Curriculum development was supported by the USDA National Institute of Food and Agriculture.	Kansas Foundation for AGRICULTURE IN THE CLASSROOM (KFAC)	Curriculum Development Team Chelsea McCall Emily Duello Katie Hutchison Celsey Crabtree

Course:	Biology 9-12	**Unit:**	Vertical Gardening - Agriculture Careers
Lesson Title:	Nutrition and Growing Media		
Estimated Time:	4 class periods of 40 minutes		

Objectives:

1) Define and identify essential elements necessary for plant growth.
2) Select growing media for seeds.

Equipment Needed:

Electronic device to access Lesson 3 slides and Mineral Nutrition
Plant nutrient test kit
Bowl/plate for media samples
Provide electronic device for students to access handouts if needed
Small whiteboards (optional)
Ph test strips

Supplies Needed:

Paper/Notebook for bell ringer
Media samples: Clay pebbles, Rockwool, potting mix, perlite, peat moss, vermiculite
Paper copies of part one of Growing Media Notes (1 per student)
Paper copies of part two of the Growing Media Notes handout. (1 per student)
Paper copies of the Plant Nutrients Notes handout. (1 per student)

Accessibility Options

Students can access information visually through online videos with subtitles and auto-translations.
Utilize Speech-to-Text and text-to-speech add-ons for reading/listening/writing support (Updated 7/17/23)
Multisensory resources- Growing media, pH measurement technology, and model supplies

For more suggestions, please visit:
https://www.washington.edu/doit/equal-access-science-and-students-sensory-impairment

Instructor Directions & Estimated Time	Procedures
Day 1 40 minute period	Essential elements - nutritional needs
Day 2 40 minute period	Soil - growing media - nutrition provided
Day 3 40 minute period	Creating nutrient cycle models
Day 4 40 minute period	pH testing stations

No.	9-12 Next Generation Science Standards		
HS-LS 1-6	Matter and Energy in Organisms and Ecosystems: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar Molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.		
	Disciplinary Core Ideas	Science and Engineering Practices	Cross-Cutting Concepts
	LS1.C: Organization of Matter and Energy Flow in Organisms	Constructing Explanations and Designing Solutions	Energy and Matter

No.	9-12 National Agriculture Literacy Outcomes
T1. 9-12 h T2. 9-12 b&d	h. Understand the natural cycles that govern the flow of nutrients as well as the the way various nutrients (organic and inorganic) move through and affect farming and natural systems b. Compare similarities and differences between organic and inorganic nutrients (i.e., fertilizer) on plant growth and development; determine how their the application affects plant and animal life d. Evaluate evidence for differing points of view on topics related to agricultural production, processing, and marketing (e.g., grazing, genetic variation, and crop

	production; use of fertilizers and pesticides; open space; farmland preservation; animal welfare practices; world hunger)

Vocabulary	
Soil Compaction	When soil particles compress together and become more dense because of external stresses.
Algae	Eukaryotic, photosynthetic organisms are mostly found in aquatic environments and can be unicellular or multicellular.
Algal bloom	a rapid increase in the population of algae in a given area of water, which often causes the water to look green
Micronutrient	a chemical element or substance (such as calcium or vitamin C) that is essential in minute (small) amounts to the growth and health of a living organism
Rockwool	a lightweight hydroponic substrate made by spinning rock into fine fibers, which are then formed into various shapes based on their intended uses.
Perlite	a naturally occurring mineral that is added to garden soil to improve aeration, water retention, and drainage.
Vermiculite	A naturally occurring mineral that is lightweight and water-absorbing, allowing for improved drainage and moisture retention when added to soil.

Careers Mentioned	
Biochemist	Study life forms, their composition functions, and how they are affected by chemical processes. They conduct research, perform experiments, and record information to better our understanding of life, death, and everything in between.
Hydrologist	Studies water and its movement around the planet. They also study how water affects its surrounding environment and how environmental factors affect the quantity and quality of available water.

Day 1

Day 1 Essential Question: What types of growing media are best for vertical gardens?

1) **Observation stations**- Set up 4 different stations (Clay pellets, rockwool, potting mix, perlite, peat moss, vermiculite) for students to visit. At each station, ask the students to observe the growing media. What quantitative or qualitative observations can they make? What questions do they have? For example: What does it look like? What does it feel like? What does it smell like? How big/heavy is it? Have students record/draw/label their observations and questions in Part 1 of the Growing Media Notes handout. After 2 minutes at each station, have students rotate. After making observations at each station, ask students to form groups of 3-4 and answer the question: Which growing medium do you think would be best for plants? Why? (15 minutes)

2) **Growing media jigsaw**- Each group will research a different type of growing medium and share the advantages and disadvantages of each. Students can present to the whole group or report findings back to individual groups using Part 2 of the Growing Media Notes handout.

