MUSIC FROM THE EARTH

From the earliest drum beat to modern arrangements, music reflects human culture and history. From the beginning, metals and minerals from the Earth have helped create music.

Mining Makes It Happen!

PERCUSSION

Percussion instruments produce sound when struck, scraped, or rubbed by hand or a beater, or when shaken. They provide rhythm, as well as melody and harmony.

TRACK NO.1 Drums

Going back to 6000 BCE, drums have been used to communicate; celebrate culture; accompany ceremonies; and prepare for battle.

India's tabla and tasha drums, originally clay or terracotta, might now include brass, steel, aluminum, nickel-plated brass, or copper. African drums include the clay or metal doumbek and the clay water-jug style udu. Trinidad and Tobago's national instrument, the steel pan, evolved from biscuit tins to tuned gongs made from steel oil drums.

The voice of the Creator to Canada's Indigenous peoples, the drum comprised wood and animal hide, while American Indian tribes used clay and metal pots.

Drum kits feature in orchestral, rock, and jazz music. Shells might be constructed of wood or metal, including steel, brass, bronze, aluminum, copper, and titanium.

TRACK NO.2 Gongs and Bells

Originating in Asia, a gong is a suspended bronze disc that is struck with a mallet. Ancient uses included healing, communication, and calls to meditation and ceremonies. Gongs are now used in orchestras worldwide.

Zhong, or Chinese bells, first made of clay, then bronze, were originally hand struck with a mallet. Suspended bells later evolved. The glockenspiel, originally graduated bells, became tuned steel bars struck with hammers. Handbells, usually brass or bronze, come in tuned sets ranging from 25 to 97 bells.

The carillon, first built around 1500, features at least 23 tuned bronze bells in a tower, played from a keyboard. Canada's Peace Tower, in Ottawa, features a 53-bell carillon. Installed in 1927, it is played daily.

TRACK NO.3 Cymbals

Originating in Central Asia, cymbals are thin, plate-shaped brass or bronze discs. Long used in religious rituals and to accompany dancers, different cymbals have different sound, depending on the copper to tin or zinc ratio. Orchestral crash cymbals contain more tin than rock music cymbals. Brass finger cymbals have a variety of tones.

AEROPHONES

Aerophones are instruments in which air is the primary vibrating medium used to produce sound.

TRACK NO.4 Brass

Brass instruments, or horns, include the bugle, trumpet, trombone, French horn, and tuba. Made of brass, or sometimes silver, they are played by pressing the lips to a mouthpiece and blowing, creating a vibration. Valves or slides produce different pitches.

TRACK NO.5 Woodwinds

Woodwind instruments, originally wood, now use brass and silver. Narrow cylinders with holes, they are played by blowing across an edge or reed mouthpiece. Opening and closing the holes changes the pitch. Woodwinds include the piccolo, flute, oboe, English horn, clarinet, bassoon, and contrabassoon.

Among North American Indigenous peoples, flutes and whistles were melodic instruments made from reeds, clay, wood, or bone.

CHORDOPHONES

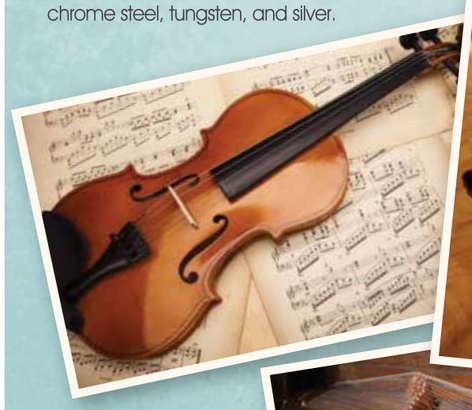
Chordophones produce sound through the vibration of chords, or strings, tightly stretched over a soundboard. Vibration occurs with bowing, plucking, striking, strumming, or blowing the strings. String position classifies an instrument as a lute, zither, harp, or lyre.

TRACK NO.6 Lutes

Lutes feature strings stretched along a neck and over an enclosed sound chamber, or resonator.

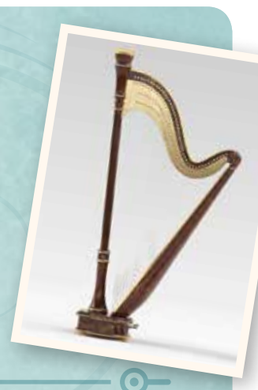
The acoustic guitar, of Spanish origin, has bronze-wound steel core strings and metal strips along the neck. Electric guitars appeared in the 1930s, using steel strings that work with magnetic pickups (magnets wrapped with fine wire). Today's strings are steel core, usually wound with nickel, nickel-plated steel, or stainless steel.

