In Search of Essential Nutrients

Subjects Taught: Science, Language Arts

Grade Levels: 5th-12th Grade

Brief Description: Students explore the meaning of essential nutrients, using periodic tables to compare the elements that are essential to people and plants. Students make predictions as to where in the environment plants obtain each of their essential elements.

Objectives: Students will:

- **1.** Define an essential element;
- 2. Compare and contrast the essential nutrient requirements of plants and humans.
- **3.** Identify the sources for each essential nutrient needed by plants.

Life Skills: Analyzing, communicating, constructing explanating, evaluating, interpreting data, investigating

Materials Needed:

- Colored pencils one per student
- Projectable images of the following handouts in this lesson:
 - Essential Nutrients
 - The Periodic Table
 - Essential Plant Nutrients
 - Essential Human Nutrients
 - Sources of Essential Nutrients
- One photocopy per student of the following handouts in this lesson:
 - The Periodic Table

- Chemical Symbols of the Elements
- Sources of Essential Nutrients

Time:

Three, 45-minute class periods

Preparation:

Have students bring a nutrition label from a box of cereal, like Cheerios®, a nutrition label from a snack food, such as a candy bar, and a nutrition label from a canned or frozen fruit or vegetable.



Florida Standards Met At-A-Glance

National Next Generation Science	5-LS2-d., 5-ESS2-a., MS-PS1-f., MS-LS2-e., MS-LS2-f., MS-LS2-a., MS-ESS3-c., HS-LS2-e., HS-LS2-f., HS-ESS3-a., HS-ESS3-b., HS-ESS3-i.
English/Language Arts	5.Rl.1.1, 5.Rl.1.3, 6.W.3.9, 7.W.3.9, 8.W.3.9, 910.W.3.9, 1112.W.3.9, 6.WHST.1.2, 6.WHST.2.4, 6.WHST.3.7, 7.WHST.1.2, 7.WHST.2.4, 7.WHST.3.7, 8.WHST.1.2, 8.WHST.2.4, 8.WHST.3.7, 910. WHST.2.4, 1112.WHST.1.2, 1112.WHST.2.4, 6.RST.1.1, 6.RST.3.7, 7.RST.1.1, 7.RST.2.4, 7.RST.3.7, 8.RST.1.1, 8.RST.2.4., 8.RST.3.7, 910.RST.2.4, 1112.RST.2.4.
Social Studies	SS.8.G.5.1
Health	HE.7.C.2.6, HE.912.P.2.1
Science	SC.5.L.17.1, SC.6.L.14.3, SC.7.L.17.1, SC.7.L.17.3, SC.8.L.18.1, SC.8.L.18.3, SC.912.L.14.7, SC.912.L.17.10, SC.912.L.18.10, SC.912.L.18.9

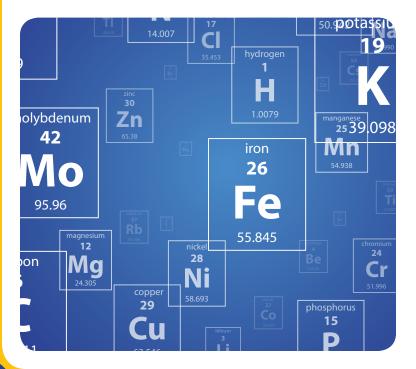
Prepare the five projectable images in this lesson in whatever media is available to you. If an overhead projector is the only audio-visual equipment available, make transparencies. If a computer and LCD projector is available, convert it to Power-Point presentation. If a Smart Board or Prometheus board is available, convert it for use with that technology.

Vocabulary: essential nutrients

Background Information:

There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and non-living substances we encounter. Out of that list of 100 elements, plants require 17 essential nutrients to complete their life cycles - germinate, grow, build tissue, flower, pollinate, produce seed or vegetative structures to reproduce (runners, tubers, bulbs, rhizomes, etc.) and/or survive cold or dry periods. A nutrient is considered essential if it is required by the plant to complete its life cycle, cannot be replaced by another nutrient, is directly involved in the plant's metabolism, and is required by many different plants. These nutrients are identified in the projectable image called "Essential Plant Nutrients." Plants that grow on land obtain these nutrients from the air, water and soil.