Day 2

Day 2 Essential Question: What nutrients do plants need to be healthy?

1) Bellringer and discussion questions (10 minutes). See the Lesson 3 slides 1 and 2. These can be completed in small groups of 3-4
with 5 minutes for discussion and 3-5 minutes for sharing with the class. Have 1 student read the question, 1 student record the group's answers on a small whiteboard or a piece of paper, and 1-2 students share each group's answers with the class.

2) Nutrient research- Students work in teams to identify the sources of each nutrient (how plants get them), why plants need them, and their effects on the environment (good and bad). Students can use the resources on Lesson 3, slide 3 to complete their column of the Plant Nutrients Notes handout.

3) Plan your Nutrient Cycle Models (Look at Lesson 3, slide 4. Discuss what good models have. Students work in teams or individually to create a rough draft to plan their model

Day 3

Day 3 (Same essential question as Day 2)

Student teams or individuals create nutrient cycle models on paper and present them to the class. Students will complete the Plant Nutrient Notes handout during the presentations. *Currently, there are resources for students to do N, P, and K. List other micronutrients as an extension

Day 4 Extension (Optional)

Essential Question: Can I use any liquid to water plants?
Students will create their own fertilizer solutions. Several of these require that they sit for a week. Students could then use these solutions on their plants.

pH Learning Stations
Station 1: pH Station: Students do pH Phet simulation

Station 2: Vocabulary station: Students use Quizlet to learn relevant terms- Can listen to words and definitions and play matching game
Station 3: pH Scale: Students draw and label their own pH Scale
Station 4: Practice taking pH
Station 5: Students diagram the preferred pH ranges of various plants to determine what an ideal pH would be for nutrient solutions.

If students made their nutrient solutions, they could then test their solutions to see if they fall within the preferred range for the plants they are growing.

Main topics teachers should know:

Growing media provides support, water, and nutrients to plants. Traditional soil may not be the best option in vertical gardens due to space constraints and water management needs. Instead, alternative, lightweight, and well-draining media are often used. Rockwool is a popular growing medium made from molten rock spun into thin fibers. It is lightweight, retains moisture well, and provides good aeration, making it ideal for hydroponic and vertical systems. Plants grown in Rockwool can easily absorb water and nutrients, and the medium is sterile, reducing the risk of pests and diseases. Another medium is perlite is a white, lightweight, volcanic rock that is expanded by heating. It provides excellent aeration and drainage, which helps prevent root rot and overwatering. It is often mixed with other growing media to improve soil texture or used alone in hydroponic systems. Vermiculite is a mineral that expands when heated. It has a spongy texture and highly retains moisture and nutrients. It can help seeds germinate and retain water in vertical garden setups, especially when mixed with other growing media like perlite.

Soil compaction occurs when soil particles are pressed tightly together, reducing the space between them. This limits the soil's ability to hold air and water, making it harder for roots to penetrate and absorb nutrients. In vertical gardening, compaction can be a problem if the wrong growing medium is used, as it can restrict plant growth. Choosing a medium with good aeration can help prevent compaction.

Plants require a range of nutrients for healthy growth which are categorized into macronutrients and micronutrients. Micronutrients are needed in smaller amounts but are still essential for plant health. These include iron, manganese, zinc, copper, boron, molybdenum, chlorine, and nickel. A deficiency in any of these nutrients can lead to poor growth, yellowing leaves, or other health issues. Measuring these nutrient levels is done by using soil test kids, electrical conductivity meters, and pH meters. Soil test kits can measure pH levels and the presence of key macronutrients like nitrogen, phosphorus, and potassium, which can be fairly simple. Electrical conductivity meters measure the concentration of nutrients dissolved in water and can be partially useful in hydroponic systems where the nutrients are mixed in water. The pH level affects nutrient availability and monitoring the levels ensures optimum plant growth. If the growing conditions are too acidic or not acidic enough the plants may have difficulty absorbing certain nutrients.

Because of the high moisture and water content, there is a chance that algae will be present. Algae are simple aquatic plants that can grow quickly in high-nutrient water. In hydroponics and vertical systems, algae can become a problem if the nutrient solution becomes exposed to light. Algal blooms happen when the algae grow out of control due to extreme access to nutrients in the water it is growing. In a vertical farming system, algal blooms can block water flow and reduce oxygen levels along with competition with other crops. To prevent algae growth, it is important to manage the nutrient levels in the water, limit light exposure, and keep the hydroponics systems clean.

