

MEDICINE FROM THE GROUND UP

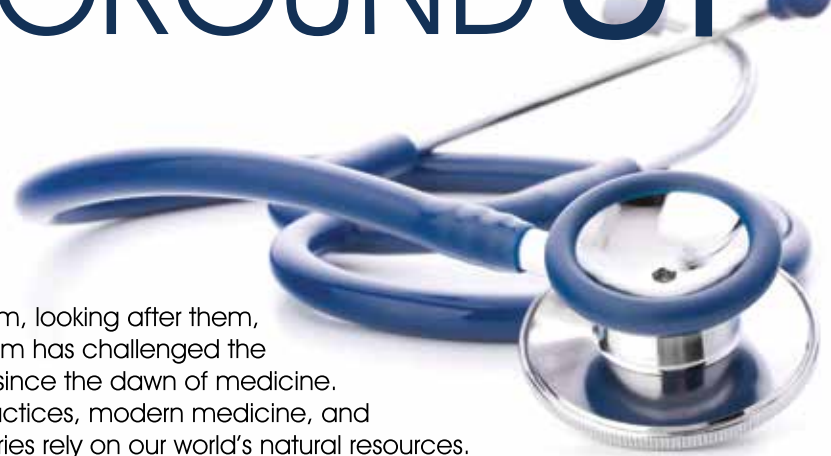


From head to toe,
skin to bone,
brain to heart,
the human body
is made up of
complex systems.



Learning about them, looking after them, and enhancing them has challenged the health community since the dawn of medicine. Ancient healing practices, modern medicine, and tomorrow's discoveries rely on our world's natural resources. The Earth supplies us with the metals and minerals that contain the necessary components for dietary essentials, care regimes, surgical instruments, medical devices, diagnostic aids, and life-saving treatments. Canada, as one of the world's largest mining nations, produces more than 60 minerals and metals, many of them necessary to the world of medicine.

Mining Makes It Happen!



BODY IN BALANCE

The human body is 96 per cent made up of six elements: **oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus.**

The remaining four per cent comprises trace elements essential to various functions, including bone and cell building, regulating pH levels, carrying electrical charge, and enabling chemical reactions. All of these elements and more are found in **Earth's four spheres**—**lithosphere, atmosphere, hydrosphere, and biosphere**—where they combine in different ways and continually cycle through and between the spheres.



As part of that cycle, we take in and release our delicately balanced combination of elements; depletion or imbalance causes our systems to suffer. To achieve that balance, we must eat nutritious food, whether animal or vegetable in origin, supported by mineral-rich soil. Where elements are missing, we turn to other sources; mineral supplements (in appropriate amounts), toothpaste, clay masks, revitalizing lotions, hot mineral baths, and more, help our bodies thrive.



medical DEVICES

A medical office or a hospital features countless medical devices, tools, and machines made of metals and minerals, from needles and stethoscopes to sophisticated machines that look inside the body, without cutting, to examine bones, blood vessels, organs, and soft tissues.

- Surgical theatres and tools gleam with medical-grade **stainless steel**.
- Magnetic resonance imaging (MRI) machines rely on **Rare Earth Elements (REEs)** in super magnets to spot damage and disease.
- Computerized axial tomography (CAT or CT) scanners create cross-sectional images of the body with the help of **molybdenum**, and X-ray machines look at bones using **copper and tungsten**, while **lead** and tungsten protect people during radiographic diagnostics.
- Solid-state lasers, using REEs **holmium** and **thulium**, make minimally invasive surgery possible.
- Orthopaedic implants allow people to regain normal function, thanks to **stainless steel, titanium, and titanium alloys**.



With new discoveries,
innovation, and material
science, the list goes on!

Diagnosis

Mineral elements are often used to help diagnose a patient's condition, whether in conjunction with medical devices to show a picture of the body's internal function or in medical research.

