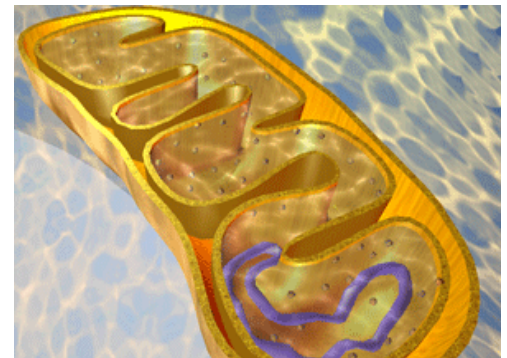
Copper plays an important role in collagen formation, a connective tissue in the skin. Collagen is the most prevalent protein found in human skin and is important in maintaining our appearance - supply, healthy appearing, wrinkle-free skin - on our faces and all other areas.

THE IMMUNE SYSTEM:

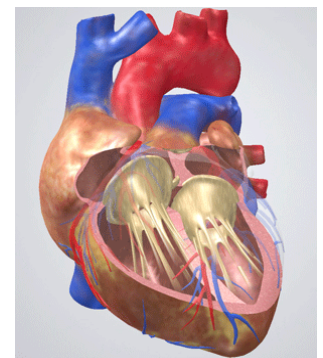
Copper is necessary for the maintenance of a healthy immune system to ward off germs and diseases. A strong and aggressive supply of germ-fighting soldiers, including white blood cells (engulf foreign material), antibodies (protein molecules), cytokines (chemical messengers), B lymphocytes (produce antibodies) and T lymphocytes (immune cells), keep the body healthy and disease-free.



Copper enables production and maintenance of myelin, which insulates nerve cells, so ensuring the proper transmission of nerve impulses. The myelin sheath is shown in green in this picture. (Courtesy of Gida.de.)



Copper is essential for the reactions in mitochondria that drive the metabolism of cells. This illustration shows a section through a mitochondrion. (Courtesy of Gida.de.)



Muscle and connective tissue in the heart contain elastin and collagen. Copper is the cofactor in lysyl oxidase, the enzyme involved in cross linking these molecules to form strong tissue. (Courtesy of Gida.de.)

[Click here](#) to enlarge.

Beyond the Brain

The liver


After copper is ingested, it is absorbed from the small intestine into the bloodstream. Here, copper bonds with transport proteins, which carry it to the liver. Once copper is taken up into the liver, it is either stored, distributed around the body in transport proteins or excreted into the bile.

Copper plays a central role in the conversion of iron to its useable iron (III) (ferric) form and also helps transport iron around the body. Copper deficiency can lead to anaemia and tissue iron overload.

The brain and nervous system

Copper is crucial for the normal development of the brain and nervous system. It plays a role in the production and maintenance of myelin, which insulates nerve cells, so ensuring the proper transmission of nerve impulses.

Copper is also involved in the synthesis of neurotransmitters, the chemicals that allow communication between nerve cells. Copper deficiency can lead to degeneration of the nervous system.



The human brain has 100 billion neurons

Copper connects them to 10 thousand other neurons
Indulge. 1mg of copper per day keeps you healthy

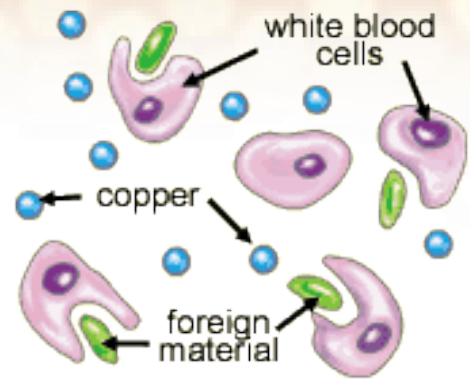
Copper is crucial for the normal formation of the brain and nervous system. It also plays a role in making neurotransmitters, the chemical messengers that facilitate communications between nerve cells, and the movement of electrical impulses along nerves.

