Gee Whiz in Agriculture

Yams in Space!

Yams in Space!

Dr. Kim Ragland-Gray, Brandy Blaine, University of Kentucky, the Tuskegee University NASA Center for CELSS, the National Aeronautics and Space Administration, and the Huntsville-Madison County Botanical Garden

Student Worksheet 1

Have you ever taken a long trip? If so, you probably took something to eat or drink with you. Now think about astronauts traveling from Earth to Mars or Pluto or even to another galaxy. Obviously, they're going to have to take their food with them. But, the distances astronauts are going to have to travel will take years and years to cover. So, not only will they have to take food with them, they will have to be able to grow more to feed themselves when their original supplies run out.

Growing food in space? Sure, and the scientists at Tuskegee University in Tuskegee, Alabama, in cooperation with NASA, are working with the sweet potato and the peanut as food sources for future space flights. These plants are versatile and can provide astronauts with a wide variety of foods. The scientists are trying to figure out how to grow and use these plants most efficiently in the conditions that will exist in space: no gravity, high levels of carbon dioxide, no sunlight, cramped spaces, hydroponic growth systems, and no garbage collection.

It takes many scientists, trained in many fields, to accomplish this goal. Some of the sciences involved in this work include:

Agronomy—The application of the soil and plant sciences to soil management and crop production.
Botany—The scientific study of plants.
Chemistry—The scientific study of the composition, structure, properties, and reactions of matter.
Engineering—The application of scientific principles to practical ends.
Genetics—The biological study of heredity, particularly hereditary transmission and variation.
Horticulture—The science and art of raising and tending plants.
Microbiology—The scientific study of microorganisms and their effects on other life forms.
Molecular Biology—The science of living organisms and their sustaining processes at the cellular and subcellular levels.
Nutrition—The study of the process by which living things ingest and use food.
Plant Physiology—The scientific study of the life processes and functions of plants.

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Student Worksheet 2

Vocabulary

Aerobic
Anaerobic
Bacteria
Carbon dioxide
Chlorophyll
Deleterious
Edible
Geotropic
Gravity
Hydroponics
Inoculate
Microorganism
Non-edible
Nutrients
Oxygen
Photosynthesis
Senescence

Learn and Write About

Booker T. Washington and **Dr. George Washington Carver** were important players in American history and, particularly, in the history of Tuskegee University. You can learn more about them from an encyclopedia or by reading books about them from the library. Write a one-page biography about Booker T. Washington and another about Dr. George Washington Carver. Include in your biographies information about where they came from, major events in their lives, their careers and families, and what we remember each of them for today.

Tuskegee University NASA Center for Controlled Ecological Life Support Systems
This group of scientists at Tuskegee University is experimenting with sweet potatoes and peanuts grown hydroponically to be used as food for long space missions. Astronauts will have to grow their own food when they travel long distances or stay in space for long periods. Before astronauts can do that, scientists on Earth must first discover how to grow and use food in space.

You can learn more about the NASA Center for CELSS by writing to them at:

Tuskegee University NASA Center for CELSS
George Washington Carver Agricultural Experiment Station
109 Campbell Hall
Tuskegee, AL 36088

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Student Worksheet 3

Reading Comprehension

Read the following paragraphs from the NASA book, *Living in Space.* Then turn the page and answer the questions about what you just read without looking back at the paragraphs.

"Foods are dehydrated to meet weight restrictions for the Space Shuttle liftoff. They are later rehydrated in orbit when they are ready to be eaten. Water used for rehydration comes from the Shuttle's fuel cells. The fuel cells produce electricity by combining hydrogen and oxygen, resulting in water. Since water is an available byproduct from the fuel cells, it is possible to send food in a dried form for later rehydration.

"The variety of food carried into orbit is so broad that crew members enjoy a six-day menu cycle. A typical dinner might consist of a shrimp cocktail, steak, broccoli, rice, fruit cocktail, chocolate pudding, and grape drink. To prepare the meal, the mission specialist chef takes a big plastic overwrap out of the food locker. The package is attached to a worktable.

"Inside the overwrap are four smaller plastic overwraps, each holding a complete meal of seven separate containers. Using a hollow needle attached to the hot water outlet, the chef injects a prescribed amount of water through a narrow passageway into the plastic bowls of dehydrated broccoli and rice.

