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AP BIOLOGY

Big Idea 2
Part D

January 2013

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Big Idea 2: Part D

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Physiology of Plants

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Contents

Bioenergetics Has Transformed Earth

The evolution of complex life has changed Earth and made it a unique planet. Life's ability to transform and use energy has created **ecosystems** that cover Earth's surface and deep into the oceans.

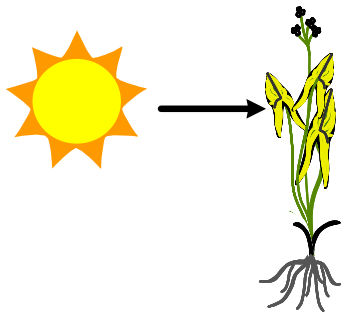
Bioenergetics Has Transformed Earth

Every ecosystem relies on a **producer** to transform energy into usable forms for the rest of the life forms in the ecosystem.

Ecosystems and Energy Transformations

As we know, the sun is the starting point for all energy in life.

Ecosystems and Energy Transformations

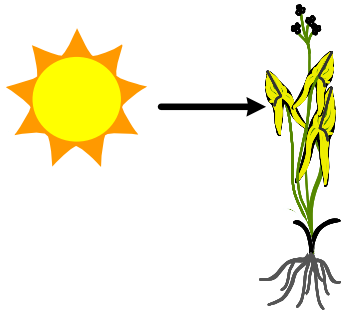


Plant

The only complex multicellular eukaryotes capable of photosynthesis are plants. Because plants are large and complex they serve as the starting point for the vast majority of ecosystems on this planet. They are the producers.

They are **photoautotrophs**, capable of producing their own chemical energy in the form of sugar from the radiant energy of the sun.

Ecosystems and Energy Transformations



Plant

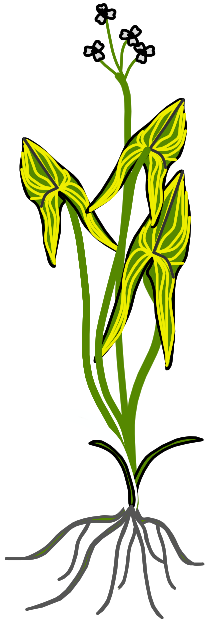
They are also known as **primary producers** because the sugar they make will be the product that feeds the rest of the ecosystem.

All others in an ecosystem are consumers, they eat plants directly or eat other organisms that eat plants.

1 Which of the following describes the role of plants in the ecosystem? (select all that apply)

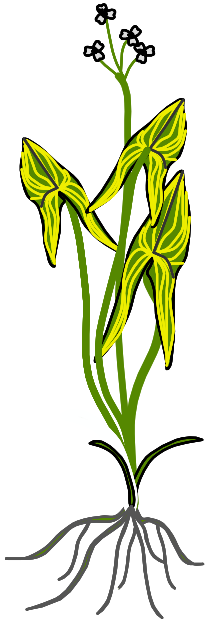
- ☐ A producers
- ☐ B photoautotrophs
- ☐ C consumers
- ☐ D derive energy from radiant heat
- ☐ E derive energy from other organisms

Physiology of Plants



We have noted on a few occasions the importance of sugar and the process of photosynthesis. We know that plants conduct photosynthesis so we know they are capable of metabolism. Are they also capable of homeostasis?

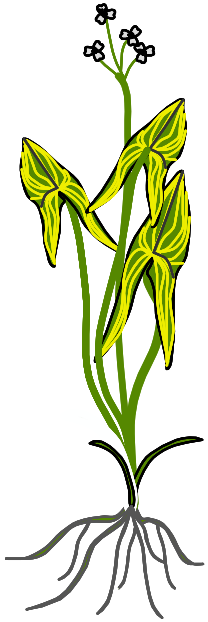
Physiology of Plants



Since plants are so important to an ecosystem, we will examine some of the reactions working inside of plants.

First, what do plants need in order to make sugar?

Physiology of Plants



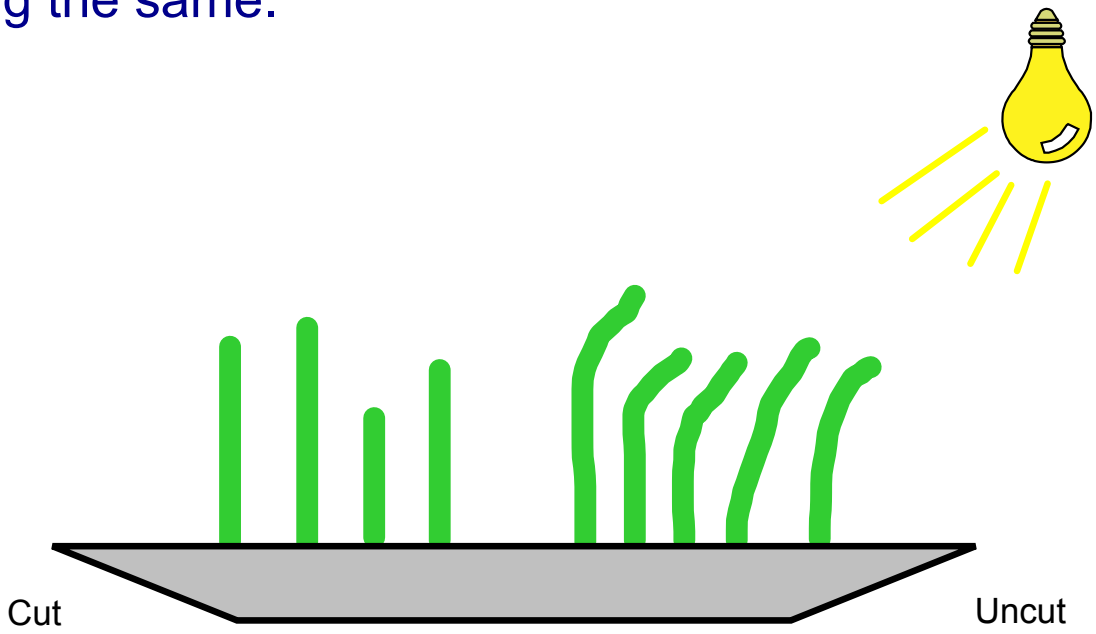
When a plant makes sugar it produces a waste product that must be eliminated as a gas from the plant. What is this gas?

Physiology of Plants: Sunlight

An important feature of plants is their ability to grow toward sunlight. This is called **phototropism**. It ensures that the plant will optimize the amount of sunlight it can gather.

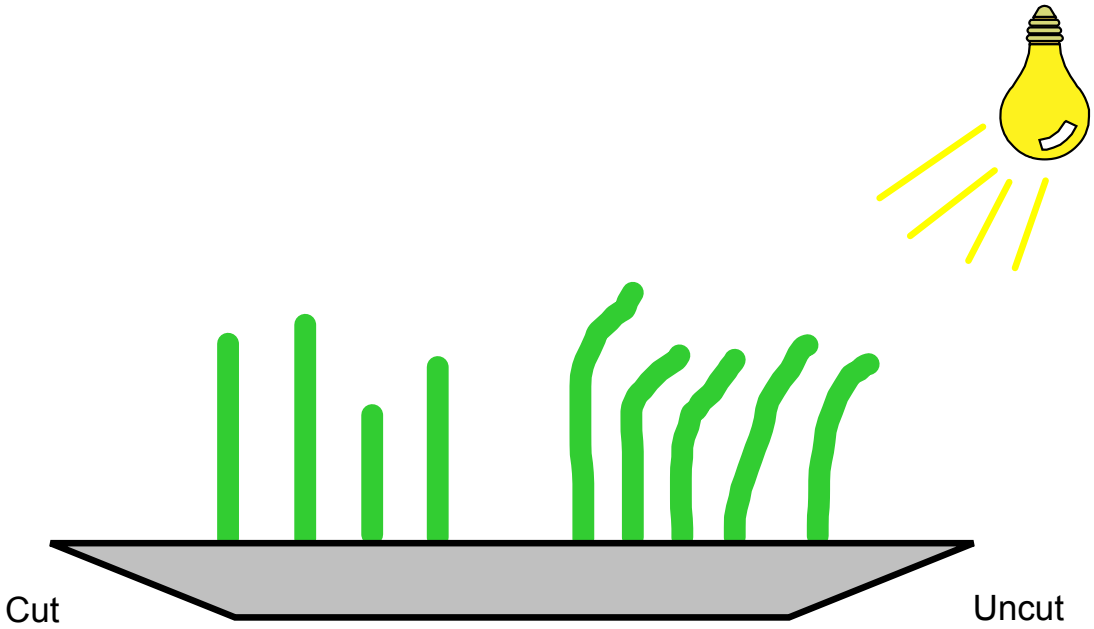
Physiology of Plants: Sunlight

A botanist is growing some plants under an artificial light source and accidentally cuts the tops of some sprouting plants. After a time she notices that the plants are not growing the same.



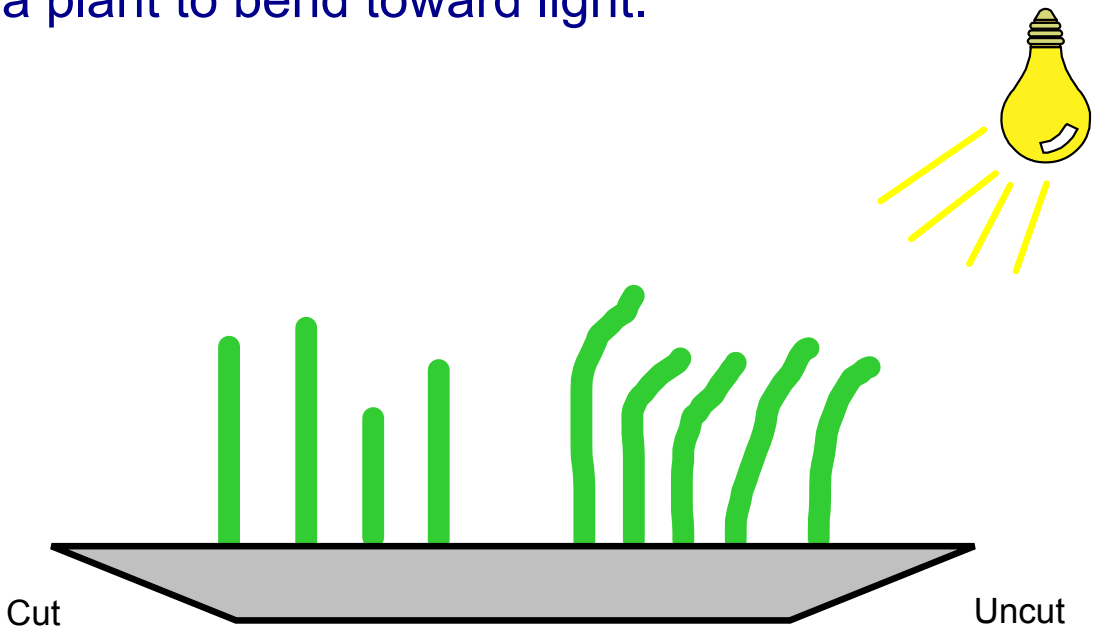
Physiology of Plants: Sunlight

For some reason the cut plants do not grow toward the light. She hypothesizes that the tip of the plant is exhibiting hormonal control of the plant.



Physiology of Plants: Sunlight

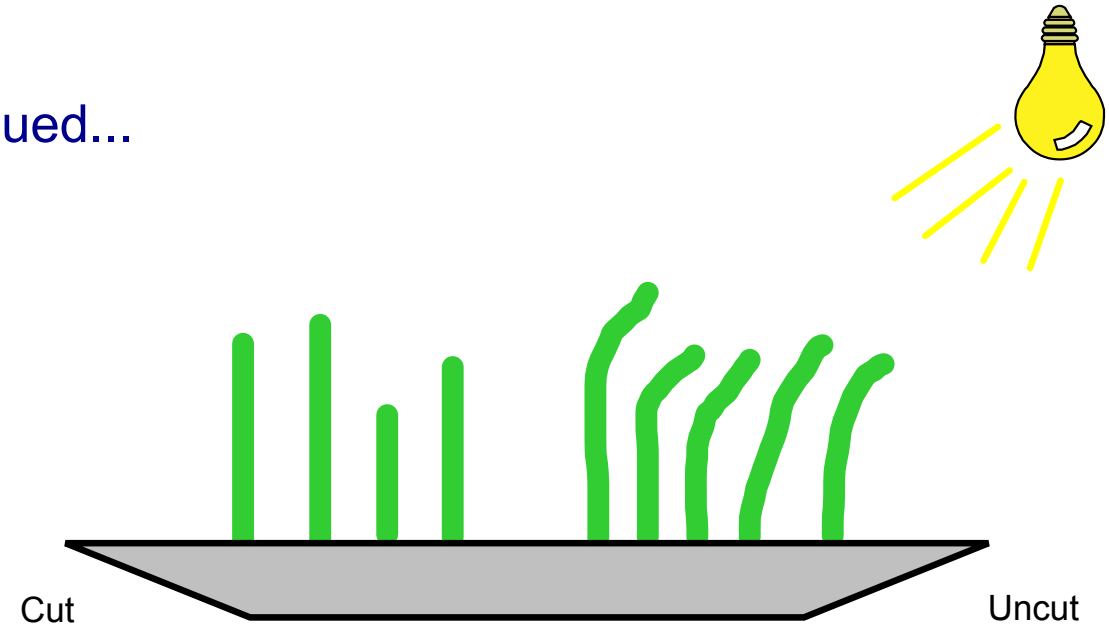
With a group, discuss what is physically happening at a cellular level to cause a plant to grow toward a light source. Consider what a hormone would have to do in order to cause a plant to bend toward light.



Physiology of Plants: Sunlight

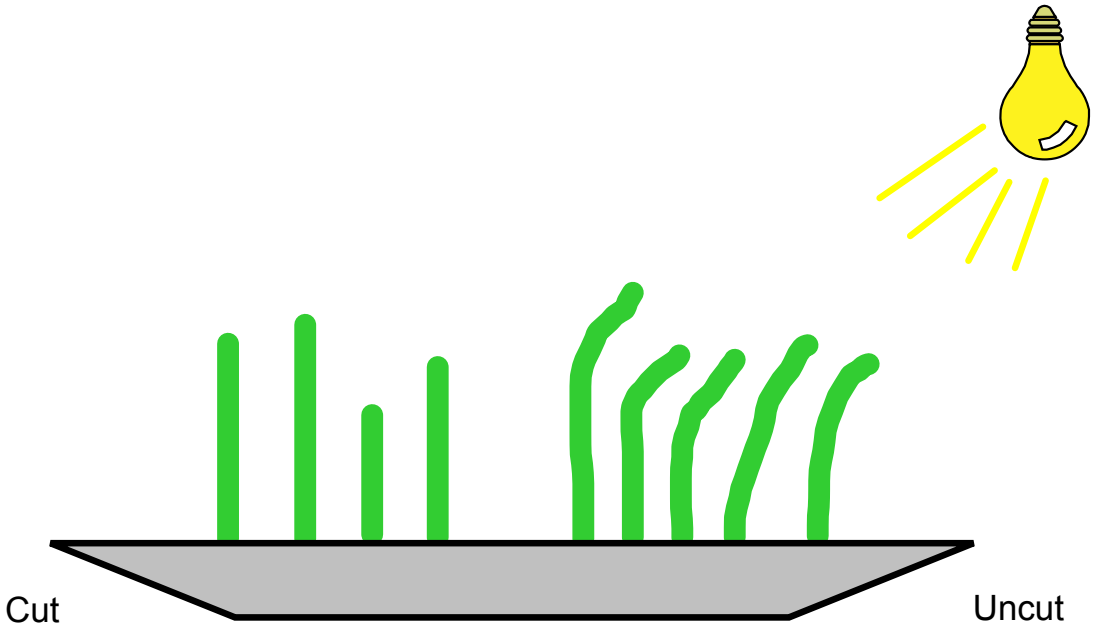
There are several possibilities for this observation:
1) The tip could be growing toward the light. This would require no hormonal control of the rest of the cells in the plant.

continued...



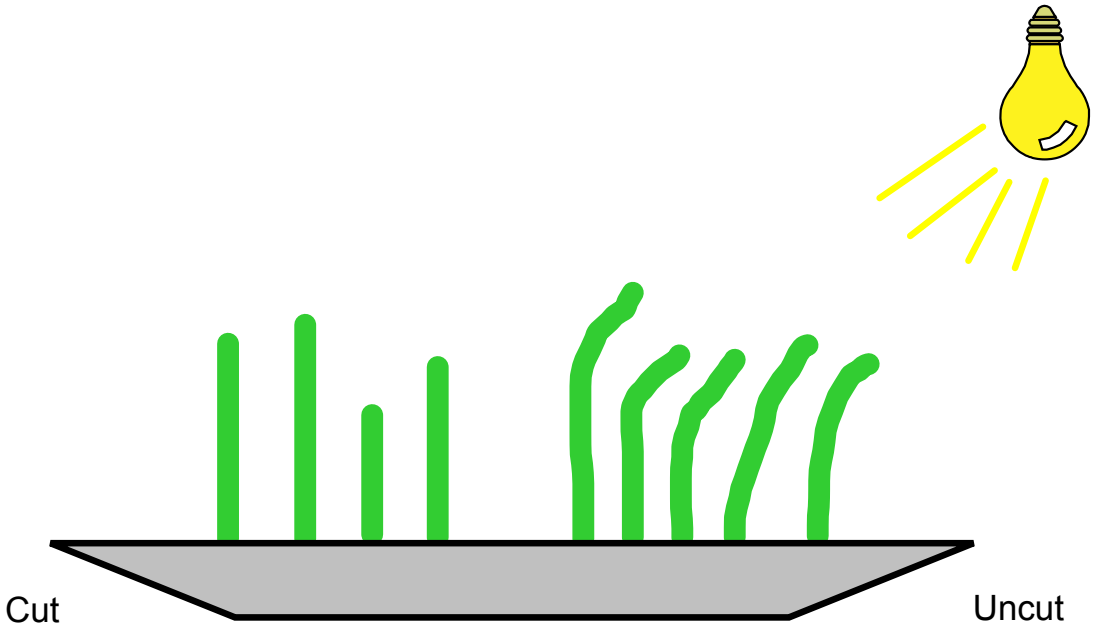
Physiology of Plants: Sunlight

There are several possibilities for this observation.
2) The tip could be releasing a hormone that stunts the growth of the cells on the light side of the plant or...