The violin family—including the violin, viola, cello, and bass—use a variety of strings comprising a metal, gut, or synthetic core wrapped with metals such as aluminum, chrome steel, tungsten, and silver.

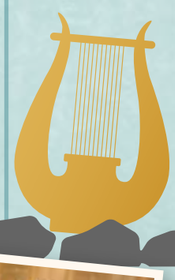


TRACK NO.7 Harps

A plucked instrument, the harp has strings strung perpendicular from a soundboard to a neck. Today's triangular frame harp originated in medieval Europe, when an added pillar supported the tension of more and stiffer strings made of copper and brass. Modern strings could include bronze, steel, nylon, and silver.



TRACK NO.8 Lyres



Lyres comprise a resonator from which two arms protrude, joined by a crossbar, and strings stretched from a tailpiece to the crossbar. A strummed instrument, it was important in ancient Babylonia, Egypt, and Greece, and is still played widely in east Africa. Today's lyres feature nylon or steel strings.

TRACK NO.9 Zithers

Zithers are stringed instruments that can be plucked or struck. Dulcimers are struck zithers. The zheng, a plucked zither, is one of China's oldest instruments and the forerunner of the Japanese koto, Korean kayagum, Mongolian yatag, and Vietnamese dan tranh.

The piano is a "keyed zither." Both a percussion and string instrument, with 220 to 250 copper-wound strings, a piano produces sound through keys that cause felt-covered hammers to strike the strings. A cast iron frame provides the strength to anchor the strings under tension.

SIDE A OF ALBUM

MUSIC AND ELECTRONICS

Once only experienced through live performance, music has become widely available via electronic technology, through devices that have ranged from the phonograph to today's digital files.

TRACK NO.10 Phonograph

The phonograph, invented in 1877 by Thomas Edison, played tin foil wrapped cylinders, then wax cylinders. Ten years later, Emile Berliner patented the gramophone, which played flat disks, or records, first made from zinc, followed by hard rubber, then a shellac compound. Vinyl records, introduced in the 1940s, remain much the same today. The gramophone stylus, once steel, now a diamond or corundum cone-shaped needle, rides a record's grooves, picking up the vibrations to be reconverted to sound.

TRACK NO.11 Amplifier

In 1906, Lee de Forest invented the Audion, a triode vacuum tube that amplified electrical signals. It revolutionized electrical technologies, contributing to telephone, television, movie, and radio innovations. The tube includes a glass casing made from quartz sand; a wire filament cathode made from tungsten or nickel coated with barium and strontium carbonates; and a grid made from platinum, nickel, or molybdenum. Over the 1960s and 1970s, transistors replaced tube amplifiers; transistors include semiconductor materials such as germanium and silicon.

TRACK NO.12 Loudspeaker

Vacuum tube amplifiers enabled the invention of the first electrodynamic speaker. The speaker is a transducer, converting electrical energy into acoustic energy. An electromagnet causes vibrations in a wire coil, which then propagate through a diaphragm and disrupt the surrounding air, producing sound waves. Iron, steel, aluminum, and magnesium can be used for a loudspeaker frame. Aluminum, titanium, or beryllium make up the diaphragm. Copper is used for the wire coil, while neodymium, strontium, or cobalt go into permanent magnets, also used in headphones to generate sound from a small enclosure.

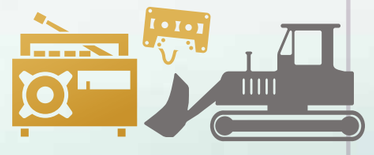
TRACK NO.13 Radio

Radio technology began with the discovery of electromagnetic, or "radio," waves that can transmit sound, pictures, and other data. Guglielmo Marconi transmitted the first radio signal in 1895, and in 1900, Canadian inventor Reginald A. Fessenden successfully sent the first audio radio transmission. A radio comprises an antenna, a diode, a tuning coil, amplifiers, and speakers. An internal antenna has copper wire wound around a ferrite core. An external antenna has telescoping aluminum tubes. Early radios used lead crystal or vacuum tube diodes. Modern radio diodes typically use silicon or selenium.