Biochemists contribute by studying the molecular processes within plants, including nutrient uptake and metabolism. They develop nutrient solutions tailored to the specific needs of crops grown in hydroponic, aeroponic, or other soilless systems, ensuring efficient growth and minimizing waste. Biochemists also research methods to prevent and manage issues like algal blooms, analyzing how nutrient imbalances and environmental factors promote their growth. On the other hand, Hydrologists focus on understanding water movement, quality, and availability within vertical farming systems. They design efficient water management strategies to minimize waste, recycle nutrient-rich solutions, and prevent waterlogging or contamination. By combining their expertise, biochemists and hydrologists help create sustainable, high-yielding vertical farming operations that maximize resource efficiency while addressing environmental concerns such as algae growth and nutrient runoff. Their contributions ensure that vertical farming remains a viable and scalable solution for global food production.

    - https://www.youtube.com/watch?v=GTUVRieYoZ8
    - https://www.trees.com/gardening-and-landscaping/growing-media
    - https://www.gardeningchores.com/natural-fertilizer-for-indoor-plants/
- Reference this document with careers related to this lesson
    - https://docs.google.com/document/d/1x_pPE16psFiNNyWm1-5CE3oZ5NQoCI0uDXKHuVJotmY/edit

Suggestions for instruction:

On day 1, choose growing media that you can easily access and use for student projects. If students will be building vertical gardens that do not use hydroponics, potting mix will be best. Students could use sand if they are studying the differences between growing plants in sand or potting mix. Edit the jigsaw activity to include whatever growing media you have decided to use for the class. Clay pebbles, rock wool, and coconut coir work well for hydroponic systems. Perlite, peat moss, and vermiculite are typically used as amendments to growing media or soil and are not used on their own typically. Peat moss is very acidic on its own, and requires a lot of water to rehydrate.

On day 3, the nitrogen cycle is the best nutrient cycle for students to work on. The phosphorus and potassium cycles are biogeochemical cycles that involve living organisms, soil, and the lithosphere. These cycles tend to be fairly simple in comparison to nitrogen. The nitrogen cycle is a gaseous nutrient cycle that includes atmospheric, biological, and geochemical components that can be more interesting and relevant to students.

Kansas Ag History

The first Kansas farmers were Indigenous growers who raised small crops of corn and beans to supplement the diet of the game. They planted seeds in holes punched in the ground with sharpened sticks and cultivated the crop with implements fashioned from buffalo bones. The first European farmers were Frenchmen who settled in the Wolf River country, now Doniphan County, during the latter part of the eighteenth century, and planted fields of corn in the rich glacial soil of this northeastern corner of the State.

In 1827 the Government decided to conduct agricultural experiments in the Territory acquired through the Louisiana Purchase and sent Daniel Morgan Boone to teach farming to the Kansas Indians. The early missionaries also engaged in agriculture to some extent, but it did not become the major occupation of the Kansas Plains until the Territory was opened to settlement in 1854. The pioneer farmers of the 1850s broke the sod with ox teams hitched to crude plows. Many of them planted corn by slitting the sod with an axe, dropping the kernels into the slits, and closing them by stamping. Corn was cultivated with the hoe; wheat was sown by hand, harvested with a cradle, and threshed with a flail. The first Mennonite wheat farmers separated the grain from the straw by rolling or dragging cogged cylindrical stones over the bundles. At the close of the Civil War, the Government offered homesteads in Kansas to Union Army veterans and more than 100,000 took advantage of the opportunity. These sturdy young veterans were Kansas' first real pioneer farmers.

The first radical change in Kansas agriculture occurred in 1874 when a colony of Mennonites came to the plains of central Kansas from southern Russia. During their sojourn in Russia, they developed a variety of hard wheat called Turkey Red because of the color of the grain and because the seed had originally been obtained from Turkey. This variety thrived on the steppes of Russia a semi-arid plains region and the Mennonites rightly believed it was adapted to Kansas' peculiar conditions of climate and soil. The second revolution in Kansas agricultural methods, machine farming, was hailed at its inception as the dawn of an era of everlasting plenty, but it has resulted in near disaster. Prairie agriculture had two elements that encouraged the rapid development of machine farming: the general level of the plains and the abundance of horsepower. There were few trees to be cut in clearing the land, and no stumps to impede the progress of wheeled implements. There were also thousands of wild horses in Kansas and horse wranglers prospered in the 1880's by roping and breaking these animals for use on farms. At the same time, horse breeders began to import heavy European workhorses and cross them with wild horses for the farm market.

