

PERIODIC TABLE OF THE ELEMENTS

18 VIIIA

1	2	13	14	15	16	17	18											
1 1.0079 H HYDROGEN	2 4.0026 He HELIUM	3 6.941 Li LITHIUM	4 9.0122 Be BERYLLIUM	5 10.81 B BORON	6 12.011 C CARBON	7 14.007 N NITROGEN	8 15.999 O OXYGEN	9 18.998 F FLUORINE	10 20.180 Ne NEON	11 22.989 Na SODIUM	12 24.305 Mg MAGNESIUM	13 26.982 Al ALUMINIUM	14 28.086 Si SILICON	15 30.974 P PHOSPHORUS	16 32.065 S SULPHUR	17 35.453 Cl CHLORINE	18 39.948 Ar ARGON	
3 39.098 K POTASSIUM	4 39.098 Ca CALCIUM	5 44.956 Sc SCANDIUM	6 47.867 Ti TITANIUM	7 50.942 V VANADIUM	8 54.938 Cr CHROMIUM	9 55.845 Mn MANGANESE	10 58.933 Fe IRON	11 58.933 Co COBALT	12 58.933 Ni NICKEL	13 63.546 Cu COPPER	14 65.39 Zn ZINC	15 69.723 Ga GALLIUM	16 72.64 Ge GERMANIUM	17 74.922 As ARSENIC	18 78.96 Se SELENIUM	19 79.904 Br BROMINE	20 83.80 Kr KRYPTON	
5 85.468 Rb RUBIDIUM	6 87.62 Sr STRONTIUM	7 88.906 Y YTTRIUM	8 91.224 Zr ZIRCONIUM	9 92.906 Nb NIOBIUM	10 95.94 Mo MOLYBDENUM	11 98 Tc TECHNETIUM	12 101.07 Ru RUTHENIUM	13 102.91 Rh RHODIUM	14 106.42 Pd PALLADIUM	15 107.87 Ag SILVER	16 112.41 Cd CADMIUM	17 114.82 In INDIUM	18 118.71 Sn TIN	19 121.76 Sb ANTIMONY	20 127.60 Te TELLURIUM	21 126.90 I IODINE	22 131.29 Xe XENON	
6 132.91 Cs CAESIUM	7 137.33 Ba BARIUM	8 140.12 La-Lu Lanthanide	9 173.07 Hf HAFNIUM	10 178.49 Ta TANTALUM	11 183.84 W TUNGSTEN	12 186.21 Re RHENIUM	13 187 Os OSMIUM	14 192.22 Ir IRIDIUM	15 195.08 Pt PLATINUM	16 196.97 Au GOLD	17 200.59 Hg MERCURY	18 204.38 Tl THALLIUM	19 208.98 Pb LEAD	20 209 Bi BISMUTH	21 210 Po POLONIUM	22 210 At ASTATINE	23 222 Rn RADON	
7 223 Fr FRANCIUM	8 226 Ra RADIUM	9 227 Ac-Lr Actinide	10 261 Rf RUTHERFORDIUM	11 262 Db DUBNIUM	12 266 Sg SEABORGIUM	13 277 Bh BOHRIUM	14 288 Hs HASSIUM	15 288 Mt MEITNERIUM	16 289 Uu UNUNUNIUM	17 289 Uub UNUNBIUM	18 289 Uuq UNUNQUADIUM	19 289 Uuq UNUNQUADIUM	20 289 Uuq UNUNQUADIUM	21 289 Uuq UNUNQUADIUM	22 289 Uuq UNUNQUADIUM	23 289 Uuq UNUNQUADIUM	24 289 Uuq UNUNQUADIUM	25 289 Uuq UNUNQUADIUM

GROUP IUPAC: IIIA, IVA, VA, VIA, VIIA, VIIIA

RELATIVE ATOMIC MASS (1): 10.81

GROUP CAS: IIIA

ATOMIC NUMBER: 5

SYMBOL: B

ELEMENT NAME: BORON

Legend for element classification:

- Metal
- Semimetal
- Nonmetal
- Alkali metal
- Alkaline earth metal
- Transition metals
- Lanthanide
- Actinide
- Chalcogens element
- Halogens element
- Noble gas

STANDARD STATE (100 °C; 101 kPa):