"The chef kneads the packages through their flexible plastic tops and secures them in the oven along with the four precooked steaks. The steaks are packaged in flexible aluminum-backed plastic bags, called flex-pouches. The heat in the oven is 82° C, which does not harm the plastic containers. A fan circulates air so that the food is heated evenly.

"While these items warm in the oven, the mission specialist takes four trays from the galley and attaches them by magnets or clamps to a portable dining table hooked to the lockers. The mission specialist then adds cold water through the hollow needle to rehydrate the bowls of shrimp, chocolate pudding, and grape drink. A plastic straw with a clamp on it is inserted into the passageway of the grape drink.

"These cold items, along with the cans of fruit cocktail, the silverware, and a can opener, are assembled on the trays and held by magnets or Velcro tape. When the heated foods are ready, it's dinner time."

Turn the page to answer questions about what you just read.

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Student Worksheet 4

Provide the answer for each question.

1. Why do foods have to be dehydrated before they're sent into space on the Space Shuttle?

2. Where does the water used to rehydrate foods on the Space Shuttle come from?

3. There are enough different kinds of foods available for the astronauts to have a ____-day menu cycle.

4. Where is the big plastic overwrap for a meal kept until it's time to eat?

5. What does the chef use to get hot water into the plastic bowls of dehydrated broccoli and rice?

6. Are the steaks cooked before or after they get into space?

7 What is packed in flex-pouches?

8. Why does a fan circulate air in the oven?

9. How do they keep the grape juice from floating out of its container through the straw?

10. How do they keep the silverware from floating away from the dinner table?

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Student Worksheet 5

Math Assignments

1. An astronaut participates in three space flights across the galaxy. On the first mission, she travels 2,345,965 miles. On the second mission, she travels, 1,324,387 miles. And on her third mission, she travels 4,322,985 miles. How many total miles has she traveled?

2. If seven astronauts have traveled a total of 5,266,870 miles in space, how many miles has each of the astronauts traveled on the average?

3. Who was the first astronaut to walk on the moon? Use the problems below to find the answer.

423 + 59 = ___ —A 823 + 102 = ___ —E 542 - 35 = ___ —G

163 - 25 = ___ —I 665 ÷ 7 = ___ —L 406 x 9 = ___ —M

367 x 5 = ___ —N 243 + 89 = ___ —O 576 - 48 = ___ —R

312 ÷ 8 = ___ —S 623 x 7 = ___ —T

1,835	925	138	95	482	528	3,654	39	4,361	528	332	1,835	507

4. Astronauts on the Space Station have nine loaves of bread, and each loaf has 22 slices in it. If there are six astronauts aboard and each eats one slice of bread each day, how many days will their bread supply last?

5. An intergalactic meeting brought 48 participants from across the universe. If 1/4 of those present were from the Thatsaferpese galaxy and 1/8 were from the Outhataway galaxy, what proportion of the total did the rest of the participants represent?

6. If six spaceships contain a total of 1,875,366 astronauts, what is the average number of astronauts per ship?

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Student Worksheet

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7. If the Space Shuttle captain ate six bags of freeze-dried apples from a case of 72 bags, what fraction of the case of freeze-dried apples did the captain eat?

8. On the Space Station, the chef makes a gallon of sweet potato juice. A gallon contains 64 ounces. If two Russians drink 7 oz of the juice each and three Americans drink a total of 30 oz, how many ounces were drunk altogether? What fraction of the gallon remains?

9. The chef makes 138 lbs of sweet potato leaf noodles and needs to bag them for storage. If each bag holds 1.5 lbs of noodles, how many bags does the chef need?

10. The peanut hydroponic system produces enough peanuts in one month for the chef to make one cup of peanut butter. If a Turkish astronaut eats 1/3 of the cup, a Brazilian astronaut eats 1/6 of the cup, and a Ukrainian astronaut eats 1/12 of the cup, what fraction of the cup of peanut butter is left for the others to eat?

11. NASA has $150,000 to spend on food for the next Space Shuttle mission. If it spends $20,000 on freeze-dried fruit, $50,000 on freeze-dried dairy products, and 1/5 of the total on pasta and bread, how much money does it have left to buy everything else? What fraction of the total is that?

12. If three Space Shuttle missions orbited the Earth a total of 180 times, what fraction of the total did each of the following represent?

