

Mineral Nutrition



1 Purpose and Content of Lesson:

Tower Tonic is a solution of minerals that plants absorb through their roots. These minerals combine with the sugar that plants make using air and light to form the building blocks of the plant body. Plants supply these minerals to animals and humans. The minerals needed by plants are similar but not identical to those needed by animals. Animals also require a source of carbohydrates, but plants use sunlight, water, and carbon dioxide in the air to make their carbohydrates.

The pH of the mineral solution is critical to efficient absorption of minerals.

Terms and concepts:

Mineral or inorganic nutrient: a nutrient that does not contain carbon and hydrogen

Organic nutrient: a nutrient made by a living organism

pH: a designation to express how acidic (acid) or alkaline (base) a solution is on a scale of 0 to 14. Less than 7 represents acidity, 7 neutrality, and more than 7 alkalinity.

2 Next Generation Science Standards (NGSS):

<http://www.nextgenscience.org/search-standards>

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (Middle School-LS2-1)

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (Middle School-LS2-3)

ESS2.E Biogeology

The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (High School-ESS2-7)

3 Common Misconceptions About Plant Nutrition:

Some learners will erroneously believe that the nutrients and water that come from the soil are the only “food” for the plant. Fertilizer is called “plant food” and we say that plants need water to grow. While this may be so, learners may have difficulty believing that leaves, together with the soil nutrients and water contribute to the making of the food the plant needs. They often hold to the idea that plants get food solely from water and nutrients in the soil.

4 Lesson Objective:

Learners will explain the importance of minerals for formation of the plant body and the role of plants in forming the animal body; this also includes the topic of human nutrition. They will be able to explain the importance of monitoring and regulating pH of the Tower Tonic nutrient solution.

Lesson Procedure— THE LEARNING CYCLE: The Five Es

ENGAGE

The PowerPoint slide show takes students through these learning sequences. Answers to the questions posed only appear in the lesson plan.

1. *What do plants need besides water, air, and sunlight? (good soil)*
2. *How can plants grow without soil?*

EXPLAIN

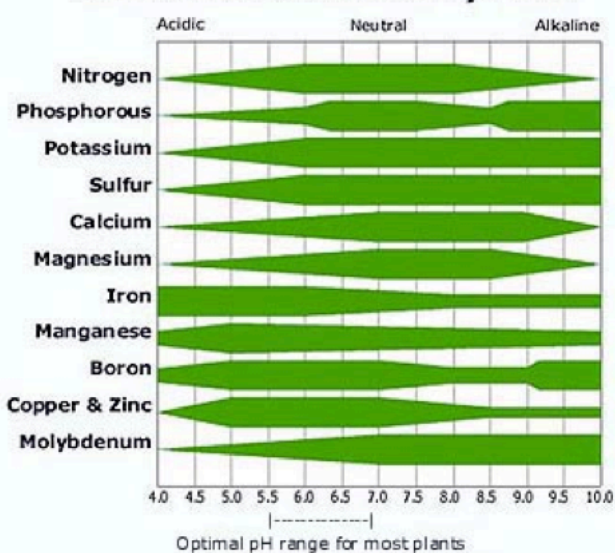
1. *What do roots do?*
2. *How do plants grow without soil?*

Roots do more than just anchor the plants. Microscopic root hairs take up water and minerals that plants need for healthy growth. They can take up these minerals from wet soil or from a mineral solution without soil.

Tower Tonic is formulated so roots can absorb the minerals efficiently. This involves maintaining a balanced pH. The PowerPoint presentation for this lesson explains pH.

3. **Explain the importance of maintaining a pH between 5.5 and 7 in the Tower Garden.** (Most plants absorb nutrients best in this range.)

Plant Nutrient Availability Chart



About pH:

- pH indicates how acidic or alkaline (basic) a solution is using a scale from 1 to 14.
- Water has a pH of 7, which is considered “neutral.” Water can ionize, and it has the same number of acidic (H_3O^+) and basic (OH^-) particles, as shown in this formula. $H_2O \rightleftharpoons H_3O^+ + OH^-$