A magnetic resonance imaging (MRI) machine detects contrast mediums, or agents, injected into patients to make certain tissues, abnormalities, or disease processes more clearly visible. Contrast agents include **manganese-, iron-, and gadolinium-based** substances, which provide imaging of the heart, gastrointestinal tract, brain, spine, other soft tissue, and bones.

X-ray machines detect technetium-99m, derived from decaying **uranium**, and the most commonly used isotope in nuclear medicine, to reveal brain, heart, and bone abnormalities. X-rays also work with **barium** compounds to examine the gastrointestinal tract.

In biomedical and chemical research, the REE **cesium** is used to separate DNA, and cesium compounds work as catalysts.



TREATMENTS

The list of metals and minerals used for medical treatment is long, including ancient and modern remedies.



Egyptians ingested **gold** for mental, bodily, and spiritual purification, and gold has been used to fix teeth for over 4,000 years. In the 20th century, gold compounds were found to alleviate symptoms of rheumatoid arthritis.



Silver, having anti-bacterial properties, is added to bandages and wound-dressings, catheters, and other medical instruments. **Gypsum-based** orthopaedic casts have immobilized many a broken bone, and **bismuth** subsalicylate has settled countless upset stomachs. **Lithium** medication helps depression sufferers, and **sulphur** treats skin diseases, arthritis, and chronic bladder inflammation.



The fight against cancer employs radiation treatment using radioactive isotopes of **iodine, yttrium, samarium, palladium**, and more. Chemotherapy, another cancer-fighting treatment, commonly uses **platinum** compounds to target and damage DNA in cancer cells.

a different approach to HEALING

Traditional western medicine has found numerous uses of metals and minerals, but historical and present-day alternative medicine suggest other approaches.

In Chinese medicine, today's fine **stainless steel** acupuncture needles were preceded over 2,000 years ago by sharp-edged stones, followed by stone or pottery needles, then ones of **bronze**, or **gold** and **silver**.

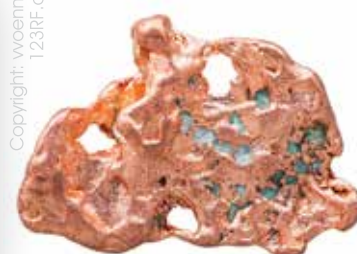
In Hinduism, crystals such as **azurite, kyanite, ruby, and amethyst** are believed to balance and amplify a person's energy, and placing crystals on energy focal points on the body, or chakras, is believed to promote healing. In Egypt, pharaohs and priests used **quartz** to balance the body's Ba and Ka energies.

Copper and **iron** figure largely in modern medicine, but many people use them in alternative approaches, believing that wearing copper relieves arthritis and wearing magnets alleviates pain and other health concerns.



Indigenous cultures have long used the healing powers of **mud**, rich with **clay** minerals. In Australia, healing mud was used to pack wounds. Cultures in the Andes, Central Africa, and Australia ingested clays to cure diarrhea and stomach upsets or prevent poisoning from toxins present in food. In Canada, the Heiltsuk First Nation has used mineral-rich clays for centuries for both external and internal medicine. Natural medicine today suggests **bentonite clay**, made up of weathered volcanic ash, for many internal and external uses.

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Native copper



Quartz/Amethyst



Clay



Stainless Steel

The alloy of **iron** with **chromium, nickel, and molybdenum**, sometimes called surgical stainless steel, plays a key role in a wide range of medical applications. Its high corrosion resistance, strength, precision, reliability, and antibacterial properties meet the stringent standards for surgical tools, from syringes, scalpels, trays, and bowls to sinks and operating tables. Sensor probes, orthodontic wires, ear scope nozzles, and catheters add to the list of uses.

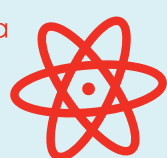
As a metallic biomaterial, it works for medical implants, including pins, screws, artificial heart valves, and hip and knee replacements. It is also used in the manufacture of pharmaceutical products, which requires minimal metallic contamination, and to contain hazardous waste.

