Grow a Living Pantry:
Growing food without soil

Objective
Students will learn about various ways to grow plants without soil, conduct experiments and explore root words and affixes related to the different growing methods.

Background
Plants need water, air and nutrients to grow. Nutrients are dissolved in water and taken up by the roots of the plant. The most important plant nutrients are nitrogen, phosphorous and potassium.

Traditionally, plants get these nutrients from the soil, but it is possible to grow plants without soil. This is helpful in circumstances when soil is not available—in urban areas where space for growing food is scarce, in areas where the soil has been depleted of nutrients, even in space. It is possible to provide all a plant needs using one of three growing methods—hydroponics, aquaponics or aeroponics.

Hydroponics involves growing plants by floating their roots in nutrient-enhanced water. Aquaponics blends aquaculture (feeding fish in tanks) with hydroponics. With aeroponics plants are suspended in air and their roots are misted with a nutrient heavy solution. In all three systems water is recirculated, so it saves water—another benefit.

If you have ever placed a plant clipping in a glass of water in the hopes it would develop roots, you've practiced a form of hydroponics. The US Army used hydroponic culture to grow fresh food for troops stationed on the infertile Pacific Islands during World War II. The word *hydroponic* comes from two Greek words meaning "working water." The word *hydro* in Greek means "water," and *ponos* means "labor." Hydroponic plants are grown in inert media that holds the roots in place but does not supply any nutrition. Some examples of inert growing media are perlite, vermiculite, coconut fiber, gravel, and sand. A perfectly balanced, pH-adjusted nutrient solution is delivered to the roots in a highly soluble form. All the nutrition comes from the nutrient solution (water and fertilizer combined).

Aquaponics uses a recirculating water system to raise and harvest plants and fish together in a symbiotic environment. Water heavy in organic animal waste is pumped from a fish tank into grow beds where plants filter out the nutrients. The purified water is then recycled back into the fish tank. Nearly any freshwater fish that thrives in captivity can be used, from goldfish to catfish. Fast-growing tilapia are the most commonly used in commercial aquaponics.

Aeroponics is the process of growing plants in an air or mist environment without the use of soil. The word "aeroponic" is derived from the Greek meanings of *aero-* (air) and *ponos* (labor). With aeroponics growing plants are suspended in a closed or semi-closed environment by spraying the plant's dangling roots

Oklahoma Academic Standards

GRADE 5
Speaking and Listening: R.1,2,3. Reading and Writing Process: R.1,2,3. Critical Reading and Writing: R.7. Vocabulary: R.1,2,3 Physical Science: 1-3. Life Science: 1-1; 2.1,2; 5. Earth Science: 2.1; 3.1

GRADE 6
Speaking and Listening: R.1,2,3. Reading and Writing Process: R.1,2,3. Critical Reading and Writing: R.7. Vocabulary: R.1,2,3 Life Science: 2-1,3,4,5. Earth Science: 3-3

GRADE 7
Speaking and Listening: R.1,2,3. Reading and Writing Process: R.1,2,3. Vocabulary: R.1,2,3 Life Science: 1-5

GRADE 8
Speaking and Listening: R.1,2,3. Reading and Writing Process: R.1,2,3. Vocabulary: R.1,2,3 Physical Science: 1-3. Earth Science: 2-1

Vocabulary

aquaculture— the cultivation of living things (as fish or shellfish) naturally occurring in water
depleted— to reduce in amount by using up
inert— unable or slow to move, act, or react
infertile— not capable of growing and developing
medium— a surrounding substance or condition
nutrient—a substance or ingredient that furnishes nourishment
pH— a number used in expressing acidity or alkalinity on a scale whose values run from 0 to 14 with 7 representing neutrality, numbers less than 7 increasing acidity, and numbers greater than 7 increasing alkalinity; also : the condition represented by such a number
soluble— capable of being dissolved in a liquid
symbiotic— the living together in close association of two different kinds of organisms (as a fungus and an algae making up a lichen) especially when such an association is of benefit to both
urban— of, relating to, typical of, or being a city

and lower stem with an atomized or sprayed, nutrient-rich water solution. Some growers favor aeroponic systems over other methods of hydroponics because the increased aeration of nutrient solution delivers more oxygen to plant roots, stimulating growth and helping to prevent pathogen formation.