    A. Columbia—20 orbits

    B. Discovery—104 orbits

    C. How many orbits did the third Shuttle perform? What fraction of the total does that represent?

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Student Worksheet 7

13. A spaceship travels 20,502,360 miles in 24 hours. How fast is the spaceship traveling?

14. On the space stations of the future, there will be plenty of coming and going. The space station Gamma Base keeps the following records of astronauts arriving and leaving over the course of a year. Can you calculate the number of astronauts present at the station on the last day of each month?

Date	Personnel Log
January 1, 2087	67 Aboard
January 12, 2087	9 Arrive 12 Depart
February 4, 2087	44 Arrive 7 Depart
March 13, 2087	32 Arrive 81 Depart
May 6, 2087	16 Arrive 4 Depart
June 29, 2087	33 Arrive 14 Depart
August 4, 2087	154 Arrive 76 Depart
September 12, 2087	52 Arrive 6 Depart
October 30, 2087	2 Arrive 43 Depart
November 4, 2087	60 Arrive 12 Depart
November 27, 2087	101 Arrive 49 Depart
December 24, 2087	25 Arrive 87 Depart

15. If 1/4 of a group of 24 astronauts has to go on a space walk, how many are going?

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16. Twelve spaceships fly a relay that covers 1,456,732 miles. The first ship flies 1/10 of the way. The next two ships each fly 1/24 of the way. The next two fly 1/8 of the way. The remainder of the ships fly equal fractions of the remaining distance. How far did each of the 12 ships fly?

17. A space station has nine decks. Decks 1 through 3 cover 345,600 square feet each. Decks 4 and 5 cover 234,056 square feet each. And decks 6 through 9 cover an average of 1,002,332 square feet each. How many total square feet does the space station cover?

Student Worksheet 8

18. Solve the following problems to find the answers to these questions.

16 x 2 = ___ —A	33 ÷ 11 = ___ —B	124 - 77 = ___ —C
12 x 3 = ___ —D	25 ÷ 5 = ___ —E	85 + 11 = ___ —F
7 x 7 = ___ —G	80 ÷ 8 = ___ —H	45-22 = ___ —I
8 x 9 = ___ —J	98 ÷ 7 = ___ —K	16 + 32 = ___ —L
6 x 5 = ___ —M	75 ÷ 5 = ___ —N	101 - 43 = ___ —O
4 x 4 = ___ —P	120 ÷ 6 = ___ —Q	7 + 17 = ___ —R
9 x 6 = ___ —S	100 ÷ 4 = ___ —T	86 - 53 = ___ —U
3 x 7 = ___ —V	18 ÷ 3 = ___ —W	52 + 17 = ___ —X
7 x 4 = ___ —Y	63 ÷ 7 = ___ —Z	

A. The name of the space telescope sending pictures of the universe back to Earth.

10	33	3	3	48	5

B. The NASA probe that sent us back detailed mapping information about Venus.

30	32	49	5	48	48	32	15

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Student Worksheet 9

C. The astronomer who discovered the planet Uranus.

10	5	24	54	47	10	5	48

D. Most of Mars' atmosphere is made of this gas.

47	32	24	3	58	15	36	23	58	69	23	36	5

E. The halo of material beyond the planets that contains most of the nuclei that become comets

58	58	24	25	47	48	58	33	36

F. One of Jupiter's moons.

49	32	15	28	30	5	36	5

G. The astronomer who named the dark areas on the moon "seas."

49	32	48	23	48	5	58

H. NASA spacecraft that flew by Venus and Mercury in 1974 and 1975.

						1	0
30	32	24	23	15	5	24	

I. The planet discovered in 1930.

16	48	33	25	58

J. Neptune owes its blue appearance to this gas.

30	5	25	10	32	15	5

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19. The personnel portal tube between Decks 3 and 4 of the Space Station is 5 kilometers long. If 1 kilometer = .621 miles, how many miles long is the personnel portal tube?

20. Each astronaut needs to take 12 kilograms of food on the next mission. If 1 kilogram equals 2.2 pounds and there are five astronauts, how many total pounds of food will they take?