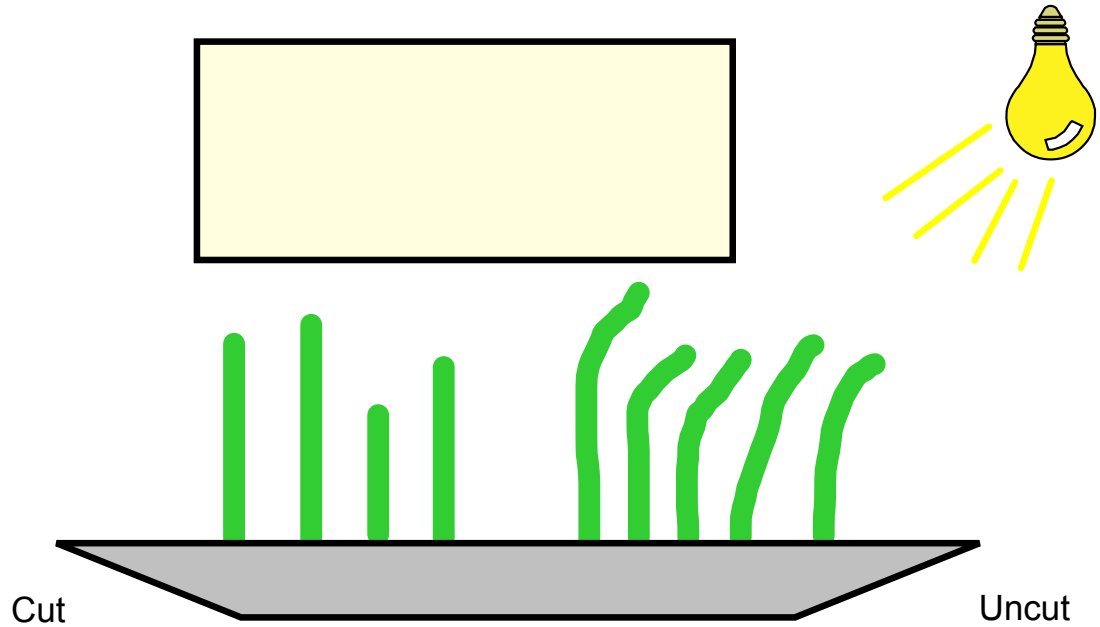
Physiology of Plants: Sunlight

There are several possibilities for this observation.
3) The tip could be releasing a hormone that speeds up or elongates the cells on the opposite side to the light source.



Physiology of Plants: Sunlight

Pick one of these theories and design an experiment that could prove your theory while eliminating the others as possibilities. Then click below to reveal which is correct.



Auxin is Plant Growth Hormone

Phototropism works because the tip of the plant produces auxin, a hormone that controls the length of cell growth in plant cells. This hormone runs down the stem. When light is directly overhead an equal amount of hormone travels down each side of the stem making the cells grow evenly. When the light is on one side of the plant more hormone travels down the dark side of the plant making these cells grow faster and the plant grow towards the light.

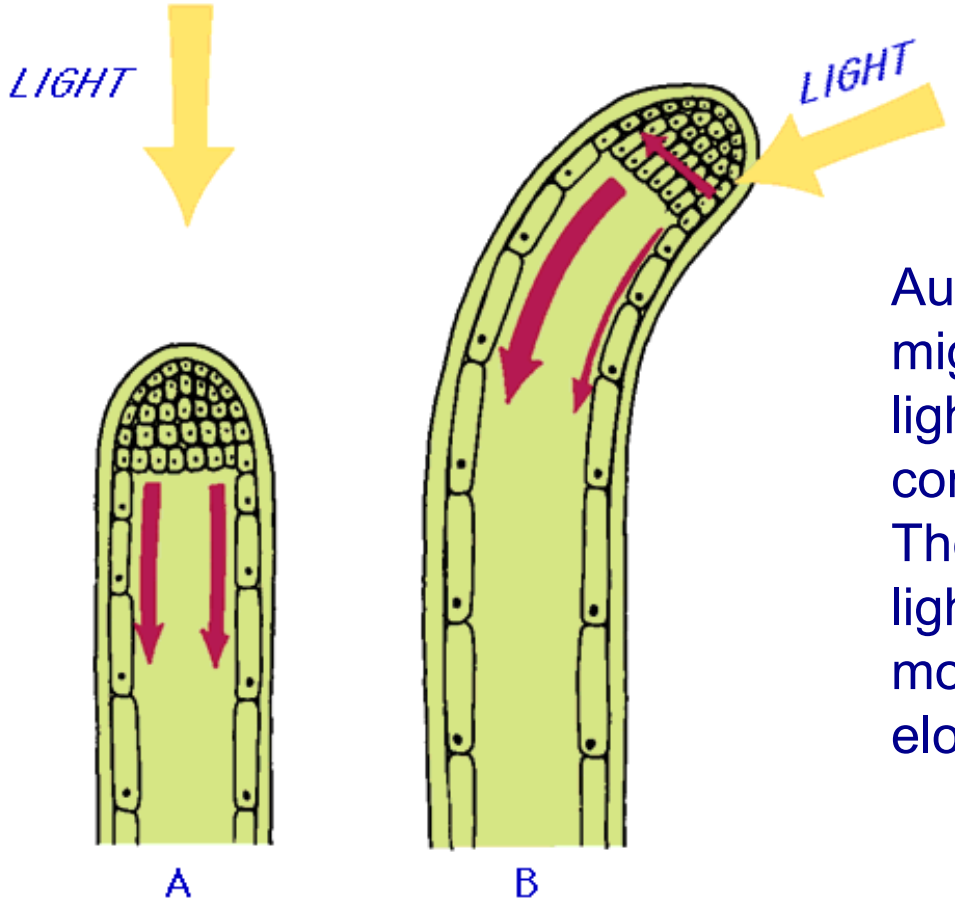
2 Auxin is a hormone found in plants and is responsible for

- A phototropism
- B photoperiodism
- C photosynthesis
- D photosensitivity

3 In which part of the plant is auxin found?

- A root
- B stem
- C leaves
- D nodes

Auxin is Plant Growth Hormone



Auxin naturally migrates away from light causing a concentration gradient. The further from the light the more auxin, more auxin = more elongation.

4 Which part of the plant will experience a higher concentration of auxin?

- A The part closest to the light
- B The part farthest from the light

Homeostasis in Plants

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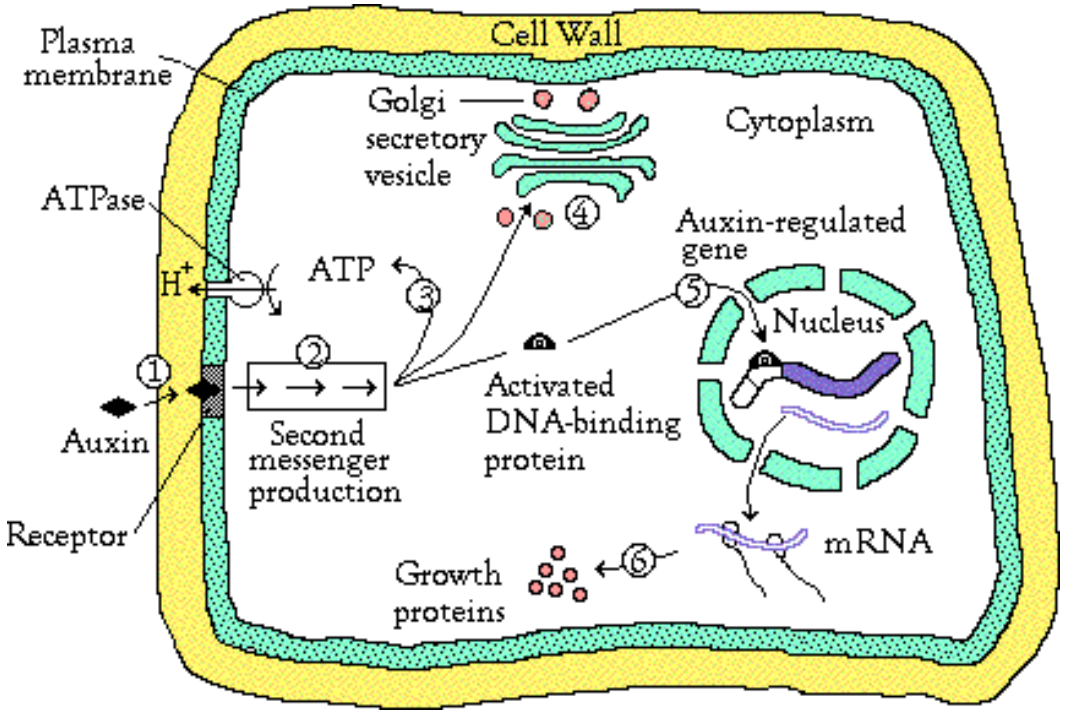
Plants use Hormonal Control to Maintain Homeostasis

Auxin is just one example of plants using hormones to exhibit whole organism control by effecting each cell. This example is just one of many hormones that control homeostasis and enable the plant to gain optimal growth and energy efficiency.

Overview of the Auxin Effect

These slides combine what we just learned about auxin with what we know about how hormonal control works on a cell.



http://www.cartage.org

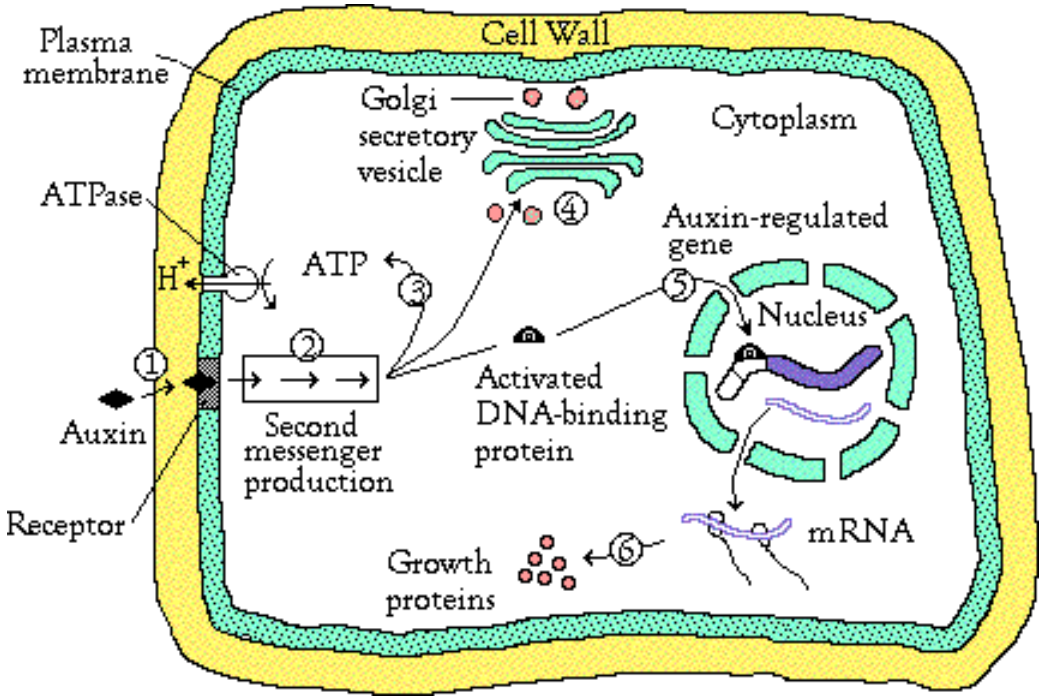
(1) The hormone binds to an auxin receptor

(2) This signal is transduced into second messengers within the cell

(3) Proton pumps are activated, and secretion of acid loosens the wall, enabling the cell to elongate.

Overview of the Auxin Effect

These slides combine what we just learned about auxin with what we know about how hormonal control works on a cell.



http://www.cartage.org

(4) The Golgi apparatus is stimulated to discharge vesicles containing materials to maintain the thickness of the cell wall.

(5) The signal-transduction pathway also activates DNA-binding proteins that induce transcription of specific genes.

(6) This leads to the production of proteins required for sustaining growth of the cell.

Other Plant Hormones

Gibberellin:

Like auxin it promotes cell elongation, and it acts as a chemical messenger (hormone) to stimulate the synthesis of hydrolytic enzymes. These enzymes are important in the germination of seedlings to ensure the release of stored nutrients.

Those nutrients feed the seedling's early development. This chemical hormone is so
industry to promote growth.

The grapes on the right were treated with a gibberellin solution.

Other Plant Hormones

Cytokinins:

Cytokinins stimulate cell division and differentiation in plants; usually coupled with auxin.

Cytokinins slow the process in which chlorophyll breaks down and various molecules and minerals are removed from leaves before they fall.

Protein synthesis stops when leaves are picked, but if they are treated with cytokinin they remain green, protein synthesis continues, and carbohydrates do not break down.

These cuttings were removed from their parent plant 7 weeks ago.

The one on the right was genetically engineered to produce more Cytokinins

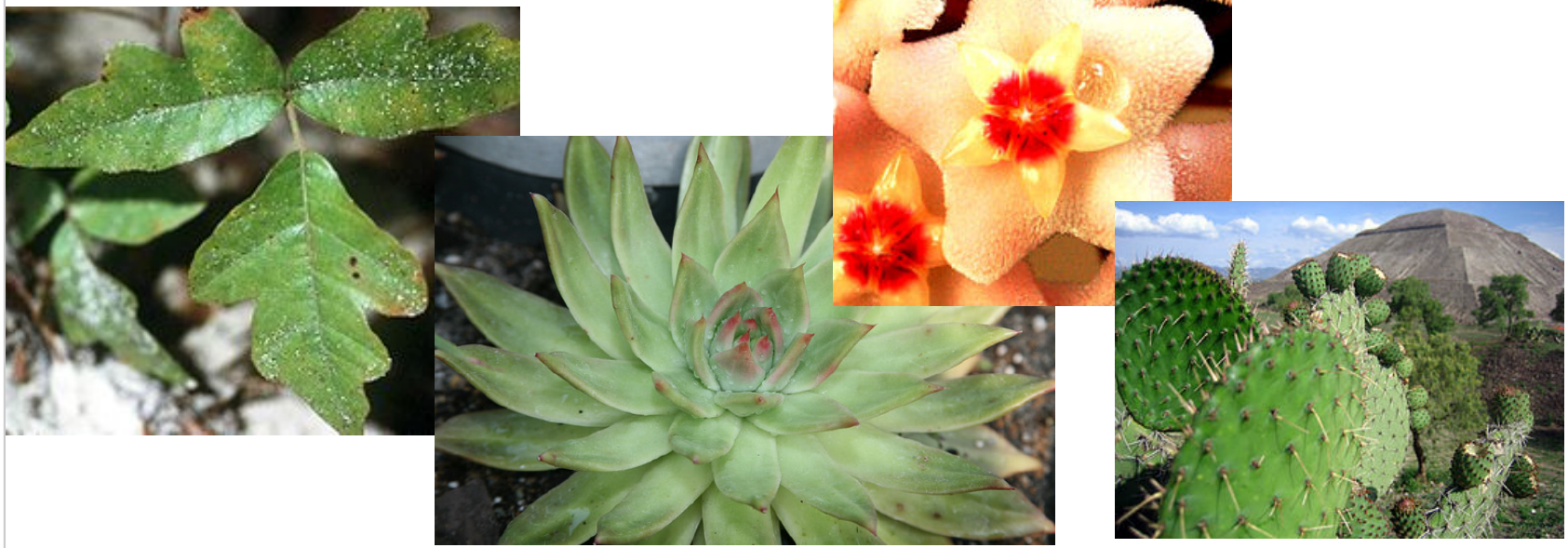
Plant Immunity

Bacteria and viruses are as much a threat to the homeostasis of plants as they are to animals. For this reason plants must also protect themselves and be able to fight foreign pathogens.

Plants only have generalized defenses against pathogens. They do not have specific immunity. Much like invertebrates, the evolution of plants came long before specific immunity evolution on the tree of life.

Plant Immunity

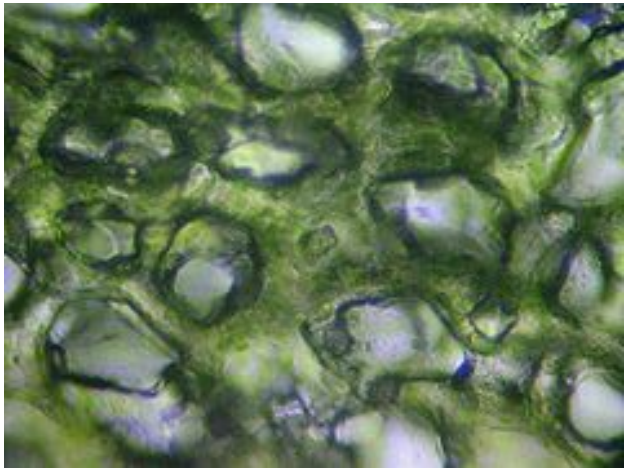
As with animals, the first line of defense against pathogens is the outer covering. Plants have varying levels of external defenses that can include waxy coatings, sticky excretions, thick cuticles and others.



Plant Immunity

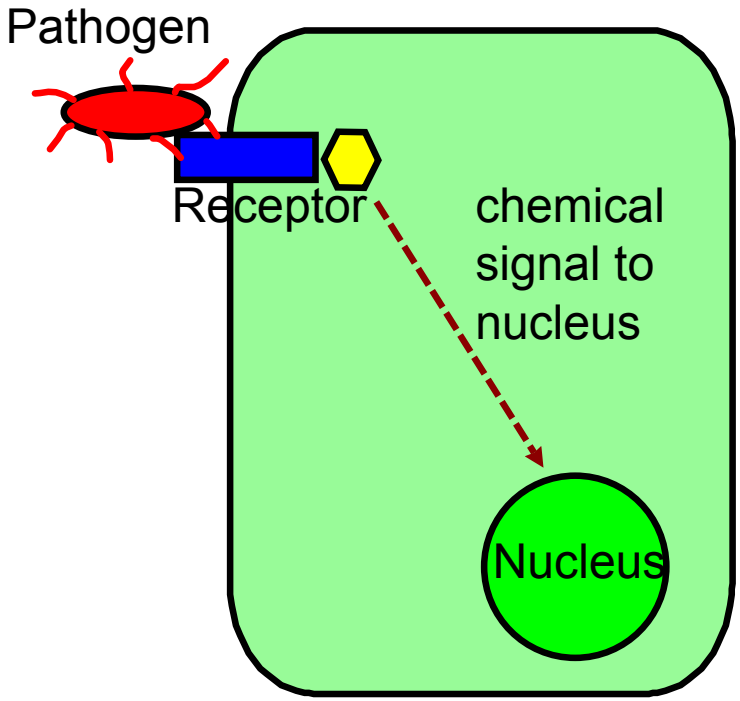
Since plants have slow moving circulation systems (or no circulation at all), if a pathogen gets past the external covering individual cells are on their own to defend themselves.