Copper dietary sources used in this image:
Oysters: 5.71mg (285% DV) per 100 g. Clams: 0.66mg (34% DV) per 100g Beef Liver: 14.588mg (729% DV) per 100g
Shiitake Mushrooms: 5.165mg (258% DV) per 100g Dark Chocolate: 3.79mg (189% DV) per 100 g Radicchio: 0.3mg (17% DV) per 100 g
Almonds: 1.031mg (52% DV) of Copper per 100g Pecans: 1.2mg (60% DV) per 100g Lentils: 1.303mg (65% DV) per 100g
Beans: 1.1mg (55% DV) per 100g Raisins: 0.353mg (18% DV) per 100g Lemon Peel: 0.092mg (5% DV) per 100g

[Click here](#) to enlarge.

Cells

The release of cellular energy (ATP) inside the mitochondria depends on the crucial involvement of a copper-containing enzyme. A similarly vital function for copper as a cofactor is the neutralisation of free radicals that would otherwise oxidise and destroy healthy cells. Copper deficiency can lead to cancer and heart disease.



Copper is essential for a healthy immune system.

Food	Copper (mg/100g edible portion)	Comments
Chicken	0.06	Roasted, meat only
Liver	4.51	Beef, braised
Tuna	0.04	White, canned in water, drained solids
Oysters	0.57	Battered or breaded, fried
Potato	0.22	Baked, without salt, flesh only
Potato	0.17	Boiled, no skin, no salt
Mushrooms	0.24	Canned, drained
Green Peas	0.14	Frozen, cooked, drained, no salt
Banana	0.10	Raw
Raisins	0.36	Golden, seedless
Peanuts	0.67	Dry roasted, no salt
Peanuts	1.14	Raw
Brazil Nuts	1.77	Dried, unblanched
Chick Peas	0.17	Canned
Chick Peas	0.85	Raw
Sunflower Seeds	1.75	Kernels, dried
Chocolate (Dark)	0.80	Dark chocolate bar

This table shows typical copper content of various food types.

The heart

Copper is essential for the synthesis of collagen. This is found in connective tissue which is the main supporting and binding tissue of the body. Copper is also needed for healthy muscle tone and function and so plays a vital role in the heart. Copper deficiency can lead to heart failure.

Blood vessels

Copper serves as a cofactor for an enzyme involved in the coagulation of blood. The blood vessels are surrounded and protected by connective tissue, and copper helps to sustain their elasticity, particularly for the aorta and smaller arteries. Copper deficiency can lead to circulatory problems and low blood pressure.

Copper is essential for a wide range of biological functions that play an important role in maintaining healthy skin, namely tone, wound healing, and ultraviolet (UV) protection.

Copper is required for the production of collagen and elastin, two components that provide support and elasticity for skin. As a cofactor for the enzyme tyrosinase, copper is involved in the synthesis of the skin pigment melanin, which provides protection from UV radiation. Copper deficiency can lead to skin degeneration and loss of pigmentation.

Bone

Collagen is the main structural material in bone. Cross-linking of collagen molecules affects bone strength. Enzymes with copper cofactors are involved in this process. Copper deficiency can lead to fractures, skeletal abnormalities and osteoporosis.

The immune system

Copper is necessary for the maintenance of a healthy white blood cell count; many of these white cells are phagocytes, which engulf and destroy microorganisms. Copper deficiency can lead to a depressed immune system, reduced white cell count and increased incidence of pneumonia.

Dietary Sources of Copper

Copper is available from a wide variety of fresh and processed foods. Good sources include grains, nuts (particularly brazil and cashew nuts), meats (liver and kidney), shellfish, legumes (peas and beans) and seeds. Dark chocolate is also a rich source of

copper. Eating a well-balanced diet should allow you to meet your daily requirements of copper.



Some of the copper rich foods. If you don't like lobster, dark chocolate is also a good source! (Courtesy of ARS.)