Creative Writing

Student Worksheet 10

Using the log provided in Math Question 14, can you write a story for Gamma Base explaining who all these people coming and going to and from the base might be and what they do on the space station? Think about the kinds of jobs that will need to be done and the kinds of skills the workers will need. Will they need people to cook, clean, paint, or repair equipment? Will they need engineers, microbiologists, astronomers, chemists, physicists, or biologists? Will they need translators, diplomats, bankers, communication specialists, teachers, babysitters, or secretaries? How about pilots, computer scientists, soldiers, politicians, clergy, or judges? Will there be writers, painters, sculptors, actors, or musicians up there? Use your imagination and make your Gamma Base the kind of place you would like to live if you were spending time in space.

Activities

Growing Plants

A Sweet Potato Garden

When astronauts grow sweet potatoes in space, it will be in hydroponic systems, but you can grow a sweet potato garden here on Earth without any special equipment. In the early spring, purchase a sweet potato. Loosen some soil in a garden patch or prepare a pot with a drainage hole by filling it to within an inch of the top with soil. Plant the sweet potato about two inches deep and water it lightly. If you plant it outside, cover your potato garden with plastic until the danger of frost has passed.

Sprouts will emerge from your potato. Allow them to grow until they are 8 inches long. Pull the sprouts from the potato. For each sprout, dig a hole in your garden or pot 4 inches deep and 10 inches apart. Pour one cup of water into each hole and then plant the sprouts (roots down). Fertilize your sprouts lightly. As your plants grow, they will need to be watered and have weeds removed from around them. The sprouts will mature in about four months.

Grow Peanuts Indoors

Purchase some uncooked, unsalted peanuts. Soak a few in water overnight. Use one or more 6- or 8-inch flower pots with drainage holes. Fill the pots with potting soil to within one inch of the top. Plant three to

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Student Worksheet 11

five soaked peanuts in each pot, 1.5 inches deep. Pack soil lightly over the nuts. Keep the soil moist, but not soggy. Put the pots in a warm (80° F is ideal), sunny place. The peanuts will sprout in one week and peanuts will form on the roots in about three months.

Waste Decomposition—Composting

In the program, Dr. Trotman showed us how astronauts will have to dispose of the unusable parts of the sweet potato plants because there won't be any garbage cans in space. The technique she demonstrated was the decomposition of the stems, roots, etc., by bacteria.

Bacteria play a very important role in the decomposition of waste here on Earth too. Bacteria break down the chemical compounds in organic matter, such as animal wastes and fallen trees. Then larger animals, like insects and worms, carry these nutrients down into the soil. This process improves the soil's ability to grow plants. The plants that grow, and the animals that consume them, then die and the whole process begins again. This is an example of nutrient cycling.

You can actually see bacterial decomposition at work by building a compost pile.

You will need:
Raw organic matter (leaves, grass clippings, weeds, kitchen refuse, manure)
Soil
10-10-10 fertilizer
Compost box—made of concrete blocks, lumber, or posts and woven wire

First, select your compost site. Choose a shady spot, but not directly under a tree. Build your compost box—a three-sided structure made from concrete blocks, lumber, or posts with woven wire stretched between them. The box should be 3 to 5 feet wide and 3 to 4 feet high.

Now begin your compost pile by spreading a layer of organic matter on the bottom of your box. If your material is dense (for example, manure or vegetable parts and peelings), the layer should be 6 inches thick. If the material is loose (for example, leaves), make the layer 12 inches deep. If the material is dry, water it down. Pour the 10-10-10 fertilizer over the organic matter at a rate of 1.5 cups/bushel of compact organic matter. Then cover with a 1-inch layer of soil, which will introduce the needed bacteria to decompose the organic matter. In this system, you're using the soil to *moculate* (introduce bacteria into) your compost pile.

Continue to alternate layers of organic matter, fertilizer, and soil in this manner until the pile is 3 to 4 feet high. If you make the center of the pile lower than the surrounding edges, watering is simpler. Be sure to top off your compost pile with a layer of soil.

Keep the pile moist, but not soggy. You can insert a thermometer deep into your compost pile over time and you'll find it will be hot. The heat is generated by the metabolic processes of all the living bacteria in there decomposing the pile.

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Student Worksheet 12

The compost pile needs to be turned several times over the course of the year. It will take six to 10 months for a well-managed compost pile to create nutrient-rich, organic material that can be used by itself as a growth medium or added to garden soils.