TRACK NO.14 Cassette Player

In 1928, Fritz Pfleumer made recording on tape possible by adhering iron oxide powder to cellulose film, creating magnetic tape. 1958 brought in large cartridge-encased tapes that could be inserted into a tape player, replaced by smaller cassettes in 1963. Pre-recorded music cassettes came next, and in 1971, tapes made with chromium dioxide launched high fidelity cassettes and players. In 1979, the cassette-based Sony Walkman®, made possible by light, efficient samarium-cobalt magnets, became the first self-contained portable music system.

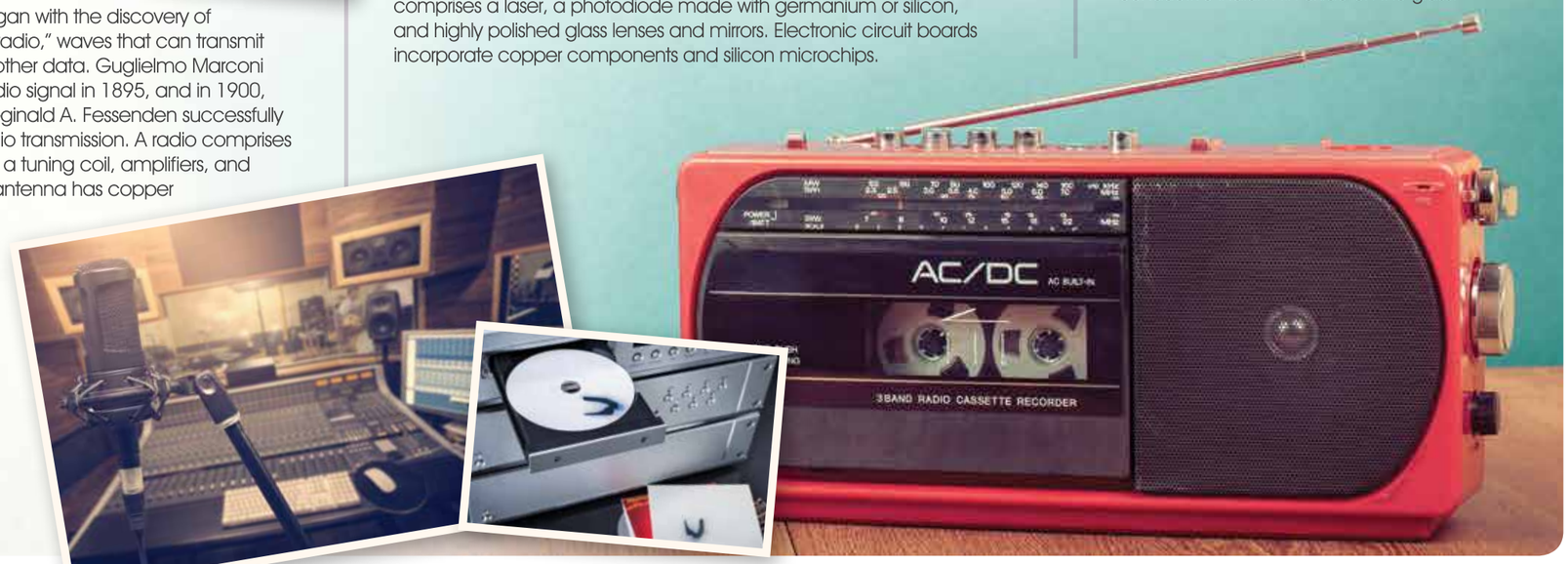
TRACK NO.15 CD Player



In 1982, compact discs (CDs) and CD players came on the market. CDs, made of polycarbonate plastic coated with reflective aluminum and protective acrylic, store digital data on the surface. A CD player rotates the CD on a turntable, reading data with an optical pick-up assembly and reproducing the content. The optical pick-up assembly comprises a laser, a photodiode made with germanium or silicon, and highly polished glass lenses and mirrors. Electronic circuit boards incorporate copper components and silicon microchips.

TRACK NO.16 MP3

The MP3 player, offering compressed digital music files, came out in 1998. MP3 players and cellphones were first combined around 2003. Portable electronics often use rechargeable lithium-ion batteries, which have electrodes made with cobalt. Electronic circuit boards incorporate copper components and silicon microchips. High-powered permanent magnets made with rare earth elements neodymium, praseodymium, and dysprosium, along with iron and boron, make speakers vibrate to create sound. Thin sheets of clear synthetic corundum protect electronic device screens, and those with touchscreens have a layer of electrically conductive indium tin oxide on the glass.



