RUSD Packet

HS Science
Horticulture

Student full name ________________________ HS _________________
Teacher _________________________ Day and block __________
Counselor________________________ Academy _________________

Horticulture

Purpose Of The Packet

Summer brain drain is a real thing and it generally takes about a month to get back in the academic swing of things in the fall. If we go back to school this year, we will not have the luxury of taking that month to get used to school again. This packet will help keep your mind and skills sharp.

If we do not go back to school, your teacher will issue you a second semester grade based on the evidence of your understanding shown by completion of this packet and the grade you had in Infinite Campus as of March 13th.

For two semester long classes: There is also material from the first semester included in this packet. Your teacher may choose to use successful completion of the review and enrichment activities to improve your first semester grade if you had a failing grade.

How The Packet Will Be Set Up

Each assessment will start with some basic review of the concept(s) needed to complete the activity. A review or enrichment assessment will follow. Each review and assessment will minimally supply a technology free option and some will also include a technology option. Each assessment will also include a time length for expected completion. A 1 Day activity should take you between 30 and 45 minutes to complete. A 2 Day activity should take you two days of work assuming you work between 30 and 45 minutes each day. You may choose to work double the time and complete a 2 Day assessment in one day. Each assessment will also include a rubric for you to use to make sure you include all of the information necessary to show your understanding of the topic.

Where Do I Start

This packet is going out to every student taking this course across the district. Start with what you know! The packet is the best representation of what MOST classes had covered as of the March 13th shut down. If your teacher had not covered a specific topic, you are not expected to teach it to yourself. But you may choose to try it to challenge yourself! If you are unsure if you have covered a topic, please contact your teacher.

How Do I Turn In My Work?

You may turn in your work digitally to your teacher based on their instructions. If you do not have access to technology at home, the district will come out with instructions on how to turn in your work on paper.

Horticulture RUSD Packet of Evidence Outline

Topic	Lesson	Page #	**Paper Option** Please write all answers in the packet. Do not take packet apart	Completed put check
Parts of a Flower	review	4-5	Flower structure and reproduction	☐
Parts of a flower	evaulation	6-8	Propaggation of Plant Evaluation	☐
Parts of a Tree	review	9-10	What can you tell from a tree stem?	☐
Parts of a leaf	review	11	Leaf Anatomy	☐
Parts of a leaf	evaluation	12	The Structure of Leaves	☐
Photosynthesis	Review and evaulation	14-16	NOVA Photosynthesis Interavtive	☐
Mocot and Dicot	Review and evaulation	17-18	Comparing Moncots and Dicots	☐
Atmosphere	review	19-20	Active Reading Atmosphere	☐
Atmosphere	evaultion	21-22	Weather Watch	☐
Hydroponics	Review and evaulation	23-25	Hydroponics: The power of water to grow food	☐
Microgreens	Review and evaulation	26-27	Specialty Greens Pack a Nutritional Punch	☐

Name:____

Flower Structure and Reproduction

Flowers are the plant's reproductive structures. Angiosperms are types of plants that bear fruits and flowers. Flowers are usually both male and female, and are brightly colored to attract insects to help them carry pollen used for sexual reproduction. Not all flowers are colorful, though. These flowers usually use the wind for pollination.

Parts of the Flower

The receptacle is the part of the branch on which a flower forms. Color the receptacle (B) brown. Sepals are leaf like structures that surround and protect the flower before it blooms. Color the sepals (C) green. Petals are the colorful part of the flower that attracts insects and even other small animals, such as mice, birds, and bats. Color the petals (D) a bright color of your choice. All flowering plants have flowers, but some are not brightly colored. The petals of these flowers are reduced or absent and the plant relies on the wind or water for pollination.

The flower has both male and female reproductive parts. The female reproductive structures are called carpels. In most flowers, the carpels are fused together to form a pistil. Color the pistil (P) pink. The pistil has three parts, which can be seen, in the box labeled "pistil". The stigma at the top is often sticky and is where the pollen attaches. Color the stigma (J) purple. The style is the long tube that attaches the stigma to the ovary. Sperm from the pollen will travel down this tube to the ovules. The ovules, or eggs, are stored in the ovary until they are fertilized. Plants can only fertilize eggs of the same species. Special chemicals prevent sperm from fertilizing the eggs of flowers that are not the same kind. Color the style (K) red, and the ovary (L) pink. Color the ovules (O) black.

The male reproductive structures are called the stamens. Color the stamens (H) blue. Each stamen consists of an anther (A), which produces pollen, and a filament (F), which supports the anther. In the box labeled "stamen" color the anther dark blue, and the filament light blue. Pollen produced by the anther is carried by insects or other animals to the pistil of another flower where it may fertilize the eggs.

Plant Reproduction

Sexual reproduction in plants occurs when the pollen from an anther is transferred to the stigma. Plants can fertilize themselves: called self-fertilization. Self-fertilization occurs when the pollen from an anther fertilizes the eggs on the same flower. Cross-fertilization occurs when the pollen is transferred to the stigma of an entirely different plant.

When the ovules are fertilized, they will develop into seeds. The petals of the flower fall off leaving only the ovary behind, which will develop into a fruit. There are many different kinds of fruits, including apples and oranges and peaches. A fruit is any structure that encloses and protects a seed, so fruits are also "helicopters" and acorns, and bean pods. When you eat a fruit, you are actually eating the ovary of the flower.

Questions

1. What is an angiosperm?

2. The flower attaches to what part of the plant?

3. Why are flowers brightly colored?

4. Name two mammals that might pollinate a plant.

5. If the petals of a flower are reduced or absent, how is the plant pollinated?

6. The female reproductive structures are called the:

7. Name the three parts of the pistil:

8. Where are the ovules stored?

9. Name the two parts of the stamen:

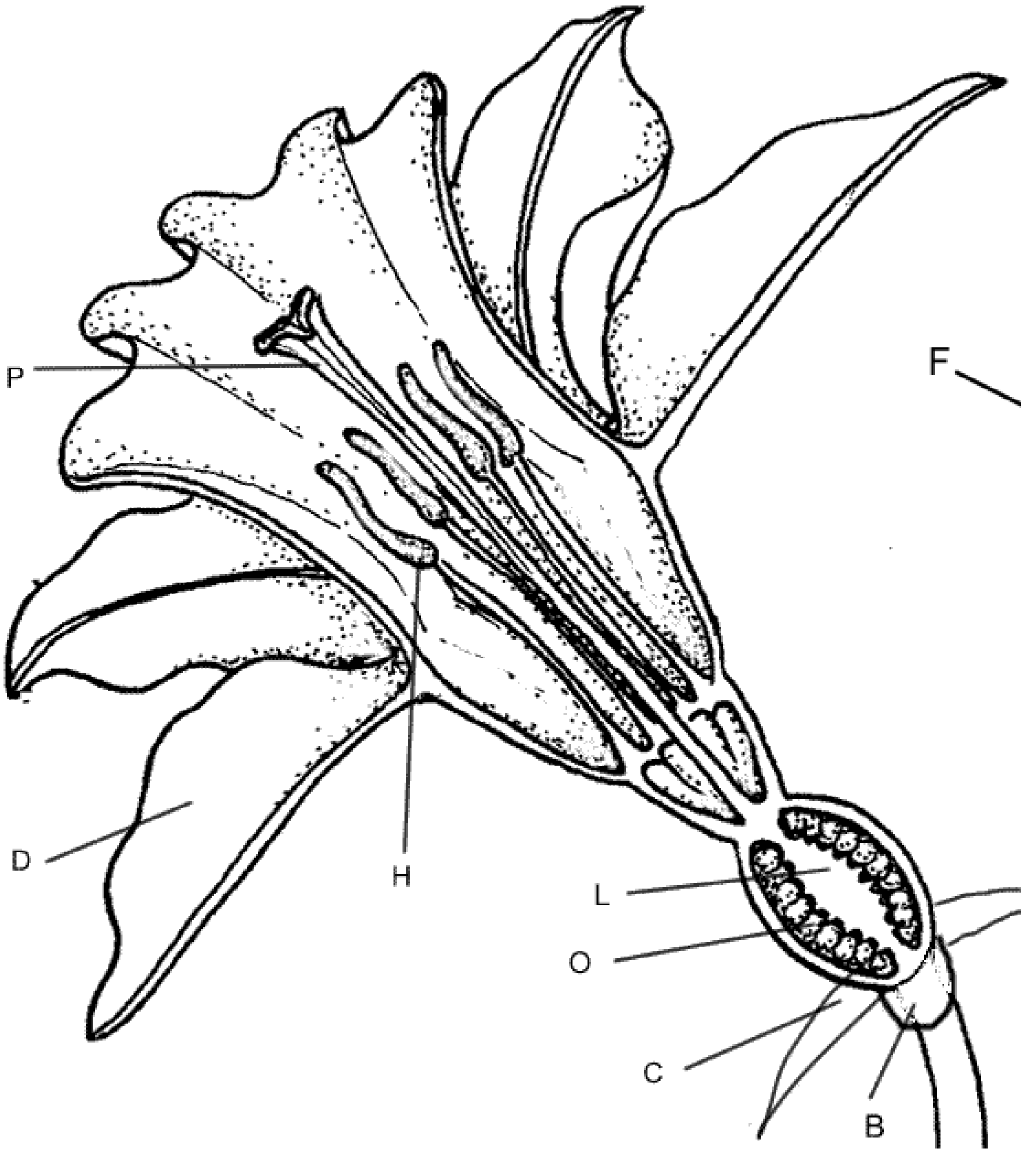
10. Describe sexual reproduction in plants.