Dehydration

Foods are dehydrated before they are sent into space so they will weigh less. Almost all of our foods have quite a bit of water in them. Try dehydrating the following foods. You may be surprised how much water each of them contains.

You will need:
- Foods to dehydrate (slice of bread, apple slices, slice of cheese, piece of bologna, lettuce leaf, etc.)
- Scale
- Cookie sheet or tray
- Oven or warm, sunny spot
- Paper and pencil

Choose the foods you want to dehydrate. Weigh each item you have selected and write its name and weight down. Place your foods on the cookie sheet or tray and put in a warm, sunny spot for a few days or use a warm (not hot) oven for a few hours. Dry the foods until they feel crumbly or hard. (Do not eat these foods if they have set out for several hours or days!)

Weigh each food item again, and write down the weights. Subtract the second weight from the first. The difference equals the amount of water present in the original food. If you use this formula, you can figure out what percentage of water is present in the foods when you eat them.

$$\frac{\text{(Original weight - Dried weight)}}{\text{Original weight}} \times 100\% = \text{Percentage of water in food as consumed}$$

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Student Worksheet 13

Word Search

Can you circle the following words in the puzzle below. They may be forward, backward, up, down, or diagonal.

Space	Florida	Gravity	Apollo	Water
Orbit	Cookie	NASA	Alabama	Space shuttle
Tuskegee	Washington	Earth	Leaf	Photosynthesis
Quasar	Jupiter	Venus	Peanut	Space station
Juice	Uranus	Mars	Astronaut	Cape Canaveral
Bread	Moon	Saturn	Sun	Sweet potato
Nutrients	Comet	Root	Neptune	Star
Pluto	Noodles	Oxygen	Mercury	Air

P H I Z E L T T U H S E C A P S P N
L A Y V N E P T U N E C B G R T O O
C X R B M U I J O T U L P O E N S I
V F U O W S F S P A C E N L T E E T
E R C X T U L X A L A B A M A I L A
N E R Y U N O T G N I H S A W R D T
U T E G A A R Q U H L T A P S T O S
S I M E N R I T T S A D N O R U O E
Q P A N O U D R J R K A L L B N N C
E U D E R F A O U Q T E T L M O R A
I J A M T E Y T I V A R G O S C U P
K G E S S T N S C F S B O E O R T S
O K R O A C A P E C A N A V E R A L
O R B I T R O T A T O P T E E W S M
C F R N S I S E H T N Y S O T O H P

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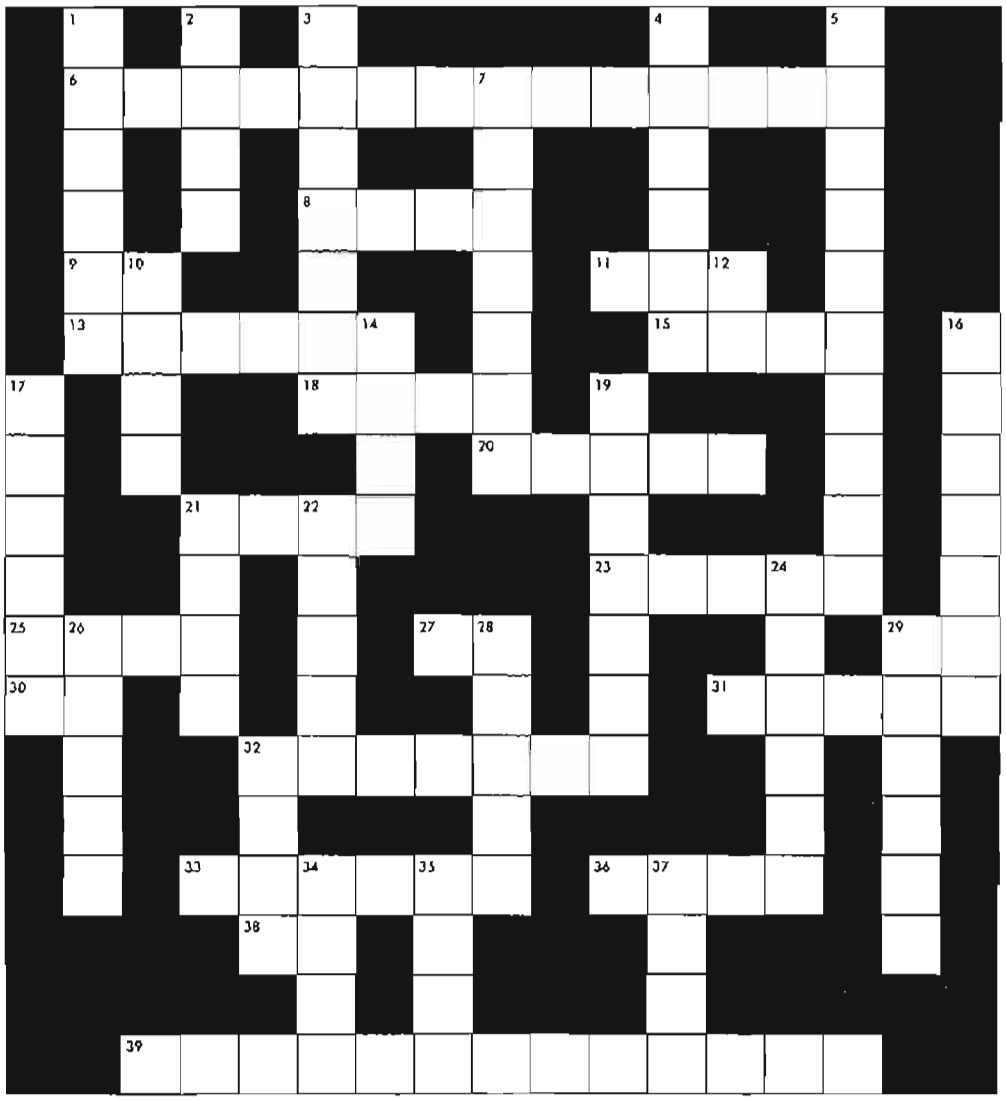
Student Worksheet 14