After the first wave of homesteaders swept across the State following the Civil War, a period of mass development and speculation began. Many Kansas farmers worked under the handicap of a heavy mortgage from the beginning. In the early 1800s, the pioneer farmers paid the interest on their mortgages by killing buffalo and selling their hides. After ruthlessly exterminating the buffalo, they paid taxes and interest by gathering buffalo bones and selling them to fertilizer manufacturers. The settlers, having acquired the land through mortgages, were forced to borrow more money to buy material for improvements in machinery and livestock. Thus mortgaged before the first plow was put to sod, a large proportion of Kansas farms never showed a profit. Therefore, hundreds of farmers were facing foreclosure in 1890. The record-breaking corn crop of 1889 had done little to relieve the situation. Hampered by their heavy mortgages and with the ever-present specter of drought, Kansas farmers needed both a bumper crop and a good price to break even. But a nationwide depression had lowered the price of farm produce so that corn sold as low as ten cents a bushel.

The Farmers' Alliance, which later became the Populist party, appeared at this time, advocating "free silver," a reform of the banking laws, and other measures calculated to enable the farmers to pay off their mortgages. In 1892 the Populists elected a Governor and succeeded in securing a majority in the State legislature. Some benefits resulted but on the whole, the speculators and industrialists succeeded in defeating the aims of the Populists.

Accompanied by a steady increase in farm tenancy, Kansas agriculture moved into the twentieth century and the motor age. The use of motorized farm machinery may be thought of as a third cycle in Kansas farming. In 1910 there were 1,150,000 horses and mules on the farms, and these draft animals provided a home market for $50,000,000 worth of Kansas' corn and other feed. But tractors began to replace draft animals in 1915 and the number of all kinds of tractors and motorized harvesters steadily increased. The greater efficiency of large-scale farming led naturally to the introduction of the combine; and the World War, through its enormous consumption of grain, accelerated its use. By 1936, motorized farming was at its height with 63,000 farm tractors and 24,000 combines; in the same year, there were only 545,000 draft animals.

In 1931, at the height of the motorized farming period, they planted 12,000,000 acres and raised 240,000,000 bushels which they sold for $81,500,000. Motorized farming surpassed the older type by a margin of 60,000,000 bushels of wheat in a year, but smaller crops brought greater financial returns. With machines, the farmers raised more wheat, by 60,000,000 bushels, and received less money, by $70,000,000. The price per bushel was ninety cents in 1914 and thirty cents in 1931. Wheat is in some ways a substitute for corn, and the thirty-cent wheat pushed corn down to ten cents a bushel. Feeding this cheap grain to hogs and cattle to market it in the form of high-priced meat, the unfortunate farmers depressed the market for hogs to two-and-one-half cents a pound. It took a 200-pound porker to bring in a five-dollar bill, just as in 1889 the farmers had to load fifty bushels of corn on a single wagon to get five dollars for one trip to the market.

It was not until 1914 that wheat acreage exceeded that of corn; there were 9,116,138 acres of wheat and only 5,279,552 acres of corn, the deposed king. This shift represented a sharp increase in wheat acreage rather than a heavy decrease in corn. Wheat reached a peak in 1931 with an acreage of 12,345,596; it dropped in 1933 to 5,755,328 acres, owing partly to the depression price of this grain, which caused many farmers to sow their land to other crops or let them lie fallow, and partly to the U. S. Agricultural Adjustment Administration program. In that year corn, with an acreage of 7,725,043, briefly regained its former supremacy.

Hot winds and inadequate rainfall during the growing season resulted in a series of corn crop failures in eastern Kansas that brought hundreds of formerly prosperous farmers to the verge of bankruptcy. Desperately in need of a cash crop to meet taxes and interest in the fall of 1936, many of these corn growers tore down their corn field and pasture fences, sawed the hedge fence posts into stove wood lengths, and sowed the fields to wheat. The venture was successful. With a good yield and prices ranging from $ I to $1.10 a bushel, profits were large.

Consequently, new wheat fields were planted in 1937 and the State's total wheat acreage leaped to the record of 13,549,000. The purchase of tractors and combines absorbed much of the profits from the 1937 crop, however, and a short crop in 1938 with a much lower price gave the novice wheat growers a severe setback. Farmers who had stubbornly "stuck to corn" were able to fill their bins for the first time in five years, while their get-rich-quick neighbors were marketing a scanty wheat crop at less than sixty cents a bushel. Grain sorghum and other forage crops were cultivated with success and the replenished supply of grain for livestock feed brought beef and pork "on the hoof" back to deserted pastures and hog lots.