- An excess of OH^- makes the pH > 7 , called alkaline or basic. An excess of H_3O^+ makes the pH < 7 , called acidic.
 - Plants can grow well in pH 5.5 to 7.
 - pH neutrality is a balance of H_3O^+ and OH^- .
 - Electrical neutrality is a balance of + and – ions of any kind.
 - Some positive ions are K^+ , Mg^{++} , Mn^{++} , Ca^{++}
 - Some negative ions are nitrate (NO_3^-), phosphate (PO_4^{--}), sulfate (SO_4^{--})
4. **Explain how to make calcium nitrate so it is electrically neutral.**

Answer: Calcium has a charge of +2, which is balanced by the two nitrates, each with a charge of minus 1 (Ca^{++} and 2 (NO_3^-) makes $Ca(NO_3)_2$

5. **Explain how to make potassium sulfate so it is electrically neutral.**

Answer: Two K^+ are needed to balance the negative charge of minus 2 on sulfate. (2 K^+ and SO_4^{--} makes K_2SO_4)

Plant roots must maintain electrical neutrality, which means they have the same number of + and – ions.

Roots take up nutrients as ions, which can be positive or negative. When roots take in a nutrient that has a negative charge, such as phosphate, nitrate, or sulfate, they lose electric neutrality. They can regain neutrality by expelling OH^- . But this raises the pH, which could lead to trouble. However, when roots take up a positive ion like Ca^{++} , they expel H^+ , which lowers pH.

Tower Tonic is formulated so roots take up a roughly even number of positive and negative nutrients; in turn, they maintain electric neutrality and don't change the pH by much.

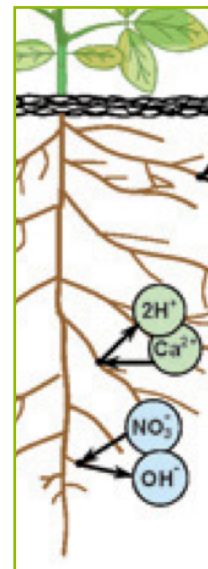
On the chart IN THE , the nutrients highlighted in yellow contain a balance of positive and negative parts.

6. **Explain how the + and – balance of nutrients helps maintain a balanced pH in the solution around the roots.** (See above content.)

7. *What is one element that animals require but is rare in plants? (Sodium [Na])* Most plants are not salty, probably so animals won't gobble them up.

Tower Tonic does not contain **carbon**, which is a major element in all living organisms.

8. *Where, then, do plants get carbon?* (Carbon comes from the air as carbon dioxide.)



EXPLORE

Students will do Internet research on mineral nutrients in Tower Tonic and complete the **Chart of Mineral Nutrients** in Plants and Humans (included under Appendices.) Students can be given printed copies or electronic versions. Have them share findings in a class discussion.

EXPLAIN

Plant nutrients are often called fertilizer. Fertilizers carry a three-number code that tells the concentration of the macronutrients: N (Nitrogen), P (Phosphorus), and K (Potassium). The other elements are called micronutrients (B, Cu, Mg, Mn, Mo, Na (Sodium), S, Zn).

These elements are present in the soil as minerals.

Tower Tonic supplies these minerals that plants would otherwise absorb from the soil.

9. How is plant fertilizer similar yet different from animal food?

Answer: Plants need only minerals, sunlight, and water to make their own food. This is called inorganic nutrition. Animals must consume organic food (made from living or dead plants or animals) such as carbohydrates, proteins, fats, and sugars.

Plants transport the minerals into their bodies, and they nourish us when we eat the plants.

Plants and animals require similar elements, but the sources of nutrients are fundamentally different for plants and animals. Plants “eat” simple inorganic minerals, whereas animals eat chemically complex organic food, which is then digested.

Plants make their own food from inorganic chemicals; animals consume organic food.

EXPAND

Dietary recommendations and human nutrition.

The *Dietary Guidelines for Americans* are jointly issued and updated every five years by the Department of Agriculture (USDA) and the Department of Health and Human Services (HHS). Recently, the concept of the Food Pyramid as a way to communicate a healthy diet was replaced by the image of a healthy serving of food, “Choose My Plate”. <http://www.choosemyplate.gov/>

10. Compare and contrast the two concepts. Which image do you find more effective to educate people about healthy eating? Explain why.

11. Use the concept you find most useful to compose a healthy menu for a breakfast, school lunch, and dinner—something you would enjoy eating.