These spongy mesophyll cells each have an internal defense system that is triggered when contacted by a pathogen.



Plant Immunity

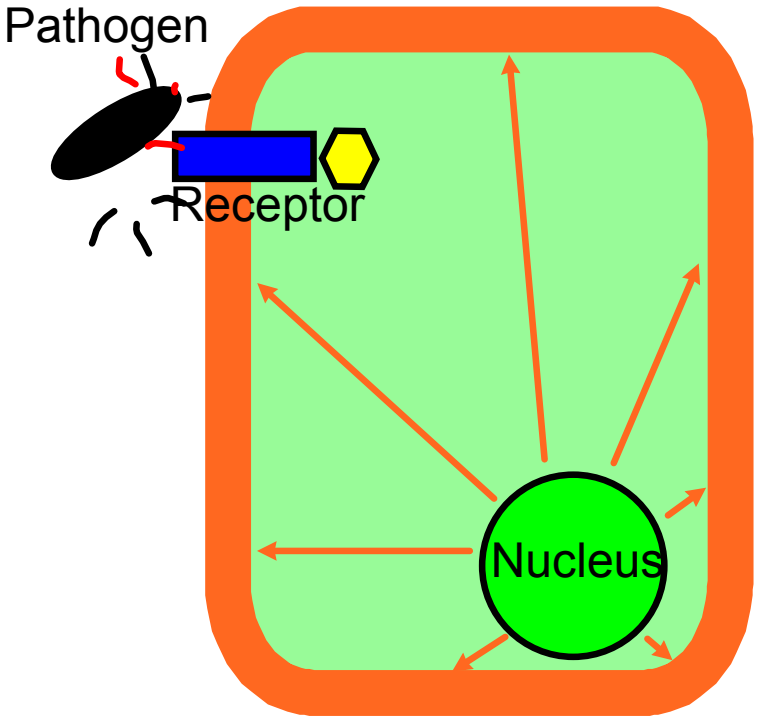
Upon pathogen attack, pathogen-associated molecular patterns (**PAMP**s) activate receptors in the plant cell, resulting in a signaling cascade that leads to PAMP-triggered immunity (**PTI**)



From this point there are 2 possible responses by the cell.

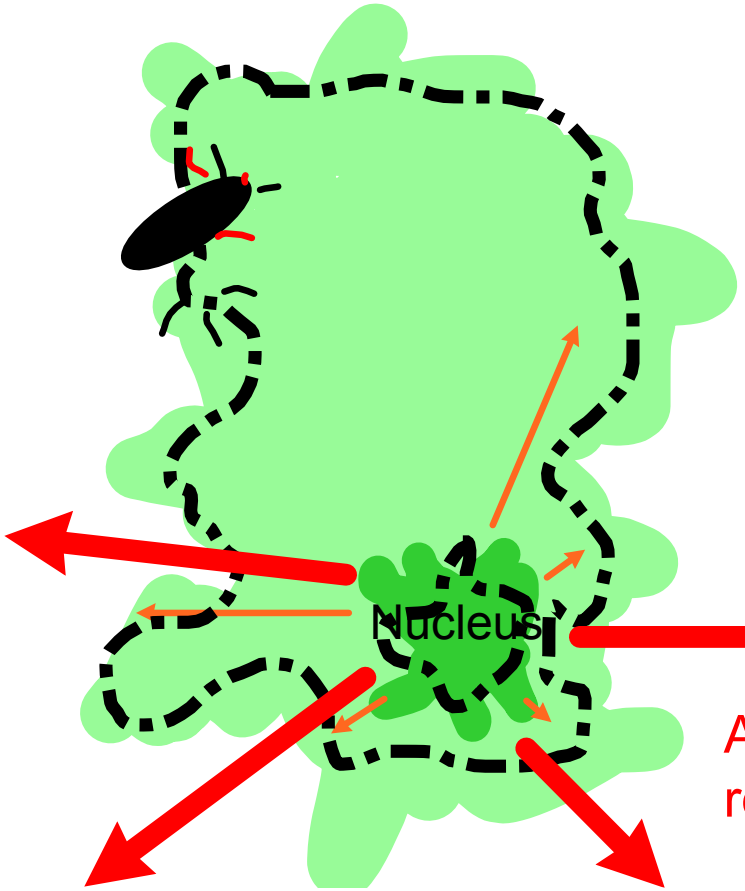
Plant Immunity

The cell can begin to secrete an antimicrobial agent (a protein designed to disrupt pathogens) that will fill the cytoplasm and secrete from the cell membrane. This will hopefully kill or disable the pathogen.



Plant Immunity

The other option is to kill itself via programed cell death and release signal molecules that will alert neighboring cells to the problem.



This option is typically used when the pathogen has breached the cell wall.

Alert signal triggers immune response in local cells

Homeostasis Without Hormones

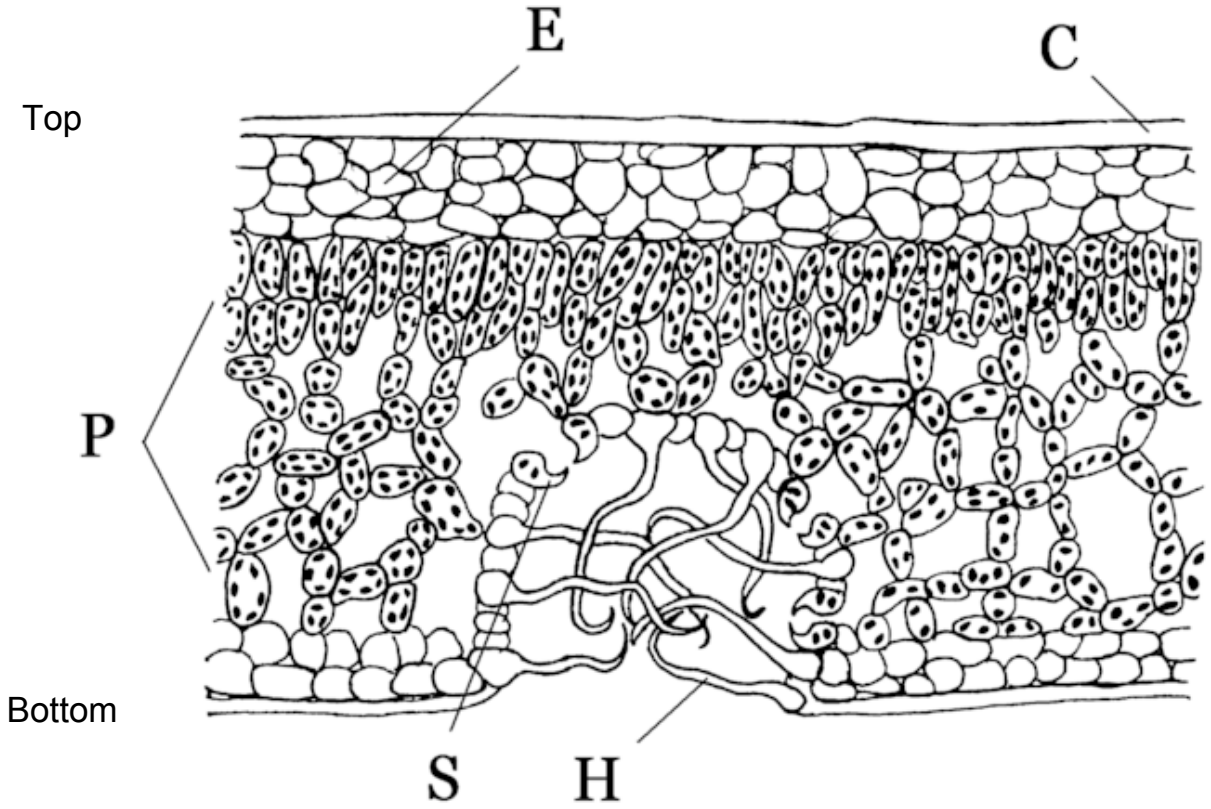
Some systems exhibit local control but effect the overall internal condition of the plant. Gas exchange with the environment is one such mechanism.

Why must a plant exchange gas with the environment?

Why is gas exchange a problem for plants?

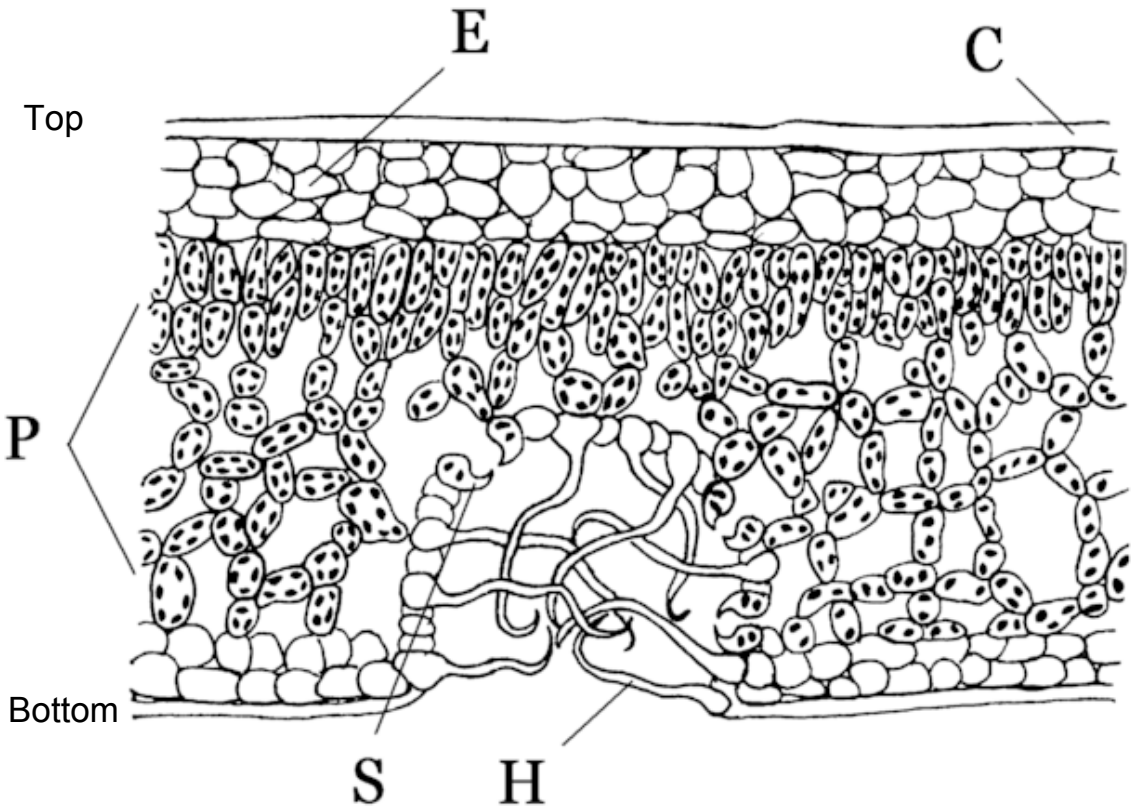
Gas Exchange

The below diagram shows a cross section of a leaf. **C** represents a **waxy coating** that produces a water (and air) tight seal to reduce evaporation. This is the top of the leaf were the sun contact produces a lot of heat.



Gas Exchange

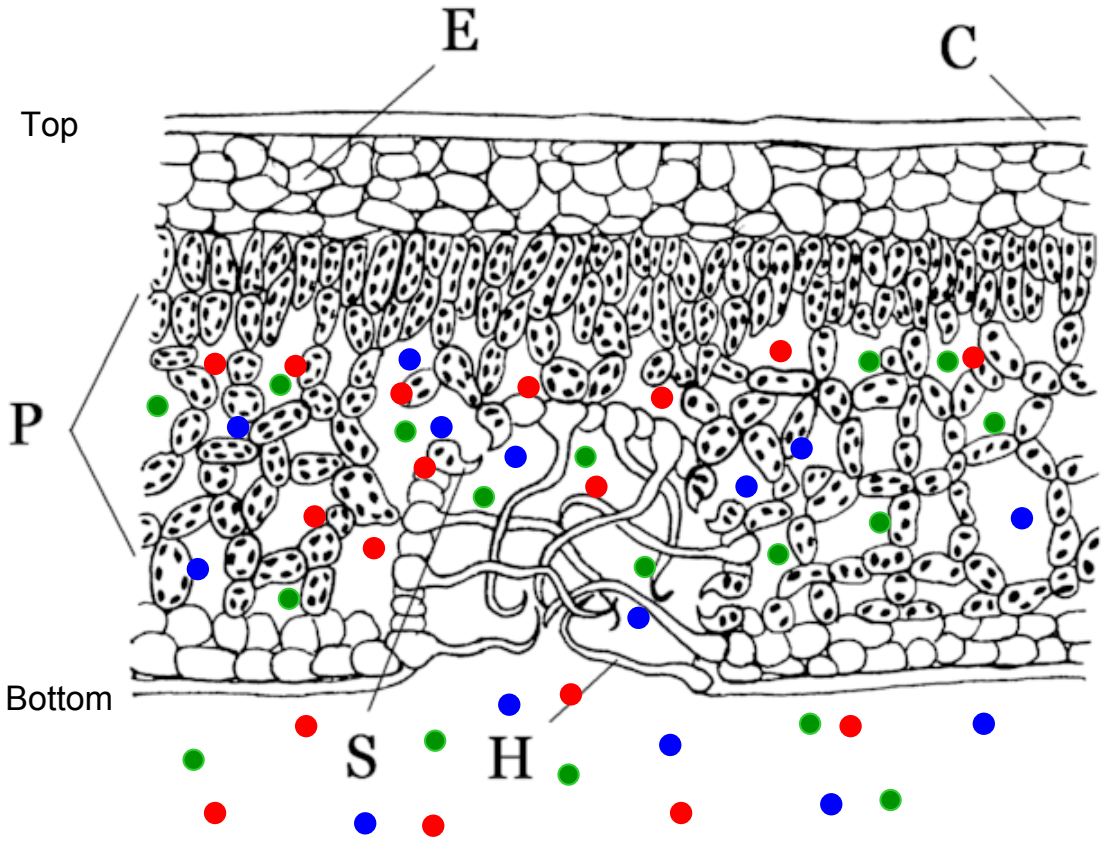
E is a **thick layer of epidermal cells** that acts as protection and a further barrier against loss of internal nutrients



P is the spongy **mesophyll** were the majority of photosynthesis takes place. This is were CO_2 is consumed and O_2 produced.

Gas Exchange

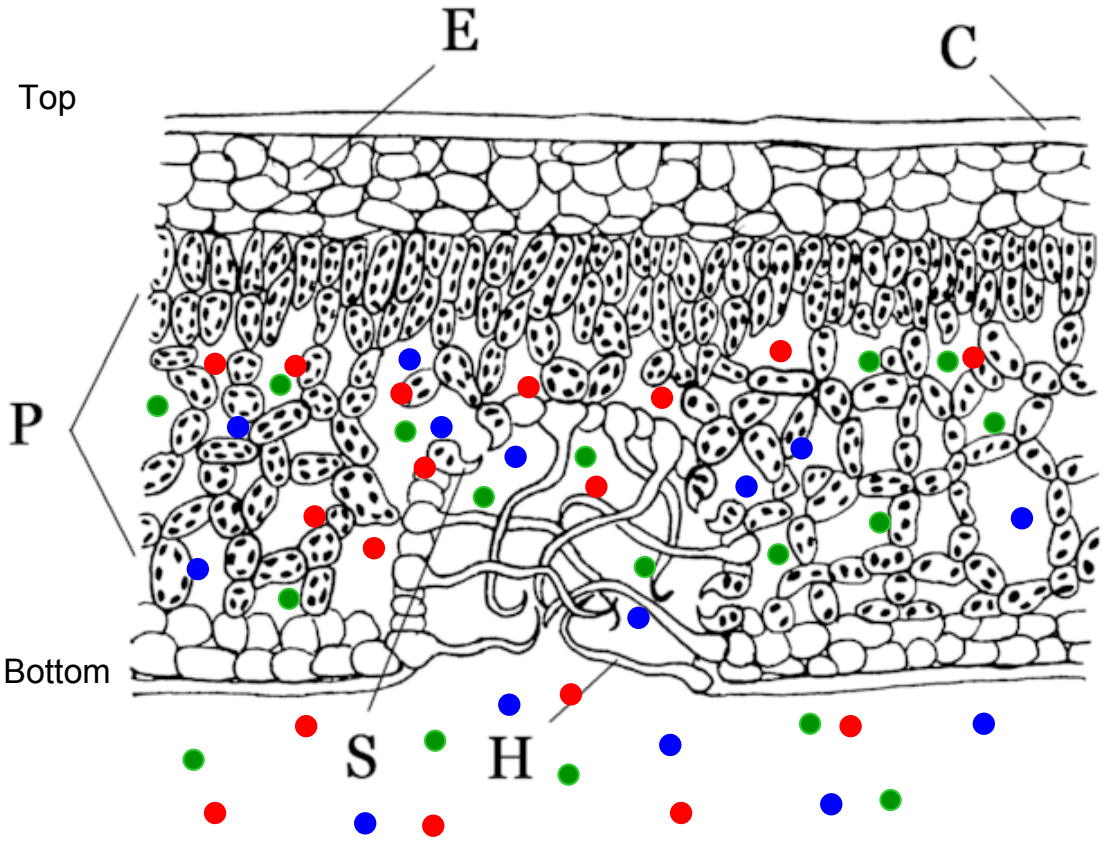
S and **H** are a **matrix of cells that comprise the stomata**, the place where gas exchange with the environment happens.