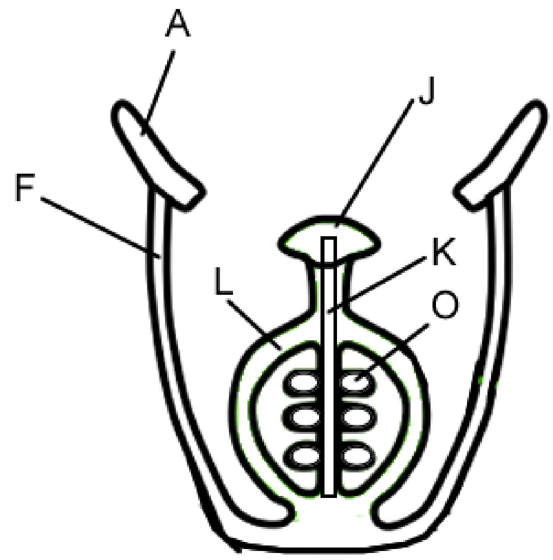
11. The ovary develops into what structure?

12. Define fruit.

13. Some flowers are not brightly colored at all, but have a very pungent odor that smells like rotting meat. How do you think these flowers are pollinated?

14. In many flowers, the pistils and stamens reach maturity at different times. Considering what you know about pollination, why would this be an advantage to the plant?


P
D
H
L
O
C
B


A
J
F
K
L
O

4-1. An understanding of the various plant parts and their functions is important in identification, plant care, and producing more when working with horticultural plants.

MOST often, horticultural plants are thought to be pretty flowers. However, they play a major role in the everyday lives of humans. Not only do they provide a food source as in fruits, nuts, and vegetables, but they are also a major producer of oxygen in and around our homes and workplace. In addition, horticultural plants beautify our environment by providing a variety of colors, textures, and patterns in the landscape. They enhance architectural structures, frame views, and add fragrances and sounds. Plants also engineer our environment to reduce solar radiation, control erosion, reduce noise pollution, absorb heat, and reduce injuries from sports fields. An added benefit of plants in the environment is that they provide food and shelter for wildlife.

Plants are complex organisms. Plants are made of organs consisting of tissues and cells. Plant organs include leaves, stems, roots, and flowers. Understanding plant growth and the function of plants is very important in horticulture. Horticulturists apply their knowledge of plant anatomy of the different plant organs to promote growth and high quality crops.

Propagation of Plants EValuation

Explain why plants are important using the 1-2-3-2-3 format. The 1-2-3-2-3 format is summarized below:

1- Topic Sentence
- *Make a claim
- *The sentence must end with the phrase “for two reasons”

2- Reason Sentence #1
- *This sentence provides “proof” for the claim
- *Provides the reader with one good reason for why the claim is true

3- Explanation Sentence (supports and explains why reason #1 is true)
- *Further explanation or support that includes examples, facts, or a description

2- Reason #2
- *This sentence provides further “proof” for the claim
- *Provides the reader with a second good reason for why the claim is true

3- Explanation for Reason #2
- *Further explanation or support that includes examples, facts, or details

Why are plants important?

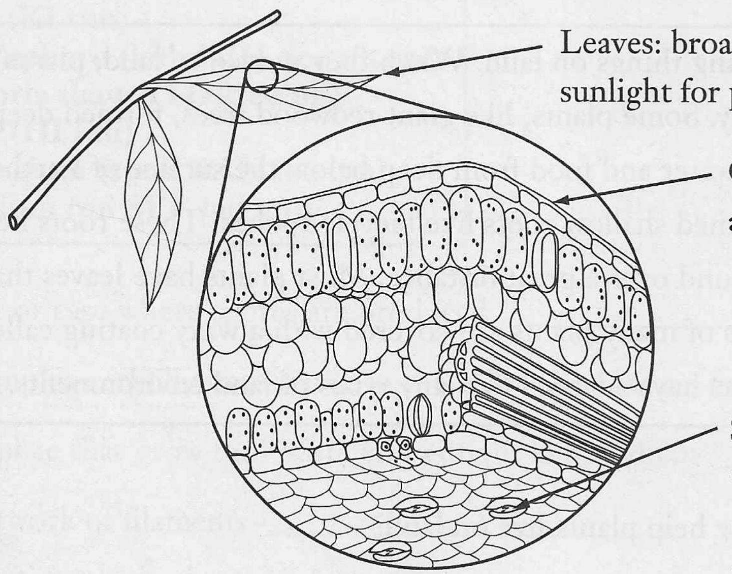
Name ______________________ Date __________ Class __________

Content Mastery

CHAPTER 24 WHAT IS A PLANT?

Section 24.1 Adapting to Life on Land
Study the Diagram

Use the diagram to answer the questions.



1. What is the purpose of a plant's cuticle?

____

____

2. What is the purpose of open stomata and closed stomata?

____

____

3. What is the purpose of leaves?

____

____

Activity: What can you tell from a tree stem?

Background information: The trunk of a tree when viewed in cross-section appears to be made up of a series of rings. The rings formed as new xylem cells. Xylem cells are living, tube-like cells that move water upward through the stem. Xylem cells make up the "woody" part of a tree stem. Each year new xylem cells are produced that make the stem thicker and thicker. A ring of xylem is called an **annual ring**. Each ring contains a dark and light band. The lighter band forms in the spring when xylem growth is more rapid. The lighter color is due to the large size of the xylem cells. The darker band forms in the summer when growth is slower. The darker color is due to the small size of the cells. You can tell the age of a tree by counting either the light or dark bands.

Materials: Metric ruler

Procedure:

1. Count the number of tree rings in each of the slices. Do not count the bark or the center. Record the number of rings in the chart below.
2. Measure the distance across each stem in centimeters, and record.
3. Measure the width of the rings in Stems A and B. Record which (A or B) has the widest rings.
4. Examine the stems for black areas. Record which ones show black areas.

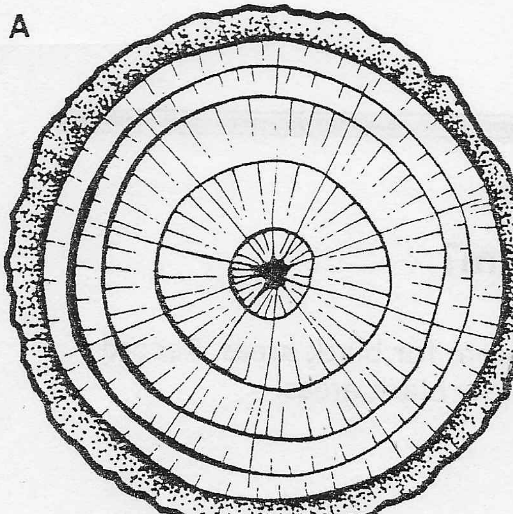
Data:

Trait	Stem A	Stem B	Stem C	Stem D	Stem E
Number of rings					
Size or stem in cm					
Which has widest rings (A or B)					
Which stem has black area					

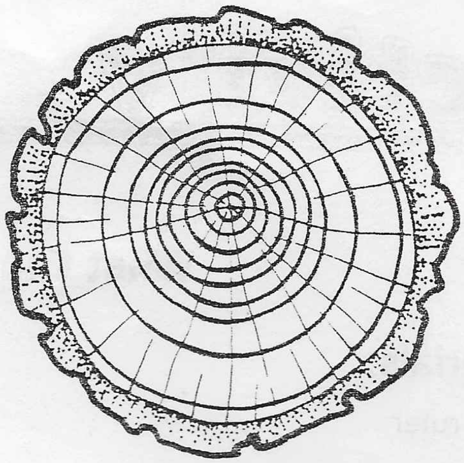
Conclusion Questions:

1. Which tree shown is the oldest? _____
2. Which tree stem shown is the widest? _____ How does the stem width relate to the tree age? ______________________________
3. If tree rings are larger, more water was present where the tree was growing. Which tree, A or B, grew in a wetter area? _____ What year did tree C receive the most water? ___
4. Black areas in the tree rings mean the tree has been burned in a fire. Which tree was in a fire? _____ What year was the fire? _____
5. If trees D and E were cut down in 1981, when did each begin growing? ____________