Cells carry on the many functions needed to sustain life. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or organism needs. Plants and humans require similar sets of essential nutrients. The essential nutrients needed by humans are identified in the projectable image called "Essential Human Nutrients."



In the context of plant requirements, carbon, oxygen, and hydrogen are called the non-mineral nutrients. Some essential nutrients are obtained from more than one source. For the purpose of this activity, you want students to realize that plants obtain their non-mineral nutrients (carbon, hydrogen, and oxygen) from the air and water, and the rest come from the soil.

Activity One: Essential Nutrients

- 1. Begin the lesson by explaining that scientists who are interested in studying human health must understand the specific needs of the body. Ask:
 - "What do humans need to live?" (Answers will vary.) Accept all answers.
- **2.** Write student responses on the board, overhead transparency, or using an electronic board.
- **3.** Direct the discussion to elicit air (oxygen), water, and food. Some students may realize that sleep is also required for survival. Other students may suggest environmental conditions such as temperature and pressure, or material things such as clothing and shelter.
- **4.** Remind students that life requires energy for its existence. Ask students:
 - "What do people take into their bodies from their environment to help them survive?" (Students should recognize from their previous answers that air, water, and food are obtained from the environment.)
 - "What do we need from the air?" (Oxygen from the air is what we require.)
 - "Why do we need water? (Students should be able to explain that our cells are mostly made of water. Water is the medium from which life has evolved. It is required for the chemistry of life.)
 - "Why do we need food to survive?" (Students should recognize that we derive chemical energy from food and that food supplies the chemical building blocks needed by our cells.)
- 5. Remind students that humans (and animals) eat plants and other animals to obtain chemical energy and provide them with the building blocks needed by their cells. Ask: "Do plants need food?" (No, not in the sense that humans or other animals eat food. Plants do not eat. Plants make food from minerals, water, and gases. Plants do need nutrients. What may be commonly be called "plant food" is actually fertilizer.) Make sure students realize that Plants Do Not Eat! Plants absorb nutrients from soil as they take in water. Plants absorb carbon dioxide through their leaves from the atmosphere during photosynthesis.
- **6.** Explain that they will now investigate the chemical elements that are essential for plant growth.
 - a. Display the image of "Essential Nutrients."

- **b.** Ask different students to read aloud the criteria that describe an essential element.
- 7. Hand out a copy of "The Periodic Table" and a copy of "Chemical Symbols of the Elements" to each student.
- **8.** Instruct the class to think about the definition of "essential element" and use a colored pencil to shade those elements on the periodic table that they think are essential for healthy plant growth based on the information they have learned in the past.
 - **a.** If possible, students should provide an example of how a given element is used by the plant (such as nitrogen being used to make protein).
 - b. Give students about five minutes to complete this task. This step gives you an opportunity to assess how well students can relate their knowledge of chemistry to biology. For example, students may respond that carbon is used to make sugar. Students will probably not suggest a function for elements needed in trace amounts. Usually such elements are needed as cofactors for enzymes. It is not important to discuss the uses of each element, but it is important that students understand that these elements are needed to build cell structures and to carry out the cell's chemistry through enzymatic reactions.
- **9.** Project the image of "The Periodic Table."
 - **a.** Ask a student volunteer to read aloud the elements shaded on his or her periodic table.
 - **b.** Have the student explain why he or she selected those particular elements.
 - **c.** Have additional students add to the list with their predictions.
 - **d.** As the elements are read off, circle them on "The Periodic Table."
 - **e.** Students are not expected to identify the complete list of essential elements. Their responses, however, will reflect their relative knowledge about the biology of plants.
- 10. Explain that you are now going to reveal which elements have been shown to be essential for plant growth and compare them with students' predictions. Display the image of "Essential Plant Nutrients."
 - **a.** Students likely will be surprised that so many elements are essential for plant growth.
 - b. The comparison between the elements predicted by the students and the accepted ones should result in some overlap, especially among the most abundant elements: carbon (C), hydrogen (H), nitrogen (N), oxygen (O), phosphorus (P), and sulfur (S).
 - **c.** If not already mentioned, ask students to name an important molecule in the cell that requires the element phosphorus. You can explain that the most important