NATURAL RESOURCE RECORDS
BILLBOARD CHARTS

TOP HITS

Alkali metals | Alkaline earth metals | Transition metals | Basic metals | Metalloids | Non-metals

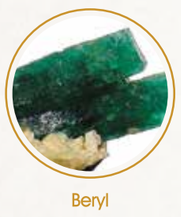
CANADA* denotes that CANADA produces, but is not one of the top five producing countries.

CANADA denotes Canadian resource potential or in development stages.

Lepidolite

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

Extracted from the minerals spodumene and lepidolite, lithium is a highly reactive element that efficiently conducts heat and electricity. It acts as a superconductor at different temperatures and pressures. Lithium is used in rechargeable lithium-ion batteries that power portable electronics.



Beryl

Beryllium (Be) *Atomic Number 4*
U.S., China, Madagascar, Nigeria, Brazil

Beryllium occurs in many minerals, the two principal ores being beryl and bertrandite. Its properties include a high stiffness-to-mass ratio, resistance to temperature extremes, and high thermal conductivity. It conducts sound unusually quickly, which combined with its stiffness and low density, makes it an excellent material for loudspeaker diaphragms.

Magnesite

Magnesium (Mg) *Atomic Number 12*
China, Russia, Israel, Brazil, Turkey, *CANADA*

Magnesium, a shiny grey solid, occurs in large deposits in minerals such as magnesite, dolomite, and serpentine, and is also extracted from seawater and natural brines. Less dense than aluminum, magnesium alloyed with other metals makes strong, lightweight materials used for loudspeaker frames, cellphones, laptop and tablet computers, and cameras.

Strontianite

Strontium (Sr) *Atomic Number 38*
Spain, Mexico, China, Argentina

Strontium, found in the minerals celestine and strontianite, is a soft, yellow-tinged silver-white metal that burns in air and reacts with water. Strontium is used in alloys; strontium ferrite permanent magnets are used in loudspeakers and recording media. In an amplifier's triode vacuum tube, strontium carbonates coat a cathode's wire filaments.

Barite

Barium (Ba) *Atomic Number 56*
China, India, Morocco, Iran, Kazakhstan, CANADA*

Barium is a soft, silvery metal derived primarily from the mineral barite. It is a highly reactive metal that oxidizes quickly in air, creating barium carbonate and barium peroxide. Barium carbonate is used to coat cathode wire filaments in the triode vacuum tubes found in amplifiers. In the metal-casting industry, barite is part of the mold-release compounds.

Rutile

Titanium (Ti) *Atomic Number 22*
South Africa, Australia, China, Mozambique, CANADA

Titanium, a hard, silver-coloured metal, occurs in several minerals, including ilmenite, leucoxene, and rutile. With high strength and low density, it is used in pure form and as an important alloying agent with many metals. Titanium is commonly used in a loudspeaker's tweeter diaphragm, which delivers high-frequency sounds, and titanium foil goes into headphones.

Chromite

Chromium (Cr) *Atomic Number 24*
South Africa, Kazakhstan, India, Turkey, *CANADA*

Chromium, a lustrous, hard, steel-grey metal, occurs primarily in the mineral chromite. It is tarnish resistant and takes a high polish. Chromium added to steel makes stainless steel highly resistant to corrosion and discolouration. Chromium plating gives a hard, polished finish to steel. Audiotapes made with chromium dioxide were the first high fidelity cassettes.

Hematite

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

Iron, extracted from the minerals hematite and magnetite, is one of the most abundant elements on Earth. Nearly all mined iron is used to manufacture steel. Iron oxide powder on cellulose film made up the first magnetic tapes for recording. High-powered permanent magnets used in electronics are made with iron. Some pianos have a cast iron frame to anchor the strings.

Pentlandite

Cobalt (Co) *Atomic Number 27*
DR Congo, Russia, Australia, CANADA, Cuba

Cobalt, permanently magnetic, is produced primarily as a by-product of nickel and copper mining. It is used to produce magnetic, wear-resistant, and high-strength alloys. Samarium-cobalt magnets are used in small motors, headphones, and high-end magnetic pickups for guitars and related musical instruments. Cobalt goes into the electrodes of rechargeable lithium-ion batteries, used to power portable electronics.

