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.RI.1.1, 5.RI.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

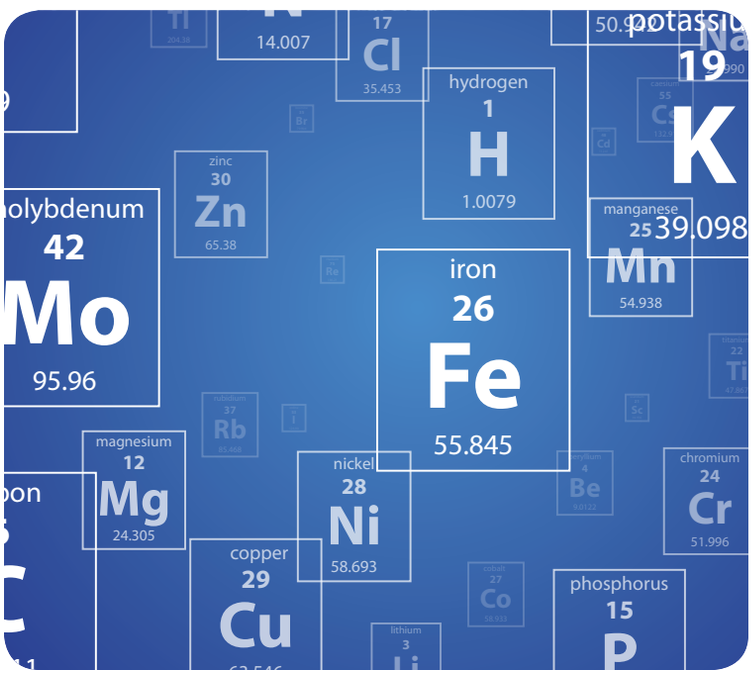
Prepare the five projectable images in this lesson in whatever media is available to you. If an overhead projector is the only audio-visual equipment available, make transparencies. If a computer and LCD projector is available, convert it to Power-Point presentation. If a Smart Board or Prometheus board 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 CO_2) and oxygen (via O_2) 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 (N_2).
   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

In Search of Essential Nutrients

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?

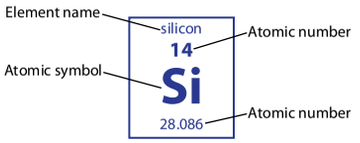
Adapted with permission from Nutrients for Life Foundation's "Nourishing the Planet in the 21st Century" Lesson 1.

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



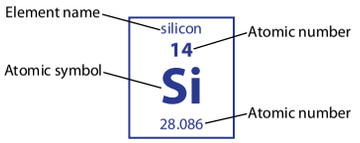
hydrogen 1 H 1.0079																	helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305											aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.38	gallium 31 Ga 69.723	germanium 32 Ge 72.64	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.798
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.96	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33		hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]		rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [277]	meitnerium 109 Mt [268]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]							

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.05	lutetium 71 Lu 174.97
actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]	lawrencium 103 Lr [262]

Chemical Symbols of the Elements

Symbol	Element	Symbol	Element	Symbol	Element	Symbol	Element	Symbol	Element	Symbol	Element
Ac	Actinium	**Cl**	Chlorine	**Ge**	Germanium	**Mo**	Molybdenum	**Pu**	Plutonium	**Tc**	Technetium
Ag	Silver	**Cm**	Curium	**H**	Hydrogen	**Mt**	Meitnerium	**Ra**	Radium	**Te**	Tellurium
Al	Aluminum	**Cn**	Copernicium	**He**	Helium	**N**	Nitrogen	**Rb**	Rubidium	**Th**	Thorium
Am	Americium	**Co**	Cobalt	**Hf**	Hafnium	**Na**	Sodium	**Re**	Rhenium	**Ti**	Titanium
Ar	Argon	**Cr**	Chromium	**Hg**	Mercury	**Nb**	Niobium	**Rf**	Rutherfordium	**Tl**	Thallium
As	Arsenic	**Cs**	Cesium	**Ho**	Holmium	**Nd**	Neodymium	**Rg**	Roentgenium	**Tm**	Thulium
At	Astatine	**Cu**	Copper	**Hs**	Hassium	**Ne**	Neon	**Rh**	Rhodium	**U**	Uranium
Au	Gold	**Db**	Dubnium	**I**	Iodine	**Ni**	Nickel	**Rn**	Radon	**Uun**	Ununnilium
B	Boron	**Ds**	Darmstadtium	**In**	Indium	**No**	Nobelium	**Ru**	Ruthenium	**Uuo**	Ununoctium
Ba	Barium	**Dy**	Dysprosium	**Ir**	Iridium	**Np**	Neptunium	**S**	Sulfur	**Uup**	Ununpentium
Be	Beryllium	**Er**	Erbium	**K**	Potassium	**O**	Oxygen	**Sb**	Antimony	**Uus**	Ununseptium
Bh	Bohrium	**Es**	Einsteinium	**Kr**	Krypton	**Os**	Osmium	**Sc**	Scandium	**Uut**	Ununtrium
Bi	Bismuth	**Eu**	Europium	**La**	Lanthanum	**P**	Phosphorus	**Se**	Selenium	**Uuu**	Ununumium
Bk	Berkelium	**F**	Fluorine	**Li**	Lithium	**Pa**	Protactinium	**Sg**	Seaborgium	**V**	Vanadium
Br	Bromine	**Fe**	Iron	**Lr**	Lawrencium	**Pb**	Lead	**Si**	Silicon	**W**	Tungsten
C	Carbon	**Fl**	Flerovium	**Lu**	Lutetium	**Pd**	Palladium	**Sm**	Samarium	**Xe**	Xenon
Ca	Calcium	**Fm**	Fermium	**Lv**	Livermorium	**Pm**	Promethium	**Sn**	Tin	**Y**	Yttrium
Cd	Cadmium	**Fr**	Francium	**Md**	Mendelevium	**Po**	Polonium	**Sr**	Strontium	**Yb**	Ytterbium
Ce	Cerium	**Ga**	Gallium	**Mg**	Magnesium	**Pr**	Praseodymium	**Ta**	Tantalum	**Zn**	Zinc
Cf	Californium	**Gd**	Gadolinium	**Mn**	Manganese	**Pt**	Platinum	**Tb**	Terbium	**Zr**	Zirconium

Essential Plant Nutrients



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potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.38	gallium 31 Ga 69.723	germanium 32 Ge 72.64	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.798
rubidium 37 Rb 85.468	strontium 38 Sr 87.62	yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.96	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33		hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]		rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [277]	meitnerium 109 Mt [268]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]							

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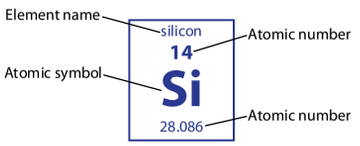
Essential Human Nutrients



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caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33		hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]		rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [277]	meitnerium 109 **Mt** [268]	darmstadtium 110 **Ds** [271]	roentgenium 111 **Rg** [272]								

lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.05	lutetium 71 **Lu** 174.97
actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]	lawrencium 103 **Lr** [262]

Sources of Essential Nutrients

Name _____ 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)			