- energy molecule in the cell is adenosine triphosphate (ATP) and it includes the element phosphorus.
- **11.** Ask:

"Do you think that humans require the same essential elements as plants?" (Responses will vary. Some students may think that since humans and plants are very different from each other, they will need different sets of elements. Others may reason that since plants and humans are each made of cells, the essential elements needed by both will be similar. Still others may think that since all of the food humans consume ultimately begins with plants that the nutrients may be similar or exactly the same.)

- **12.** Display the image of "Essential Human Nutrients."
 - **a.** Ask students to comment on how similar or dissimilar the pattern of elements is compared with that shown previously for plants.
 - **b.** Students should notice that the two patterns are more alike than different. If using transparencies, you can align and overlap the transparencies of "Essential Plant Nutrients" and "Essential Human Nutrients" to make this point clearer. If using other technology, circle the similarities.
- 13. Referring to the box of cereal, candy bar and fruit or vegetable nutrition labels, ask students what types of nutrients they think humans need and how different foods can provide those nutrients. Have the students look at the three labels to see how they compare. Ask:
 - "Which nutrients from both labels are the same?"
 - **a.** Have students share with another student nearby the ingredients listed on the labels.
 - **b.** Have students refer back to The Periodic Table of elements. Which of the nutrients from the nutrition label can students find on the periodic table?
 - **c.** Which of the nutrients on the labels are also nutrients that plants need?
 - **d.** Ask students to compare some of the common nutrients that plants and humans both need, such as calcium, copper, iron, magnesium, phosphorus, potassium and zinc.
 - **e.** Based on the cereal nutrition label, have five students share which of their foods seem to provide the most nutrients for humans and create a list.
- **14.** Summarize the concept that nutrients plants require to grow are similar to the ones humans need to grow. Humans receive these nutrients from plants.

Activity Two: Sources of Essential Nutrients

1. Explain that you will conclude the lesson with a brief activity that explores where plants obtain their essential nutrients.

- 2. Pass out to each student a copy of the handout "Sources of Essential Nutrients."
- **3.** Explain that the handout lists the 17 essential plant nutrients. Instruct students to think about where a plant obtains its essential nutrients.
 - **a.** Students should indicate the source—air, water, and soil—of each nutrient (that is each chemical element) by checking the appropriate boxes on the handout.
 - **b.** For the purpose of this activity, students should think about water as rainfall (before it reaches the ground). It therefore should not include those elements found in soil that may be dissolved in it.
 - **c.** Students are free to check more than one box for any element.
 - **d.** Give students about five minutes to complete this task.
- **4.** Review the following information with students:
 - The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor.
 - Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle."
 - Soil consists of weathered rocks and decomposed organic material from dead plants, animals and bacteria.
- 5. Display a transparency of "Sources of Essential Nutrients."
 - **a.** Ask a student volunteer to describe which elements he or she listed as coming from water.
 - **b.** Put a "W" next to the elements named by the students. Of course, students probably will mention hydrogen and oxygen. Actually, rainwater may contain small amounts of other elements derived from atmospheric gases and dust particles.
- **6.** Ask another student volunteer to describe which elements he or she listed as coming from the soil.
 - **a.** Put an "S" next to the elements named by the students.
 - **b.** Students should list most if not all of the essential elements.