In 1936 there were 174,580 farms in cultivation in the State, averaging 275 acres in area. Of these 96,896 were wholly or partially owned by their occupants, while 76,771 were occupied by tenants. Farms vary in size from lo-acre truck patches in the eastern river valleys to 50,000-acre ranches in some of the western counties. In sections of eastern Kansas, where rainfall is adequate and soil sufficiently fertile to permit intensive farming and wide diversification, 80 to 160 acres is normally a subsistence homestead. On the western plains where wheat is often the only crop, few farmers attempt to make a living on less than 240 acres and many wheat farmers plant several sections.

The northeastern section of the State is regarded as part of the Corn Belt, especially Doniphan, Atchison, Brown, Nemaha, Jackson, Jefferson, Leavenworth, and Shawnee counties, which have large areas of rich glacial drift, and to a lesser degree the remaining counties in the northern tier as far west as Jewell County. Before the drought cycle, more than half of the average homestead of 160 acres was devoted to corn. The remaining portions of the typical Kansas corn-hog farms were pasture, and small fields of wheat, oats, or grain sorghum. The farmer developed the self-sustaining corn-hog economy by feeding his corn to the hogs to fatten them for market and selling the surplus grain.

The river valleys of northeastern Kansas and the major portion of southeastern Kansas are devoted to general farming with diversified cultivation. The Flint Hills region, which is carpeted with blue-stem grass, is one of the finest grazing sections of the United States. West of an imaginary line extending north and south through Salina and Wichita to the Oklahoma Line is the winter wheat country, where until recent years, nearly one-half of the hard wheat in the United States was produced.

Efforts at fruit growing, especially in eastern Kansas, met with phenomenal success during the early seventies. But, as the virgin soil was drained of its productivity, many orchards died and were never successfully replanted. The upland glacial drift in Doniphan County, however, still supports large apple orchards and the cultivation of this fruit is a leading industry in the areas along the great bend of the Missouri River. Strawberries are also grown in the three river counties.

Broom corn is grown extensively in the southwestern corner of the State, in Seward, Stanton, Stevens, and Morton counties. Before the dust storms that accompanied the recent drought cycle, the towns of Elkhart and Liberal were among the largest shipping centers of this product in the world. Sugar beets are grown in the Arkansas River Valley near Garden City and Larned where large areas are irrigated. The cultivation of flax, which was an important crop before the introduction of winter wheat, has been revived to a considerable extent in recent years, especially in southeastern Kansas. Experts from the State College are urging farmers to grow flax on a larger scale.

In the fertile valleys of eastern Kansas, particularly the Kaw Valley, potatoes and melons are major crops. In a good season, the State produces 2,500,000 bushels of Irish potatoes. Alfalfa, a deep-rooted drought-resistant hay, is important among the lesser crops. Introduced by Charles J. Grosse, of Marion, who planted 90 bushels of seed imported from California in 1869, its first recorded acreage was in 1891, when 34,384 acres were planted. A peak acreage of 1,277,875 was reached in 1918 and the ten-year average since 1927 has been approximately 750,000 acres.

In general, the years of drought have considerably reduced the returns from Kansas agriculture; yet in one of the worst drought years, 1934, the wheat crop was valued at $67,205,989, and the corn crop at $9,183,968. The 1937 wheat crop was valued at $170,000,000. In 1933 Kansas livestock was valued at more than $100,000,000. Before the emergency drought programs of 1934 more cattle were raised on Kansas farms than in the days when the western part of the State was an open range. It is estimated (1937) that Kansas has nearly 3,000,000 cattle; 2,500,000 beef cattle, and 500,000 dairy animals. Approximately 2,000,000 hogs and 300,000 sheep are raised for market annually.

Drought-resistant strains of corn and wheat have been developed, and farmers have learned through experience to diversify their crops. In recent years the acreage of grain sorghum, of which many varieties have been produced, has increased, especially in western areas where the rainfall is not adequate for growing corn and the soil has been pulverized to the danger point by a series of unsuccessful attempts to grow wheat.

Nearly every Kansas county is receiving the benefits of the extension service conducted by the United States Department of Agriculture and Kansas State College. The three phases of this service include working with the farmers in agricultural methods, working with farm women in home economics, and working with boys and girls in the 4-H Clubs.

"Through the development of the head, heart, hand, and health," writes M. H. Coe, State club leader, "comes the term '4-H,' which signifies the fourfold educational development or training which 4-H Club boys and girls must receive to ensure success in any undertaking." Each club member selects a project designed to show some better practice on the farm or in the home. In 1933 there were 19,353 members in 100 counties with 26,239 completed projects. In the same year, 4-H Club members made 4,321 entries at the Topeka and Hutchinson State Fairs and won $4,325 in prize money." The total value of products raised by 4-H Club members was $387,726.