KEY TERMS

A **PURE SUBSTANCE** consists of matter that comprises only one type of particle and that can be classified as either an element or a compound. E.g., Gold (Au), Oxygen (O₂), and water (H₂O)



An **ELEMENT** is the simplest form of a pure substance; it cannot be broken down using chemical methods. E.g., Copper (Cu)



A **COMPOUND** is a pure substance made up of two or more different elements chemically combined. E.g., Sodium fluoride (NaF)

A **MINERAL** is a natural compound formed through geological processes; to be considered "true" mineral, a substance must be solid, inorganic, and crystalline, with a defined chemical composition. E.g., Sodium chloride (NaCl)



A **MIXTURE** is a combination of two or more pure substances, in which each pure substance retains its individual chemical properties. E.g., Alloy (steel)



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NATURAL RESOURCES



LITHIUM (Li) *Atomic Number: 3*
Australia, Chile, Argentina, China, Zimbabwe, **CANADA***

Lithium, the lightest metal and least dense solid element, is never found in nature as a pure element; however, it can be synthesized. Highly chemically active, this alkali metal occurs in minerals such as spodumene and lepidolite, or in lithium chloride salts dissolved in brine pools. As a drug, lithium acts on the central nervous system, stabilizing a person's mood. Lithium effectively treats bipolar disorder and depression, and reduces the risk of suicide in patients with those conditions.



SODIUM (Na) *Atomic Number: 11*
China, U.S., India, **CANADA**/Germany (tied), Australia

Sodium, an essential element in the human body, is found in numerous minerals such as feldspars, sodalite, and halite. It helps maintain proper muscle and nerve function, stable blood pressure levels, and balance of water in and around cells. Healthy children need 1,000 to 1,500 mg and adults need 1,500 mg of sodium per day. One teaspoon of table salt contains 2,300 mg of sodium. Sodium bicarbonate is used as an antacid to treat heartburn, indigestion, and upset stomach.



POTASSIUM (K) *Atomic Number: 19*
CANADA, Russia, Belarus, China, Germany

Potassium, an element available from potash sources such as the minerals sylvite and carnallite, is an electrolyte in the human body. It helps maintain proper function of all cells, tissues, and organs. It plays a key role in heart function, as well as skeletal and smooth muscle contraction. As an electrolyte, it conducts electricity in the body, along with sodium, chloride, calcium, and magnesium. Food usually supplies sufficient potassium, but disease or drugs such as diuretics and laxatives can cause deficiency; potassium supplements, such as potassium chloride and potassium gluconate, correct the balance.



CESIUM (Cs) *Atomic Number: 55*
CANADA, Zimbabwe, Namibia

Cesium, a very rare element, occurs in granite pegmatites rich with the minerals pollucite and lepidolite. Its main biomedical use is the separation of deoxyribonucleic acid (DNA). Cesium compounds act as catalysts in biomedical and chemical research. Cesium chloride treats all forms of cancer and shows potential as an alternative cure. Radioactive cesium isotopes are used in cancer radiation treatment.



CALCIUM (Ca) *Atomic Number: 20*
China, Iran, Thailand, U.S., Turkey, **CANADA***

Calcium is obtained from the minerals calcite and gypsum, and from the rocks limestone, dolostone, and marble. Gypsum, familiar in construction as drywall, is a non-toxic mineral also used as an ingredient in toothpaste, drugs, and cosmetics, and as a calcium supplement in food. Gypsum also goes into surgical and orthopaedic casts for broken bones. Calcium is the fifth most common element in the human body; as a structural material, it occurs in cell walls, bones, and teeth. It plays a role in regulating the heartbeat and in blood clotting. Calcium supplements help maintain bone density as people age.