- **C.** Share that the soil not only contains many elements that reflect its geological history, but it also contains organic material from once-living plants and animals as well as from the abundant microbial life that resides there.
- **7.** Ask another student volunteer to describe which elements he or she listed as coming from the air.
 - **a.** Put an "A" next to the elements named by the students.
 - b. Students should recognize that plants obtain carbon (via CO₂) and oxygen (via O₂) from the air. (Plants take in carbon dioxide and release oxygen while the sun shines and they are undergoing photosynthesis. But at night, the plant respires just like other organisms and takes in oxygen and gives off carbon dioxide.)
 - **c.** Some students may know that most of the atmosphere is nitrogen (N₂).
 - **d.** As with water, small amounts of other elements also may be present due to air pollution.

Evaluation Options:

- 1. Assess student completion and accuracy of "Sources of Essential Nutrients."
- 2. Evaluate student participation in discussion and activities.
- **3.** Have students select one of the nutrients discussed that is essential to both humans and plants. Ask them to research the nutrient and write how it is used in plants and in humans, what symptoms occur if there is a deficiency of this nutrient and sources of this nutrient for both plants and humans.
- **4.** Have students research and diagram the nitrogen, carbon and water cycles.

Lesson adapted with permission from Nutrients for Life Foundation's "Nourishing the Planet in the 21st Century" Lesson 1

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Sample Pre-Post Assessment

1.	What is an essential element?
2.	Do plants and animals have the same essential elements? If so name three.
3.	How do plants obtain essential elements?

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Essential Nutrients



An essential element

- 1. is required for a plant to complete its life cycle
- 2. cannot be replaced by another element
- 3. is directly involved in the plant's metabolism
- 4. is required by many different plants

Periodic Table of Elements

beryllium 4 Bee 9,0122 magnesium 12 Mg 24,305 calcium 20 Ca 40,078 strontium 38 39 Str 4,956 strontium 39 39 Str 4,956 strontium 39 39 39 39 39 39 39 39 39 39 39 39 39	caesium 55 55	19 39.098 rubidium 37 85.468	1,0079 lithium 3 6,941 sodium 11 22,990
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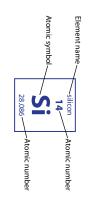
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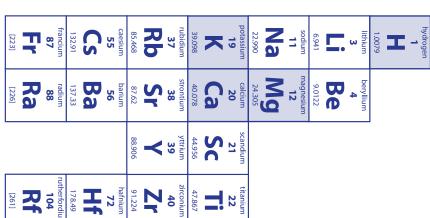
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americium 95	151.96	Eu	63	europium
curium 96	157.25	Gd	64	gadolinium
berkelium 97	158.93	Tb	65	terbium
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	thulium	erbium	holmium	dysprosium	terbium	gadolinium	europium	samarium	promethium	neodymium	praseodymium	cerium	lanthanum