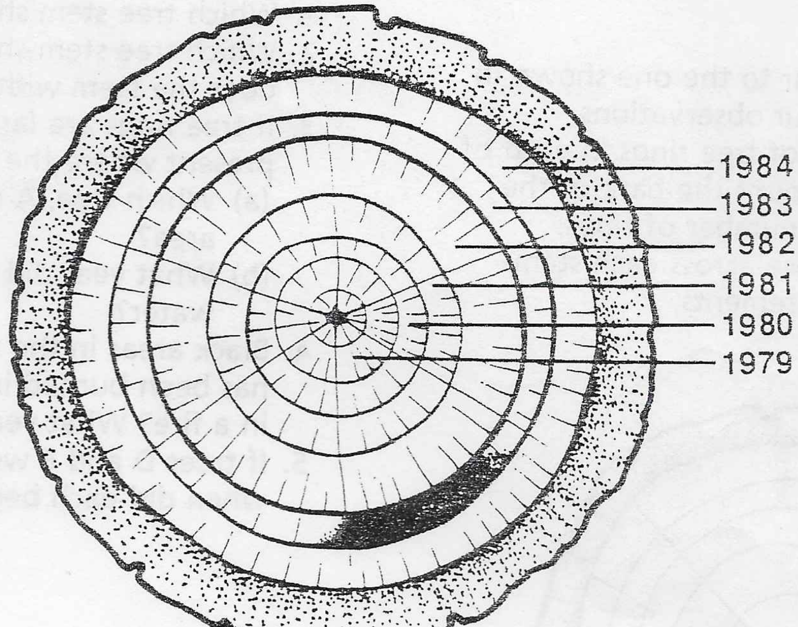
A

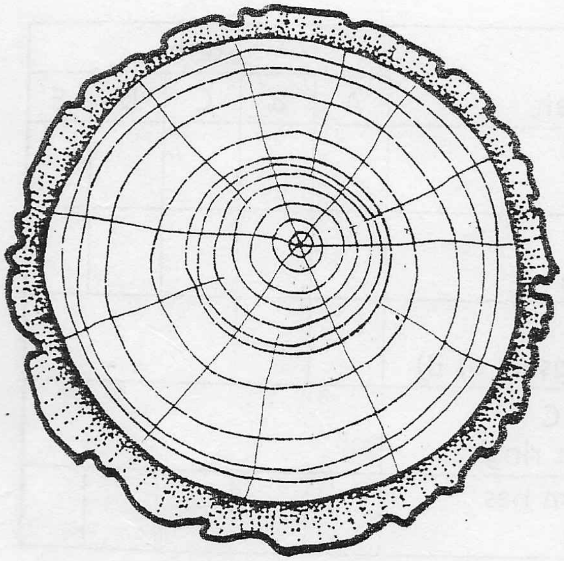


B

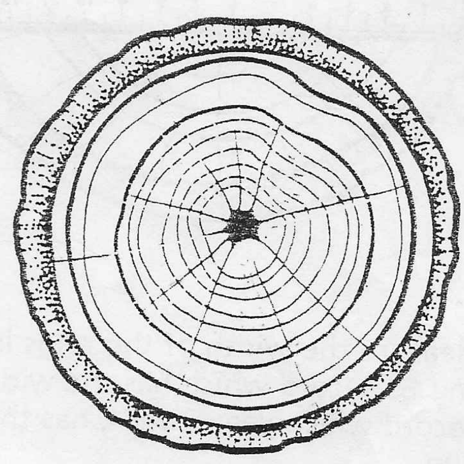


C





D



E

Name: ____________________________________ Hr.: ________ **Leaf Structure**

LEAF ANATOMY

The leaf is the primary photosynthetic organ of the plant. It consists of a flattened portion, called the blade, that is attached to the plant by a structure called the petiole. Sometimes leaves are divided into two or more sections called leaflets. Leaves with a single undivided blade are called simple, those with two or more leaflets are called compound.

The outer surface of the leaf has a thin waxy covering called the **cuticle** (A), this layer's primary function is to prevent water loss within the leaf. (Plants that leave entirely within water do not have a cuticle). Directly underneath the cuticle is a layer of cells called the **epidermis** (B). The vascular tissue, xylem and phloem are found within the veins of the leaf. Veins are actually extensions that run from to tips of the roots all the way up to the edges of the leaves. The outer layer of the vein is made of cells called **bundle sheath cells** (E), and they create a circle around the xylem and the phloem. On the picture, **xylem** is the upper layer of cells (G) and is shaded a little lighter than the lower layer of cells - **phloem** (H). Recall that xylem transports water and phloem transports sugar (food).

Within the leaf, there is a layer of cells called the **mesophyll**. The word mesophyll is greek and means "middle" (meso) "leaf" (phyllon). Mesophyll can then be divided into two layers, the **palisade layer** (D) and the **spongy layer** (F). Palisade cells are more column-like, and lie just under the epidermis, the spongy cells are more loosely packed and lie between the palisade layer and the lower epidermis. The air spaces between the spongy cells allow for gas exchange. Mesophyll cells (both palisade and spongy) are packed with chloroplasts, and this is where photosynthesis actually occurs.

Epidermis also lines the lower area of the leaf (as does the cuticle). The leaf also has tiny holes within the epidermis called stomata. Specialized cells, called **guard cells** (C) surround the stomata and are shaped like two cupped hands. Changes within water pressure cause the stoma (singular of stomata) to open or close. If the guard cells are full of water, they swell up and bend away from each other which opens the stoma. During dry times, the guard cells close.

Color the structures underlined above. Make sure that the entire picture is colored and that the color matches the words. For simplicity only part of the picture is labeled.

Questions:

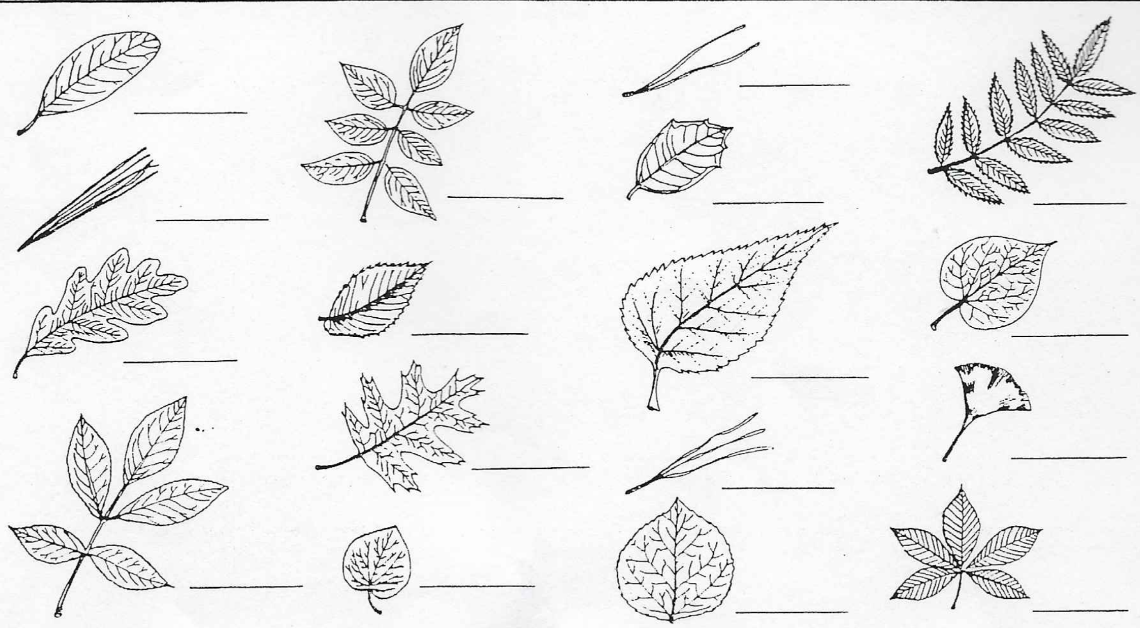
1. What two tissues are found within a vein? ______________________________
2. What does the word "mesophyll" mean? ________________________
3. What two layers of the plant contain chloroplasts? ________________________________
4. The outermost layer of cells: __________________________
5. The waxy covering of the leaf: _________________________
6. These cells function to open and close stomata. ____________________
7. Outer layer of the vein: _________________________
8. Column like cells that lie just under the epidermis. _____________________
9. Openings that allow for gas exchange. _________________________
10. The stalk that connects the leaf to the stem. __________________

Name ______________________________ Date ____________ Class ____________

THE STRUCTURE OF LEAVES

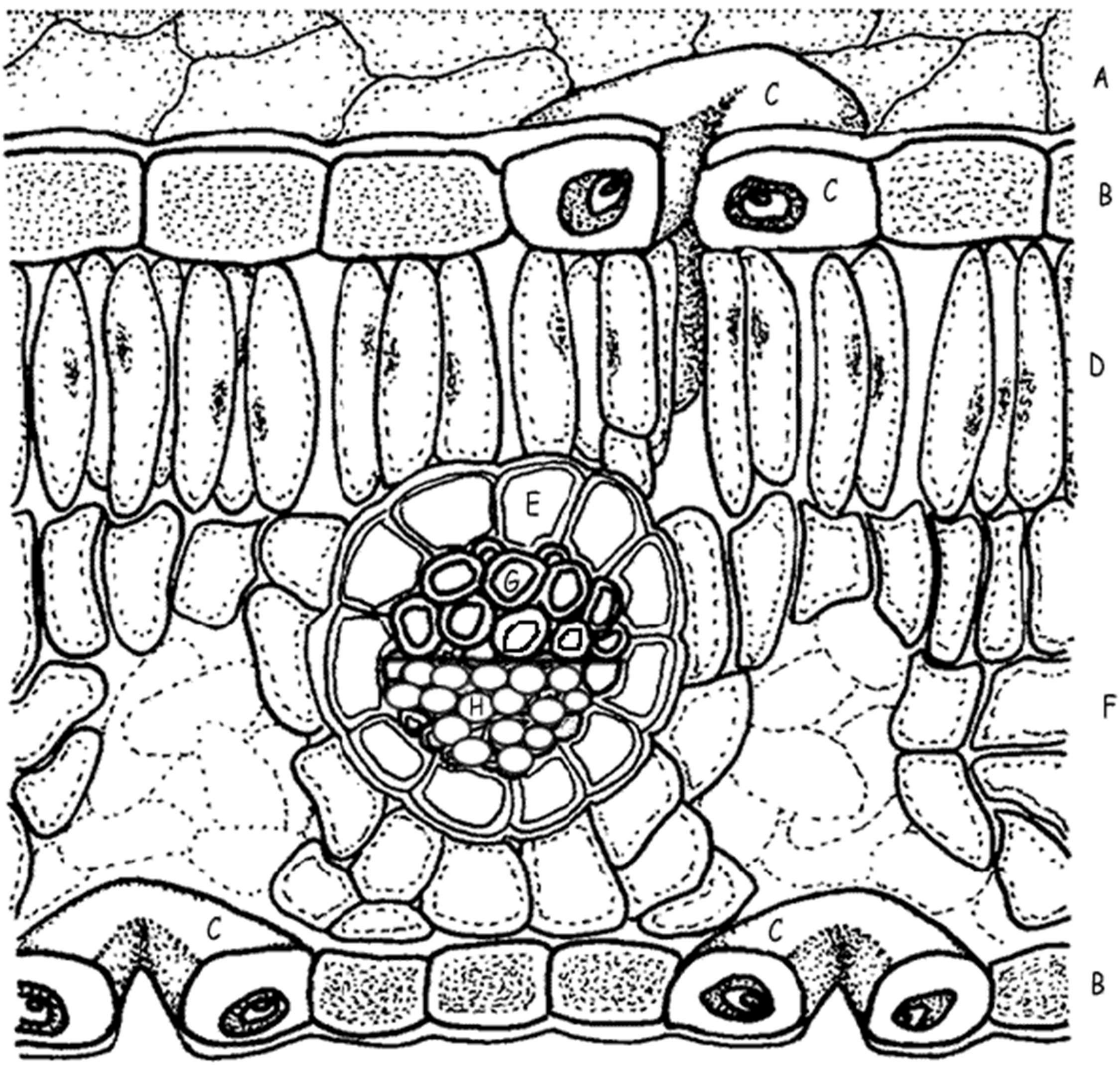
The chart below describes several different kinds of leaves and gives an example of each. Read each description and example. Examine the diagrams carefully. Then, write the letter of the leaf type on the blank next to the diagram that it best matches.