Adapted from:
https://www.kspatriot.org/index.php/articles/48-kansas-agriculture/226-history-of-kansas-agriculture.html

Careers:

Biochemist:

Description: Biochemists study life forms, their composition functions, and how they are affected by chemical processes. They conduct research, perform experiments, and record information to better our understanding of life, death, and everything in between. A biochemist may have responsibilities such as: identifying new areas of beneficial research in the bounds of a company's market, creating a working hypothesizes of function for all potential bio-products, designing experiments to test hypothesizes, conducting all experiments within the guidelines of the scientific standards, and condense and compile findings into reports for management to review.

Education: Biochemists and biophysicists need a Ph.D. to work in independent research and development. Many Ph.D. holders begin their careers in temporary postdoctoral research positions. Bachelor’s and master’s degree holders qualify for some entry-level positions in biochemistry and biophysics.

Salary: The estimated total pay for a Biochemist is $83,440 per year in the United States area, with an average salary of $75,684 per year.

Links:
https://www.purdue.edu/science/careers/what_can_i_do_with_a_major/Career%20Pages/biochemist.html

https://www.glassdoor.com/Salaries/biochemist-salary-SRCH_KO0,10.htm

Hydrologist:

Description: A hydrologist is a scientist who studies water and its movement around the planet. Hydrologists also study how water affects its surrounding environment and how environmental factors affect the quantity and quality of available water. It’s the job of a hydrologist to determine how to best manage water resources and examine how human activities impact them. Hydrologists are primarily problem solvers. They may work on a wide range of issues, such as the following: the identification of water resources for cities or individual facilities, the control of floodwaters from a river, the cleanup of pollution in a coastal wetlands region, the identification of ideal sites for hazardous waste disposal where the waste will not affect water supplies, and monitoring groundwater aquifers.

Education: Undergraduate degree programs in hydrology are few and far between. Instead, aspiring hydrologists can earn an environmental science degree. This degree program focuses on environmental health issues and their remediation. Many hydrologists earn a master’s degree before beginning work in the field. It’s ideal to choose a master’s degree program that is specific to hydrology. Alternatively, students might look for a program in geosciences or environmental science with a concentration in hydrology. With a master’s degree, graduates are

well-qualified to pursue positions as hydrology scientists. After gaining at least a few years of relevant work experience, professionals may decide to go back to school to earn their doctoral degree. This terminal degree is typically a requirement for individuals who intend on making the transition to a faculty or advanced research position at a university.
Salary: The average Hydrologist salary in Kansas is $94,559 as of July 25, 2023, but the range typically falls between $82,959 and $108,443.

Links:
https://www.agcareers.com/career-profiles/hydrologist.cfm
https://www.salary.com/research/salary/benchmark/hydrologist-salary/ks

Take a look at the Career Glossary to find other related careers!

Editors, B. (2019, April 17). *Algae: Botany Basics*. Biology Dictionary. https://biologydictionary.net/algae/#algae-definition

Federal Writers Project. (n.d.). *History of Kansas Agriculture*. Kansas State History. https://www.kspatriot.org/index.php/articles/48-kansas-agriculture/226-history-of-kansas-agriculture.html

Hydrologist. AgCareers. (n.d.). https://www.agcareers.com/career-profiles/hydrologist.cfm

Morgan, L. (2013, February 5). *Characteristics of Rock Wool*. Characteristics of Rock Wool | CANNA Gardening USA. https://www.cannagardening.com/characteristics_of_rockwool#:~:text=Rockwool%2C%20a%20lightweight%20hydroponic%20substrate,growing%20slabs%20and%20granular%20products

Ocken, J., Williamson, S., Hanson, R. L., Noyes, A., Orr, F., & Maria, T. (2023, February 10). *Homemade fertilizers: 10 simple and inexpensive options to fertilize houseplants naturally*. Gardening Chores. https://www.gardeningchores.com/natural-fertilizer-for-indoor-plants/

Purdue College of Science. (n.d.). *Biochemist*. Biochemist - College of Science - Purdue University. https://www.purdue.edu/science/careers/what_can_i_do_with_a_major/Career%20Pages/biochemist.html

Salary.com. (2024, November 1). *Hydrologist salary in Kansas*. https://www.salary.com/research/salary/benchmark/hydrologist-salary/ks

Salary: Biochemist. Glassdoor. (2024, June 6). https://www.glassdoor.com/Salaries/biochemist-salary-SRCH_KO0,10.htm

Staff, Trees. com. (2023, April 13). *Hydroponic Growing Media 101 - the ultimate guide*. https://www.trees.com/gardening-and-landscaping/growing-media

Chemistry in Soil-Plant Relationships

By Andrew and Erin Oxford, Bethel

Objective
Apply the science of chemistry to soil and plant relationships.