- Oxygen
- Carbon Dioxide
- Water Vapor

Gas Exchange

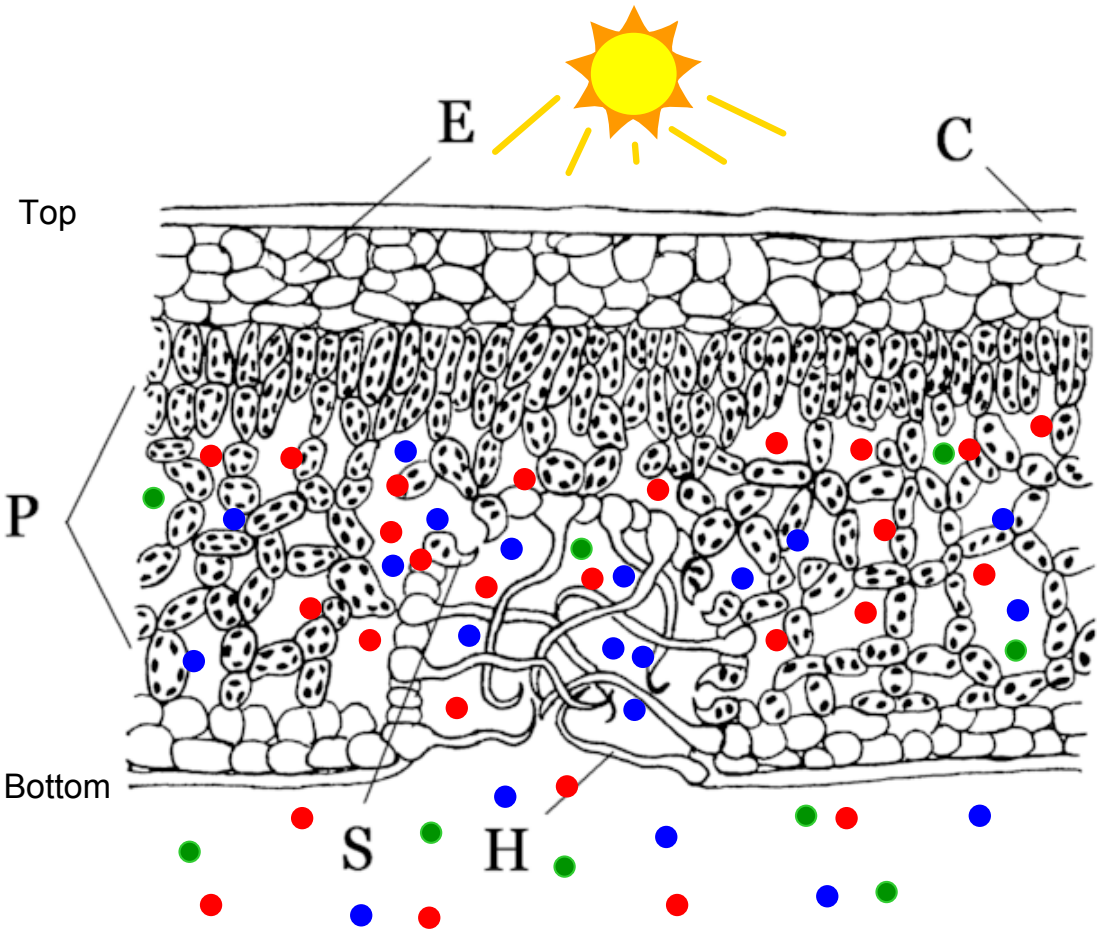
When the sun shines, photosynthesis increases as well as heat. What changes in gas will take place inside the leaf?



- Oxygen
- Carbon Dioxide
- Water Vapor

Gas Exchange

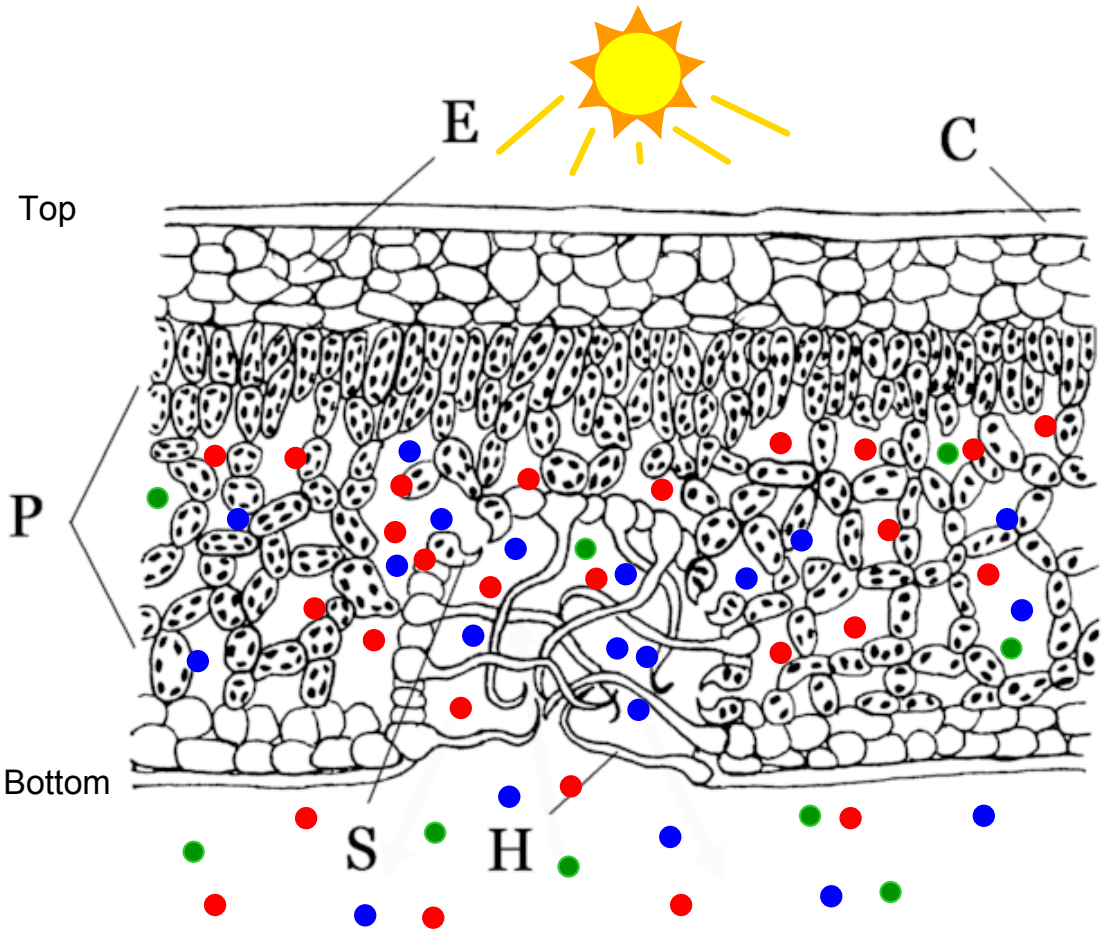
As the suns rays hit the leaf CO_2 is used more, O_2 is produced and more water is vaporized by the increased temp.



- Oxygen
- Carbon Dioxide
- Water Vapor

Gas Exchange

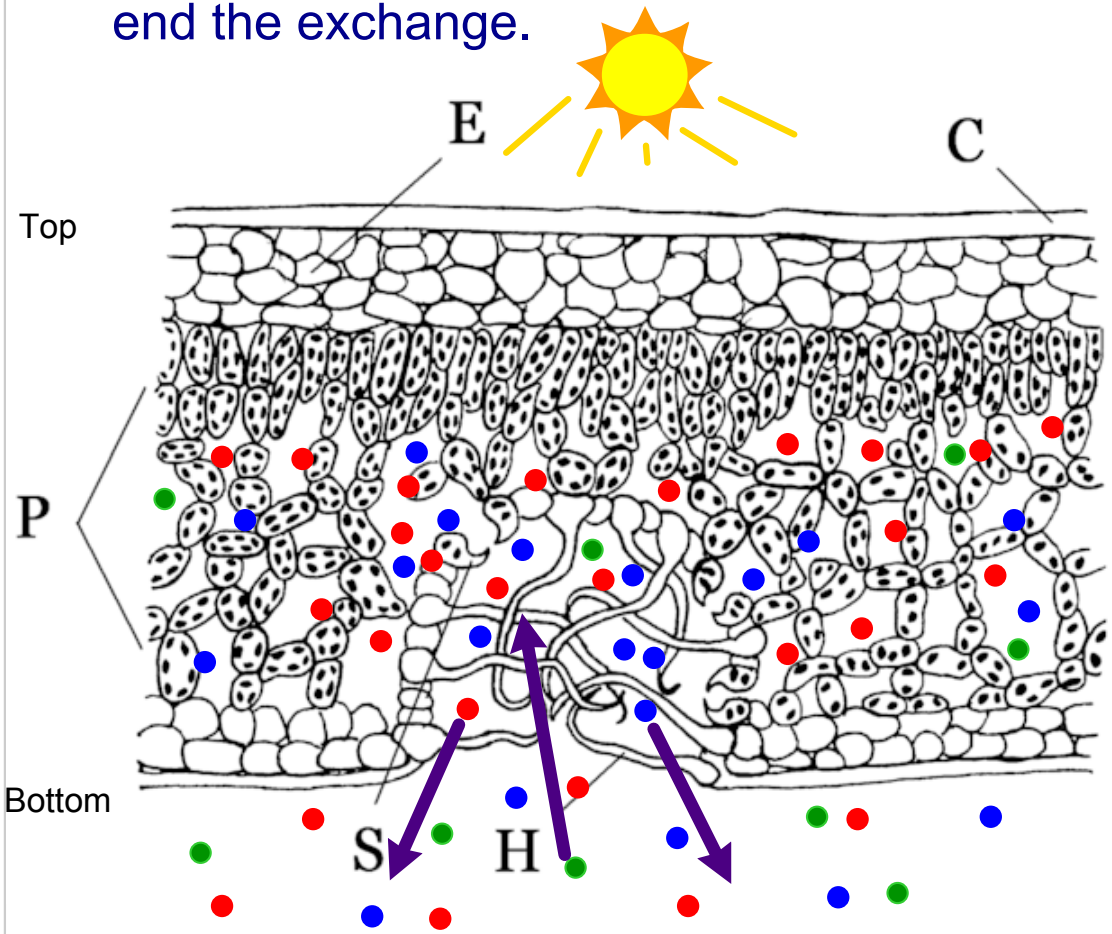
The concentration changes cause diffusion through the stomata down concentration gradients



- Oxygen
- Carbon Dioxide
- Water Vapor

Gas Exchange

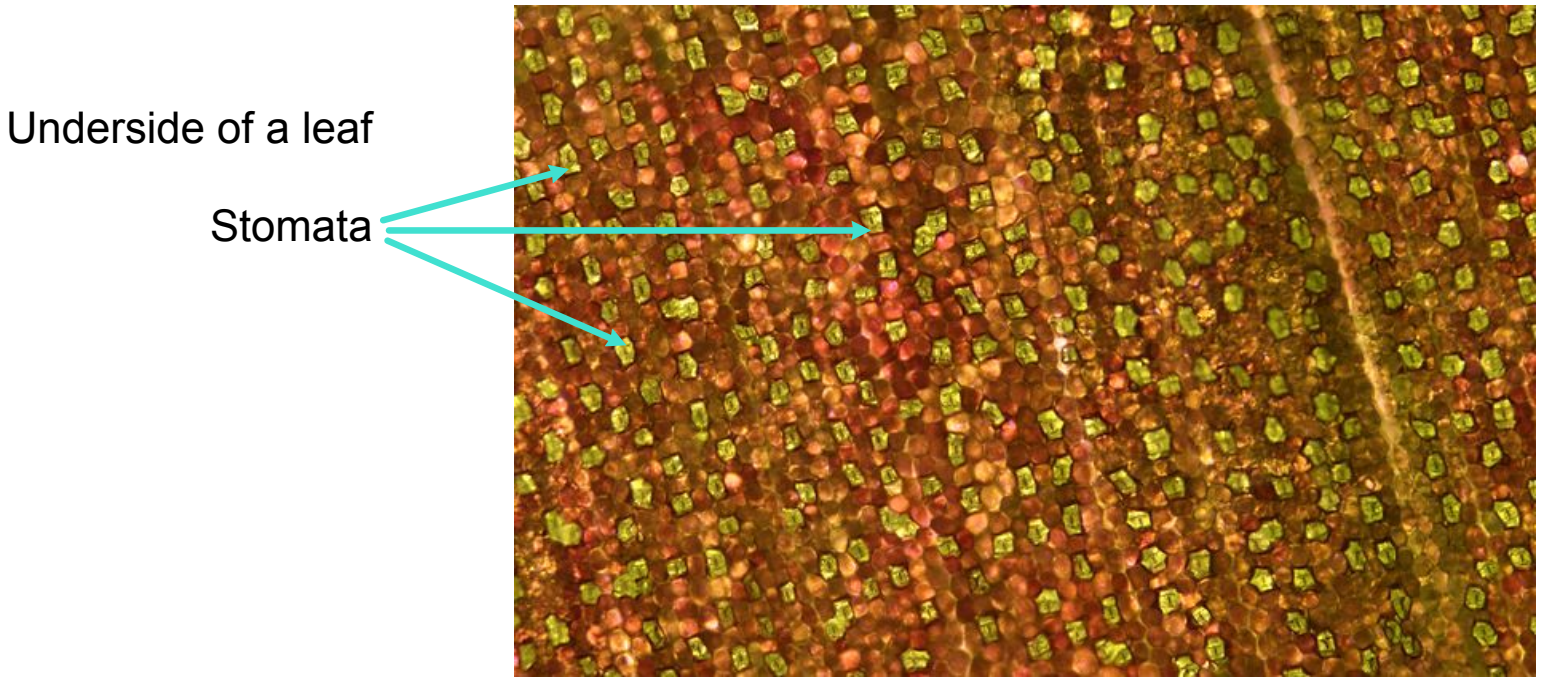
This allows a constant flow of CO_2 for continued photosynthesis, unless the plant is low on water. Then the stomata must close and end the exchange.



- Oxygen
- Carbon Dioxide
- Water Vapor

Stomata

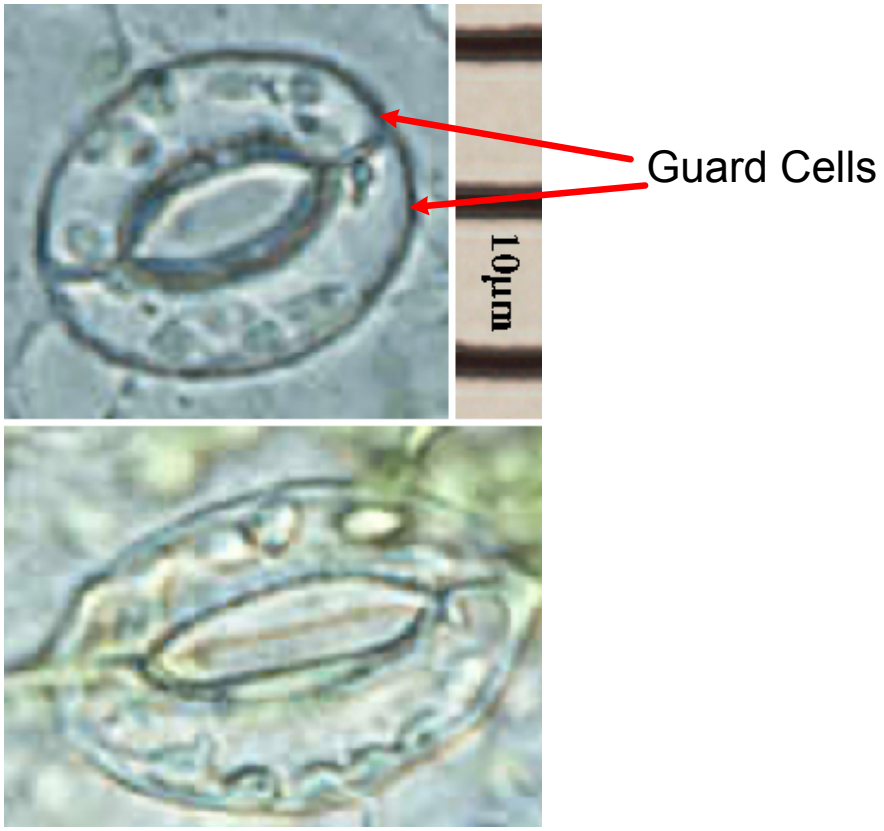
Stomata play an important role in the homeostasis of a plant. As we have seen they control the concentration of gases in the plant. This is a delicate balance: Not enough water and the plant will die; Not enough CO_2 for photosynthesis and the plant will die; Too much oxygen will disrupt internal systems and the plant will die.



Guard Cells

Guard cells are the cells on either side of the stomata pore. They work on a simple mechanism that does not require hormonal control.

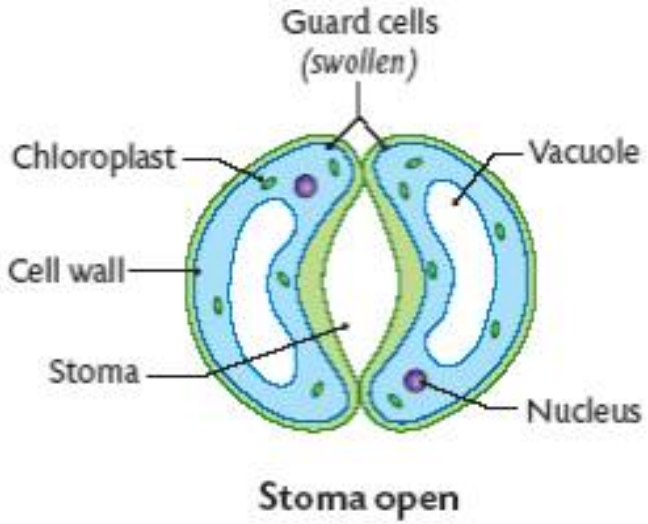
Since the quickest path to plant death is loss of water, they allow the plant to exchange gas when water is plentiful but close when water is scarce.



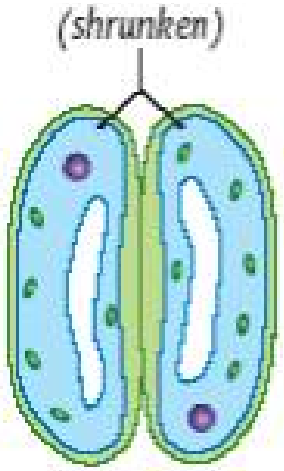
Guard Cells

When water is plentiful the guard cells central vacuole fills, like a balloon, and puts turgor force on the cell walls. The shape of the cells is such that they push against each other opening a pore.