All three forms of soilless gardening conserve water and reduce the amount of space needed for growing. Plants can be planted closer together because root structures tend to grow down, not out, because they are not competing with other plants for water and nutrients. Since the plants are grown inside, under lights, they can be grown year round.

English Language Arts

1. Read and discuss background and vocabulary.
2. Hand out the Reading Page for students to read individually or as a group.
   —Students will answer the comprehension questions included on the Reading Page.
   —Students will compare and contrast the three methods of growing plants without soil. Students will develop charts to demonstrate the similarities and differences.
3. The three methods of soilless growing get their names from Greek root words—*aero*, *hydro*, *aqua* and *ponos*.
   —Students will make a list, with definitions, of other words containing these roots.

Science

1. Students will design experiments for growing plants without soil, using one or more of the methods discussed. Instructions for three different simple growing systems are included with this lesson.
   —Students will design variables to test, e.g., different fertilizer products, temperature, light, different plants, etc.
   —The control of pH (potential Hydrogen) is extremely important, not only in hydroponics but in soil as well. Plants lose the ability to absorb different nutrients when the pH varies. Correct pH aids in nutrient uptake. 0-6 is acidic; 8-14 is basic (base); 7 is neutral and ideal. Students will include pH testing in their experiments.

Extra Reading

Bramwell, Martyn, *Food Watch: Protecting Our Planet*, DK Children, 2001.
Burnie, David, *Plant*, Eyewitness Books, DK, 2011.
Edom, Helen, *Science With Plants*, Usborne, 2007.

Reading Page

Growing Food Without Soil

Plants need water, air and nutrients to grow. Nutrients are dissolved in water and taken up by the roots of the plant. The most important plant nutrients are nitrogen, phosphorous and potassium.

Traditionally, plants get these nutrients from the soil, but it is possible to grow plants without soil. This is helpful in circumstances when soil is not available—in urban areas where space for growing food is scarce, in areas where the soil has been depleted of nutrients, even in space. It is possible to provide all a plant needs using one of three growing methods—hydroponics, aquaponics or aeroponics.

Hydroponics involves growing plants by floating their roots in nutrient-enhanced water. Aquaponics blends aquaculture (feeding fish in tanks) with hydroponics. With aeroponics plants are suspended in air and their roots are misted with a nutrient heavy solution. In all three systems water is recirculated, so it saves water—another benefit.

If you have ever placed a plant clipping in a glass of water in the hopes it would develop roots, you've practiced a form of hydroponics. The US Army used hydroponic culture to grow fresh food for troops stationed on the infertile Pacific Islands during World War II. The word *hydroponic* comes from two Greek words meaning "working water." The word *hydro* in Greek means "water," and *ponos* means "labor." Hydroponic plants are grown in inert media that holds the roots in place but does not supply any nutrition. Some examples of inert growing media are perlite, vermiculite, coconut fiber, gravel, and sand. A perfectly balanced, pH-adjusted nutrient solution is delivered to the roots in a highly soluble form. All the nutrition comes from the nutrient solution (water and fertilizer combined).

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Aeroponics is the process of growing plants in an air or mist environment without the use of soil. The word "aeroponic" is derived from the Greek meanings of *aero-* (air) and *ponos* (labor). With aeroponics growing plants are suspended in a closed or semi-closed environment by spraying the plant's dangling roots and lower stem with an atomized or sprayed, nutrient-rich water solution. Some growers favor aeroponic systems over other methods of hydroponics because the increased aeration of nutrient solution delivers more oxygen to plant roots, stimulating growth and helping to prevent pathogen formation.

All three forms of soilless gardening conserve water and reduce the amount of space needed. Since the plants are grown inside, under lights, they can be grown year round. Growing cycles are faster with certain crops. Plants can be planted closer together because root structures tend to grow down, not out, because they are not competing with other plants for water and nutrients.

COMPREHENSION QUESTIONS

What is the main idea of this passage? What are some of the supporting details?

Summarize the author's intent.

List some of the circumstances in which growing plants without soil would be useful.

What are some of the advantages of growing plants without soil?

Compare and contrast the three methods of soilless growing. Explain how the advantage and disadvantage of each.

Oklahoma Ag in the Classroom is a program of the Oklahoma Cooperative Extension Service, the Oklahoma Department of Agriculture, Food and Forestry and the Oklahoma State Department of Education.