- Ne - gas
- Ga - liquid
- Fe - solid
- Tc - synthetic

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LANTHANIDE

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
138.91 La LANTHANUM	140.12 Ce CERIUM	140.91 Pr PRASEODYMIUM	144.24 Nd NEODYMIUM	144.24 Pm PROMETHIUM	150.36 Sm SAMARIUM	151.96 Eu EUROPIUM	157.25 Gd GADOLINIUM	158.93 Tb TERBIUM	162.50 Dy DYSPROSIUM	164.93 Ho HOLMIUM	167.26 Er ERBIUM	168.93 Tm THULIUM	173.04 Yb YTTERIUM	174.97 Lu LUTETIUM

ACTINIDE

89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
227 Ac ACTINIUM	232.04 Th THORIUM	231.04 Pa PROTACTINIUM	238.03 U URANIUM	237 Np NEPTUNIUM	244 Pu PLUTONIUM	243 Am AMERICIUM	247 Cm CURIUM	247 Bk BERKELIUM	251 Cf CALIFORNIUM	252 Es EINSTEINIUM	257 Fm FERMIUM	258 Md MENDELEVIUM	259 No NOBELIUM	262 Lr LAWRENCIUM

(1) Pure Appl. Chem., 73, No. 4, 667-683 (2001)
Relative atomic mass is shown with five significant figures. For elements with no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.
However three such elements (Th, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

HEAVY METALS: METALLURGY PRIMER

Teri Junge, CST/CFA

AS ROBOTICS BECOME INCREAS- TECHNOLOGIST. THIS ARTICLE
INGLY PREVALENT IN SURGERY, PROVIDES BASIC COMPOSITION
THE SURGICAL TECHNOLOGIST AND PERFORMANCE INFORMA-
WILL COME IN CONTACT WITH TION ABOUT SOME OF THE MORE
MORE AND VARIED TYPES OF SUR- COMMONLY USED TYPES OF FER-
FACES. MANY OF THE PROPERTIES ROUS METALS AND THEIR ALLOYS,
OF THE METALS THAT ARE COM- AS WELL AS A GLOSSARY CON-
MONLY USED IN THE OPERATING TAINING RELATED TERMS AND
ROOM AND THE RELATED TERMI- THEIR DEFINITIONS.
NOLOGY ARE OFTEN LITTLE
UNDERSTOOD BY THE SURGICAL

Properties of metals

Metallic elements are located on the left side of the periodic table (Table 1) and are separated from the nonmetals by a diagonal line of elements that exhibit both metallic and nonmetallic qualities. The elements creating the separation are boron (B, 5), silicon (Si, 14), germanium (Ge, 32), arsenic (As, 33), antimony (Sb, 51), tellurium (Te, 52), polonium (Po, 84), and astatine (At, 85).

Although there is great variation from one metal to the next, most metals are strong and resistant to various stresses. Metals are rated according to their ductility, elasticity, fatigue resistance, hardness, inertness, malleability, tensile strength, and resistance to abrasion and corrosion.

Very few metals, such as gold (Au, 79) and platinum (Pt, 78), are found in their pure state; the rest must be refined prior to use.

Most metals are cationic, meaning that they are positively charged, and are capable of donating electrons. Most nonmetallic elements are anionic, meaning that they are negatively charged, and are capable of accepting electrons. The exchange of positive and negative electrons sets up the potential for chemical reactions to occur that are capable of changing the properties of the element.

Corrosion

Corrosion is a complex chemical or electrochemical reaction that occurs when a metal is exposed to another element capable of causing oxidation. Corrosion of medical devices occurs from exposure to dissimilar metals (electrolytic reaction), the atmosphere, body fluids, irrigation fluid, and the presence of foreign bodies. Fretting corrosion occurs when abrasive wear is accompanied by corrosion. Formation of rust on iron is probably the best-known example of corrosion. Three methods are used to prevent corrosion of metallic devices.

1. An alloy is used that is resistant to corrosion.
2. A coating, such as nitric acid, is used to form a protective oxide on the surface.
3. An impermeable coating is applied to prevent oxidation.