Goodbye Pyramid.....Hello My Plate



Breakfast

Lunch

Dinner

12. What plants would you choose to grow in the Tower Garden® to meet the dietary recommendations? <http://www.towergarden.com/>

EVALUATE

1. Explain how plants in the Tower Garden® are able to grow without soil. Use facts from this lesson to support your answer.
2. What differences would you expect to find between plants grown in the tower and those grown outside in soil? List at least three.
3. How could growing plants in the Tower Garden lead you to healthier eating habits? List three ways.

The worksheet that includes all questions from the lesson plan, the chart of nutrients, and the assessment are attached for students to write or type responses. A PowerPoint presentation accompanies this lesson.

Useful References for the Chart:

1. http://kidshealth.org/teen/misc/mineral_chart.html
2. <http://www.nhs.uk/Conditions/vitamins-minerals/Pages/Other-vitamins-minerals.aspx>
3. http://en.wikipedia.org/wiki/Dietary_element

MINERAL NUTRIENTS IN PLANTS AND ANIMALS

Name _____

CONTENTS OF TOWER TONIC A

Mineral Forms	Major Function in Plant	Major Function in Human	References
Nitrogen (N) 2%	Ca ⁺⁺ and 2 NO ₃ ⁻	proteins, DNA, RNA contain N	
Calcium (Ca) 1%	Calcium nitrate	Plant cell wall	
Iron (Fe) 0.5%	FeNa EDTA Chelated iron	Energy in cells	

CONTENTS OF TOWER TONIC B

Element %	Mineral Forms	Major Function in Plants	Major Function in Humans	References
Phosphorus (P) 1%	H ₃ PO ₄ Phosphoric acid	DNA, RNA cell membrane energy (ATP) promotes roots, flowers, and fruits		
Potassium (K) 3%	2 K ⁺ and SO ₄ ²⁻ Potassium Sulfate	Cell sap, promotes vigor		
Sulfur (S) 3%	Potassium Sulfate	To make proteins defensive molecules		
Magnesium (Mg) 0.5%	Mg SO ₄ Magnesium sulfate	Chlorophyll for photosynthesis		
Boron (B) 0.01%	H ₃ BO ₃ Boric Acid	Cell wall		
Copper (Cu) 0.001%	Cu SO ₄ Copper sulfate	Energy production		
Manganese (Mn) 0.01%	Mn SO ₄ Manganese sulfate	Photosynthesis		
Molybdenum (Mo) 0.0005%	Na ₂ Mo ₄ Sodium molybdate	To absorb N and P		
Zinc (Zn) 0.005%	Zn SO ₄ Zinc sulfate	To make DNA		

MINERAL NUTRITION WORKSHEET

Name _____ Date _____

1. What do plants need besides water, air, and sunlight?
2. How can plants grow without soil?
3. Explain the importance of maintaining a pH between 5.5 and 7 in the Tower Garden.
4. Explain how to make calcium nitrate so it is electrically neutral. Ca^{++} and $2(\text{NO}_3)^-$ makes $\text{Ca}(\text{NO}_3)_2$
5. Explain how to make potassium sulfate so it is electrically neutral. 2K^+ and SO_4^{--} makes K_2SO_4
6. In the chart, the nutrients highlighted in yellow contain a balance of positive and negative parts.
Explain how this helps maintain a balanced pH around the roots in the Tower Garden.
7. What is one element that animals require, but is rare in plants? _____
8. Tower Tonic does not contain carbon, which is a major element in all living organisms.
Where, then, do plants get carbon?
9. Use these references and others you may find to complete the chart on page 4, comparing the function of minerals in plants and animals. Be prepared to explain your findings to the class.
10. How is plant fertilizer similar yet different from animal food?
11. Compare and contrast the Food Pyramid and the My Plate concepts. Which image do you find more effective to educate people about healthy eating? Explain why.
<http://www.choosemyplate.gov/>
12. Use the concept you find most useful to compose a healthy menu for a breakfast, school lunch, and dinner. List foods you would enjoy eating and be sure to follow the guidelines.

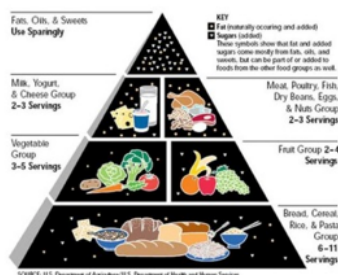
Food Pyramid or My Plate? _____

Breakfast

Lunch

Dinner

Goodbye Pyramid.....Hello My Plate



13. What plants would you choose to grow in the Tower Garden to meet the dietary recommendations?
<http://www.towergarden.com/>

MINERAL NUTRITION ASSESSMENT

1. Explain how plants in the Tower Garden are able to grow without soil? Use facts from this lesson to support your answer.
2. What differences would you expect to find between plants grown in the tower and those grown outside in soil? List at least three.
3. How could growing plants in the Tower Garden lead you to healthier eating habits? List three ways.