Chemical Symbols of the Elements

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	Gallium	Francium		Fermium Lv	Flerovium	lron Flerovium Fermium	Fluorine Iron Flerovium	Europium Fluorine Iron Flerovium Fermium	Einsteinium Europium Fluorine Iron Flerovium Fermium	Erbium Einsteinium Europium Fluorine Iron Flerovium Fermium	Erbium Einsteinium Europium Fluorine Iron Flerovium Fermium	Darmstadtium Dysprosium Erbium Einsteinium Europium Fluorine Iron Flerovium Fermium	Dubnium Darmstadtium Dysprosium Erbium Einsteinium Fluorine Iron Flerovium Fermium	Dubnium Darmstadtium Dysprosium Erbium Einsteinium Einorine Iron Flerovium Fermium	Cesium Copper Dubnium Darmstadtium Erbium Erbium Einsteinium Fluorine Iron Flerovium Fermium	Chromium Copper Dubnium Darmstadtium Dysprosium Erbium Einsteinium Fluorine Iron Flerovium Fermium	Cobalt Chromium Cesium Copper Dubnium Darmstadtium Erbium Erbium Einsteinium Fluorine Iron Flerovium Fermium	Copernicium Cobalt Chromium Cesium Copper Dubnium Darmstadtium Erbium Erbium Erbium Fluorine Iron Flerovium Fermium	Curium Copernicium Cobalt Chromium Cesium Copper Dubnium Darmstadtium Erbium Erbium Einsteinium Fluorine Iron Flerovium Fermium	Chlorine Curium Copernicium Cobalt Chromium Cobalt Chromium Copper Dubnium Ersium Erbium Erbium Fluorine Iron Flerovium Fermium
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		Mendelevium	Livermorium	Lutetium	•	Lawrencium	Lithium Lawrencium	Lanthanum Lithium Lawrencium	Krypton Lanthanum Lithium Lawrencium	Potassium Krypton Lanthanum Lithium Lawrencium	Potassium Krypton Lanthanum Lithium Lawrencium	Indium Iridium Potassium Krypton Lanthanum Lithium Lawrencium	lodine Indium Iridium Potassium Krypton Lanthanum Lithium Lawrencium	Hassium Indium Iridium Potassium Krypton Lanthanum Lithium Lawrencium	Holmium Hassium lodine Indium Iridium Rrypton Lanthanum Lithium Lawrencium	Mercury Holmium Hassium lodine Indium Potassium Krypton Lanthanum Lithium Lawrencium	Hafnium Holmium Holmium Hassium Indium Iridium Rrypton Lanthanum Lithium Lawrencium	Helium Hafnium Mercury Holmium Hassium Iodine Indium Potassium Krypton Lanthanum Lanthanum Lawrencium	Hydrogen Helium Hafnium Hafnium Holmium Holmium Fotassium Iridium Potassium Lanthanum Lanthanum Lawrencium	Germanium Hydrogen Helium Hafnium Hafnium Holmium Holmium Hodine Indium Iridium Potassium Lanthanum Lanthanum Lawrencium
D																				
	Pr	Po	Pm	Pd		В	Pb Pa	P P P	PB P Os	PB P OS O	B B B B B B B B B B B B B B B B B B B	P P P O P P	면	면	면	PB PD PO OS OO NO NO<	B B B C	B B B C	B P O O E O E O E	Po Po<
_	Pr Praseodymium	Po Polonium	Pm Promethium	Pd Palladium																Molybdenum Meitnerium Nitrogen Sodium Niobium Neodymium Neodymium Nobelium Nobelium Noptunium Oxygen Oxygen Phosphorus Phosphorus Protactinium
_			Prome		Lead Si		Protactinium Sg	Phosphorus Se Protactinium Sg	Osmium Sc Phosphorus Se Protactinium Sg	Oxygen Sb Osmium Sc Phosphorus Se Protactinium Sg	Neptunium Sb Oxygen Sb Osmium Sc Phosphorus Se Protactinium Sg	Nobelium Ru Neptunium S Oxygen Sb Osmium Sc Phosphorus Se Protactinium Sg	Nickel Rn Nobelium Ru Nopetunium S Neptunium S Oxygen Sb Sc Phosphorus Sc Protactinium Sg	Neon Rh Nickel Rn Nobelium Ru Nobelium S Neptunium S Neptunium S Phosphorus Se Protactinium Sg	Neodymium Rg Neon Rh Nickel Rn Nobelium Ru Oxygen Sb Sc Phosphorus Sc Protactinium Sg	Niobium Rf Neodymium Rg Neon Rh Nickel Rn Nobelium Ru Oxygen Sb Sc Phosphorus Sc Protactinium Sg	Niobium Re Neodymium Rg Neon Nickel Nickel Rn Oxygen Sc Phosphorus Se Protactinium Sg	Nitrogen Rb Sodium Re Niobium Rf Neodymium Rf Nickel Rh Nobelium Rh Oxygen Sb Phosphorus Se Protactinium Sg	t Meitnerium Ra Nitrogen Rb Sodium Re Niobium Rf Neodymium Rg Neon Rh Nobelium Ru Noygen Sb Sc Phosphorus Se Protactinium Sg	Molybdenum Meitnerium Nitrogen Nitrogen Niobium Neodymium Nickel Nobelium Nobelium Noptunium Sc Oxygen Sc Phosphorus Se Protactinium Sg