When water is scarce the central vacuole loses water and the turgor force is reduced, causing the pore to close and preventing gas exchange.



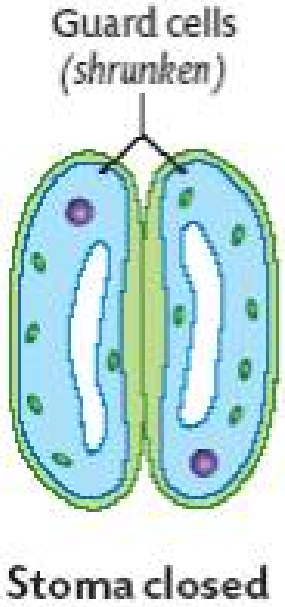
Stoma open



Stoma closed

Guard Cells

With a partner draw a flow chart that shows the events that will lead to a plant's death if more water is not obtained soon.



5 Which of the following is a plant's first line of defense from the rays of the sun?

- A Stomata
- B Mesophyll
- C Guard cells
- D Waxy cuticle

6 Which of the following allow for the exchange of gases between a plant and the atmosphere?

- A Stomata
- B Mesophyll
- C Guard cells
- D Waxy cuticle

7 Which of the following control the exchange of gases between a plant and the atmosphere?

- A Stomata
- B Mesophyll
- C Guard cells
- D Waxy cuticle

Plant Anatomy

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Plant Anatomy

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The plant body

Two main sections to the plant body: the roots and the shoots.

shoots

roots

Functions of the Root System

The 3 functions of the root system are to:

(1) anchor the plant

(2) absorb and transport minerals and water

(3) store food

8 The main function of the root hair is to

- A increase anchoring power of the plant
- B increase surface area for absorption
- C protect roots from freezing temperatures
- D provide a passageway for nutrients

Shoot System

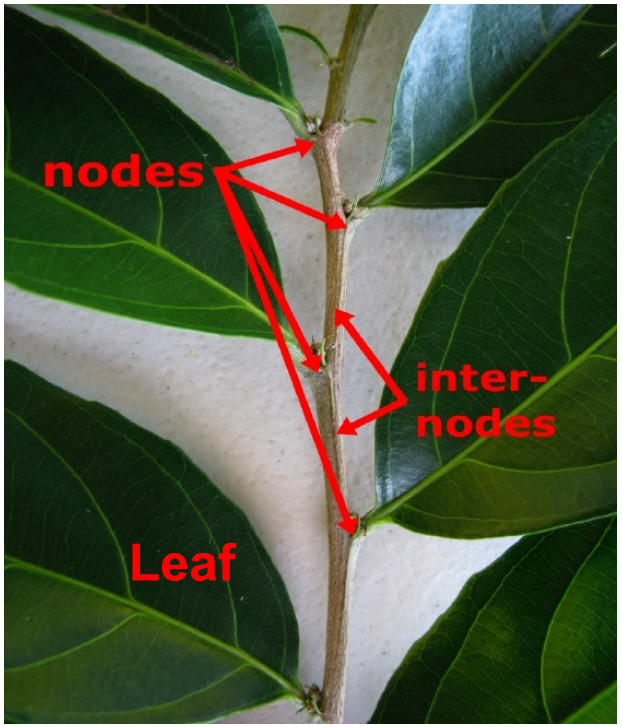
The shoot system consists of the stems, leaves, and reproductive structures

Parts of the stem

Stems are composed of **nodes**, where leaves, flowers, and other stems attach.

Space between the nodes is the **internode.**

Leaves are composed of photosynthetic blades and short stalks that attach at the nodes.



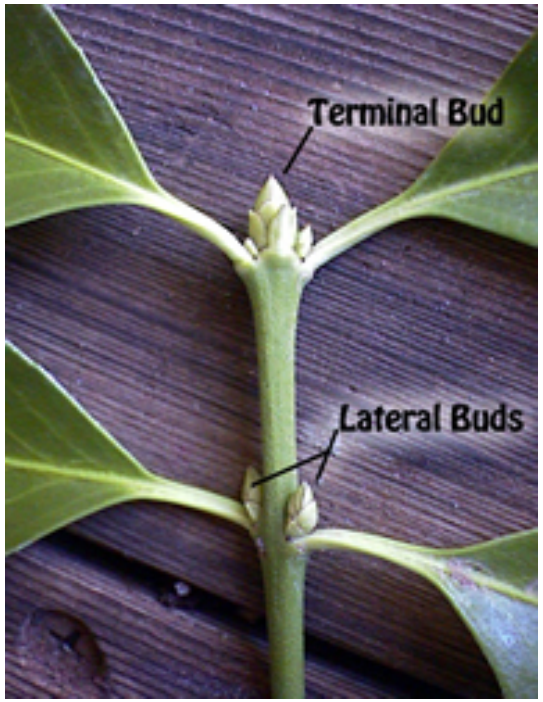
Buds

Buds are undeveloped shoots which have the potential to grow into nodes, internodes, and leaves.

Types of Buds

Terminal Buds are found at the top of the plant and are responsible for the growth in height.

Axillary (or lateral) Buds are found at each point of attachment for a leaf and the stem and are responsible for growth in width.



Apical Dominance

Apical Dominance results from the release of the hormone *Auxin* by the terminal bud which inhibits the growth from the lateral buds.

To made a plant bushier, you remove the terminal bud, which then allows for growth from the lateral buds. This is because the bud is removed, which means the hormone suppressing the growth is also removed.

This is also why pruning makes fruit trees produce more fruit.

9 Removing the terminal bud of a plant will cause:

- A an increase in the root system
- B an increase in the size of the leaves
- C increased axillary bud growth
- D a plant to lose the ability to flower

Ecosystems & Evolution

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Ecosystems and Evolution

Ecosystems represent the continuation of evolution. Instead of individual organisms evolving now the life in a particular region of the planet evolves together. A symbiosis of multiple organisms forms and the energy first gathered by the **producers** is passed through multiple levels of **consumers**.

Recall that an ecosystem is made of the biotic and abiotic factors in a specified location of the planet.

Ecosystems and Evolution

The complexity of this relationship continues to become ever more complex. But the basis of ecological evolution is the flow of energy through it.

Each **community** in an ecosystem will use the abiotic materials in their own way, but the constant for all ecosystems is the transformation of energy to supply all the living things.

Biodiversity

The earth is home to a wide variety of landscapes and an amazing range of biodiversity with an estimated +1.7 million species in existence today.

Life can be studied on a variety of levels. The following slides will concentrate on the primary reason for ecosystems: energy.

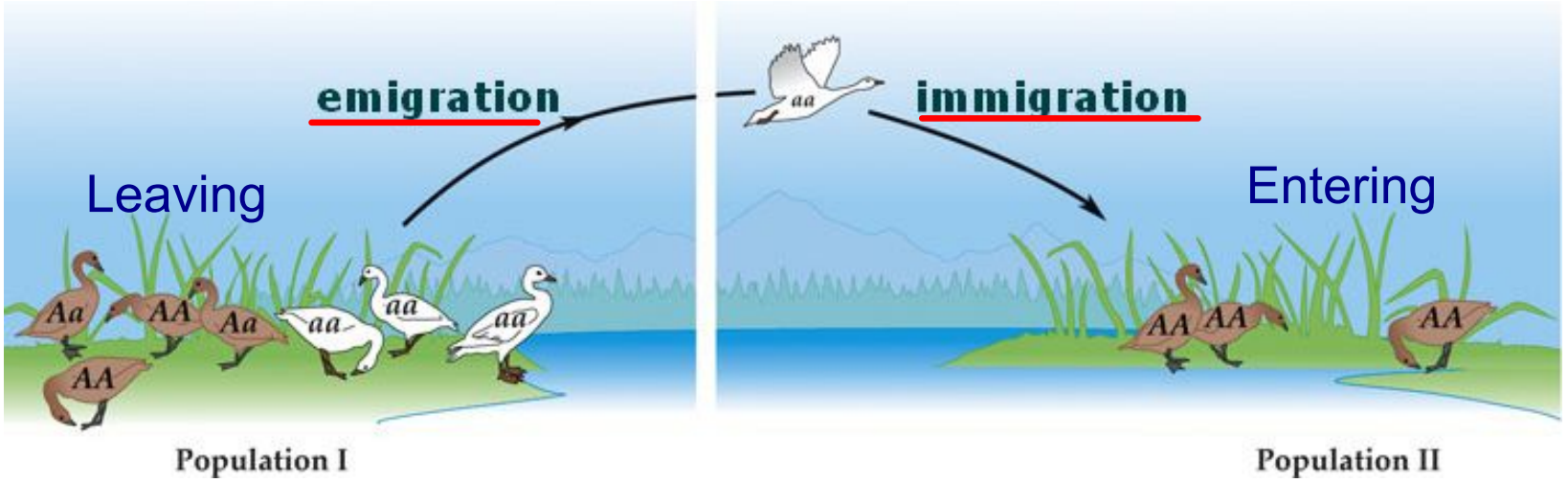
Ecology

Ecology is the study of the interactions between organisms and their environment.

The study of ecology is concerned with events at the level of populations, communities, ecosystems, and biomes.

Population

Ecologists (scientists who study ecology) are interested in how populations change. Population growth is dependent on the number of births, the number of deaths, and the number of individuals who enter or leave the population. The change in numbers of individuals is typically related to a shift in the energy dynamics of the ecosystem.

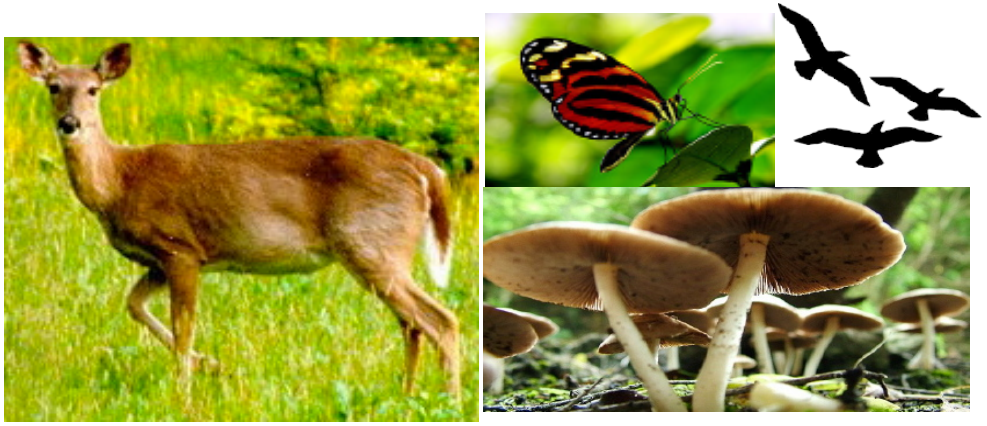


Community

A **community** is composed of all the different groups of species that live in a given area.

Organisms within a community interact with each other in many different ways that can be both beneficial and harmful.

Competition for resources between members of a community is one factor that shapes evolution by natural selection.



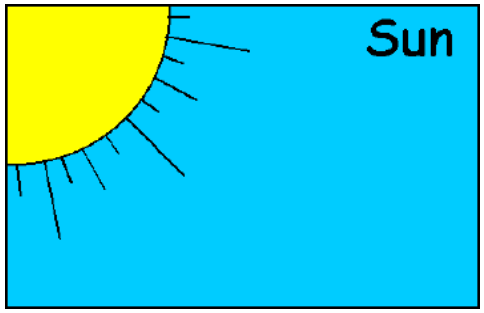
Ecosystem

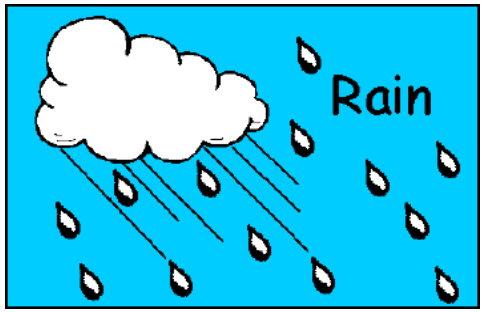
An **ecosystem** is a collection of all the organisms that live in a particular area along with their nonliving, physical environment.

Abiotic factors are physical, nonliving factors that shape an ecosystem.

Biotic factors are the living things that make up an ecosystem.

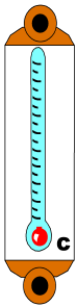
Ecosystem Abiotic Factors





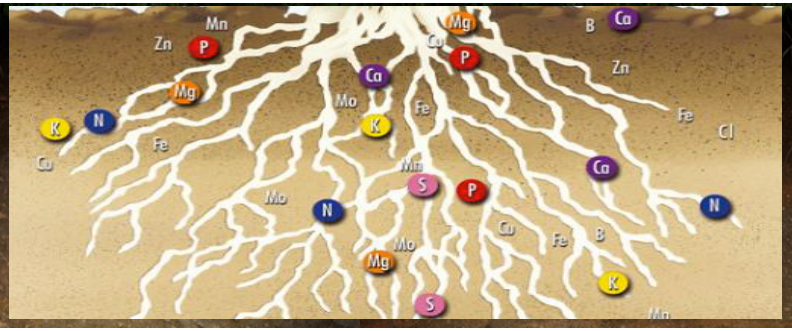
- Sunlight
- Precipitation
- Temperature
- Wind
- Soil type
- Nutrient availability

Temperature



Wind

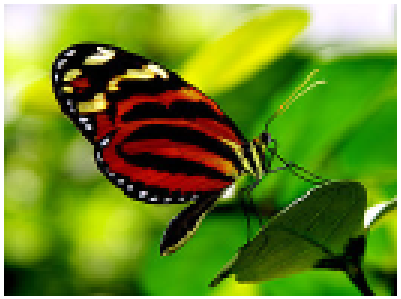
Nutrients



Soil

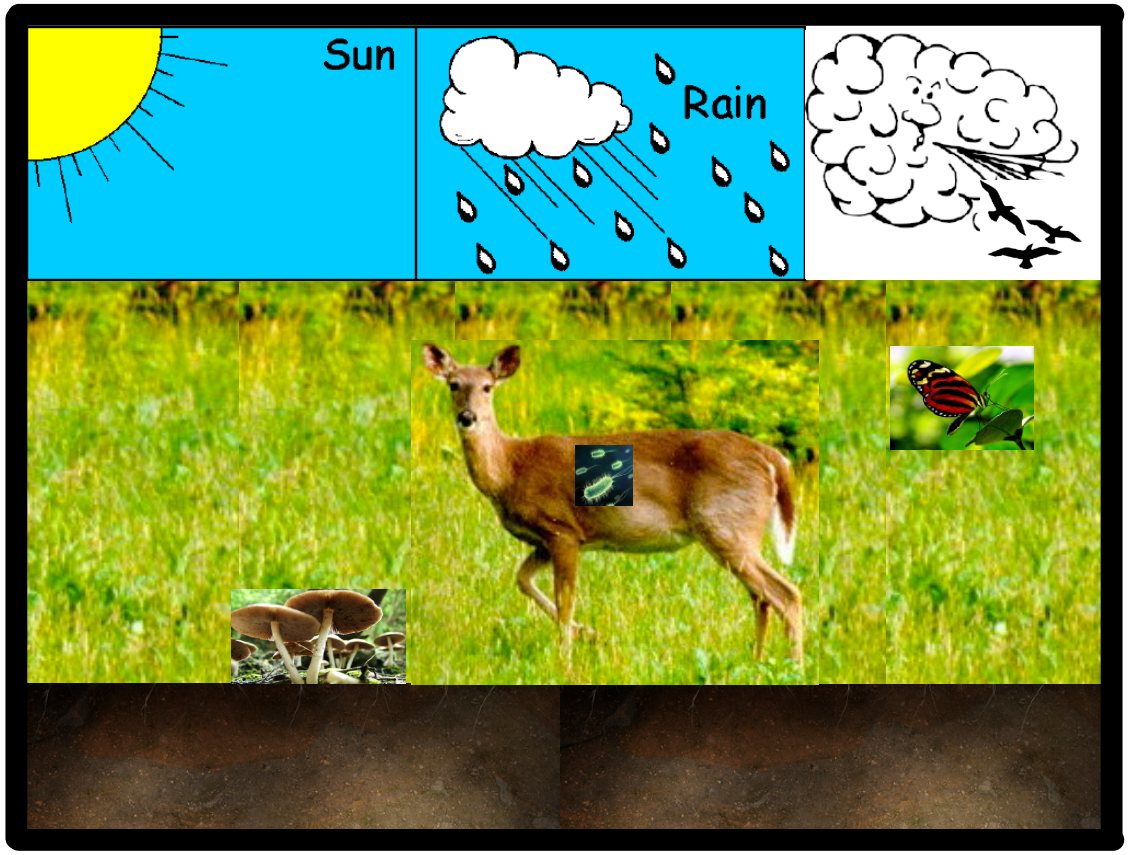
Ecosystem Biotic Factors

- Plants
- Animals
- Fungi
- Bacteria



Ecosystem

Together the abiotic and biotic factors make up an ecosystem.



Biomes

A **biome** is a group of ecosystems that have similar climates and dominant communities.

desert

tundra

temperate woodland

rainforest

aquatic

Biosphere

The biosphere is the portion of Earth in which all life exists. This includes the land, water, and air.