Mineral Nutrition

How Plants Make Their Own Food from Minerals, Air and Sunlight



DEVELOPED BY:

Debra Zinicola, Ed.D., Seton Hall University, Chair, Department of Educational Studies, and
Marian Glenn, Ph.D., Seton Hall University, Professor, Department of Biological Sciences





Mineral Nutrition

What do plants need to grow?

- air
- water
- sunlight
- _____ ?



Mineral Nutrition

How can plants grow without soil?

- Plant nutrients are often called “fertilizer”.
- Fertilizers carry a 3-number code that tells the concentration of the macro-nutrients: N, P, and K (chemical symbols for Nitrogen, Phosphorus, Potassium).
- Other elements needed by plants are called micro-nutrients (B, Cu, Mg, Mn, Mo, S, Zn) .
- These elements are present in the soil as minerals.
- Tower Tonic supplies the minerals that roots would otherwise absorb from the soil.
- Watch this video on how nutrients help the plants grow in the Tower Garden. (Vertical Aeroponic Technology)

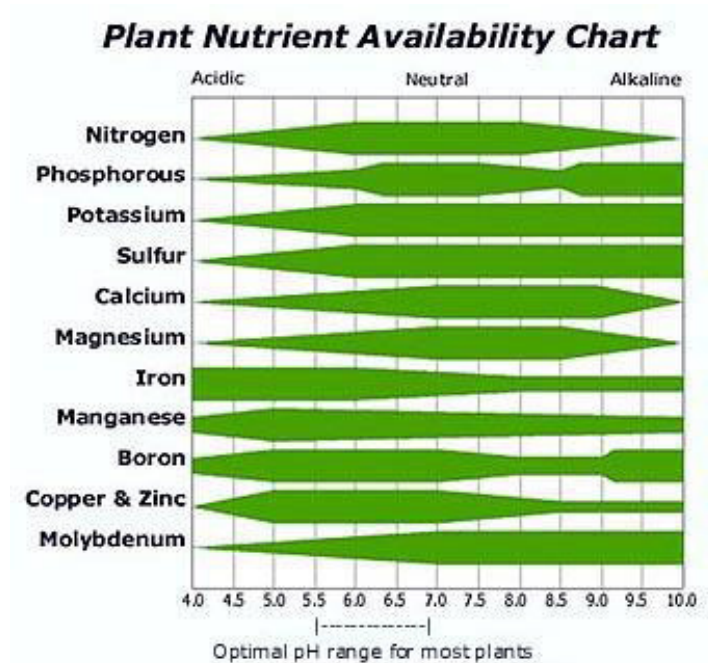




Mineral Nutrition

pH affects the ability of plants to absorb minerals.

- pH indicates how acidic or alkaline a solution is.
- Pure water has pH=7 which is considered “neutral”.
- Most plants grow best in pH that is slightly acidic. What number might that be?