	Praseodymium	Polonium	Promethium	Palladium			Protactinium	Phosphorus Se Protactinium Sg	Osmium Sc Phosphorus Se Protactinium Sg	Oxygen Sb Osmium Sc Phosphorus Se Protactinium Sg	Neptunium Sb Oxygen Sb Osmium Sc Phosphorus Se Protactinium Sg	Nobelium Ru Neptunium S Oxygen Sb Osmium Sc Phosphorus Se Protactinium Sg	Nickel Rn Nobelium Ru Neptunium S Oxygen Sb Sh Phosphorus Sc Protactinium Sg	Neon Nickel Nobelium Nobelium Noptunium So Neptunium So Phosphorus Protactinium Sg Neon Ru So So So So Phosphorus Se	Neodymium Rg Neon Rh Nickel Rn Nobelium Ru Noptunium S Neptunium S Neptunium S Phosphorus Se Protactinium Sg	Niobium Neodymium Neon Nickel Nickel Nobelium Nobelium Noptunium So Neptunium So Phosphorus Se Protactinium Sg Sg	Niobium Re Niobium Re Neodymium Rg Neon Nickel Nickel Rn Oxygen Sb Oxygen Sc Phosphorus Se Protactinium Sg	Nitrogen Rb Sodium Re Nickel Rh Neon Rh Nickel Rn Oxygen Sb Oxygen Sc Phosphorus Se Protactinium Sg	Meitnerium Ra Nitrogen Rb Sodium Re Niobium Rf Neodymium Rf Neon Rh Nobelium Rh Oxygen Sb Oxygen Sc Phosphorus Se	Molybdenum Pu Meitnerium Ra Nitrogen Rb Nickel Rn Nickel Rn Oxygen Sb Oxygen Sc Phosphorus Se Protactinium Sg
	Praseodymium Ta	Polonium Sr	Promethium Sn	Palladium Sm	Lead Si		Protactinium Sg Seaborgium	Phosphorus Se Selenium Protactinium Sg Seaborgium	Osmium Sc Scandium Phosphorus Se Selenium Protactinium Sg Seaborgium	Oxygen Sb Antimony Osmium Sc Scandium Phosphorus Se Selenium Protactinium Sg Seaborgium	Neptunium S Sulfur Oxygen Sb Antimony Osmium Sc Scandium Phosphorus Se Selenium Protactinium Sg Seaborgium	Nobelium Ru Ruthenium Neptunium Sb Sulfur Oxygen Sc Scandium Phosphorus Protactinium Sg Seaborgium	Nickel Nobelium Nobelium Nobelium Noptunium School Sulfur School Sulfur Antimony School Scandium Phosphorus Sehorgium Sehorgium	Neon Nickel Nickel Ru Ru Ruthenium Neptunium Sulfur Oxygen Sc Oxygen Sc Scandium Phosphorus Se Selenium Se Seaborgium	Neodymium Rh Rhodium Nickel Rn Radon Nobelium Noptunium S Sulfur Oxygen Sc Scandium Phosphorus Se Selenium Se Seaborgium	Niobium Rf Rutherfordium Neodymium Rh Roentgenium Nickel Nickel Ru Radon Nobelium Sulfur Oxygen Sc Scandium Phosphorus Se Selenium Se Seaborgium	Niobium Rf Rutherfordium Neodymium Rg Roentgenium Neon Nickel Rn Radon Nobelium Ru Rutherium Sulfur Sulfur Sc Scandium Phosphorus Se Selenium Se Seaborgium	Nitrogen Re Rubidium Re Rhenium Niobium Re Rhenium Re Rutherfordium Re Roentgenium Rh Rhodium Nickel Rn Radon Nobelium Ru Rutherium Sulfur Sulfur Scandium Phosphorus Se Selenium Se Seaborgium	tMeitneriumRaRadiumNitrogenRbRubidiumSodiumReRheniumNiobiumRfRutherfordiumNeonRhRoentgeniumNickelRnRhodiumNobeliumRuRutheniumSomiumScSulfurOxygenScScandiumPhosphorusSeSeleniumProtactiniumSgSeaborgium	Molybdenum Pu Plutonium Meitnerium Ra Radium Nitrogen Rb Rubidium Niobium Re Rhenium Neodymium Rg Roentgenium Nickel Rn Radon Nobelium Ru Rutherfordium Sub Sulfur Oxygen Sc Scandium Phosphorus Se Selenium Sg Seaborgium