Copper Deficiency

Copper is an essential micronutrient. Deficiency causes serious health problems, but is very rare. Deficiency disorders are more often caused by genetic faults in the transport proteins than by a diet low in copper. The copper is available, but it cannot get into cells.

A healthy balanced diet should provide the copper required each day. There is concern that poor or unbalanced diets may not provide sufficient copper.

Copper Excess

Copper homeostasis balances uptake and excretion of copper to meet the body's needs on a continuous basis. Acute copper poisoning is a rare event, largely restricted to the accidental drinking of solutions of copper nitrate or copper sulfate, which should be kept out of easy access in the home. These, and organic copper salts, are powerful emetics and large doses are normally rejected by vomiting. The capacity for healthy human livers to excrete copper is considerable and chronic copper poisoning is very rare, with the few reports of it restricted to patients with liver disease.

Balancing Trace Elements

The intake of adequate copper is, on its own, not good enough. Minerals interact in the body, working as a team. The advice of research scientists is to regard copper, iron and zinc as an essential trio - too much of one can hamper the body's ability to absorb or process the other two. Deficiency diseases may then result.

Sources of minerals

Mineral	Function in human body	Deficiency disease	Common food sources
Iron	<ul style="list-style-type: none">• Oxygen carrier (haem) in haemoglobin• Electron carrier (in respiration)• Enzyme cofactor (catalase; peroxidase - breakdown of hydrogen peroxide)	<ul style="list-style-type: none">• Anaemia	<ul style="list-style-type: none">• Liver• Red meat• Spinach
Zinc	<ul style="list-style-type: none">• Enzyme cofactor (carbonic anhydrase - carriage of carbon dioxide; carboxypeptidase - protein digestion)	<ul style="list-style-type: none">• Growth retardation• Loss of appetite• Impaired immune function	<ul style="list-style-type: none">• Most foods

[Click here](#) to enlarge.

Deficiencies

For example:

- Too much zinc can inhibit the absorption of copper. This may result in poor copper status in the body, which over time may lead to bone abnormalities, problems with the heart and circulation and impaired immunity.
- Iron needs copper; without adequate copper, iron cannot be converted to its most useful iron (III) (ferric) form. Copper is also necessary for the transport of iron to and from the tissues.

Copper is increasingly being recognised as an essential micronutrient. A growing body of research indicates that, as part of a balanced diet, an adequate intake of copper is vital to ensure a wide range of health benefits.

Suggestions for Research

1. What other metal ions are cofactors?
What are the main medical disorders linked with copper deficiency?

Questions and Activities

1. **What is a cofactor?**
2. **Calculate the fraction by mass of copper in a human body (e.g. body mass = 75 kg, mass of copper = 150 mg).**
3. **How many atoms of copper would there be in a single human (given the atomic mass of copper ≈ 63 and Avogadro's number $\approx 6 \times 10^{23}$)?**
4. **How does copper get into the human food chain?**

[Click here for answers](#)

Suggested Activity

1. Visualise what the amount of copper in a human body may look like.
2. Use a small length of mains flex and scissors to cut small strands of copper wire about 1mm long.
3. Add these to a precision balance with a sensitivity of better than 1.0 mg.
4. Calculate the amount of copper in your own body.
5. Keep adding strand fragments until you have the equivalent of the mass of copper in your own body.
6. Tip the copper onto a filter paper.
7. Use a digital camera to photograph the copper strands and record this in a document.
8. Show all your calculations.

If you do not have such a sensitive balance, you can use a less sensitive one and a longer length of stripped copper flex. Then calculate by measuring and counting the strands how much your cuttings weigh.

Copper Development Association is a non-profit organisation that provides information on copper's properties and applications, its essentiality for health, quality of life and its role in technology. It supports education through a collection of resources spanning biology, chemistry and physics. These materials have been developed in conjunction with the Association for Science Education, and reviewed by teachers.

For more resources, visit www.copperalliance.org.uk/education.