◀ would be high enough to entice those foes to supply the U.S. war machine with raw materials. War is often the result when a country can't get the natural resources it needs. Resource-poor Japan occupied Manchuria before World War II to get its iron ore. Germany, lacking in just about every resource but coal, sought Lebensraum—literally, "living room"—to grab cobalt, copper, iron ore, petroleum, rubber, tungsten, and bauxite for aluminum. The Axis powers eventually lost in part because the Allies cut off their access to those critical raw materials.

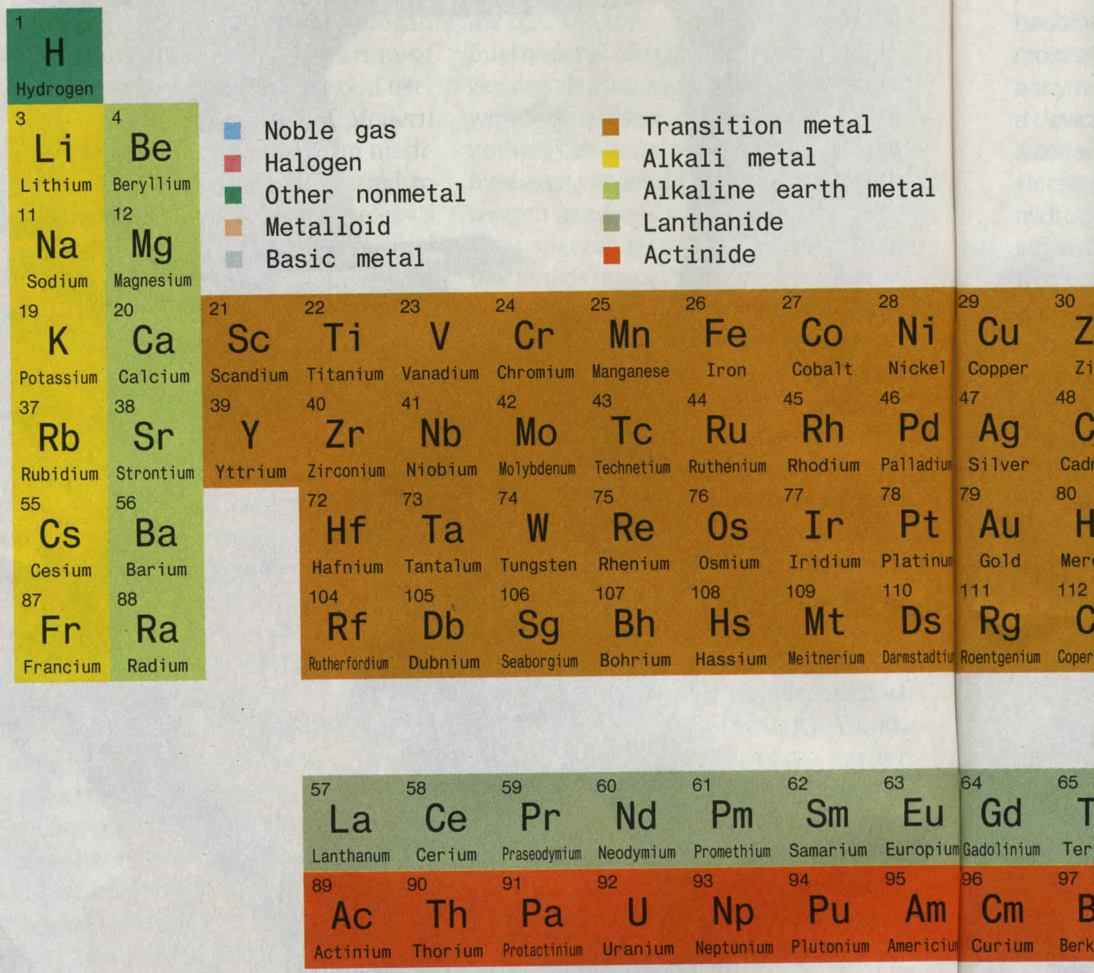
Saleem Ali, an environmental planning professor at the University of Delaware, argues for an international treaty to prevent a repetition of "old colonial scrambles for wealth," which he points out have occurred not only with minerals but also with sugar, spice, and vanilla.

Market forces can also respond too slowly. Yale's Graedel, a professor emeritus of industrial ecology, estimates that it takes 15 to 30 years to bring a new mine into commercial production. Expedited permitting would help with that, he says, as long as it doesn't open the door to abuses by mining companies. Ironically, the green economy depends on many elements whose production is anything but green. Without strong global standards, the free market could push production to the countries that do the least to protect the environment.

Both economics and geopolitics will drive the world toward greater reuse of elements. Recycling will be built into the design of products. That will favor the elements that are most adaptable. "Carbon, which can be as soft as graphite or as hard as diamond, may be the material of choice," Jamais Cascio, a research fellow at the Institute for the Future, a think tank in Palo Alto, Calif., wrote in 2012. "Instead of worrying about minimizing carbon outputs, we may find ourselves working to maximize carbon inputs," he added.