BARIUM (Ba) *Atomic Number: 56*
China, India/Morocco (tied), U.S., Iran/Kazakhstan (tied), **CANADA***

Barium, a soft silvery metal, comes primarily from the mineral barite. Barium is used as an X-ray radiocontrast agent for imaging the human gastrointestinal tract. Barite blocks X-ray and gamma-ray emissions; it is added to high-density concrete for radiation shielding around X-ray units in hospitals.



URANIUM (U) *Atomic Number: 92*
Kazakhstan, **CANADA**, Australia, Niger, Russia

Uranium, relatively common in the Earth's crust, comes from the mineral uraninite, also known as pitchblende. It fuels nuclear reactors around the world, some of which produce technetium-99m (Tc-99m), the most-used radiopharmaceutical in nuclear medicine. A synthetic element, Tc-99m results from fission of highly enriched uranium; fission first produces molybdenum-99 (and other isotopes), which then decays into Tc-99m. The National Research Universal reactor in Chalk River, Ontario, is one of five reactors that supplies the world's Tc-99m, used for the diagnosis and treatment of life-threatening diseases.



TITANIUM (Ti) *Atomic Number: 22*
China, Australia, Vietnam, South Africa, Mozambique, **CANADA***

Titanium, from the minerals rutile and ilmenite, offers the strength of steel with only 60 per cent of the weight, as well as high corrosion resistance. As metallic biomaterials, titanium and titanium alloys are used for implants, from dental implants and hip replacements to heart pacemakers and cochlear implants. Magnetic resonance imaging (MRI) and nuclear magnetic resonance (NMR) instruments use superconductor magnets made from niobium-titanium alloy embedded in copper. Titanium dioxide is used to give whiteness and opacity to foods, medicines, and toothpaste.



MANGANESE (Mn) *Atomic Number: 25*
South Africa, China, Australia, Gabon, Brazil

Manganese usually occurs with iron or in other minerals. When mined, it is primarily derived from the mineral pyrolusite. Manganese is required for normal biological functions in humans, including development, metabolism, and the antioxidant system. Manganese-based contrast agents injected into the body work with MRI machines; for example, manganous salts can be used for heart imaging.



IRON (Fe) *Atomic Number: 26*
China, Australia, Brazil, India, Russia, **CANADA***

Iron, the fourth most abundant element in the Earth's crust, is most often extracted from the minerals hematite and magnetite. Iron is the main component in stainless steel and is a trace element essential for growth and development of the human body. The body gets iron from food, using it to help metabolize proteins and to make hemoglobin, which carries oxygen from the lungs to the rest of the body. Iron-poor blood is a common nutritional deficiency that can cause anemia; iron supplements combat this, as do some breakfast cereals containing powdered metallic iron. Ferric chloride, injected into the body, works as a contrast agent with an MRI machine to improve gastrointestinal tract images.



NICKEL (Ni) *Atomic Number: 28*
Philippines, **CANADA**/Russia (tied), Australia, New Caledonia, Indonesia

Nickel, derived from garnierite, pentlandite, and other minerals, is used primarily to make stainless steel, contributing corrosion resistance, formability, high temperature strength, weldability, and toughness. Nickel-containing stainless steels can be sterilized using harsh disinfecting chemicals without degradation of the material, and they can be produced with no ferromagnetism, making them compatible with MRI and X-ray machines. Shape memory alloys (metals that remember their original shape) of nickel-titanium are used for orthodontic wires and spectacle frames.

LEGEND

Alkali metals | **Alkaline earth metals** | **Actinides** | **Transition metals** | **Other metals** | **Non-metals**
Asterisk (*) denotes that **CANADA** produces, but is not one of the top five producing countries.



COPPER (Cu) *Atomic Number: 29*
Chile, China, Peru, U.S., Congo, **CANADA***

Copper, the oldest metal known to humankind, can be found in native element form, but is generally derived from copper ores, including the minerals chalcopyrite and chalcocite. With high ductility, malleability, thermal and electrical conductivity, and corrosion resistance, copper is a major industrial metal, used extensively for power transmission and telecommunications, both essential to medical facilities and devices. In MRI superconductor magnets, niobium-titanium or niobium-tin filaments are embedded in copper. Antimicrobial copper surfaces effectively kill infectious microbes in healthcare facilities and intensive care units.