Crossword Puzzle



Down

1. Name of the series of rockets that took Americans to the moon
2. "Apple ____, Baltimore, who's your friend?"
3. Type of pasta astronauts can make from sweet potato leaf flour
4. Tasty legume Tuskegee University is testing for growth in space
5. Title for people who travel into space
7. The eighth planet from the sun
10. The imaginary straight line or rod through the Earth around which the planet spins
12. Opposite of yes
14. A variable star that brightens suddenly and then gradually dims
16. The largest planet in our solar system
17. The ringed planet
19. The earthly force that makes what goes up come down
21. Almonds, cashews, and pecans
22. "Yams in _____!"
24. The planet between Saturn and Neptune

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26. A gaseous form of oxygen that is an important part of Earth's atmosphere
28. The coldest planet in our solar system
29. Sweet potatoes can be orange, white, or _____
32. The captive of Earth's gravitational pull
34. Video or cassette
35. Roman attire
37. The basic unit of farm land

Across

6. The chemical process plants use to turn light into food for themselves
8. "The ____ blue sea"
9. Abbreviation for Los Angeles
11. The common name for our solar system's star
13. 2 Hydrogen + 1 _____ = Water
15. Allen_____, Pennsylvania
18. Oklahoma _____ers
20. The third planet from the sun
21. Abbreviation for the National Aeronautics and Space Administration
23. The planet we call the evening star
25. The part of the sweet potato we usually eat is the storage ____
27. The direction a rocket goes when taking off
29. "Oh Come All ___ Faithful"
30. Abbreviation for New Zealand
31. Chemical compound that makes life on Earth possible
32. The hottest planet in our solar system
33. They aren't the same, but in America, we often call a sweet ____ a yam
36. The red planet
38. Abbreviation for North America
39. The famous place in Florida where space flights begin