The value of the world's output keeps going up in terms of dollars per ton—more value for less mass. But Buckminster Fuller was wrong. Technological progress isn't ephemeralization. It's invention—and there's no clearer example of invention than the exploitation of Mendeleev's table of elements. Ⓑ

PERIODIC TABLE OF CONTENTS



The Periodic Table at 150

By Joanna Ossinger

Scientists have long sought to catalog the known elements: In 1789, Antoine Lavoisier sorted them by their properties. By 1808, John Dalton was listing them by atomic weight. In 1864, John Newlands argued for a law of octaves, asserting that every eighth element had similar attributes. But it took Dmitri Mendeleev to create a genuinely systematic and predictive table.

Born in Tobolsk, Siberia, in 1834, the youngest of more than a dozen children, Mendeleev graduated from the Main Pedagogical Institute in St. Petersburg in 1855. He studied chemistry in Heidelberg and Paris, then earned a doctorate back home and became a tenured professor at Saint Petersburg Imperial University. Dissatisfied by existing Russian inorganic chemistry textbooks, he decided to write one himself.

The work Mendeleev published beginning in 1869 both laid out the periodicity of the elements and predicted spaces for ones not yet identified. With the discovery of gallium in 1875, scandium in 1879, and germanium in 1886, the theories underlying the table were shown scientif theories into the its indu applicat took pa process coal, oi duction fitful dr

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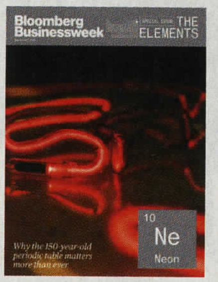
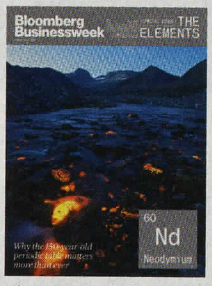
								2 He Helium
			5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
			13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
i ckel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
d adium	7 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
t tinum	9 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
s tadtium	11 Rg oentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Eu opium	4 Gd adolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
Am ricium	6 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

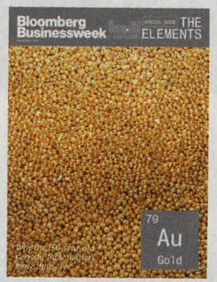


A neon sign in a design lab at Hong Kong Polytechnic

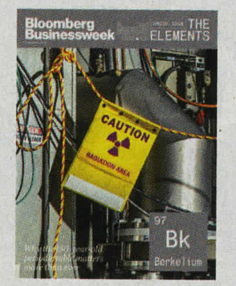
Making salt at Netarts Bay on the Oregon coast



Minerals glowing under UV light near Narsaq, Greenland



A display at a facility that extracts gold from discarded motherboards



Warning signs at the Berkeley cyclotron

PHOTOGRAPHS FOR BLOOMBERG BUSINESSWEEK BY TOMMY TRENCHARD (NEON), SHAWN RECORDS (SODIUM), KILIII YUYAN (NEODYMIUM), CARLOTTA CARDANA (GOLD), AND CHRISTIE HEMM KLOK (BERKELIUM)

shown to be true. Increasing scientific acceptance of these theories accelerated research into the material world and its industrial and commercial applications. Mendeleev himself took part in this, investigating processes related to Russian coal, oil, and even cheese production during the country's fitful drive to modernize.

Since his death from influenza in 1907, the table has changed some, but its fundamental organization remains. Each element has a one- or two-letter chemical symbol, usually derived from its common name but sometimes from another language, making gold, for example, "Au" for the Latin *aurum*. The atomic number tallies the protons in the atom's nucleus. The standard atomic mass is sometimes given to multiple decimal places, with the number in parentheses if it's for the longest-lived isotope.

The columns depict elements that have similar chemical properties. The alkali metals, shown in the first column on the left, for example, have one electron in their outer shell and therefore tend to bond particularly well with the halogens, in the second column from the right, which have seven electrons in their outer shell and lack the single electron needed to complete it. That's how we get compounds such as sodium chloride—table salt—and potassium iodide, which helps protect the thyroid from the effects of radiation.

The column on the far right shows the noble gases, whose outer electron shells are full, making most of these elements useful in lighting since they won't react with others. In most periodic tables, the lanthanides and actinides are placed in rows at the bottom to avoid making the table impractically wide.

Mendeleev didn't get everything right: He believed that elements were unique and resisted the idea that they had the same building blocks. He also produced a convoluted case that ether was an element. But he got the basic design right, and that's why he's regarded as its inventor today—and why its sesquicentennial is being celebrated as the International Year of the Periodic Table.