10 Which shows the levels of organization that ecology is concerned with from largest to smallest?

- A Biome, ecosystem, population, community
- B Population, community, ecosystem, biome
- C Community, population, ecosystem, biome
- D Biome, ecosystem, community, population

Review: Forms of Energy

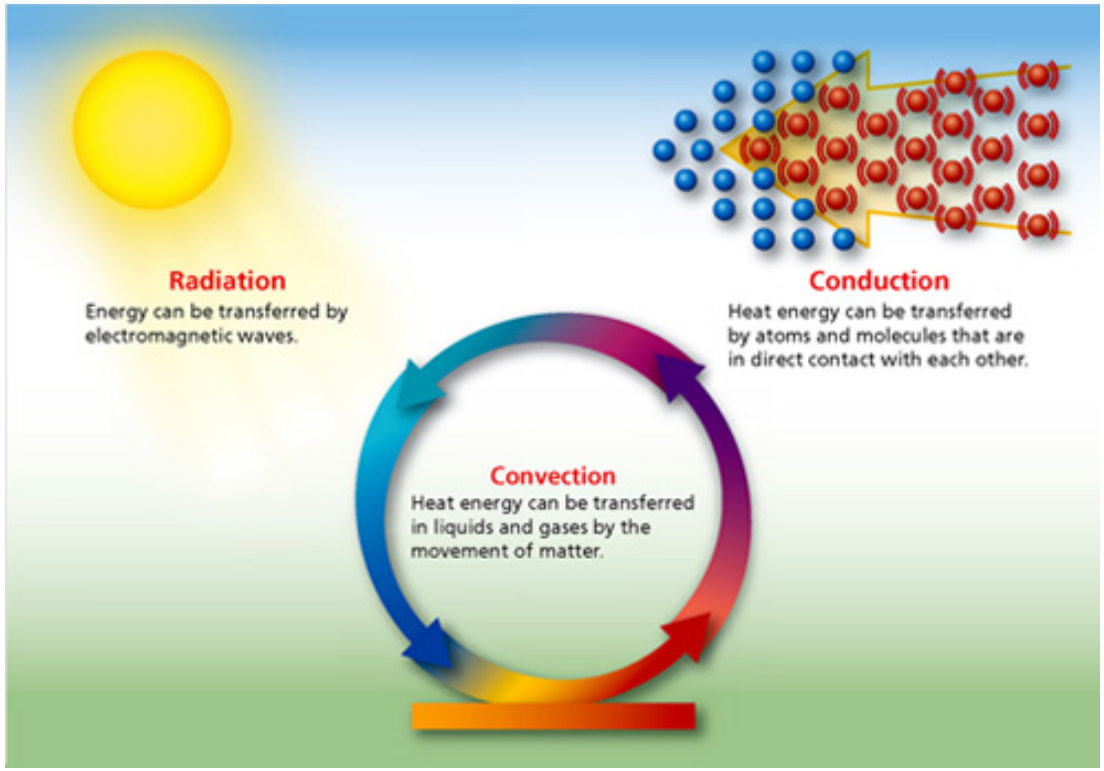
Energy cannot be created or destroyed, but it can change forms.

Recall that forms of energy include among others:

kinetic - movement
potential - gravitational, elastic, stored energy
thermal - radiates from the sun, organisms
electrical - results from charged particles
chemical - stored and released by chemical bonds
nuclear - stored and released by atomic particles

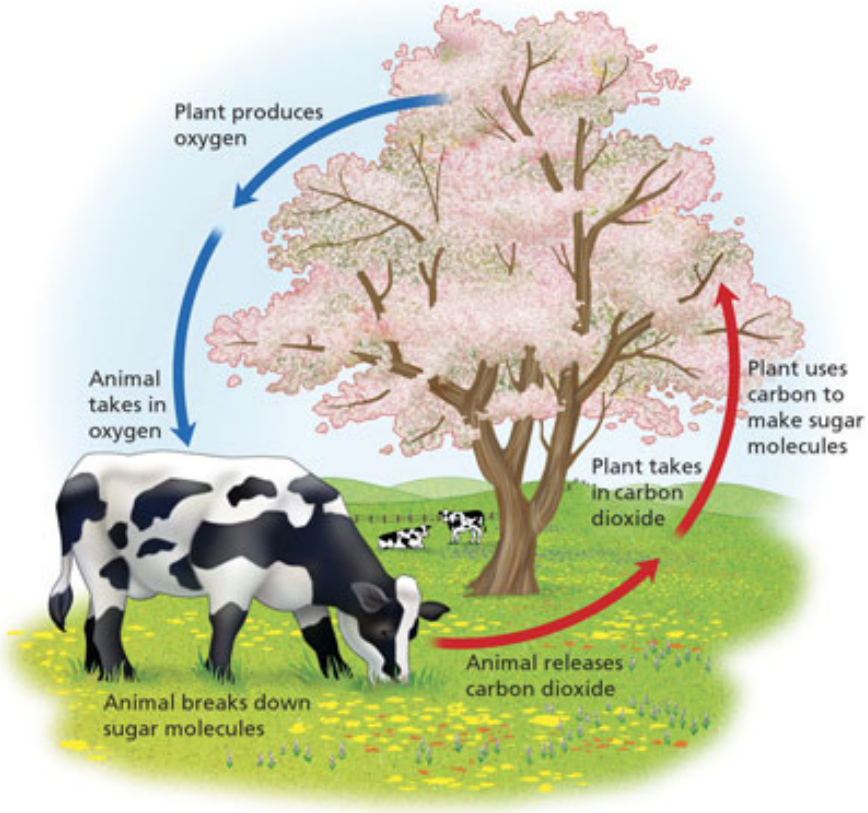
How is energy transferred from the Sun to living things?

In physics and chemistry you learned that energy can be transferred via radiation, conduction, and convection.



Radiant Energy Becomes Chemical Energy

Energy from the sun is transformed from radiant energy to chemical energy by the process of **photosynthesis** and from chemical energy to thermal energy (heat) by **cellular respiration**.

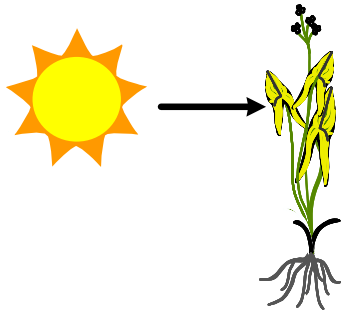


Ecosystems and Energy Transformations

As we know, the sun is the starting point for all energy in life.

Ecosystems and Energy Transformations

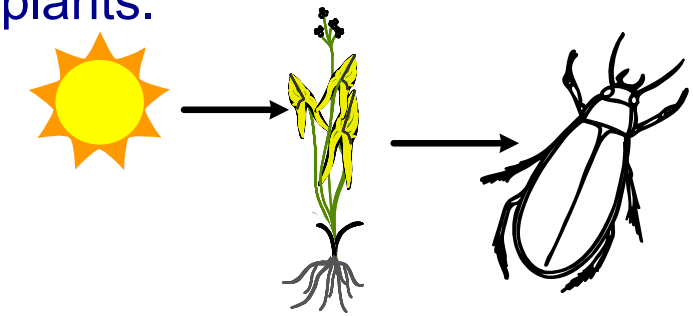
Plants provide the conversion from the energy of sunlight to the chemical energy of sugar



Plant

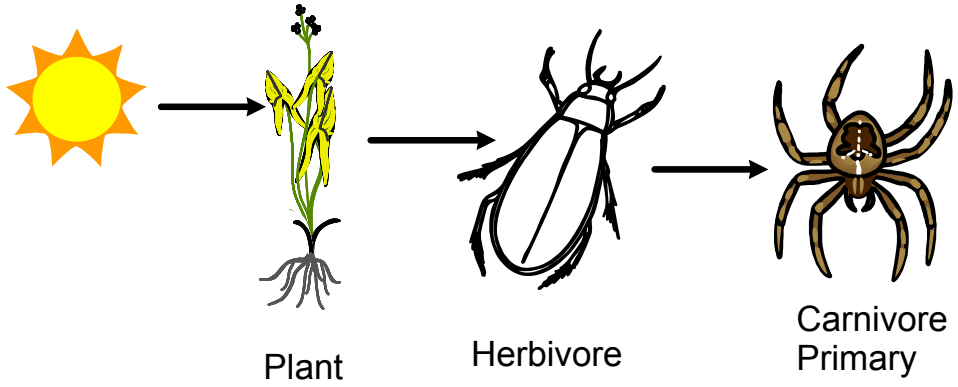
Ecosystems and Energy Transformations

Plant eating animals take advantage of the energy stored in the plants.



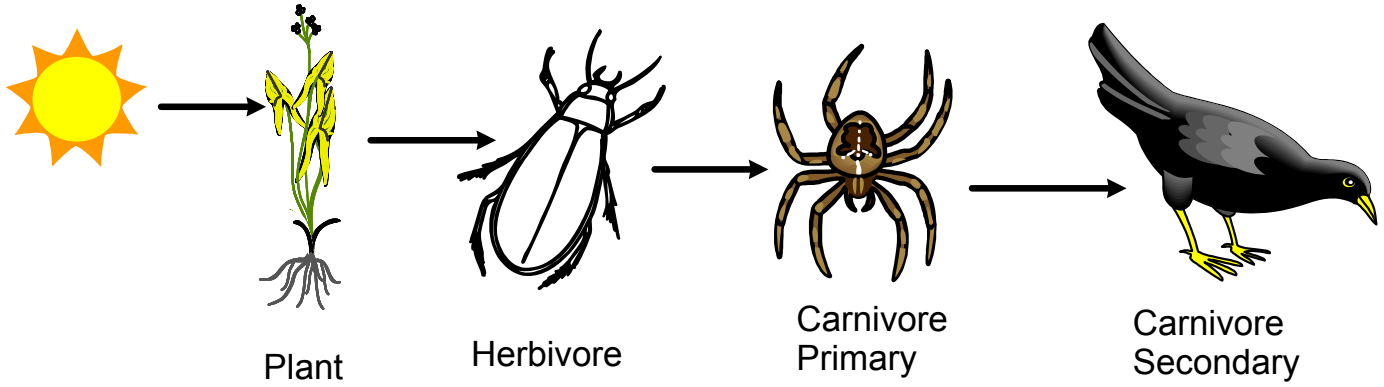
Ecosystems and Energy Transformations

Primary carnivores capture and take the energy from the herbivores.



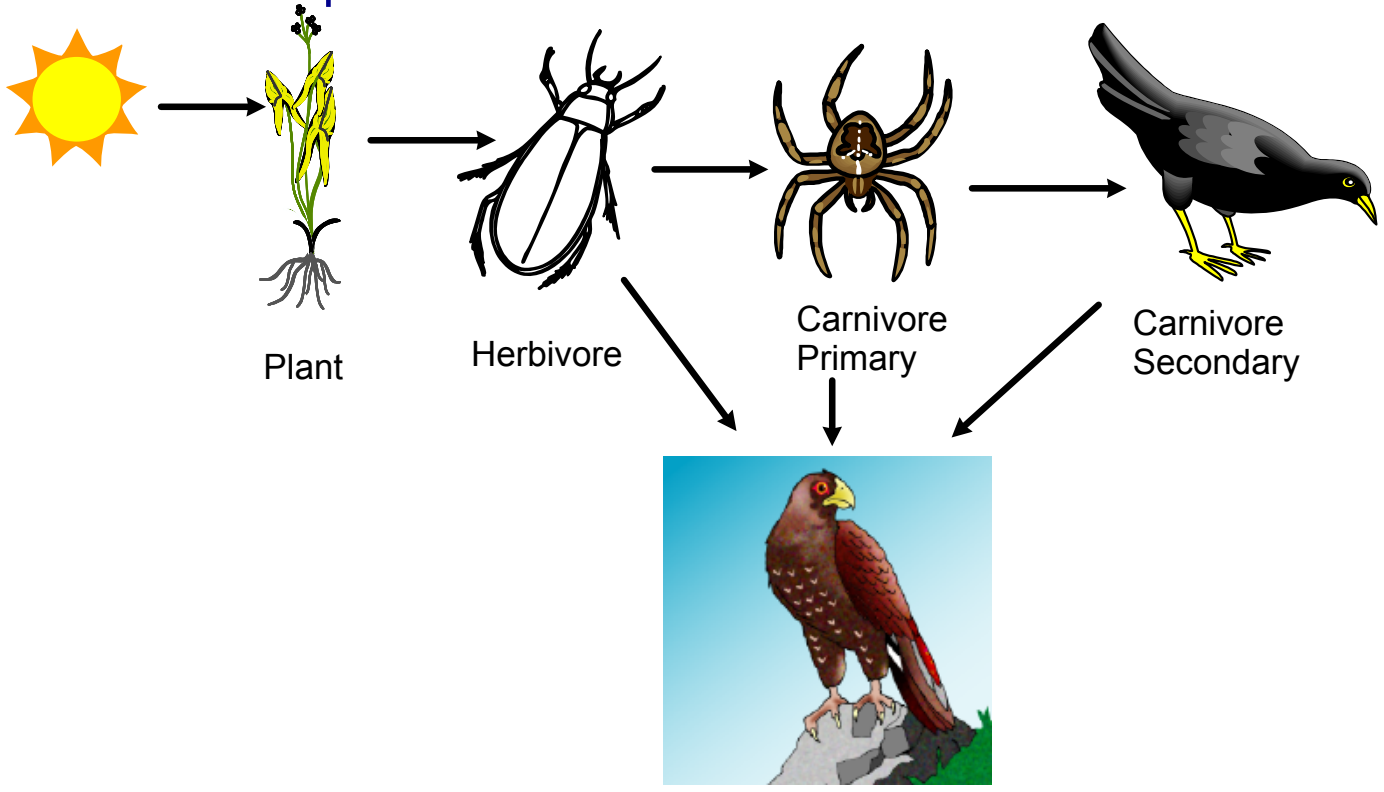
Ecosystems and Energy Transformations

The food source of a secondary consumer, is a primary consumer.

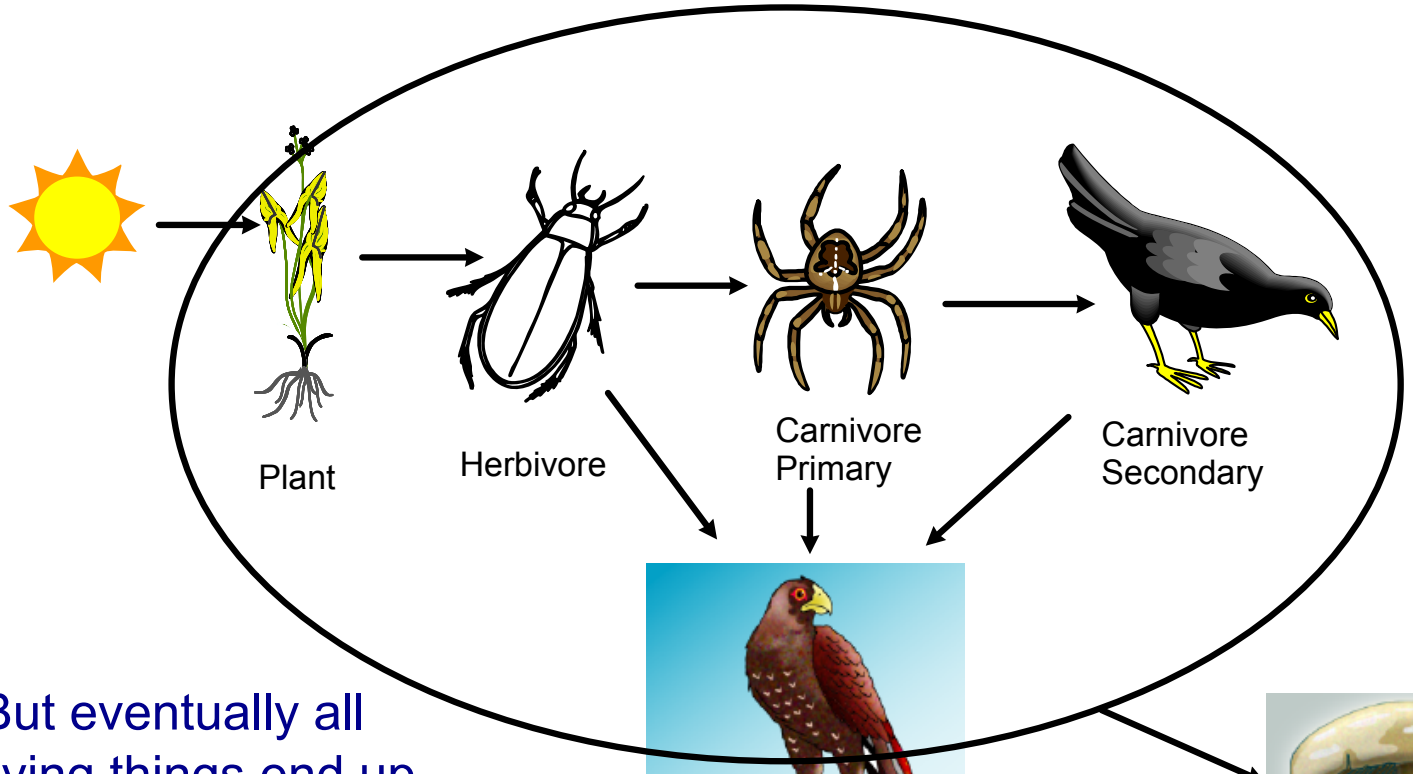


Ecosystems and Energy Transformations

There can even be tertiary and quaternary consumers that consume other heterotrophs.



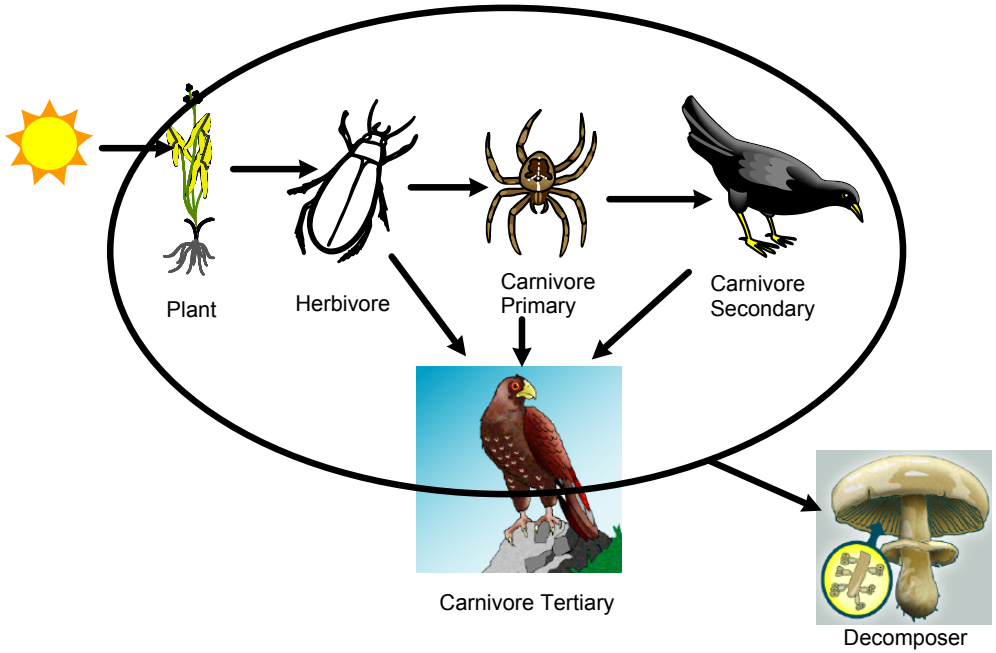
Ecosystems and Energy Transformations



But eventually all living things end up as energy for decomposers.