Electrolytic reaction

An electrolytic reaction, sometimes referred to as the battery effect, is an unfavorable electrochemical reaction resulting in corrosion of a metal or tissue destruction within the body. An electrolytic reaction can occur with implantation of a single metal simply from exposure to saline solution or oxygen. However, an electrolytic reaction most often occurs due to implantation of two or more different kinds of metal. Biocompatible metals must be used to prevent electrolytic reactions in the surgical patient. For example, stainless steel alloys can be combined with themselves and with each other. The same is true for titanium- and cobalt-based alloys; however, they cannot be combined with stainless steel alloys.⁹ *Note: When implanting metallic devices, related instrumentation and suture material must be of the same type of metal to prevent an electrolytic reaction.*

Stainless steel

Carbon steel is made from refined iron (Fe, 26) ore and varying amounts (up to 0.8 %) of carbon (C, 6) and approximately 0.5 % manganese (Mn, 25). Carbon steel is highly susceptible to corrosion. Stainless steel, which is resistant to corrosion, is manufactured by adding a minimum of 10.5 % chromium (Cr, 24) to carbon steel. Elements, such as nickel (Ni, 28), may also be added to improve corrosion resistance. Other elements may be added to increase tensile strength. Stainless steel is recyclable.

Stainless steel was invented by Harry Brearley, an English metallurgist, in 1913. Brearley was experimenting with an alloy that he thought would be more resistant to erosion, when, by chance, he discovered its anticorrosive properties. The alloy revolutionized the cutlery industry and was quickly adopted by emerging aircraft manufacturers.⁴

Stainless steel has many applications related to the medical field. Not only is stainless steel resistant to corrosion, but it also has several other qualities that make its use desirable. Medical equipment, such as patient beds, OR tables, stretchers, and cabinets have long been manu-

factured from stainless steel because of its hygienic, easy-to-clean qualities and aesthetic appearance. The fact that stainless steel does not shed particles or absorb liquids makes it ideal for use in the preparation of pharmaceuticals.

Surgical instruments made from stainless steel are light weight and several finishes (ebonized, mirror, or satin) are available. Its strength and resistance to fatigue make it an ideal candidate for medical implants, such as artificial joints and internal fracture stabilization devices.⁴ Stainless steel is considered the most inert of all currently available suture materials.¹

Chromium

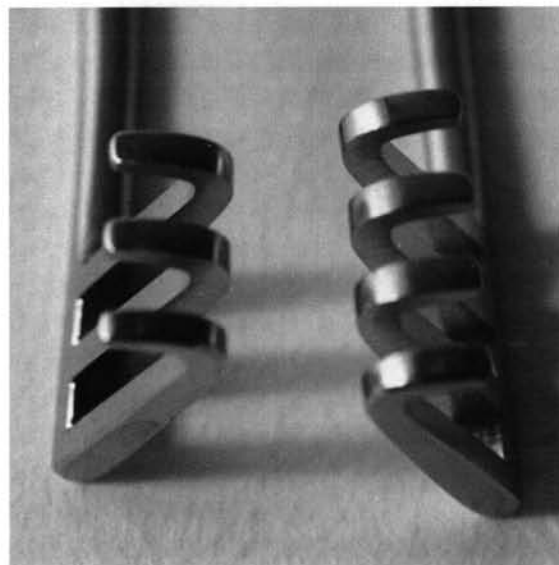
Chromium (Cr, 24) was discovered by Louis Nicolas Vauquelin, a French chemist, in 1797. Chromium is used primarily as an alloy, replacing iron or aluminum in some metals, providing strength, hardness, and corrosion resistance. Chromium gets its name from the Greek "chroma" meaning color, because various chromium compounds feature unique colors.³