Shape	Other traits	Example	
Fan		Ginkgo	(a)
Heart	Edges have teeth.	Cottonwood	(b)
Heart	Edges are smooth. Tip is very pointed.	Catalpa	(c)
Heart	Edges are smooth. Tip is not very pointed.	Redbud	(d)
Oval	Edges are smooth.	Magnolia	(e)
Oval	Edges have a few large teeth.	Holly	(f)
Oval	Edges have many small teeth.	Elm	(g)
Needle	Needles are in twos.	Virginia pine	(h)
Needle	Needles are in threes.	Pitch pine	(i)
Needle	Needles are in fives.	White pine	(j)
5-part	All leaflets attach at same point.	Buckeye	(k)
5-part	Three leaflets attach at top, two near bottom.	Shagbark hickory	(l)
More than 5-parts	Edges have teeth. Leaflets are oppositely attached.	Sumac	(m)
More than 5-parts	Edges are smooth. Leaflets are oppositely attached.	White ash	(n)
Oval	Edges are toothed. Tip is very pointed.	Hackberry	(o)
Wavy lobed	Lobes are pointed.	Pin oak	(p)
Wavy lobed	Lobes are rounded.	White oak	(q)



Name: ______________________________ Hr.: ________ **Leaf Structure**

Cuticle (light Blue)	Spongy Mesophyll (light green)	Palisade Mesophyll (dark green)
Epidermis (yellow)	Guard Cells (pink)	Phloem (purple)
Xylem (orange)	Bundle Sheath (dark blue)	



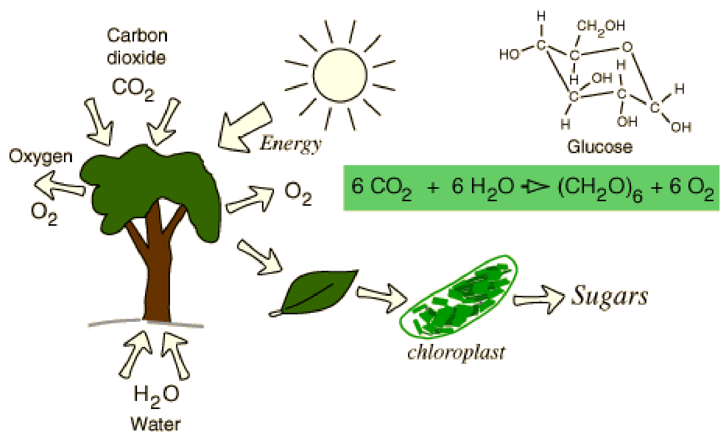
Date ______________________________ Block _________ Name ____
https://www.pbs.org/wgbh/nova/nature/photosynthesis.html NOVA Photosynthesis interactve (Please try!)

Photosynthetic Cells

Cells get nutrients from their environment, but where do those nutrients come from? Virtually all organic material on Earth has been produced by cells that convert energy from the Sun into energy-containing macromolecules. This process, called photosynthesis, is essential to the global carbon cycle and organisms that conduct photosynthesis represent the lowest level in most food chains.

What Is Photosynthesis? Why Is it Important?

Most living things depend on photosynthetic cells to manufacture the complex organic molecules they require as a source of energy. Photosynthetic cells are quite diverse and include cells found in green plants, phytoplankton, and cyanobacteria. During the process of photosynthesis, cells use carbon dioxide and energy from the Sun to make sugar molecules and oxygen. These sugar molecules are the basis for more complex molecules made by the photosynthetic cell, such as glucose. Then, via respiration processes, cells use oxygen and glucose to synthesize energy-rich carrier molecules, such as ATP, and carbon dioxide is produced as a waste product. Therefore, the synthesis of glucose and its breakdown by cells are opposing processes.



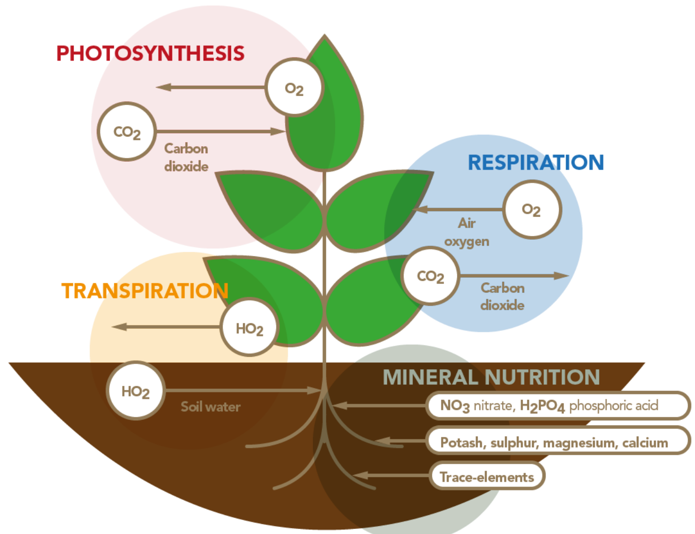


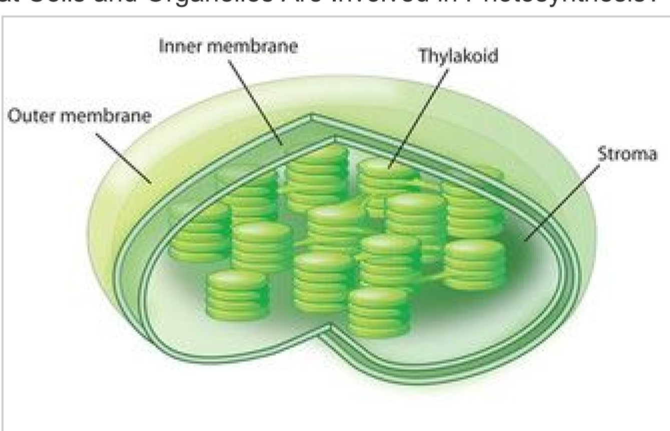
Figure 2

Figure Detail

The building and breaking of carbon-based material — from carbon dioxide to complex organic molecules (photosynthesis) then back to carbon dioxide (respiration) — is part of what is commonly called the **global carbon cycle**. Indeed, the fossil fuels we use to power our world today are the ancient remains of once-living organisms, and they provide a dramatic example of this cycle at work. The carbon cycle would not be possible without photosynthesis, because this process accounts for the "building" portion of the cycle (Figure 2).

However, photosynthesis doesn't just drive the carbon cycle — it also creates the oxygen necessary for respiring organisms. Interestingly, although green plants contribute much of the oxygen in the air we breathe, phytoplankton and cyanobacteria in the world's oceans are thought to produce between one-third and one-half of atmospheric oxygen on Earth.

What Cells and Organelles Are Involved in Photosynthesis?



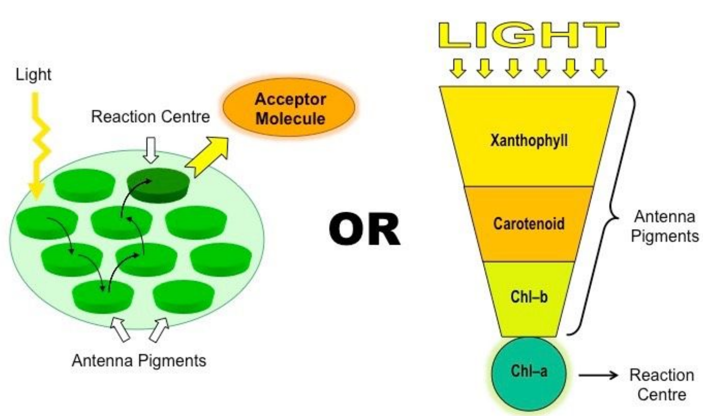
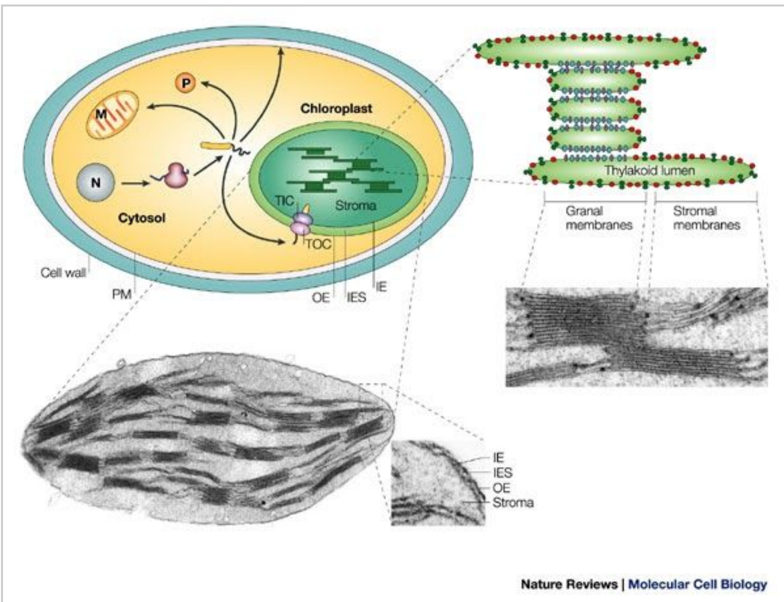