Garnierite

Nickel (Ni) *Atomic Number 28*
Indonesia, Philippines, CANADA, Australia
New Caledonia

Nickel, a hard and ductile metal, occurs in laterites, such as garnierite, and in metallic ores, such as pentlandite. It is ferromagnetic at low temperatures. Nickel is used as a refined metal, in stainless steel, superalloy production, and in batteries. Some bronze alloys, common in percussion instruments, contain nickel. Instrument parts can be nickel alloy or nickel plated.

Chalcopyrite

Copper (Cu) *Atomic Number 29*
Chile, Peru, U.S., China, Australia, CANADA*

Copper, the oldest known metal, occurs in elemental form but is most often extracted from ores like chalcopyrite and chalcocite. It is resistant to corrosion, highly ductile, malleable, and thermally and electrically conductive. Brass and bronze, with high copper content, are used for multiple instruments such as horns, cymbals, gongs, bells, and windings on strings. Copper goes into circuit boards and wire coils in various music electronics.

Smithsonite

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

Zinc, from the minerals sphalerite and smithsonite, is a grey, lustrous metal that is hard and brittle. The main industrial uses of zinc include galvanized coatings that protect iron and steel from corrosion and as an alloying metal to make brass and some bronze, both used extensively in musical instruments.

Molybdenite

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

Molybdenum, from the mineral molybdenite, is a silver-grey metal used principally as an alloying agent in steel, enhancing hardness, strength, toughness, and wear and corrosion resistance. Some triode vacuum tubes in amplifiers incorporate a plate and wire grid made from molybdenum. Molybdenum is also used in electronics for electrodes and inks for circuit boards.

Argentite

Silver (Ag) *Atomic Number 47*
Mexico, Peru, China, Russia, Poland, CANADA*

Silver, a soft, white metal, occurs in free elemental form, as an alloy with gold and other metals, and in minerals such as argentite, chlorargyrite, and galena. Most silver is produced as a by-product of copper, gold, lead, and zinc refining. Silver exhibits the highest electrical and thermal conductivity and highest optical reflectivity of any metal. Some stringed instruments have silver-wrapped strings and some horns and woodwinds are made of silver. Silver paints are used for making printed circuits.

Scheelite

Tungsten (W) *Atomic Number 74*
China, Vietnam, Russia, Bolivia, United Kingdom, *CANADA*

Tungsten, mostly from the minerals wolframite and scheelite, has high corrosion resistance and the highest melting point of all metals. It is brittle and hard to work, unless in pure form. Applications of tungsten include metal wires, electrodes, and contacts in electronics and lighting. Tungsten goes into the wire filament cathode in a triode vacuum tube, and some stringed instruments have tungsten-wrapped strings.

Platinum

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

Platinum, a silver-white metal, occurs in alluvial deposits and is also produced as a by-product of copper and nickel refining. It is malleable, ductile, and highly unreactive. It has a high melting point and exceptional catalytic properties. Platinum is used in triode vacuum tubes and in many electronic applications, such cellphones, MP3 players, video recorders, and computer hard disks.

Bauxite

Aluminum (Al) *Atomic Number 13*
Australia, China, Guinea, Brazil, India

Aluminum, extracted primarily from the rock bauxite, is lightweight, easily shaped, easily machined and cast, and has tremendous corrosion resistance and durability. Its uses related to music production are varied, from snare drum shells, lightweight cases for microphones and MP3 players, and CD reflective surfacing, to bronze alloys, loudspeaker diaphragms, and wrapping for strings.

Sphalerite

Indium (In) *Atomic Number 49*
China, Republic of Korea, Japan, CANADA, Belgium/France

Indium, most commonly recovered as a by-product of zinc ore processing, occurs in the mineral sphalerite. Malleable and ductile, with a low melting point, it acts as a superconductor below a certain temperature. It is used in semiconductors, alloys, solders, and soft-metal high-vacuum seals. A layer of indium tin oxide works as a transparent electrical conductor on MP3 and cellphone touchscreens.

Cassiterite

Tin (Sn) *Atomic Number 50*
China, Indonesia, Burma, Brazil, Bolivia, CANADA*

Tin, a silvery-white metal derived from the mineral cassiterite, is soft, malleable, ductile, and highly crystalline. Alloys of tin are used for soft solder, pewter, and bronze. Bell bronze, used for cymbals, gongs, and bells, has high tin content. A layer of indium tin oxide works as a transparent electrical conductor on MP3 and cellphone touchscreens. A niobium-tin alloy is used for superconducting magnets.