Food Webs

This simple example is a basic food web. These can be extremely complex or extremely simple. But no matter the level of complexity a food web is always the basis of an ecosystem.



Different Types of Heterotrophs

Herbivores - obtain energy by eating only plants; ex. cows, caterpillars

Carnivores - eat animals; ex. lions, owls, snakes

Omnivores - eat plants and animals; ex. humans, bears

Different Types of Heterotrophs

Detritivores - feed on plant and animal remains; ex. snails, crabs, mites, earthworms

Decomposers - break down organic matter; ex. bacteria, mushrooms

Water, Carbon, Nitrogen, and Phosphorus Cycles

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Movement of Energy and Nutrients

Nutrients are the chemical substances an organism needs to sustain life.

Primary producers like plants typically obtain nutrients from their environment. Consumers obtain nutrients by eating other organisms.

Carbon, nitrogen, and phosphorous are all key nutrients that cycle through the biosphere.

Cycles of Matter

Energy from the sun can enter Earth, constantly adding new energy to the biosphere. However, when it comes to matter, the Earth is a closed system.

The law of conservation of matter informs that in closed systems, matter can neither be created or destroyed.

Atoms of elements, chemical compounds, and other forms of matter that exist on Earth cycle through the biosphere as they are passed from one organism to the next.

Matter is recycled within and between ecosystems.

Living organisms are composed primarily of the elements carbon, hydrogen, oxygen, phosphorous, and nitrogen in various combinations.

11 Since the same matter is continuously cycled through the biosphere and cannot be created or destroyed, which of the following may be true?

- A You inhale oxygen atoms that may have been breathed by dinosaurs millions of years ago.
- B You are made out of elements that were once part of a star.
- C The carbon dioxide you exhale will still be here in 1000 years.
- D All of the above

Cycles of Matter

Biogeochemical cycles refer to to the pathways through which a chemical moves through the biosphere.

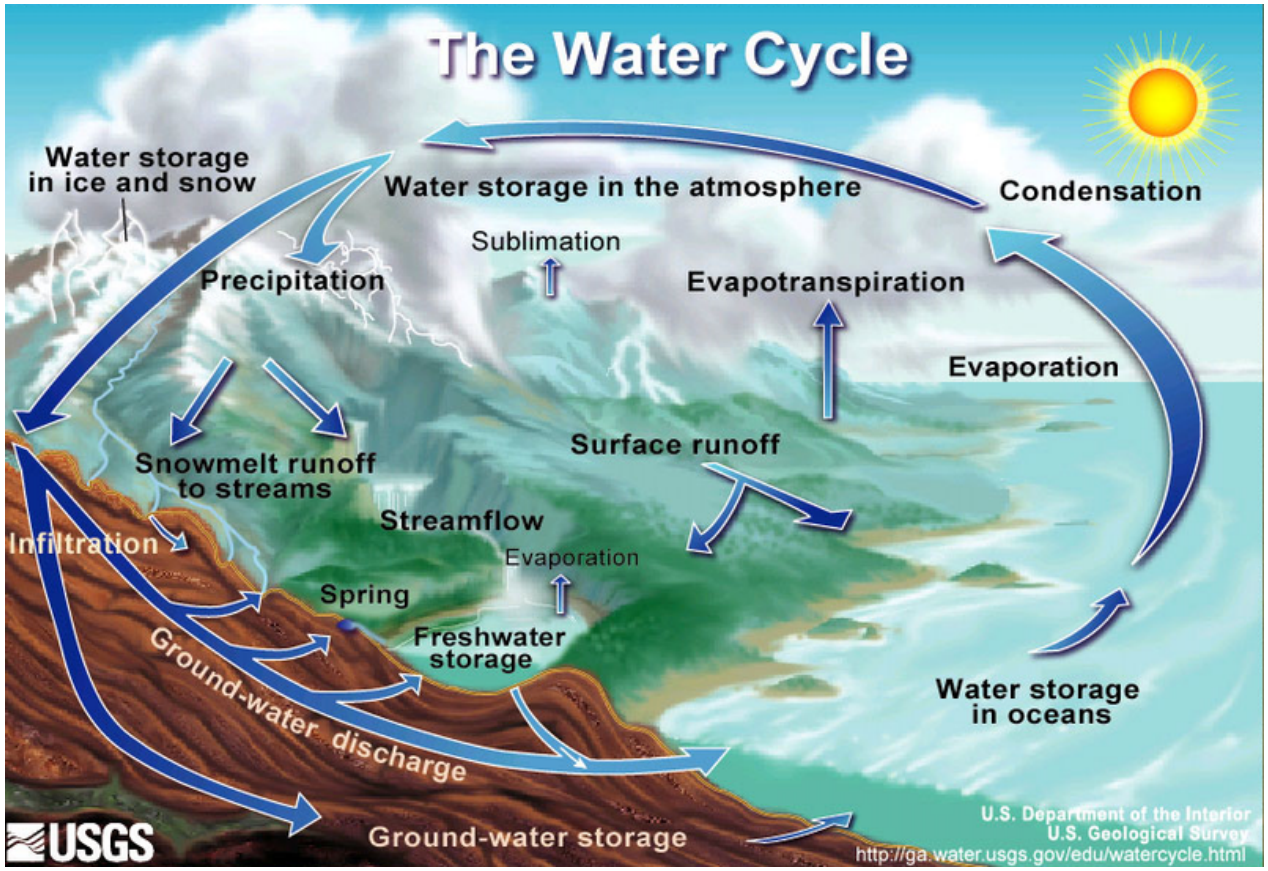
The primary biogeochemical cycles studied in biology are:

Water Cycle
Carbon Cycle
Nitrogen Cycle
Phosphorous Cycle

The Water Cycle

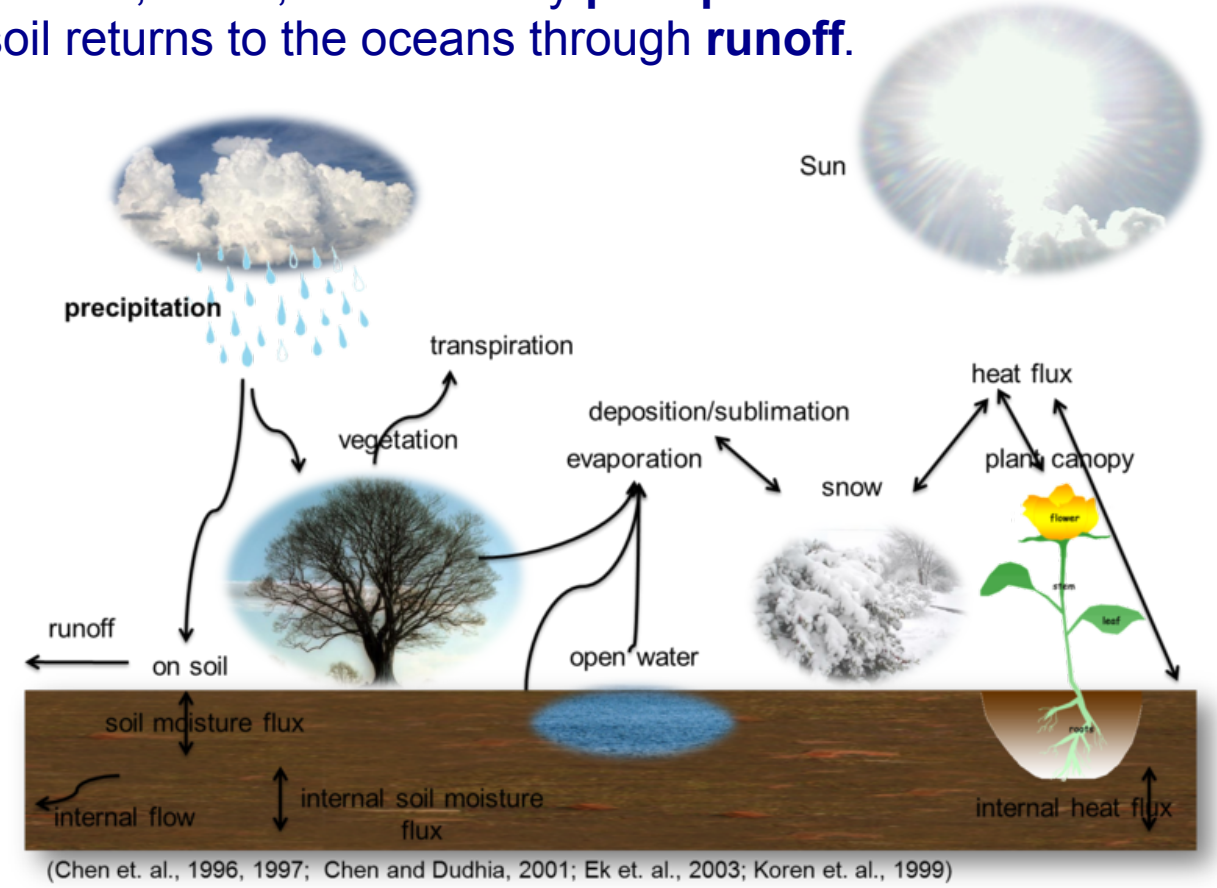
Water is essential to living organisms.

Water moves between the ocean, atmosphere, and land.



Movement of Water

Most water molecules are taken up into the clouds by **evaporation** and **transpiration**. The water returns to the oceans, lands, and lakes by **precipitation**. Water that enters the soil returns to the oceans through **runoff**.



(Chen et. al., 1996, 1997; Chen and Dudhia, 2001; Ek et. al., 2003; Koren et. al., 1999)

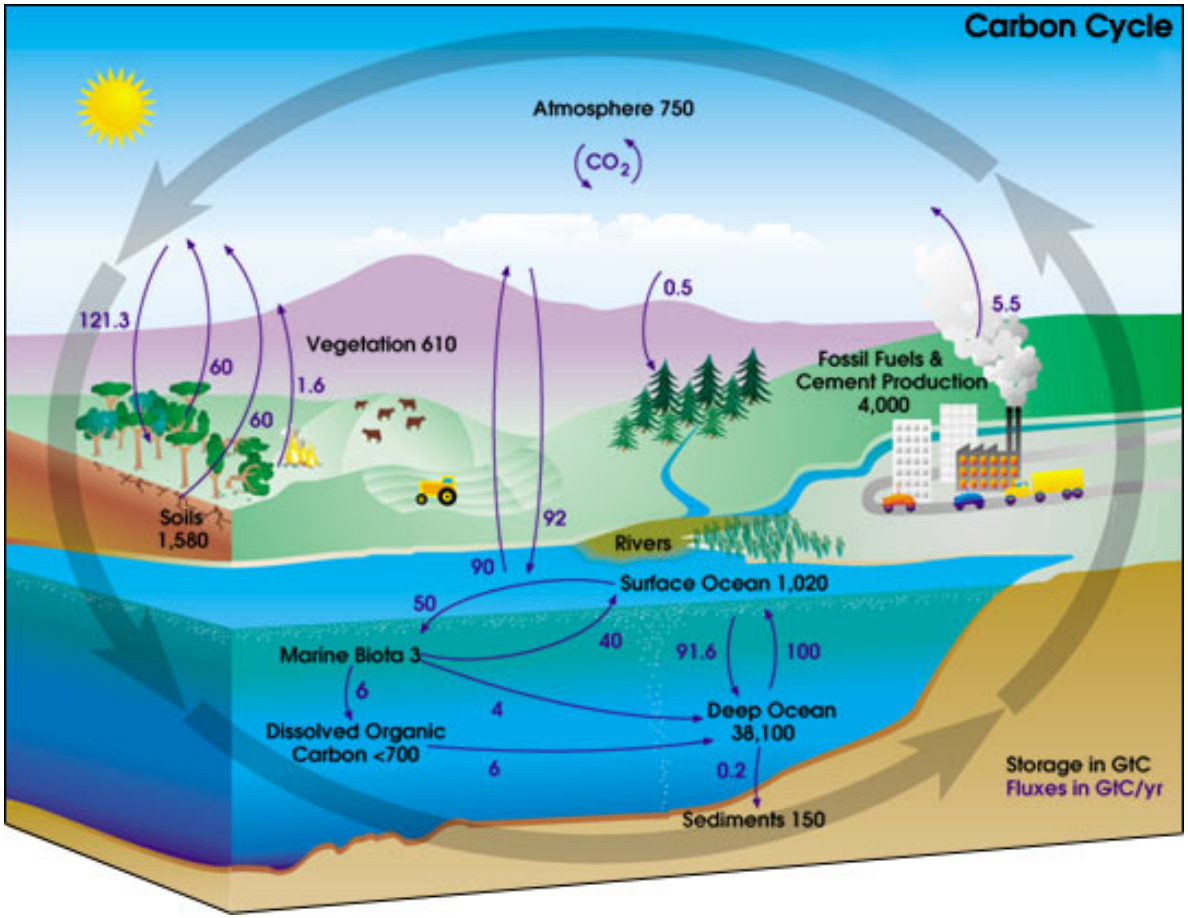
12 What is transpiration?

- A The precipitation of water from clouds.
- B The movement of water from the ocean to the atmosphere.
- C The movement of water through plants to the atmosphere.
- D The movement of water from the ground to the ocean.

13 How does water that enters the soil eventually return to the ocean?

- A Precipitation
- B Transpiration
- C Condensation
- D Runoff

The Carbon Cycle



Carbon is the basic building block of all organic material.

Most carbon is found as carbon dioxide in the atmosphere.

4 Ways to Move Carbon

Carbon is moved through the biosphere in four main ways:

(1) Photosynthesis, cellular respiration, and decomposition in living organisms take up and release carbon.

(2) Geochemical processes like erosion and volcanic activity release carbon dioxide into the atmosphere and ocean.

(3) Burial and decomposition under pressure converts dead organisms into fossil fuels like coal and petroleum, storing carbon underground.

(4)Human activities like mining, slashing and burning forests, and burning fossil fuels release carbon dioxide into the atmosphere.

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Click here to watch a video on The Carbon Cycle

14 Most carbon is found

- A as carbon dioxide
- B in plants
- C in fossil fuels
- D as glucose

15 How does carbon return to the atmosphere?

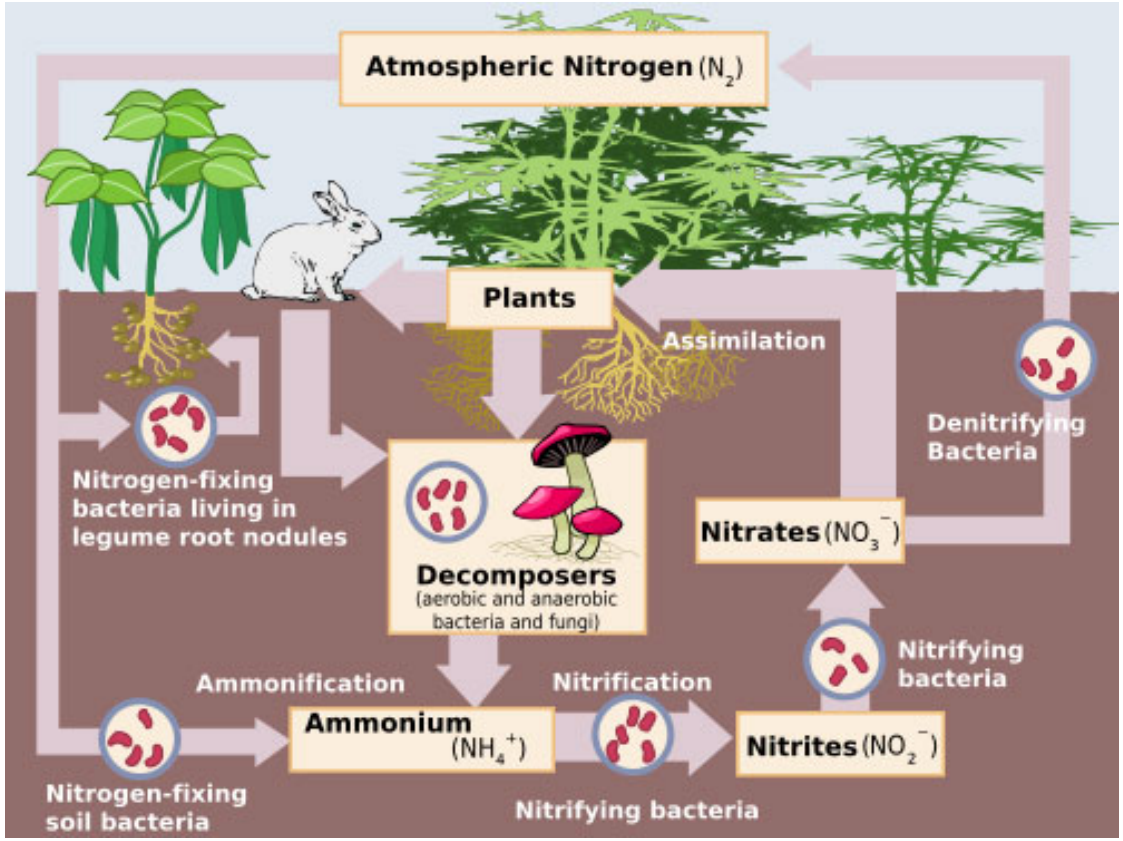
- A It is released by organisms during cellular respiration
- B It is released by the burning of fossil fuels
- C It can be released by volcanic activity
- D All of the above

Nitrogen Cycle

Nitrogen is the an important nutrient found in all amino acids. All organisms from bacteria to humans require nitrogen to make proteins.

Most nitrogen is found as a gas in the atmosphere, but this form is unavailable for protein synthesis.

Bacteria in soil fix nitrogen so that it can be used by plants and animals.



Nitrogen Cycle

Bacteria in soil and in symbiotic relationships with plants convert atmosphere nitrogen (N_2) into ammonia (NH_3^+) or ammonium (NH_4) in a process called **nitrogen fixation**.

Other bacteria in soil convert ammonia into nitrates (NO_3^-) and nitrites (NO_2^-).

Producers use ammonium, nitrates, and nitrites to make proteins. Consumers eat producers and reuse the nitrogen to make their own proteins.

When organisms die, decomposers release the nitrogen in their bodies back into the soil or convert the nitrates back into nitrogen gas in a process called **denitrification**.