Suggested grade levels
11-12

Alaska Content Standards
Science, D1,D3

Terms to Define
ion
nutrients
diffusion
migration
mass flow
transpiration
concentration gradient
solubility
tortuosity

This project presented by Alaska Agriculture in the Classroom through funding from the Agriculture in the Classroom Consortium and the USDA. For more information, visit www.agclassroom.org/ak or www.agclassroom.org

A. Movement of nutrients from the soil to the plant root
For nutrients to be absorbed by plants, they must come in contact with the roots. There are three ways this can occur.

1. Mass Flow
Definition: nutrient ions are transported to the root surface via the flow of water. Plants transpire water which causes a gradient that allows water to flow towards the root. If nutrients are in the water, they will be absorbed by the root.

Nutrients supplied to plant roots by mass flow: Ca^{+2}, Mg^{+2}, NO_3^-, Cl^-, H_3BO_3
These nutrients are not held tightly by the soil which is why these nutrients can be supplied by mass flow.
Mass flow is most important for nutrients or ions in relative abundance in the soil solution.

Factors influencing mass flow:
Soil moisture-drier the soil, less mass flow
Size of root system
Soil temperature-cooler temperatures means less transpiration

2. Diffusion
Definition: in chemistry, diffusion is the spontaneous migration of substances from regions where their concentration is high to regions where their concentration is low. Ion diffusion occurs in the soil solution. Ions dissolved in the soil solution will move from areas of high concentration to areas of low concentration.

Area around the root of an actively growing plant is depleted of nutrients (low concentration), so nutrients in the soil will migrate towards the root

Nutrients supplied to plant root by diffusion: P and K
These nutrients have a low solubility
Factors influencing diffusion:
Concentration gradient- Diffusion rate = Dc x Area x gradient
    Dc = Diffusion coefficient (tortuosity)
    Area = root area
    Gradient = concentration gradient

Tortuosity — the path the diffusion ion must take
Large soil pore and adequate soil moisture decreases tortuosity, so diffusion is easier and occurs more.
Small pores (clay soil) and low soil moisture increases tortuosity which makes diffusion more difficult

Temperature — motion of atoms or ions increases with temperature; hence diffusion rates are greater at higher temperatures; cool soil temperatures often limit diffusion rates in Alaska soils

Chemical and physical properties of the soil
Lower the pH, the more quickly ions will diffuse

How far can nutrients diffuse at field capacity?
1 cm/day for N
0.2 cm/day for K^+
0.02 cm/day for $H_2PO_4^-$

Field capacity is the percentage of water remaining in a soil two days after being saturated and allowed to freely drain.

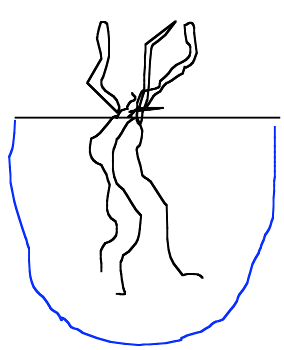
3. Root Interception
Definition— as roots extend through the soil, they continually come in contact with previously unexplored soil. Therefore root surfaces come in direct contact with nutrients during this displacement process.

Factors influencing root interception
The quantity of nutrients absorbed by root interception is a function of the root volume. Typically, no more than 1% of the soil by volume is ever directly contacted by roots. Ca and Mg are most often intercepted by root contact

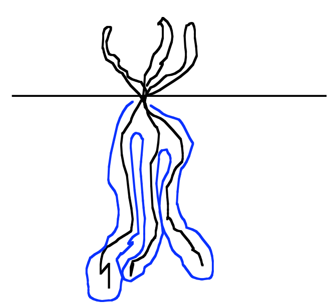
Mycorrhizae can increase nutrient uptake by root interception. Mycorrhiza are a symbiotic association between fungi and the roots of seed plants. This association increases the surface area that roots can extract nutrients from.

B. Root system sorption zone for mobile and immobile nutrients
Mobile nutrients form soluble compounds and do not interact with the soil (i.e. they do not attach to soil particles) and are found in comparatively high concentration in the soil solution. The nutrient sorption zone will be comparatively large.

Immobile nutrients are insoluble and attach to the soil particles. The nutrient sorption zone is more localized around the plant roots.



Mobile Nutrient Root Sorption Zone
NO_3^- is mobile



Immobile Nutrient Root Sorption Zone
K and P are immobile

This project presented by Alaska Agriculture in the Classroom through funding from the Agriculture in the Classroom Consortium and the USDA. For more information, visit www.agclassroom.org/ak or www.agclassroom.org

Erin Oxford teaches at Mikelnguut Elitnaurviat Elementary in Bethel; Andrew Oxford is a district conservationist for the USDA Natural Resources Conservation Services in Bethel.