Quartz

Silicon (Si) *Atomic Number 14*
China, Russia, U.S., Norway, France, CANADA*

Silica (silicon dioxide) in various natural forms, including quartzite, is used to produce silicon ferroalloys and silicon metal. Silicon is a semiconductor and a metalloid, a chemical element with properties between those of typical metals and non-metals. Elemental silicon is used in manufacturing, including steel refining and aluminum-casting, and in semiconductor electronics. A CD player optical pick-up assembly includes a photodiode made with silicon, and electronic circuit boards incorporate silicon microchips.

Germanite

Germanium (Ge) *Atomic Number 32*
China, Russia, CANADA, Belgium

Germanium is a lustrous, hard, greyish-white metalloid, a chemical element with properties between those of typical metals and non-metals. Germanium is primarily produced as a by-product from zinc ore but also occurs in the minerals germanite and argyrodite, and in silver, lead, and copper ores. The most common use of germanium is as a semiconductor. The germanium transistor led to the development of many solid-state electronics.

Diamond

Carbon (C) *Atomic Number 6*
Russia, Botswana, D.R. Congo, Australia, CANADA

Diamond, a crystallized form of carbon, is the hardest natural substance. It has extremely high thermal conductivity and low thermal expansion. Found in the rock kimberlite, diamonds have many industrial applications, including drilling, cutting, and polishing. Diamond needles are used in record players and diamond is used as a heat sink for integrated circuits in electronics because of its high thermal conductivity.

Sapphire

Corundum (Al_2O_3)
India, Myanmar, Russia, Zimbabwe, South Africa

The third-hardest mineral, after diamond and moissanite, corundum occurs naturally in igneous rocks such as syenite, nepheline syenite, and pegmatite, and can be synthesized. Typically grey to brown, corundum occurs in other colours; chromium turns it red (ruby), and iron and titanium produce blue (sapphire). Record players often use a corundum stylus. Clear synthetic corundum protects electronic device screens and goes into lasers, used to play CDs and DVDs.

SIDE B OF ALBUM

RARE EARTH ELEMENTS

Bastnäsite

Monazite

China, Australia, Russia, Brazil, Thailand, *CANADA*

Fifteen lanthanide elements, along with yttrium and scandium, make up the group of rare earth elements (REEs). Generally found together in deposits, REEs are abundant in the Earth's crust but not in large concentrations, so they 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.

Praseodymium, **Neodymium** and **Samarium** are examples of REEs. Many REEs are used to produce strong and permanent magnets that are used in electronic applications such as headphones, microphones, speakers, and high end pickups for guitars and related musical instruments. REE's are also used in lasers.

ALLOYS

Brass, an alloy of copper and zinc, has a relatively low melting point and is easily cast. Different ratios of copper to zinc result in brasses with differing hardness, along with different acoustic, mechanical, and electrical properties. Because of its workability, durability, and acoustic properties, brass is used for horns and some woodwinds and their components. Brass also goes into percussion instruments such as cymbals, gongs, and bells.

Bronze, an alloy of copper and tin, often includes other metals such as aluminum, manganese, nickel, or zinc, or non-metals or metalloids like arsenic and phosphorus, to produce alloys with differing hardness, stiffness, ductility, or machinability. Bell bronze, with high tin content, is the traditional alloy for fine cymbals, many gongs, and bells. Phosphor bronze is used to wrap steel and nylon strings on stringed instruments and to make some saxophones.

Steel is one of the most common materials used today. An alloy of iron and carbon, it often includes other elements such as manganese, niobium, or vanadium to give it strength and hardness. Adding nickel and chromium creates stainless steel, a corrosion-resistant alloy. Steel serves in multiple ways to make music: it goes into drum and loudspeaker frames, steel pan drums, triangles, glockenspiel steel-tuned bars, steel guitars, and wires for a variety of stringed instruments.

PHOTO CREDITS

Metal/Mineral Photos Courtesy of the Following: *R.Weller/Cochise College:* Argentite, Barite, Bauxite, Beryl, Chalcopyrite, Chromite, Diamond, Garnierite, Hematite, Lepidolite, Magnesite, Molybdenite, Pendlandite, Platinum, Quartz, Rutile, Sapphire, Scheelite, Smithsonite, Sphalerite, Strontianite *Rob Lavinsky/www.iRocks.com/Arkenstone:* Bastnäsite, Cassiterite, Monazite *Maggie Wilson:* Germanite

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