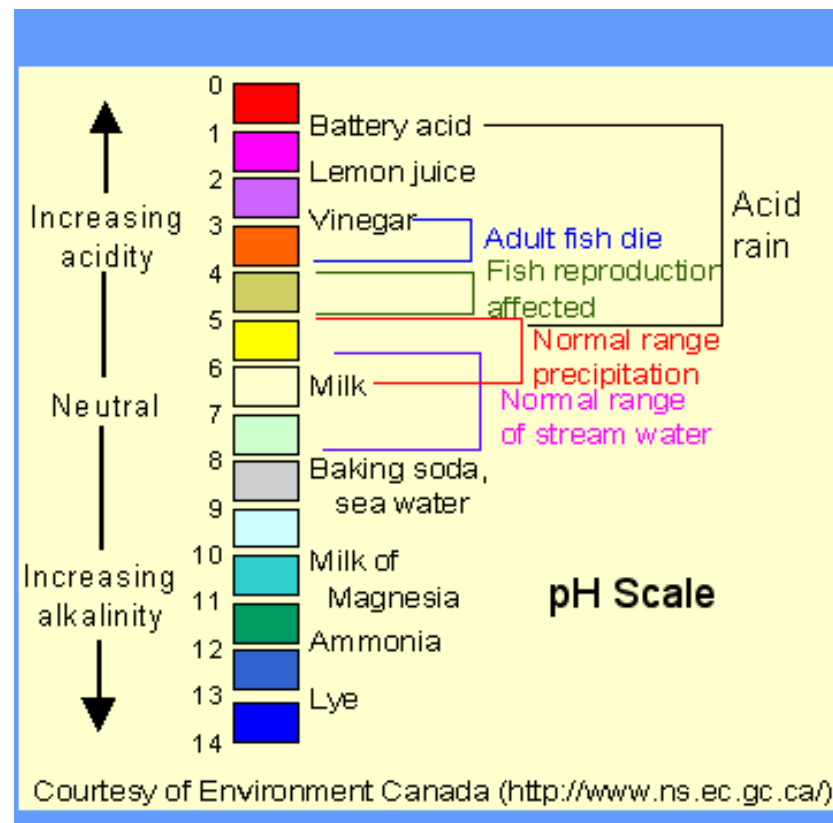




Mineral Nutrition

A Primer About pH:

- pH indicates how acidic or alkaline (basic) a solution is using a scale from 1 to 14; water is pH 7 (neutral)
- Water can ionize which means it breaks into charged ions, like this:
 $2 \text{H}_2\text{O} \text{ (yields) } \text{H}_3\text{O}^+ + \text{OH}^-$
- An excess of OH^- is called alkaline or basic, $\text{pH} > 7$
- An excess of H_3O^+ is called acidic, $\text{pH} < 7$
- Why would pure water be considered “neutral pH”?





Mineral Nutrition

Two kinds of neutrality:

- pH neutrality is having equal numbers of H_3O^+ and OH^-
 - Electrical neutrality is having equal numbers of + and - charges.
 - Some negative ions and their charges: nitrate (NO_3^-); phosphate (PO_4^{3-}); sulfate (SO_4^{2-})
 - Some positive ions and their charges: K^+ , Mg^{2+} , Mn^{2+} , Ca^{2+}
- 1 Explain how to make calcium nitrate so it is electrically neutral.
 - 2 Explain how to make potassium sulfate so it is electrically neutral.

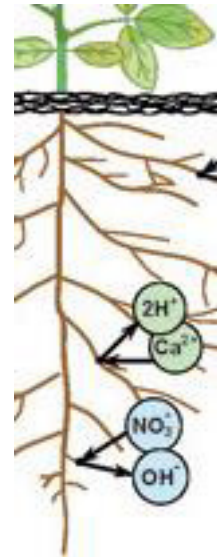


Mineral Nutrition

Plant roots maintain electric neutrality.

This can affect the pH in the solution around the roots.

- Roots take in nutrients as positive or negative ions.
- When roots take in nitrate, they expel OH^- to regain electric neutrality.
- When roots take in Ca^{++} they regain neutrality by expelling 2H^+
- Tower Tonic is formulated so roots take in roughly even positive and negative nutrients. This way, the roots maintain electric neutrality and don't change the pH in the solution.





Mineral Nutrition

Nutrients in Tower Tonic A:

- The nutrients highlighted in yellow, contain a balance of positive and negative parts.
- Explain how this helps maintain a balanced pH in the solution around the roots.

Element %	Mineral Forms	Major function in Plant
Nitrogen (N) 2%	Ca ⁺⁺ and 2 NO ₃ ⁻	proteins, DNA, RNA contain N
Calcium (Ca) 1%	Calcium nitrate	Plant cell wall
Iron (Fe) 0.5%	FeNa EDTA Chelated iron	Energy in Cells



Mineral Nutrition

Nutrition in Plants and Animals:

- Fill in the chart on your worksheet to explore how plant nutrients are used in humans.
- How is Tower Tonic similar and different from human food?





Mineral Nutrition

Dietary recommendations and human nutrition:

- Dietary Guidelines for Americans are issued by the Department of Agriculture (USDA) and the Department of Health and Human Services (HHS).
- Recently, the “Food Pyramid” was replaced by “Choose My Plate.”
- Compare and contrast the two concepts for helping people understand good nutrition.

Goodbye Pyramid.....Hello My Plate