Cobalt

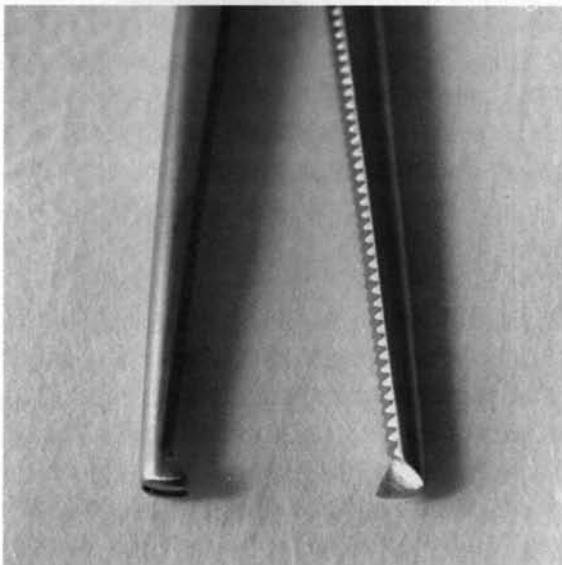
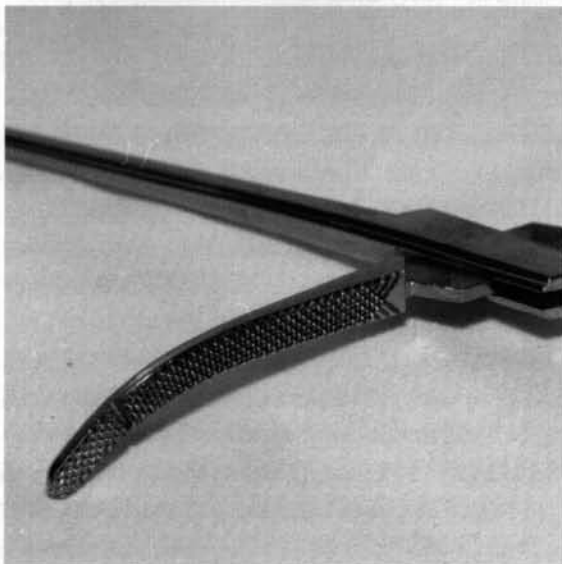
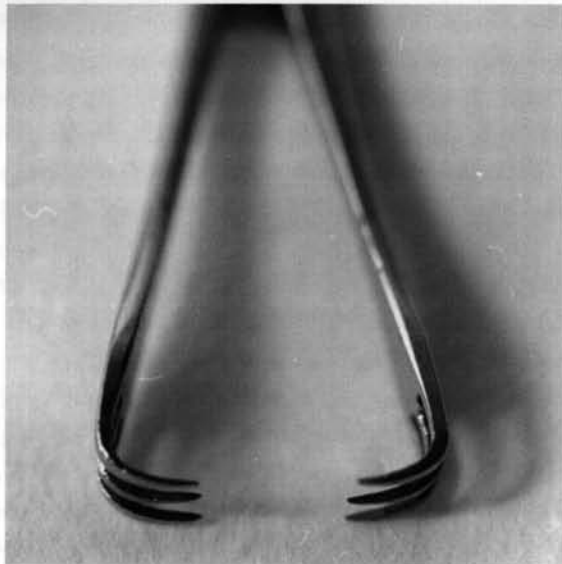
Cobalt (Co, 27) was discovered by George Brandt, a Swedish chemist, in 1735. Cobalt is found in the earth's crustal rocks and is primarily used for making alloys such as cobalt chromium and vitallium. Cobalt-60 is a radioactive isotope of cobalt that is a principle source of gamma radiation used for industrial sterilization. Cobalt-60 is also used in nuclear medicine to help diagnose and treat malignancies.³

Mercury

Mercury (Hg, 80) has been known to man since ancient times and is named after the Roman god Mercury. Its symbol on the periodic chart is derived from the Latin word hydrargyrum, which means liquid silver. Mercury is the only metal commonly found in the liquid state at atmospheric temperatures. In the past, mercury has been used in thermometers, sphygmomanometers, and dental fillings. Because mercury is a poison that can be absorbed through



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the respiratory and gastrointestinal tracts and through intact skin, its medical use has diminished in recent times. Mercury is still widely used in industrial settings, and pollution of lakes and rivers from industrial waste remains a problem.⁸

Titanium

Titanium (Ti, 22) was discovered by William Gregor, a British clergyman, in 1791. It was originally found in the mineral menachanite and was named menachite. In 1910, the element was rediscovered in the mineral rutile by German chemist Martin Heinrich Klaproth. Because of its strength, Klaproth named the element titanium in reference to the Titans in Greek mythology.⁸

Vitallium

Vitallium was first patented by in Germany by Reiner W Erdle, a dental technician, and his brother-in-law Charles H Prange, an engineer and businessman, in 1933. Vitallium is an alloy consisting of cobalt, chromium, tungsten, and small amounts of carbon, manganese, and nickel. The alloy was first used in the manufacture of dental appliances. When vitallium was found resistant to the hostile saline environment within the human body, it was considered for orthopedic use. In 1936, following experiments on dogs, WG Stuck, an orthopedic surgeon in San Antonio, Texas, implanted the first vitallium alloy to stabilize a fracture, without evidence of corrosion or tissue reaction. A subtle change in the formula for vitallium was made in 1936 to increase its strength and ductility without disturbing its other properties. Vitallium continues to be used as dental and orthopedic implant material.⁷

Conclusion

An understanding of metals and their properties applies to many aspects of the OR, including asepsis, instrumentation, sterilization, and implanted materials. As more technology is introduced into this setting, this knowledge will become even more valuable to the surgical technologist.