Figure 3: Structure of a chloroplast

Photosynthetic cells contain special pigments that absorb light energy. Different pigments respond to different wavelengths of visible light. **Chlorophyll**, the primary pigment used in photosynthesis, reflects green light and absorbs red and blue light most strongly. In plants, photosynthesis takes place in chloroplasts, which contain the chlorophyll. Chloroplasts are surrounded by a double membrane and contain a third inner membrane, called the **thylakoid membrane**, that forms long folds within the organelle. In electron micrographs, thylakoid membranes look like stacks of coins, although the compartments they form are connected like a maze of chambers. The green pigment chlorophyll is located within the thylakoid membrane, and the space between the thylakoid and the chloroplast membranes is called the **stroma** (Figure 3, Figure 4).

Chlorophyll A is the major pigment used in photosynthesis, but there are several types of chlorophyll and numerous other pigments that respond to light, including red, brown, and blue pigments. These other pigments may help channel light energy to chlorophyll A or protect the cell from photo-damage. For example, the photosynthetic protists called dinoflagellates, which are responsible for the "red tides" that often prompt warnings against eating shellfish, contain a variety of light-sensitive pigments, including both chlorophyll and the red pigments responsible for their dramatic coloration.



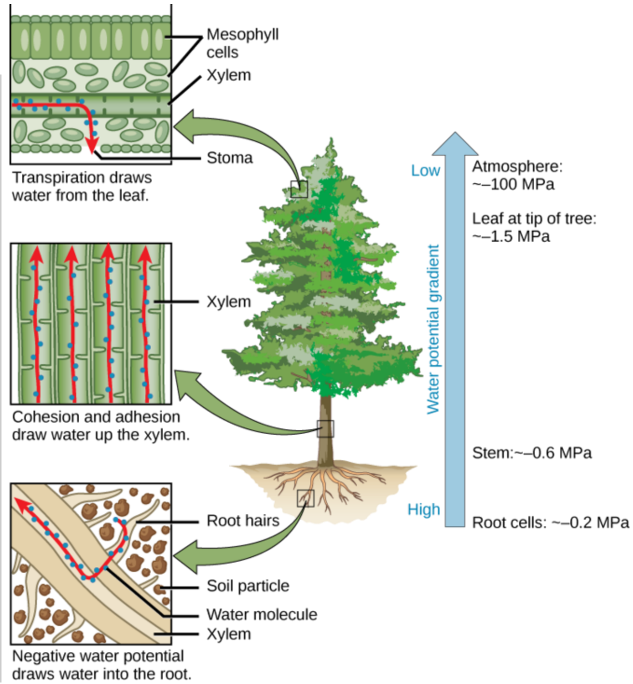


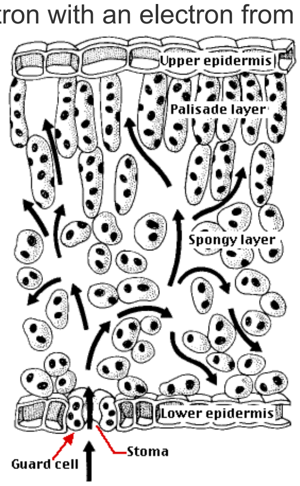
Figure 4: Diagram of a chloroplast inside a cell, showing thylakoid stacks

Shown here is a chloroplast inside a cell, with the outer membrane (OE) and inner membrane (IE) labeled. Other features of the cell include the nucleus (N), mitochondrion (M), and plasma membrane (PM). At right and below are microscopic images of thylakoid stacks called grana. Note the relationship between the granal and stromal membranes.

 Figure Detail

What Are the Steps of Photosynthesis?

Photosynthesis consists of both **light-dependent reactions** and **light-independent reactions**. In plants, the so-called "light" reactions occur within the chloroplast thylakoids, where the aforementioned chlorophyll pigments reside. When light energy reaches the pigment molecules, it energizes the electrons within them, and these electrons are shunted to an electron transport chain in the thylakoid membrane. Every step in the electron transport chain then brings each electron to a lower energy state and harnesses its energy by producing ATP and NADPH. Meanwhile, each chlorophyll molecule replaces its lost electron with an electron from water; this process essentially splits water molecules to produce oxygen (Figure 5).



Leaf Cross Section

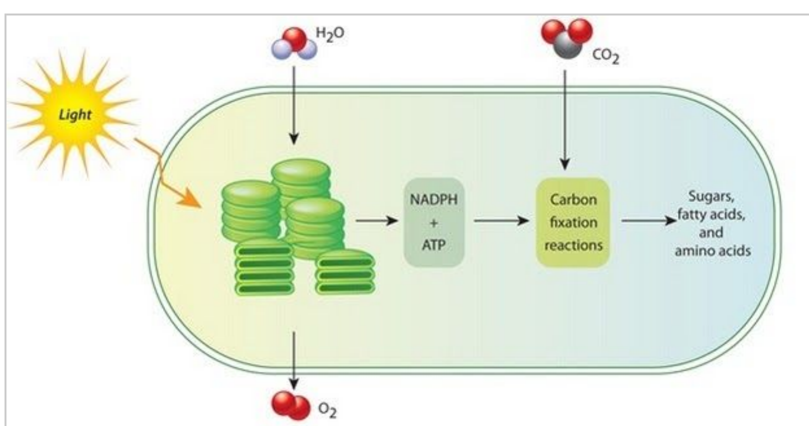


Figure 5: The light and dark reactions in the chloroplast

The chloroplast is involved in both stages of photosynthesis. The light reactions take place in the thylakoid. There, water (H_2O) is oxidized, and oxygen (O_2) is released. The electrons that are freed from the water are transferred to ATP and NADPH. The dark reactions then occur outside the thylakoid. In these reactions, the energy from ATP and NADPH is used to fix carbon dioxide (CO_2). The products of this reaction are sugar molecules and various other organic molecules necessary for cell function and metabolism. Note that the dark reaction takes place in the stroma (the aqueous fluid surrounding the stacks of thylakoids) and in the cytoplasm.

Figure Detail

Once the light reactions have occurred, the light-independent or "dark" reactions take place in the chloroplast stroma. During this process, also known as carbon fixation, energy from the ATP and NADPH molecules generated by the light reactions drives a chemical pathway that uses the carbon in carbon dioxide (from the atmosphere) to build a three-carbon sugar called glyceraldehyde-3-phosphate (G3P). Cells then use G3P to build a wide variety of other sugars (such as glucose) and organic molecules. Many of these interconversions occur outside the chloroplast, following the transport of G3P from the stroma. The products of these reactions are then transported to other parts of the cell, including the mitochondria, where they are broken down to make more energy carrier molecules to satisfy the metabolic demands of the cell. In plants, some sugar molecules are stored as sucrose or starch.

Conclusion

Photosynthetic cells contain chlorophyll and other light-sensitive pigments that capture solar energy. In the presence of carbon dioxide, such cells are able to convert this solar energy into energy-rich organic molecules, such as glucose. These cells not only drive the global carbon cycle, but they also produce much of the oxygen present in the atmosphere of the Earth. Essentially, nonphotosynthetic cells use the products of photosynthesis to do the *opposite* of photosynthesis: break down glucose and release carbon dioxide.

Questions:

1. What is Photosynthesis?____
2. Where does photosynthesis take place and how do we know by looking at the plant? ____________________________
3. Name at least three chemical pigments and how they help the process of photosynthesis. ____________________________
4. What is the dominant chemical product of photosynthesis? ____________________________
5. Name two chemicals products of photosynthesis. ____________________________
6. Why would chloroplasts be less densely packed in the spongy layer? ____________________________
7. As modified leaves, why are bulb onions red, brown or white? ____________________________
8. Describe the process that allows water to travel to the leaves for photosynthesis. ____________________________
9. Why was there mention of a subatomic particle and what is its role in photosynthesis? ____________________________
10. Extension: If you were to design a symbolic sculpture to describe the photosynthetic process, what would it look like and what imagery would you choose to represent the various components of the photosynthetic cycle?

Comparing Monocots and Dicots

Both monocot and dicot seeds develop in similar ways and have the same parts. There are a few minor differences: monocots start out with one seed leaf, while dicots have two. The technical word for seed leaf is cotyledon: you can find it on the coloring sheet; it is the first leaf to emerge from a developing seed. **Color all the cotyledons (A) on the seeds dark green**. As a seed, both monocots and dicots are covered by a seed coat. **Color the seed coat (B) yellow**.