Hydroponic Garden

Materials

black plastic heavy-duty receptacle liner bag
styrofoam ice chest with deep lid cover
6 styrofoam cups
6 gallons distilled water
marking pen
craft knife
perlite
sphagnum moss
lettuce seedlings
plant nutrient mix

1. Line Styrofoam ice chest with black liner bag. Fill with distilled water.
2. Using the top of the Styrofoam cups as a template, trace six evenly-spaced circles on the Styrofoam chest's deep lid cover. With a craft knife, cut out circles 1/4 inch smaller than the Styrofoam lid circles.
3. Using a craft knife, cut a small hole in the bottom of each Styrofoam cup. Place Sphagnum moss in the cups and top with perlite, filling to just under the rim of the cup.
4. Insert lettuce seedlings into perlite, and fill in perlite around seedling.
5. Place lid upside down on the chest. Place cups in holes of lid.
6. Water seedlings each day with nutrient mix, making sure the water level in the container is not too high. There should be about an inch of space between the water line and the bottom of the Styrofoam cups. After a week to 10 days, roots from the seedlings should begin entering the container. As the plants grow, pick leaves as desired, but be careful not to overharvest.

Source: http://www.marthastewart.com/343325/how-to-build-a-hydroponic-garden?center=859439&gallery=275706&slide=344310

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Bucket Aeroponics

Materials

saw to cut poly riser
sharpie
hole saw
drill for hole saw
safety glasses
5-gallon food-grade bucket with lid
1/2- by 12-inch cut-off threaded poly riser
360-degree 1/2-inch plastic headed threaded sprinkler head
317-gallon-per-hour (or equivalent) 1/2-inch threaded hydroponics or pond pump with suction cups and pre-filter
indoor/outdoor electrical timer with 30-minute increments
hydroponic net pots with rubber foam lids
lettuce seedlings

1. Carefully cut holes for the net pots using a drill and ole saw. The net pots should fit snugly in the holes and not fall through.
2. Screw the threaded poly cut riser to the hydroponic pump. Cut the threaded rise to desired height and add the threaded sprinkler head. Place the pump with riser and sprinkler head in the bottom of the bucket.
3. Run the pump plug through a net pot hole and plug it into the timer. Set the timer for 30 minutes on and 30 minutes off.
4. Fill the bucket with 2 gallons of water.
5. Place the net pots in the holes.
6. Place the lettuce plants in the net pots.

For a video demonstration and illustrated instructions, go to http://gardenpool.org/online-classes/how-to-make-a-simple-5-gallon-bucket-aeroponics-system

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Tabletop Aquaponics

Materials

drill with 1/8-in and 1/16-in drill bits
caulk and caulk gun
hacksaw
10 gallon fish tank
2-foot section of 4-inch PVC pipe
two 4-inch PVC endcaps
30-45 gal/hr fountain pump
3 feet of 3/8 inch vinyl tubing
5-15 gal air pump
1 air stone
connective tubing
aquarium gravel
plants
handful of feeder goldfish*
(optional) red wiggler worms to help break down fish waste and help keep the system clean
clean sponge

1. Place gravel at the bottom of the aquarium, fill it with water and put in the air pump. Allow the water to sit for at least 24 hours to allow chlorine from the tap water to evaporate.
2. After 24 hours, add fish and sponge (The sponge will transfer some of the beneficial bacteria needed for cycling your system).
3. Use a hacksaw to cut a 2-inch wide opening along the length of the 4-inch PVC pipe. (This will take patience.) This open section becomes the top of the pipe for the plants to sit in.
4. Flip over the PVC pipe and drill 4 holes on the bottom to one side. Use the larger drill bit for the holes nearest the end of the pipe. Start with two or three holes and add more if necessary. Too many holes may cause the plants to dry out. Be careful to remove all the shavings left over from the sawing and drilling to keep it out of the water.
5. Add a line of caulk along the edges of the PVC pipe and secure the end caps. Dry the caulk overnight.
6. Set the PVC pipe on top of the aquarium and partially fill with gravel.
7. Submerge the fountain pump and run the vinyl tubing up into the PVC pipe. Secure the tubing with gravel inside the PVC pipe.
8. Add plants and turn on the fountain pump.

*Start with inexpensive fish until the system is established, and add more expensive fish later. Feeder fish tend to jump out of the tank. Fantail goldfish are slightly more expensive but can't jump out as easily.

Source: "The Thrify Gardener," http://gardenthrifty.blogspot.com/2012/11/bare-bones-home-aquaponic-system-50.html

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