Related Terminology

Abrasion—to roughen or remove by friction; erosion.

Alloy—a substance composed of two or more metals; or a substance composed of a nonmetal and a metal such as carbon.

Amalgam—an alloy that contains mercury.

Axial tension—stress or force applied to the long axis of an object.

Cast—to form an object by pouring into a mold.

Compression—stress or force applied in an attempt to press together or condense an object.

Corrosion—disintegration of the texture or substance of an item by a destructive agent.

Ductility—a metal's ability to be stretched into wire.

Elastic limit—maximum strain that can be applied to an object that will allow it to resume its original shape.

Elastic strain—stretch applied to an object that produces a linear slope (bend), but allows the object to return to its original length (shape) when removed.

Electrolytic reaction—an unfavorable electrochemical reaction (resulting in decomposition) that occurs due to implantation of two or more different kinds of metals.

Ferrous—containing iron.

Force—energy or power exerted on an object to either initiate or arrest movement. The metric measure of force is the newton. One newton equals 0.225 pound of force.

Forge—to shape a metal by heating it and then beating or hammering it into shape

Fretting corrosion—corrosion accompanied by abrasion.

Inert—displays no chemical activity.

Load—weight applied or stress imposed.

Load test—performed to determine an object's ability to withstand or absorb the weight or stress applied.

Malleable—pliable; capable of bending.

Metal fatigue—fracture or breakdown of a metal caused by repeated application of a load.

Strain—application of a force or load that is capable of producing a change (deformity) in the linear dimension of an object.

Stress—intensity of a load that produces an intense force within an object.

Tensile strength—the breaking point of an object due to an applied force.

Tension—stress or force applied in an attempt to pull an object apart.

Wrought—to form an object by hammering or forcing into shape.

Yield strength—limit of an object's elastic region.

Yield point—stress beyond the elastic limit (also referred to as the fatigue or endurance limit) of an object to produce a permanent deformity. Metals are ranked according to their yield strength and are in order from highest to lowest: cast cobalt chrome, titanium, wrought cobalt chrome, stainless steel.

References

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Heavy metals: metallurgy primer

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1. Amalgam is _____.
 - A. an alloy containing mercury
 - B. carbon steel
 - C. corrosion accompanied by abrasion
 - D. none of the above

2. Ferrous metals contain _____.
 - A. mercury
 - B. iron
 - C. carbon
 - D. titanium

3. Corrosion is _____.
 - A. the breaking point of an object due to an applied force
 - B. fracture or breakdown of a metal caused by repeated application of a load
 - C. erosion or disintegration of the texture or substance of an item by a destructive agent, such as a chemical
 - D. stress or force applied in an attempt to pull an object apart

4. Iron (Fe, 26) is considered _____.
 - A. a metal
 - B. a transition element
 - C. an inert gas
 - D. both A and B

5. Nonmetals are located on the ____ of the periodic table.
 - A. left
 - B. right
 - C. both A and B
 - D. neither A nor B

6. Chromium is represented on the periodic table by the symbol _____.
 - A. Cu
 - B. C
 - C. Cr
 - D. Co

7. Stainless steel contains a minimum of 10.5 % of ____ to help prevent corrosion.
 - A. chromium
 - B. nickel
 - C. iron
 - D. titanium

8. An electrolytic reaction may occur due to _____.
 - A. exposure to salt solution
 - B. exposure to oxygen
 - C. implantation of two or more different kinds of metal
 - D. all of the above

9. Cobalt-60 is used in _____.
 - A. industrial sterilization
 - B. nuclear medicine
 - C. both A and B
 - D. none of the above

10. Cobalt (Co, 27) was discovered by _____.
 - A. George Brandt
 - B. Louis Nicolas Vauquelin
 - C. William Gregor
 - D. Martin Heinrich Klaproth

Heavy metals: metallurgy primer

Certified Member Certified Nonmember

Certification No _____

Name _____

Address _____

City _____ State _____ ZIP _____

Telephone _____

	a	b	c	d		a	b	c	d
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2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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Mark one box next to each number. Only one correct or best answer can be selected for each question.