Peter Bierman, UAF Cooperative Extension Service Land Agent in Palmer, contributed to this lesson.

Soil-Plant Relationships Problems Solutions (see problems on separate student sheet)

1. a. Diffusion is the movement of ions or nutrients from areas of high concentration to areas of low concentration in the soil solution. Generally, the area around plant roots is void of nutrients, so they will diffuse from the bulk soil to the roots. Diffusion is most important for P and K.

b. Diffusion is the least important for N. N moves to the plant roots by mass flow.

c. Three factors that influence diffusion rates are tortuosity, temperature, and soil pH. Tortuosity is the path an ion takes to the root, so if the path is easy and open (soil with large pores) then diffusion will be quicker and easier. Diffusion rates are greater at higher temperatures and less at lower temperatures. The lower the soil pH is, the faster diffusion occurs and vice versa.

2. Soil weight = 2 x 10^6 lbs/acre = 2,000,000 lbs/acre

Soil moisture (water) content = 2,000,000 lbs/acre (0.20) = 400,000 lbs/acre

2000 lbs/acre biomass (0.025) = 50 lbs/acre of N in the plants (0.025 = 2.5% N)
2000 lbs/acre biomass (0.002) = 4 lbs/acre of P in the plants (0.002 = 0.2% P)

400,000 lbs/acre H20 x (100/10^6 or 1,000,000) = 40 lbs/acre of N
400,000 lbs/acre H20 x (0.2/10^6 or 1,000,000) = 0.08 lbs/acre of P

40 lbs/acre of N in the soil solution / 50 lbs/acre of N in the plants = 0.80 = 80%
0.08 lbs/acre of P in the soil solution / 4 lbs/acre of P in the plants = 0.02 = 2%

Amount of N supplied by mass flow = 80%
Amount of P supplied by mass flow = 2%

3. Fertilizer placement is more important with immobile nutrients because in order for them to be utilized by the plant, they need to be placed near the roots. They need to be placed near the roots because they are insoluble and attach to the soil which means they only move by diffusion and not mass flow. In order for the root to be able to readily absorb the immobile nutrients, they must be placed in the root sorption zone which is in direct contact with or in the immediate vicinity of the plant roots.

Name ________________________________

Soil-Plant Relationship Problems

1. Nutrients with low soil solution concentrations move to the plant roots primarily by diffusion. Consider the three nutrients N, P, and K.

a. Briefly define diffusion and indicate for which of these nutrient(s) would you expect diffusion to be the most important for movement to the plant root?

b. For which of these nutrient(s) is diffusion the least important and how does this nutrient move to the plant root?

c. Indicate three factors that influence the rate at which ions diffuse and briefly explain why.

2. A soil contains the following nutrients in solution: Nitrogen (N) at a concentration of 100 ppm and Phosphorous (P) at a concentration of 0.2 ppm. The soil has a moisture content of 20% by weight. Range and pasture grasses growing at this site have the potential to produce 2000 lbs/acre of biomass. Assume the N and P concentration in the plant tissue produced is 2.5% and 0.2%, respectively. What fraction of the N and P could potentially be supplied by mass flow from the soil (top 6'' only)?
Assumptions: Consider only the nutrients present in the solution and assume no additional recharge of nutrients from the soil; Top 6" of soil weighs 2×10^6 lbs/acre

3. Is fertilizer placement a more important issue with mobile or immobile nutrients? Why?

Name Date Class **Growing Media Notes**

Goal: Identify which type of growing medium would be best for your vertical garden.

Part 1: Growing media observations
***Remember: Qualitative r**efers to a sensory description (appearance, texture, etc.) **Quantitative** refers to a measurable amount.

Growing Medium Name	Qualitative observations	Quantitative observations	Questions

Part 2: Growing media observations advantages and disadvantages

Speaker's name	Name of Growing Medium	Advantages	Disadvantages

Reflect: Which growing media would be best for your vertical tower? Give 2 or more reasons to support your claim.

Name: ___________________ Station 4: Practice Measuring pH

Item	What do you predict its pH will be?	Actual pH	Is this item basic, acidic, or neutral?

Name: ________________________ **Plant Nutrients Notes Handout**

Use Slide 3 in the presentation for this section to complete the following notes table.

Nutrient	How do plants acquire this nutrient?	What is this nutrient used for in plants? (Why does it need it?)	What is the effect of this nutrient on the environment (good and bad)?
Nitrogen			
Phosphorus			
Potassium			

List other nutrients that are needed by plants in the space below (you will need to look this up):