The seed consists of the outside seed coat and a large area called the endosperm which functions as a source of reserve materials and food for the developing embryo. As germination occurs, the endosperm will be broken down and used by the plant. **Color the endosperm blue (C).**

Germination occurs when the seed begins to sprout, usually in the spring and under appropriate conditions the radicle, the part of the seed that will become the root, begins to elongate and grow downward. **Color the root brown (D)**. Meanwhile, the coleoptile begins to grow upward. The coleoptile is a sheath that encloses the shoot of the embryo. The primary function of the coleoptile is to provide protection to the developing shoot as it is passing through the soil. **Color the coleoptile orange (E)**. Extending out from the coleoptile is the shoot. **Color the shoot purple (F)**.

Eventually adult leaves grow on the plant. **Color these leaves light green. (G)**

Adult Monocots and Dicots

Angiosperms are divided into two classes, the monocots and the dicots. The majority of flowering plants are dicots. Dicots include maples, oaks, and magnolias. Monocots are grasses, wheat, corn, and rice. Most of our food supply comes from monocots. The diagram compares the differences between the two.

First of all look at the roots. The root of a monocot is called a fibrous root and the root of a dicot is a taproot. Notice how taproots have one main part - called the primary root. In a taproot the primary root grows very large and small roots spread out from it. Fibrous roots, on the other hand, do not have very large primary roots, and many small roots develop and remain near the surface. **Color the taproot dark brown and the fibrous root light brown.**

Monocots and dicots also differ in their leaf structure. Adult monocots usually have parallel venation, whereas dicots have net-like venation. For monocots and dicots, **color the leaves green and outline the veins in a darker green**. The flowers of monocots and dicots differ in the number of petals they have. Monocots tend to have flower parts that occur in 3's (3, 6, 9, 12…). Dicot flowers usually have 4 to 5 petals. **Color the monocot flower purple, and the dicot flower pink** (make sure all petals are colored). Stems hold the flowers up and attach the leaves, **color the stems blue.**

Monocot and dicots also differ in the way their vascular systems are arranged. In monocots, the vascular bundles are scattered throughout the stem. In dicots, the vascular bundles are arranged in a ring. **Color the vascular bundles in both types of plants purple (V), color the stems blue**.

Questions:

1. Give two examples of plants that are monocots. ____
2. Give two examples of plants that are dicots. ____
3. What is a cotyledon? ____
4. What is the radicle? ____

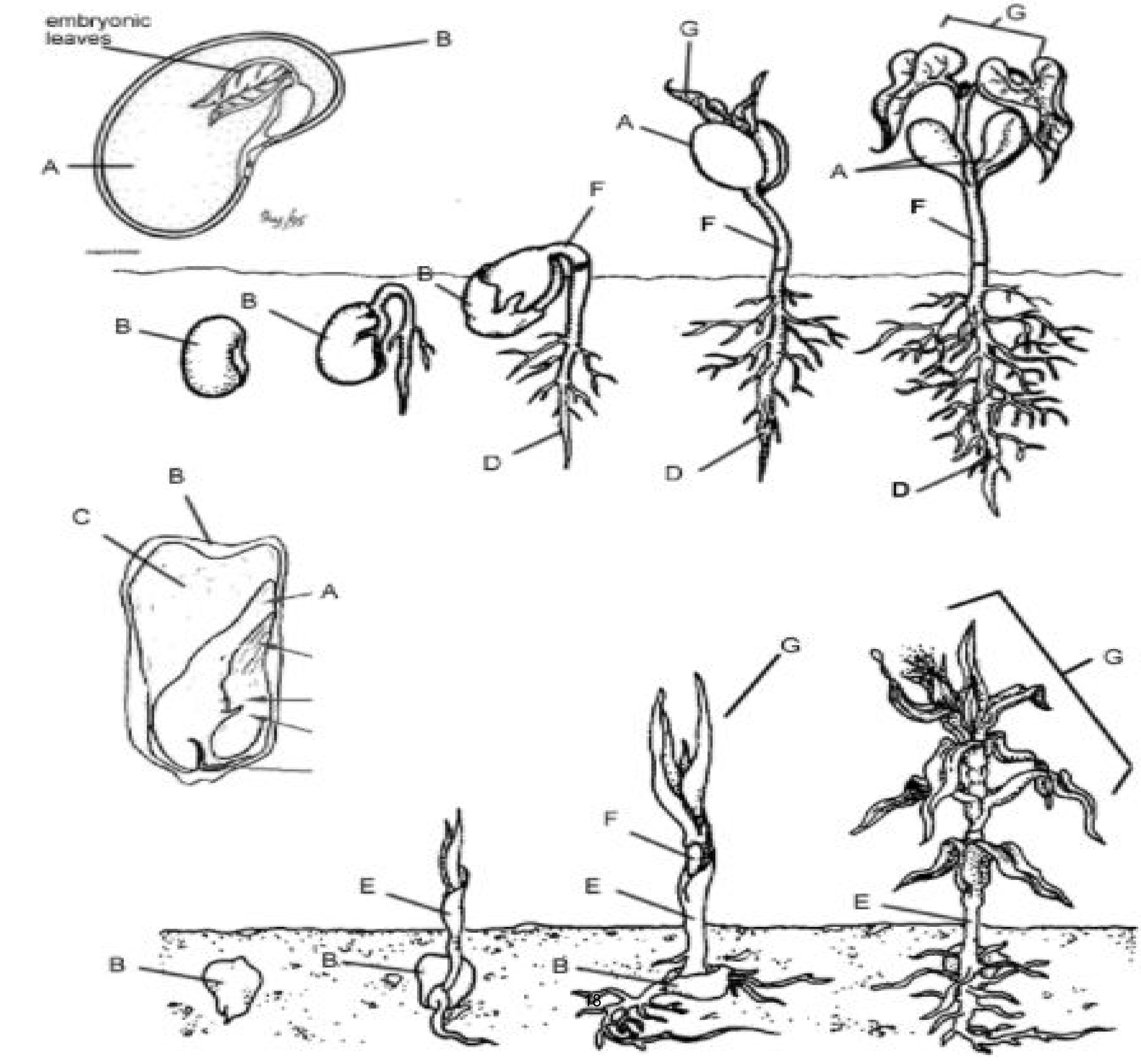
5. What is the coleoptile? ____
6. What is the function of the endosperm? ____

7. Fill out the table below.

	Number of Seed Leaves	Type of Leaf Venation	Number of Flower Parts	Type of Roots	Example
Monocot					
Dicot					

8. An unknown plant is brought to you and your job is to determine whether it is a monocot or a dicot. You observe that the plant has 6 petals and its leaves have parallel veins. Is it a monocot or a dicot?

COLORING



Skills Worksheet

Active Reading

Section: The Atmosphere

Read the passage below and answer the questions that follow.

Solar energy reaches the Earth as electromagnetic radiation, which includes visible light, infrared radiation, and ultraviolet light. The sun releases a vast amount of radiation, but our planet only receives about two-billionths of this energy. This seemingly small amount of radiation contains a tremendous amount of energy, however. About half of the solar energy that enters the atmosphere passes through the atmosphere and reaches the Earth's surface. The rest of the energy is absorbed or reflected in the atmosphere by clouds, gases, and dust, or it is reflected by the Earth's surface. On a sunny day, rocks may become too hot to touch. If the Earth's surface continually absorbed energy, the Earth would get hotter and hotter. The Earth does not continue to get warmer, because the oceans and the land radiate the energy they have absorbed back into the atmosphere.

IDENTIFYING MAIN IDEAS

One reading skill is the ability to identify the main idea of a passage. The main idea is the main focus or key idea. Frequently, a main idea is accompanied by supporting information that offers detailed facts about main ideas.

In the space provided, write the letter of the term or phrase that best completes each statement or best answers each question.

______ **1.** When solar energy reaches Earth, it is in the form of
- **a.** visible light.
- **b.** infrared radiation.
- **c.** ultraviolet light.
- **d.** All of the above

______ **2.** How much of the sun's radiation does Earth receive?
- **a.** one-millionth
- **b.** two-hundredths
- **c.** half
- **d.** two-billionths

______ **3.** Approximately what percentage of solar energy that passes through the atmosphere reaches Earth?
- **a.** 5 percent
- **b.** 20 percent
- **c.** 25 percent
- **d.** 50 percent

In the space provided, write the letter of the phrase that best completes the statement.

______ **4.** Visible light, infrared radiation, and ultraviolet light are all forms of
- **a.** ions.
- **b.** electromagnetic radiation.
- **c.** atmospheric gases.
- **d.** aerosols.

RECOGNIZING SIMILARITIES AND DIFFERENCES

One reading skill is the ability to recognize similarities and differences between two phrases, ideas, or things. This is sometimes known as comparing and contrasting.

Read each question and write the answer in the space provided.

5. A park bench may become very hot on a sunny day. Why is the bench like the rock mentioned in the passage above?

____

____

____

6. What happens to the solar energy that is not absorbed by Earth's surface?

____

____

____

RECOGNIZING CAUSE AND EFFECT

One reading skill is the ability to recognize cause and effect.

In the space provided, write the letter of the term or phrase that best completes each statement or best answers the question.

______ **7.** All of the solar energy that enters Earth's atmosphere does not reach Earth's surface because it is either absorbed or

a. scattered.
b. refracted.
c. reflected.
d. Both (a) and (c)

Read the following question and write the answer in the space provided.

8. Explain why Earth's surface does *not* get hotter and hotter.

____

____

____

Weather Watch

You may wonder how meteorologists forecast the weather. The science of forecasting deals with water. Meteorologists work with water in all three of its states (solid, liquid, and gas) to predict the weather.