ZINC (Zn) *Atomic Number: 30*
China, Australia, Peru, U.S., India, **CANADA***

Zinc, from minerals such as sphalerite and smithsonite, is the fourth most commonly used metal and the second most common trace metal in the human body. As an important micronutrient, it helps generate cells, activate bone and organ development, enable brain functions, and strengthen the immune system. Zinc deficiency, correctable by supplements, can cause stunted growth, impeded intellectual development, and vulnerability to diarrhea. Zinc oxide in sunscreens absorbs UV light; in baby creams and wound care ointments, it helps regenerate the skin.



NIOBIUM (Nb) *Atomic Number: 41*
Brazil, **CANADA**

Niobium is derived from the minerals pyrochlore and columbite. It is a lustrous, grey, ductile metal with a high melting point, relatively low density, and superconductor properties. Magnetic resonance imaging (MRI) and nuclear magnetic resonance (NMR) machines use superconductor magnets made from niobium-titanium alloy embedded in copper. Titanium-niobium alloys, having good biocompatibility, are used for orthopaedic implants.



MOLYBDENUM (Mo) *Atomic Number: 42*
China, U.S., Chile, Peru, Mexico, **CANADA***

Molybdenum, from the mineral molybdenite, contributes corrosion resistance and hardness to stainless steel, making it excellent for sharp cutting edges, like scalpel blades. Molybdenum components are also found in the high-power X-ray tubes of computerized axial tomography (CAT or CT) scanners used to take images of bones, internal organs, blood vessels, and other soft tissue to detect a variety of diseases and conditions. As a trace mineral obtained mostly from food, molybdenum works in the human body to protect cells, create energy, and help organs eliminate waste products.



TUNGSTEN (W) *Atomic Number: 74*
China, Vietnam, Russia, **CANADA**, Bolivia

Tungsten, derived from the minerals scheelite and wolframite, has the highest melting point and lowest vapour pressure of all metals and has high corrosion resistance. In an electron microscope, a tungsten filament is used for the cathode, and in X-ray tubes, tungsten can work as both the cathode and anode. Tungsten alloy provides radiation shielding in nuclear medicine.



PLATINUM (Pt) *Atomic Number: 78*
South Africa, Russia, Zimbabwe, **CANADA**, U.S.

Platinum, produced primarily as a by-product of nickel and copper mining, is one of the rarer elements in the Earth's crust. The least reactive of all metals, it is also one of the densest, has high corrosion resistance, and is easily worked. It has a variety of medical applications, such as dental work, cochlear implants, heart pacemakers, medical implants, and catheters used for minimally invasive heart surgery. Platinum chemotherapy agents, the most commonly used being cisplatin, are used to treat testicular, ovarian, bladder, lung, and other cancers.



GOLD (Au) *Atomic Number: 79*
China, Australia, Russia, U.S., **CANADA**

Gold is widely distributed in the Earth's crust in low concentrations; it is mined directly and also recovered as a by-product, primarily of copper mining. The most malleable metal known, it conducts heat and electricity and will not tarnish, rust, or corrode. Used in dentistry for more than 4,000 years, gold's biocompatibility now proves useful in diagnosing and combating disease. Complexes of gold treat arthritic disorders. Gold nanoparticles help diagnose malaria and treat cancer, and they show promise in detecting HIV/Aids and prostate cancer.



TIN (Sn) *Atomic Number: 50*
China, Indonesia, Burma, Peru, Bolivia

Tin, a silvery-white metal derived from the mineral cassiterite, is corrosion resistant, malleable, and somewhat ductile. MRI superconductor magnets use niobium-tin alloy embedded in copper. Stannous (tin) fluoride in toothpaste makes tooth enamel more resistant to decay.