Essential Plant Nutrients



chromium
24
Cr
51.996
nolybdenur
42
Mo
95.96
tungsten
74
W
183.84
seaborgium
106

26
26
55.845
ruthenium
44
101.07
cosmium
76
05
190.23
hassium
108

cobalt 27 Co 58.933 rhodium 45 Rh 102.91 iridium 77 Tr 192.22 rheitnerium 109

29
29
63.546
8ilver
47
47
49
107.87
gold
79
111
196.97
Dentigenium
1111
Rg
1272

zinc 30 2n 65.38 cadmium 48 (2d 112.41 mercury 80 80

5 5 BB 10.811 aluminium 13 13 26.982 gallium 9 49 69.723 indium 49 114.82 thallium 81 114.82 204.38

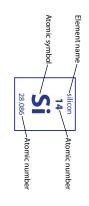
12,011 silicon 14 Silicon 28.086 germanium 27.64 tin 50 Silicon 118.71 lead 82 82 82 Pb

nitrogen
7
14,007
hhosphoru
15
P
30,974
arsenic
33
AS
74,922
antimony
51
51
51
51
Sb
ibismuth
83
83

oxygen oxygen 8 8 15.999 sulfur 16 5 32.065 selenium selenium 52 78.96 tellurium 52 78.96 tellurium 52 84 84 Pool 127.60 polonium 84 190 polonium 85 190 polonium 84 190 polonium 85 190 polon

fluorine 9
18.998
Chlorine 17
35.433
bromine 35
Br 79.904
lodine 53
126.90
astatine 85

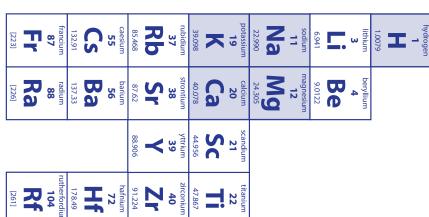
helium
2
2
4,0026
neon
10
Ne
20,180
argon
18
Ar
39,948
krypton
36
krypton
36
krypton
54
81,798
82,798



lanthanum	
cerium	
praseodymium	
neodymium	
promethium	
samarium	
europium	
gadolinium	
terbium	
dysprosium	
holmium	
erbium	
thulium	
ytterbium	
lutetium	

[227]	Ac	89	actinium	138.91	La	57	lanthanum
232.04	Ŧ	90	thorium	140.12	Ce	58	cerium
231.04	Pa	91	protactinium	140.91	Pr	59	praseodymium
238.03	C	92	uranium	144.24	Z	60	neodymium
[237]	Z	93	neptunium	[145]	Pm	61	promethium
[244]	Pu		3	150.36	Sm	62	samarium
[243]	Am	95	americium	151.96	E	63	europium
[247]	Cm	96		157.25	Gd	64	gadolinium
[247]	BK	97	berkelium	158.93	T b	65	terbium
[251]	₽	98	californium	162.50	Dy	66	dysprosium
[252]	ES	99	einsteinium	164.93	Ho	67	holmium
[257]	Fm	100	fermium	167.26	F	68	erbium
[258]	Md	101	mendelevium	168.93	Ħ	69	thulium
[259]	Z 0	102	nobelium	173.05	4	70	ytterbium
[262]	5	103	lawrencium	174.97		71	lutetium