At different temperatures, water molecules form different types of clouds. There are four major types of clouds. Cumulus clouds are white, puffy clouds common on warm summer afternoons. Under the right conditions, cumulus clouds can form cumulonimbus clouds. Cumulonimbus clouds are storm clouds. Stratus clouds, the third type, are gray, sheetlike clouds that cover the sky. Finally, cirrus clouds are thin clouds that resemble feathers. They are found high in the atmosphere.

Meteorologists use their knowledge of cloud types along with other information to forecast local weather. Other factors considered for weather forecasting include temperature, humidity, and air pressure.

Directions Compare your local weather forecast to the weather you observe where you live. Use the table below to keep records of the temperature, wind speed, wind direction, cloud types, and precipitation in your community. Write the meteorologist's forecast for your community in the middle column. Write your records in the right-hand column.

Weather elements	Meteorologist forecast	Your findings
Temperature		
Cloud Types		
Wind Speeds		
Wind Directions		
Precipitation		

Directions Write the answers to the questions on the lines below.

1. What are the four major types of clouds? ______________________

____

2. What are some weather elements associated with cloud types? ______________________

____

Weather Watch, continued

3. What are some weather elements that make up Earth's weather? ______________________

____

4. Were your findings similar to the meteorologist's forecasts?
Why or why not? ____

____

5. Would you be interested in forecasting the weather for your
local weather station? Explain your answer. ______________________

____

Date ______________________________ Block ___________ Name ____

Hydroponics **Horticulture Enrichment Packet**

https://www.youtube.com/watch?v=J0fsehjZfzc 7min Comparing hydroponics vs aquaponics by a fervent lover of the latter.
https://www.youtube.com/watch?v=vPRySy3Qtvs 24 min Discovery Science Singapore's urban farmers.
https://www.youtube.com/watch?v=vPRySy3Qtvs University of Arkansas Article: Hydroponics and Aquaponics

Hydroponics: The power of water to grow food

Harvard.edu

by Valentina Lagomarsino, figures by Rebecca Senft

In the year 600 B.C.E., the climate was arid and dry along the Euphrates River in Western Asia, but there were lush gardens climbing up the walls of the metropolis, Babylon. It is believed that the Hanging Gardens of Babylon were surviving through a pulley-system of water from the river, a technique of agriculture that today is known as hydroponics. More specifically, hydroponics is the method of farming where plants can be grown in nutrient-fortified water, instead of in soil. Given concerns of feeding a growing human population in a changing climate, scientists believe hydroponic technology may be able to mitigate impending food shortages.

The need for innovative agriculture

The United Nations (UN) has projected the global population to reach nearly 10 billion people by 2050, with "roughly 83 million people being added to the world's population each year until then." In 2019 alone, an estimated 124 million people faced acute food shortages from climate-related events such as flooding, irregular rains, droughts, and high temperatures. Given that hydroponics can grow food in a controlled environment, with less water and in higher yields, the Food and Agriculture Organization of the United Nations has been implementing hydroponic farming in areas of the world that suffer from food shortages. There are currently ongoing projects to establish large hydroponic farms in Latin American and African countries.

The technology used in hydroponic systems being implemented in developing countries around the world are largely based off of hydroponic systems that were designed at NASA. In the late 20th century, physicists and biologists got together to figure out a way to grow food in one of the starkest climate known to humans: space. Aerospace plant physiologists at NASA began experimenting with growing plants on the International Space Station using hydroponics technology because it requires less space and less resources than conventional farming. After extensive tests, astronauts ate the first space-grown leafy vegetables in 2015. How did NASA get the idea to use this technology in space? It was from a century of work by scientists who found that plants were surviving–and thriving–while being grown in water.

<u>Invention of modern day hydroponics</u>

In the 19th century, a German botanist at the University of Wurzburg, Julius Sachs, dedicated his career to understanding the essential elements that plants need to survive. By examining differences between plants grown in soil and those grown in water, Sachs found that plants did not need to grow in soil but only needed the nutrients that are derived from microorganisms that live in the soil. In 1860, Sachs published the "nutrient solution" formula for growing plants in water, which set the foundation for modern day hydroponic technology (Figure 1).

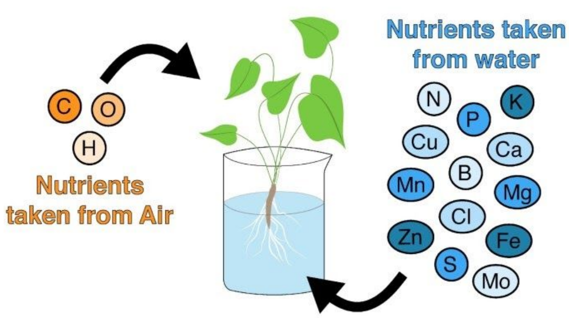
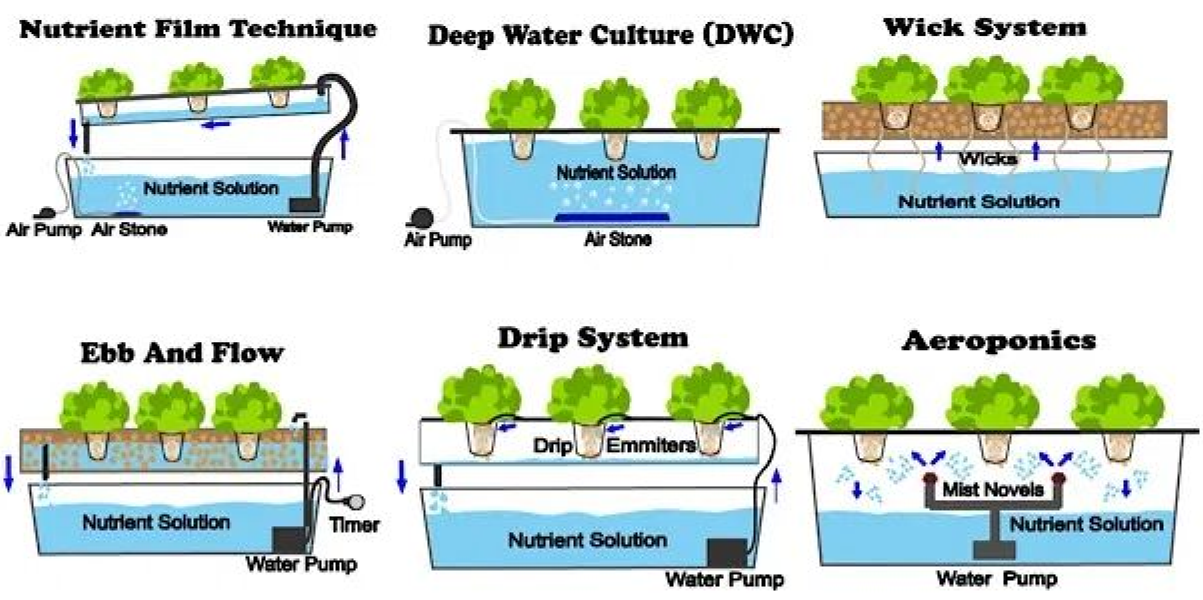


Figure 1: **Nutrient Solution.** Plants obtain 3 nutrients from the air–carbon, hydrogen, and oxygen–and 13 nutrients from supplemented water: nitrogen, phosphorous, potassium, calcium, magnesium, sulfur, iron, manganese, copper, zinc, boron, chlorine, and molybdate.

In 1937, an American scientist, Dr. W.E. Gericke described how this method of growing plants could be used for agricultural purposes to produce large amounts of crops. Gericke and others demonstrated that the fluid dynamics of water changed the architecture of plant roots, which allowed them to uptake nutrients more efficiently than plants grown in soil, causing them to grow larger in a shorter amount of time. Since then, scientists have optimized the nutrient solution, a total of 13 macronutrients and micronutrients, that are added to water for hydroponic farming (Figure 1).Hydroponic systems today are very sophisticated; there are systems that will monitor the level of nutrients pH, and temperature of the water, and even the amount of light the plants are receiving. There are three main types of hydroponic systems: a nutrient film technique, an Ebb and Flow System, and a Wick system (Figure 2). A nutrient film hydroponic technique involves plants being grown in a grow tray that is slightly angled and positioned above a reservoir filled with the water-nutrient mix. This allows a thin stream of water to flow across plant roots, allowing



the plants to have sufficient water, nutrients and aeration, and then drained back into the reservoir. The nutrient film technique is the most common hydroponic system used today. Plenty and Bowery, two of the largest hydroponic farms in the US, use nutrient film techniques to grow lettuce, spinach and other leafy greens. The Ebb and Flow technique allows plants to be flooded with the nutrient-rich water, and after the plant roots uptake nutrients, water is actively drained back into a reservoir to be reused. Finally, a hydroponic wick system is the simplest of all, as nutrients are passively given to the plant from a wick or piece of string running up to the plant from the water reservoir. In this system, plants are grown in an inert growing medium such as sand, rock, wool or clay balls that help anchor the plant roots. These different systems are interchangeable, but some systems may be better for growing different types of plants.

Figure 2: **The three most common techniques for hydroponic farming.** In all approaches, water fortified with a nutrient solution is stored in a nutrient reservoir. The water is then actively pumped to the grow tray (panels A and B) or it is passively passed to the grow tray (panel C) through a wick. The plant roots grow thicker than those of plants grown in soil, which allow them to uptake nutrients more effectively.

The advantages of using any of these hydroponic systems are manifold. First, since there is no soil, there is no need to worry about having a plot of land, weeds, pathogens living in dirt, or treating the crops with pesticides. Water is also greatly conserved due to the nutrient reservoir because the same water can be reused over and over. Moreover, as most of these hydroponics farms are indoors, food can be produced all year round and even in the middle of a large city, like New York City. Given all of these benefits, we may begin to see more hydroponic farms sprouting up across the US and around the world because this method of farming holds much promise to revolutionize agriculture by using less water and other resources.