LEAD (Pb) *Atomic Number: 82*
China, Australia, U.S., Peru, Mexico

Lead, a metal found in the mineral galena, is heavy and has high molecular density. This density works to provide radiation shielding in applications such as X-ray imaging and positron emission tomography (PET) scans, which involve a radiopharmaceutical. Shielding, which ensures protection and safety for patients and technicians, can range from lead aprons and storage containers to exam rooms and laboratories constructed with lead bricks, leaded glass, and lead-lined walls, doors, and doorframes.



BISMUTH (Bi) *Atomic Number: 83*
China, Vietnam, Mexico, Russia, Bolivia, **CANADA***

Bismuth is primarily produced as a by-product, mostly from processing lead ores; some comes from tungsten ores. Bismuth is found in pharmaceuticals, including bismuth salicylate, commonly used for stomach upset and diarrhea, bismuth-containing salves for wound infections, and bismuth compounds that treat peptic ulcers and other diseases of the gastrointestinal tract.



SULPHUR (S) *Atomic Number: 16*
China, U.S., Russia, **CANADA**, Germany

Sulphur is a yellow, brittle, non-metallic element, primarily obtained by removing sulphur-containing contaminants from natural gas and petroleum using a process called hydrogenation. Sulphur is an essential plant nutrient; added to soil, it improves crop production. Synthetic sulphur is used to treat arthritis, skin diseases such as psoriasis and eczema, and interstitial cystitis, a chronic bladder inflammation. The alternative treatment balneotherapy, involving soaking in natural hot springs, which typically contain significant sulphate levels, has long been recommended for its healing properties.



SELENIUM (Se) *Atomic Number: 34*
Japan, Germany, Belgium, **CANADA**, Russia

Selenium, primarily a by-product of copper refining, typically from chalcopyrite, also occurs in sulphide minerals containing pentlandite, mined for nickel, and galena, mined for lead. It is a trace element nutrient in the human body, essential for proper immune system function, thyroid gland function, and cell usage of thyroid hormone. Food usually supplies enough for daily human needs; however, studies show that supplements help prevent diseases of the heart and blood vessels and some cancers, including cancer of the prostate, stomach, lung, and skin.



BASTNÄSITE



MONAZITE

RARE EARTH ELEMENTS

China, Australia, U.S., Russia, Thailand

Fifteen lanthanide elements and the metals yttrium and scandium make up the group of **Rare Earth Elements (REEs)**. REEs are generally found together in deposits and are abundant in the Earth's crust; however, they do not occur in large concentrations, so are difficult to mine. The world's most abundant REE source is **bastnäsite**, followed by **monazite**. REEs are usually high-lustre silver, silvery-white, or grey metals.

YTTRIUM (Y) *Atomic Number: 39*

Yttrium gives a sharp edge to specialty scalpels and needles. Yttrium-stabilized ceramics are used in artificial joints and other prosthetics. Yttrium-90, a radioactive isotope, treats various cancers and is being explored as treatment of inflamed joints in conditions such as rheumatoid arthritis.

LANTHANUM (La) *Atomic Number: 57*

Lanthanum, in the form of lanthanum carbonate, rids the body of excess phosphate in the treatment of hyperphosphatemia (excess phosphate in the blood) and renal failure.

SAMARIUM (Sm) *Atomic Number: 62*

Samarium, in the form of isotope samarium-153, is a radiopharmaceutical used to alleviate pain from cancer that has spread to bone.

GADOLINIUM (Gd) *Atomic Number: 64*

Gadolinium has paramagnetic properties that work in compounds injected into the body to enhance contrast when using MRI machines.

HOLMIUM (Ho) *Atomic Number: 67*

Holmium is found in solid-state lasers used in medical applications such as tissue ablation, kidney stone removal, and prostate surgery.

THULIUM (Tm) *Atomic Number: 69*

Thulium is used as a radiation source in portable X-ray devices and for cancer treatment via brachytherapy (implanted radioactive seeds).