Essential Human Nutrients

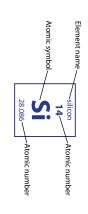


23
25
50.942
niobium
41
11
105
92.906
tantalum
73
73
180.95
dubnium
105

24
Cr
51.996
molybdenur
42
Mo
95.96
tungsten
74
W
183.84
seaborgium
106

26
26
55.845
ruthenium
44
101.07
cosmium
76
76
0S
190.23
hassium
108

cobalt 27 Co 58.933 rhodium 45 Rh 102.91 iridium 77 192.22 meitnerium 109



Helium 2

lanthanum	
cerium	
praseodymium	
neodymium	
promethium	
samarium	
europium	
gadolinium	
terbium	
dysprosium	
holmium	
erbium	
thulium	
ytterbium	
lutetium	

[227]	Ac	actinium 89	138.91	La	57	lanthanum
232.04	H	thorium 90	140.12	Ce	58	cerium
231.04	Pa	protactinium 91	140.91	Pr	59	praseodymium
238.03	C	uranium 92	144.24	P	60	neodymium
[237]	Z O	neptunium 93	[145]	Pm	61	promethium
[244]	Pu	plutonium 94	150.36	Sm	62	samarium
[243]	Am	americium 95	151.96	Eu	63	europium
[247]	Cm	curium 96	157.25	Gd	64	gadolinium
[247]	BK	berkelium 97	158.93	7	65	terbium
[251]	Ç	californium 98	162.50	Dy	66	dysprosium
[252]	Es	einsteinium 99	164.93	Ho	67	holmium
[257]	Fm	fermium 100	167.26	T,	68	erbium
[258]	Md	mendelevium 101	168.93	Ħ	69	thulium
[259]	N _o	nobelium 102	173.05	4	70	ytterbium
[262]	<u>_</u>	lawrencium 103	174.97		71	lutetium

[271]	darmstadtium	195.08	Pt	78	106.42	Pd	palladium 46	58.693	Z	28	nickel						
[272]	roentgenium 111	196.97	Au	90Id 79	107.87	Ag	47	63.546	C	29	Copper						
		200.59	Hg	mercury 80	112.41	6	48	65.38	Zn	30	zinc						
		204.38	=	thallium 81	114.82	5	49	69.723	Ga	31	Z6.98Z	2	aluminium 13	10.811	W	U S	horon
		207.2	Pb	82	118.71	Sn	50	72.64	Ge	32	Z8.086	S	silicon 14	12.011	\cap	6	Carbon
		208.98	<u></u>	83	121.76	dS	51	74.922	As	33	arsenic	T	phosphorus 15	14.007	Z	7	nitrogen
		[209]	Po	84	127.60	Te	52	78.96	Se	34	selenium	S	sulfur 16	15.999	0	8	Owigen
		[210]	At	astatine 85	126.90	_	53	79.904	B	35	bromine	Ω	chlorine 17	18.998	TI	9	fluorine
		[222]	Rn	86	131.29	Xe	54	83.798	주 ~	36	krynton	P	argon 18	20.180	Z	10	4.0026
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Sources of Essential Nutrients

Vame	Date	







Essential Nutrient	Source		
	Air	Water	Soil
Boron (B)			
Calcium (Ca)			
Carbon (C)			
Chlorine (Cl)			
Copper (Cu)			
Hydrogen (H)			
Iron (Fe)			
Magnesium (Mg)			
Manganese (Mn)			
Molybdenum (Mo)			
Nickel (Ni)			
Nitrogen (N)			
Oxygen (O)			
Phosphorus (P)			
Potassium (K)			
Sulfur (S)			
Zinc (Zn)			