Hydroponics for a sustainable future

Given the need for more sustainable agriculture, there has been a rise in eco-friendly start-up companies around the world that are using hydroponic technology to produce crops on a large scale with a technique known as "Vertical Farming" (Figure 3).

Vertical farms are buildings filled with countless levels of hydroponic systems (or nutrient film style planters), growing different crops in an indoor, controlled temperature environment (Figure 3). The largest vertical farm is being built in Dubai, covering 130,000 square feet of land and aiming to produce 6,000 pounds of food per day, "using 1/2500th the amount of water as an equivalent soil operation". For a city that imports 85% of their food, this will greatly revolutionize the way the city eats.

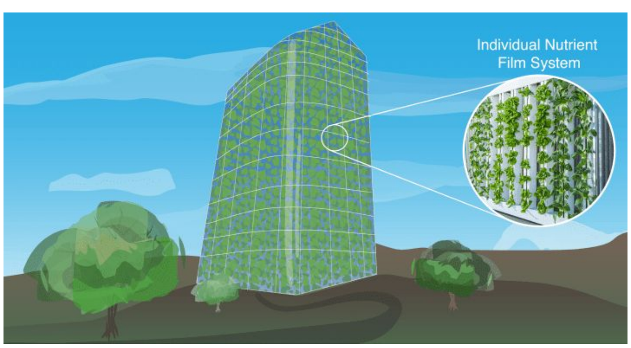


Figure 3: **Vertical Farming.** Vertical Farming is the term for large-scale hydroponic systems that are engineered to house thousands of square feet of growing systems, across many floors in a skyscraper-esque building.

While vertical farms hold a lot of promise, they are expensive to implement, technically difficult on a large scale, and the food produced from these systems is generally more expensive than equivalent soil grown food because of the high-energy costs of maintaining the systems. Even so, the Associated Press estimates that food produced by hydroponic technology in 2019 is worth $32 billion USD, and this is projected to grow at a rate of 5% per year until 2025.

While hydroponic technology may never replace conventional farming, it is breaking the paradigm of food production; we may see a new generation of modern farmers building green walls inside their houses or community centers to feed families with fresh produce grown all year round.

Valentina Lagomarsino is a second-year PhD student in the Biological Biomedical Sciences program at Harvard University. Rebecca Senft is a fifth-year Program in Neuroscience PhD student at Harvard University who studies the circuitry and function of serotonin neurons in the mouse.

Questions:

1. Explain the origin of hydroponics. ______________________________

   ____

   ____

2. Discuss the need for innovative agricultural systems. ______________________________

   ____

   ____

3. Compare 3 styles of hydroponics systems. ______________________________

   ____

4. Differentiate between rural and urban hydroponic designs. ______________________________

   ____

   ____

5. Describe how you would design a hydroponics structure for corn? ______________________________

   ____

   ____

6. How might your corn structure differ from one for potatoes or onions? ______________________________

   ____

7. Analyze the cost effectiveness of hydroponics farming. ______________________________

   ____

8. How could the increased cost of production be counterbalanced? ______________________________

   ____

9. Explain which crops you see becoming more or less prioritized in hydroponics farming and why. ________

   ____

10. Draw a hydroponics wall in your home. Label water source, flow system, nutrients, crops, & maintenance.
    https://www.youtube.com/watch?v=zockOFKKX2E 7:43 min Qanat of Iran in the desert

Date ___________________________ Block __________ Name ______________________________________

Microgreens Horticulture Enrichment Packet

https://www.youtube.com/watch?v=bRgYbFJpwFU 2min Urban Farmer planting and harvesting microgreens

Specialty Greens Pack a Nutritional Punch

"Microgreens" is a marketing term used to describe tiny, tender, edible greens that germinate in soil or a soil substitute from the seeds of vegetables and herbs. Smaller than "baby greens," and harvested later than "sprouts," microgreens can provide a variety of leaf flavors, such as sweet and spicy. They are also known for their various colors and textures. Among upscale markets, they are now considered a specialty genre of greens that are good for garnishing salads, soups, plates, and sandwiches.

Microgreens began showing up on chefs' menus as early as the 1980s, in San Francisco, according to a local industry source. Today, the U.S. microgreens industry consists of a variety of seed companies & growers.

A microgreen has a single central stem, which has been cut just above the soil during harvesting—in fact, home gardeners often snip them with scissors. The seedlings are well suited for local growers because microgreens are harvested just 7 to 14 days after germination when the cotyledons (seed leaves) have fully developed and before the true leaves have expanded.

Now, a team of Agricultural Research Service scientists and colleagues has published several studies that shed light not only on microgreens' nutritional benefits, but also on their complex shelf-life requirements.

Tiny But Mighty Produce

Microgreens are usually harvested at 1 to 3 inches tall and, depending on the species, are sold with the stem attached to the cotyledons. Plants with two cotyledons are called "dicots," and those are the leaves that the scientists studied. Plants with a single cotyledon are "monocots."

Crops that germinate easily and grow quickly are good candidates for growing as microgreens. ARS plant physiologist Gene Lester led a team of scientists who analyzed the key nutrients in different varieties of vegetable microgreens. The study results could be used as a reference in estimating the amounts and adequacies of specific vitamins that are gained when consumers eat microgreens, according to the authors.

The researchers determined the concentration of essential vitamins and carotenoids in 25 commercially available varieties of microgreens. Key nutrients measured were ascorbic acid (vitamin C), tocopherols (vitamin E), phylloquinone (vitamin K), and beta-carotene (a vitamin A precursor), plus other related carotenoids in the cotyledons.

The team showed that different microgreens contained widely differing amounts of vitamins and carotenoids. Total vitamin C content ranged from 20 to 147 milligrams (mg) per 100 grams of cotyledon fresh weight, depending on which plant species was being tested. The amounts of the carotenoids beta-carotene, lutein/zeaxanthin, and violaxanthin ranged from about 0.6 mg to 12.1 mg per 100 grams of fresh weight. For comparison, an average apple weighs 100-150 grams.

Among the 25 microgreens tested, red cabbage, cilantro, garnet amaranth, and green daikon radish had the highest concentrations of vitamin C, carotenoids, vitamin K, and vitamin E, respectively. In general, microgreens contained considerably higher levels of vitamins and carotenoids—about five times greater—than their mature plant counterparts, an indication that microgreens may be worth the trouble of delivering them fresh during their short lives.

Growing, harvesting, and handling conditions may have a considerable effect on nutrient content. Additional studies are needed to evaluate the effect of these agricultural practices on nutrient retention. The study was published in 2012 in the *Journal of Agricultural and Food Chemistry*.

Buckwheat Is Not Just for Pancakes

Buckwheat "seeds" look like cereal grains, but they are actually dry, hard-covered fruits called "achenes." Each achene contains one small seed. During germination, the seed bears cotyledons, thus accounting for buckwheat's candidacy as a microgreen.

Gram for gram, buckwheat has almost the same amount of protein as oats, according to the ARS National Nutrient Database for Standard Reference. It's also gluten free.

In a study headed by ARS food technologist Yaguang Luo with the Food Quality Laboratory in Beltsville, Maryland, the researchers focused on buckwheat microgreens, which, in addition to high protein, are considered high in antioxidants, flavonoids, carotenoids, and alpha-tocopherol. Like all microgreens, buckwheat microgreens typically have only a few days of shelf life. The team found that storage temperature and atmospheric composition are key variables when it comes to fresh-cut buckwheat microgreens. They extended shelf life by storing the greens at a relatively low 5°C and by elevating CO_2 and reducing O_2.

The researchers also fine-tuned packages to provide the optimal atmospheric composition required to extend the shelf life of buckwheat microgreens. Commercial microgreens are most often stored in plastic clamshell containers, which do not provide the right balance of O_2 and CO_2 for live greens to "breathe." Among package materials called "films," differences in permeability are referred to as "oxygen transmission rate."
The researchers found that buckwheat microgreens packaged in films with an oxygen transmission rate of 225 cubic centimeters per square inch per day had a fresher appearance and better cell membrane integrity than those packaged in other films tested. Following these steps, the team maintained acceptable buckwheat microgreen quality for more than 14 days—a significant extension, according to authors. The study was published in *LWT-Food Science and Technology* in 2013.
"Due to their short shelf life and growing requirements, bringing safe, high-quality microgreens to market can be relatively complex and labor-intensive," says Luo. "More studies are needed to understand their postharvest processing requirements." Studies on individual plant species grown and harvested as microgreens are helping to fill the dearth of information on this budding industry, which will ultimately assist growers, grocers, and chefs.—By Rosalie Marion Bliss, Agricultural Research Service Information Staff.

1. Explain the origin and benefits of microgreens. ____

   ____

2. Explain what would you need to successfully mature and harvest a crop of microgreens? _____________

   ____

3. Select and explain your top 3 choices of microgreens to grow. ___________________________________

   ____

4. Discuss nutritional content of microgreens. ____

   ____

5. How are buckwheat different from amaranth or radish in terms of microgreens and seeds? ____________

   ____

6. What are some marketing and packaging concerns with microgreens? ___________________________

   ____

7. How are these marketing and packaging concerns resolved? _____________________________________

   ____

8. How could the increase in CO_2 and the decrease in O_2 affect the shelf life and quality of product? _______

   ____

9. What blending of microgreens could increase sales? ____

   ____

10. Design a packaging label that touts the nutrition, flavor and shelf life.…. of your microgreen blend.