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Student Worksheet

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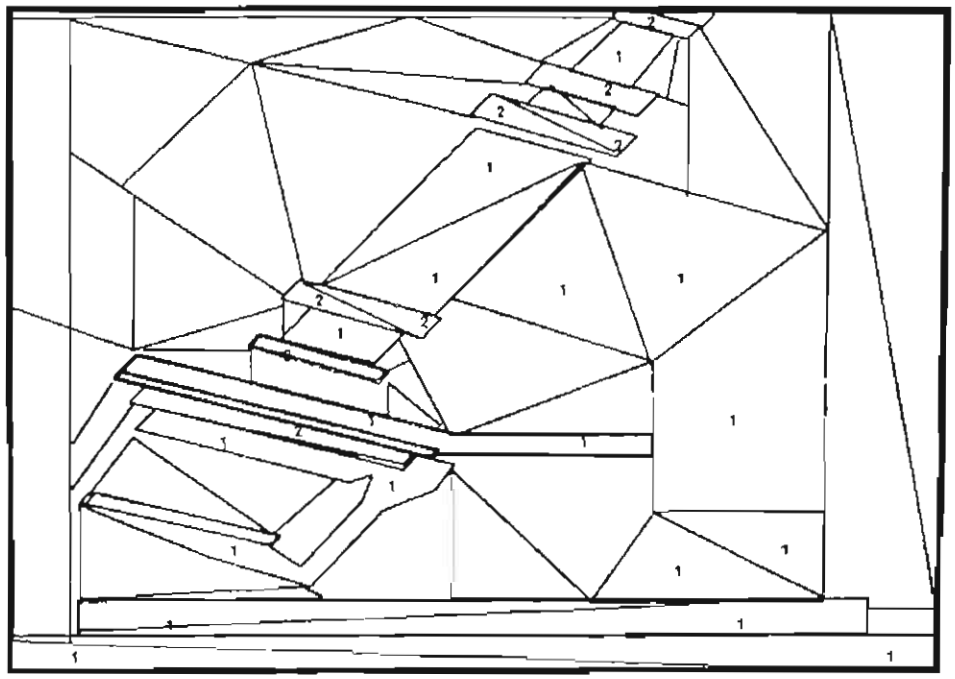
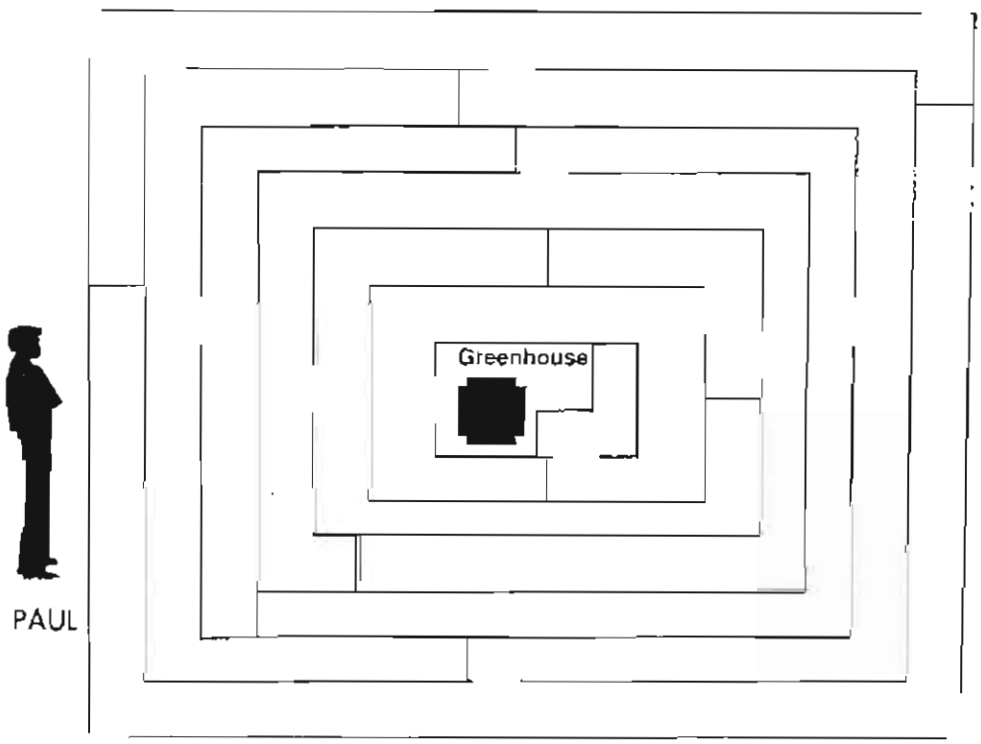
Picture Puzzle

The puzzle contains something research scientists often use. To find out what it is, color the shapes with the same numbers the same colors.



Maze

Paul is a Tuskegee University student scientist. He needs to get to the greenhouse to check on an experiment. Can you help Paul find his way?



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