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16 All nitrogen obtained by animals can be traced back to

A The eating of bacteria at some stage in the food chain

B The eating of plants at some stage in the food chain

C The absorption of atmospheric nitrogen

D None of the above

17 Nitrogen fixation is the process by which

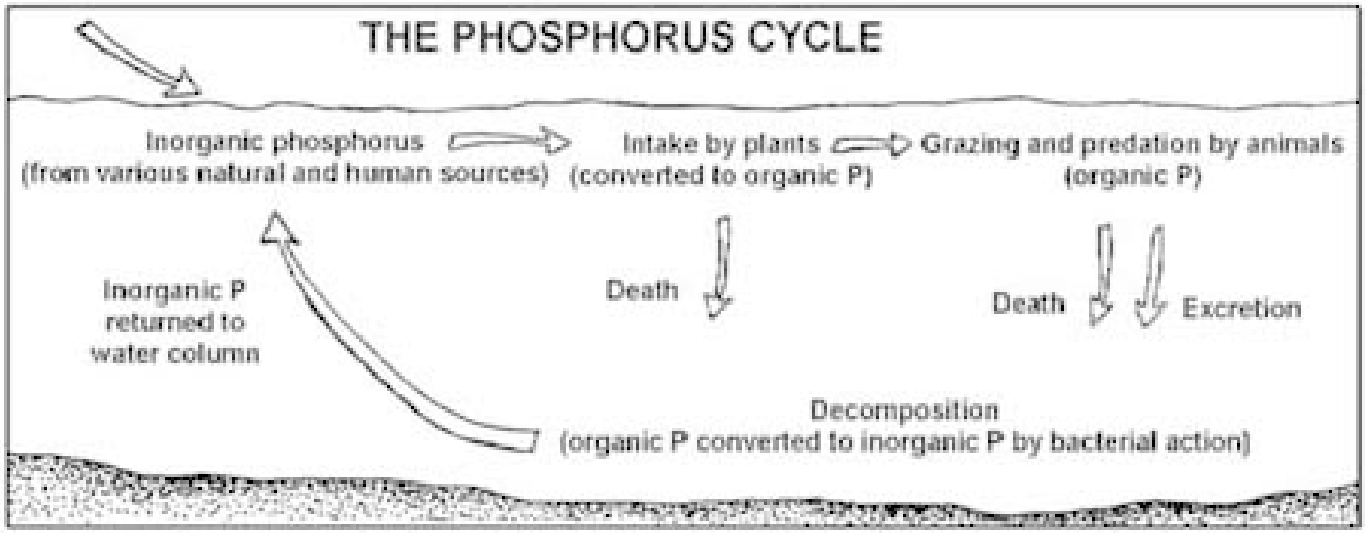
A Bacteria convert atmospheric nitrogen into ammonium

B Bacteria convert nitrates and nitrites into atmospheric nitrogen

C Decomposers release nitrates and nitrites from decaying organisms

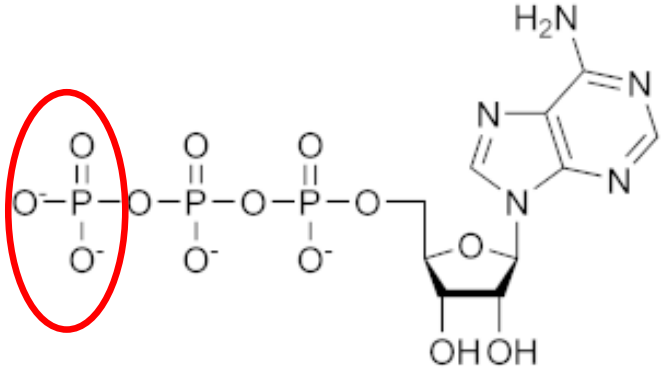
D Plants release atmospheric nitrogen into the atmosphere

The Phosphorous Cycle



Phosphorus

Phosphorous is an essential nutrient because it is a building block for RNA, DNA, and ATP.



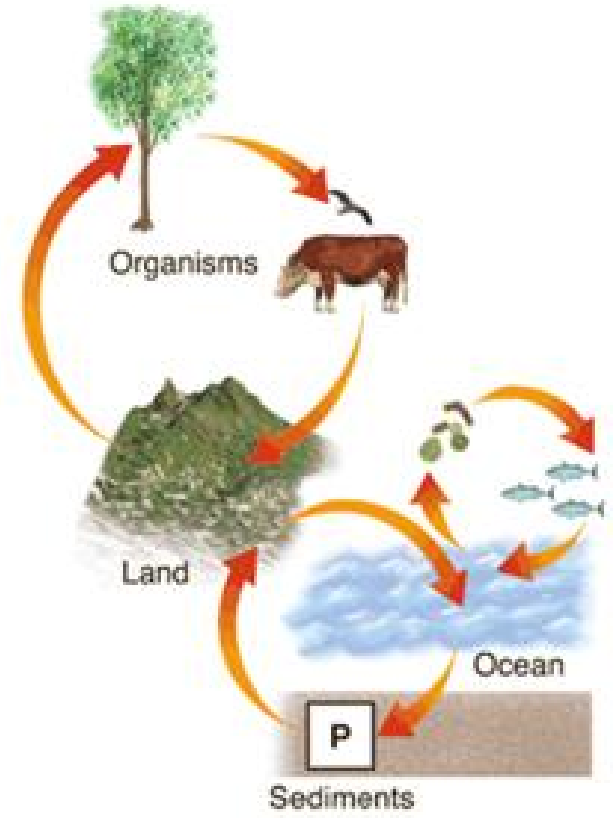
Unlike carbon and nitrogen, phosphorous is not abundant in the atmosphere and is mostly found on land in rocks, soil, and ocean sediment.

Storage of Phosphorus

Most phosphorous is stored in the form of inorganic phosphate within rocks and sediment until they eventually wear down and release the phosphate.

Phosphate molecules may be washed into rivers, streams, and eventually the ocean where they are used by marine organisms.

Phosphate may remain in soil on land and be absorbed into plants that convert them into organic compounds to be useful to living organisms.



18 Most phosphorous is found

- A In the atmosphere
- B In plants and animals
- C In rocks and sediment beneath the ocean
- D In bacteria

Properties of Water

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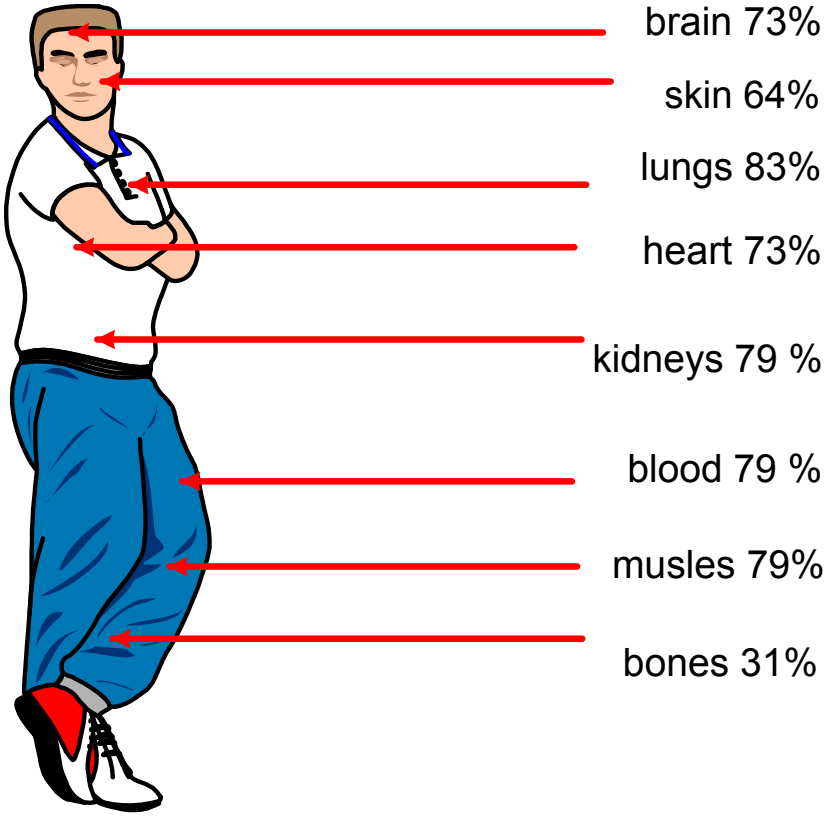
Water is the Molecule That Supports All Life

All living organisms require water more than any other substance

Most cells are surrounded by water, and cells consist of about 70-95% water



Water and Earth

Three-quarters of Earth's surface is submerged in water.

The abundance of water is the main reason the Earth is habitable.

image courtesy NASA

Four Properties of Water Contribute to Earth's Fitness for Life

Cohesive behavior

Ability to moderate temperature

Expansion upon freezing

Versatility as a solvent

Cohesion and Adhesion

Cohesion is the bonding of a high percentage of the water molecules to neighboring water molecules. Cohesion is due to hydrogen bonding.

Adhesion is similar to cohesion except that adhesion involves the attraction of a water molecule to a non-water molecule.

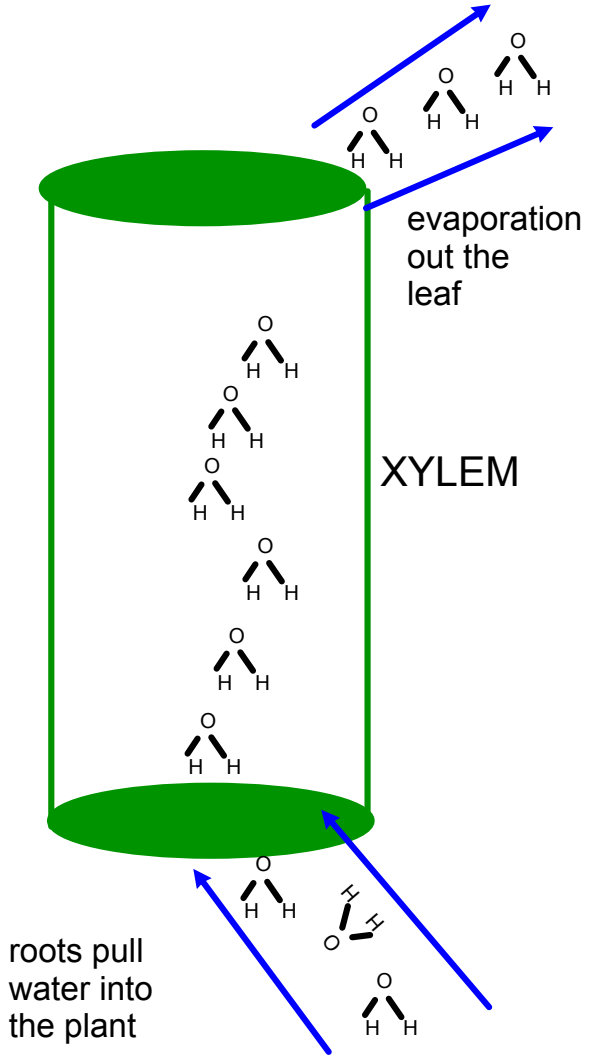
Cohesion is a special case of adhesion.

Click Here
to see an animation of
hydrogen bonding

Cohesion and Adhesion in Plants

Hydrogen bonds allows for cohesion between water molecules in the microscopic vessels of plants.

Adhesion of water to plant cell walls also helps counteract the force of gravity.



Cohesion and Surface Tension

Surface tension is related to cohesion.

It is a measure of how hard it is to break the surface of a liquid

Click Here
to see a video about
cohesion, adhesion,
and surface tension

19 What do cohesion, surface tension, and adhesion have in common with reference to water?

- A All increase when temperature increases.
- B All are produced by ionic bonding.
- C All are properties related to hydrogen bonding.
- D All have to do with nonpolar covalent bonds.

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21 Which of the following is possible due to the high surface tension of water?

- A Lakes don't freeze solid in winter, despite low temperatures.
- B A water strider can walk across the surface of a small pond.
- C Organisms resist temperature changes, although they give off heat due to chemical reactions.
- D Water can act as a solvent.

Evaporative Cooling

Evaporation is the transformation of a substance from a liquid to a gas.

Heat of vaporization is the quantity of heat a liquid must absorb for 1 gram of liquid to be converted to a gas.

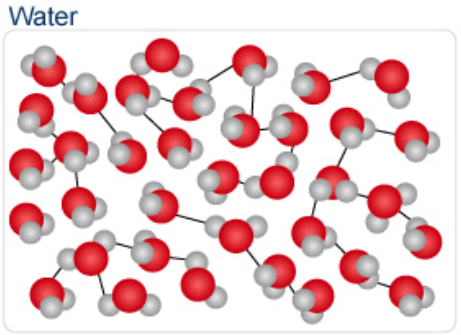
Evaporative Cooling

As liquid evaporates, its remaining surface cools.

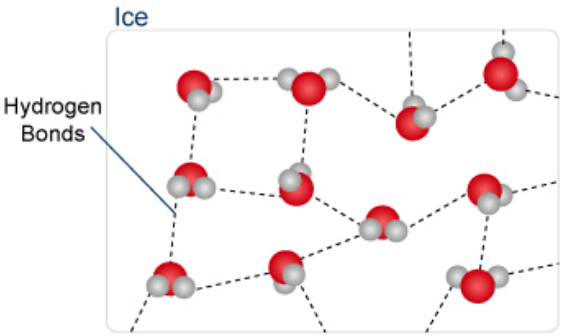
Evaporative cooling is due to water's high heat of vaporization. Evaporative cooling of water helps stabilize temperatures in living things and in bodies of water

Insulation of Bodies of Water by Floating Ice

The hydrogen bonds in ice are more “ordered” than in liquid water, making ice less dense.



Hydrogen bonds being formed and breaking up



Stable hydrogen bonds

Ice floats due to hydrogen bonding. The stable hydrogen bonds cause ice to be less dense than water

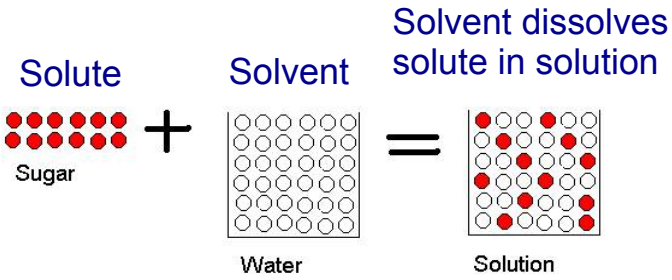
22 Which property of water best explains why humans sweat to maintain a normal body temperatue?

- A Expansion upon freezing
- B Evaporative cooling
- C Specific gravity
- D Cohesion

23 Lettuce that has been frozen turns into green mush when thawed. What causes this to happen?
Discuss at your table and come up with an answer to share.

The Solvent of Life

A solution is a homogeneous mixture of substances.



An aqueous solution has water as the solvent. Water is a versatile solvent due to its polarity.

Water Biochemistry

Most biochemical reactions occur in water.

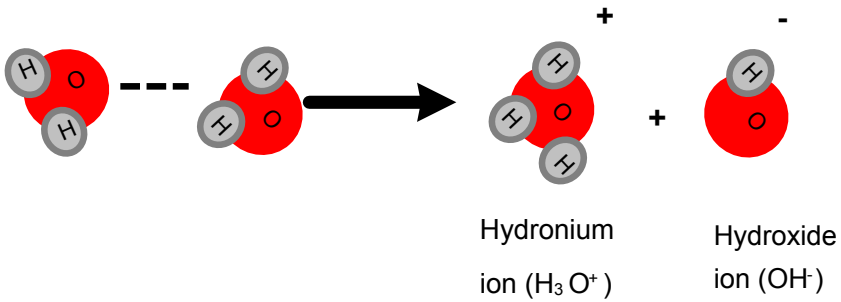
The different regions of the polar water molecule can interact with ionic compounds called solutes and dissolve them.

Water can also interact with large polar molecules such as proteins. Certain enzymes, like those in saliva, can only act in the presence of water.

Click Here
to see water
dissolving a solute.

Dissociation of Water Molecules

In liquid water, hydrogen bonds are constantly breaking and re-forming, causing water to dissociate into hydronium (H_3^+) ions and hydroxide (OH^-) ions.



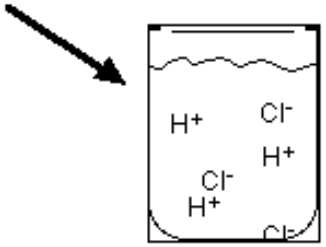
In biological systems, chemical compounds flow through and dissolve in liquid water.

When chemicals dissolve in biological solutions they add ions to liquid water, changing the concentrations of H_3O^+ and OH^- ions. These changes in ionic concentration have a great effect on biochemical reactions in living organisms.

Acids and Bases

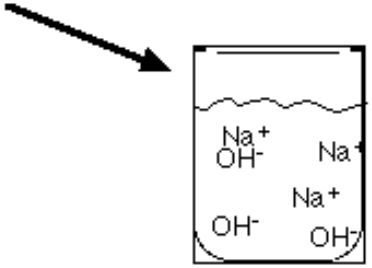
Acids are ionic compounds that break apart in water to form H^+ ions.

Ex. HCl



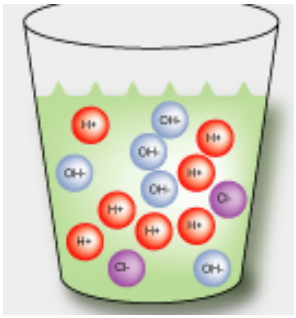
Bases are ionic compounds that break apart in water to form OH^- ions.

Ex. NaOH



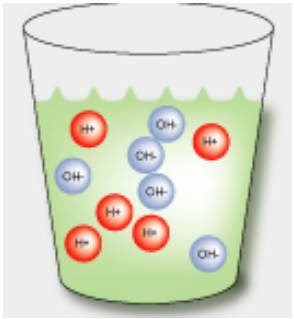
Acidic and Basic Solutions

Acidic Solution



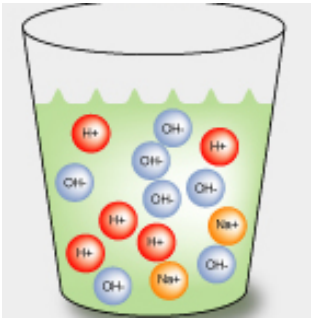
[H+] > [OH–]

Neutral Solution



[H+] = [OH–]

Basic Solution



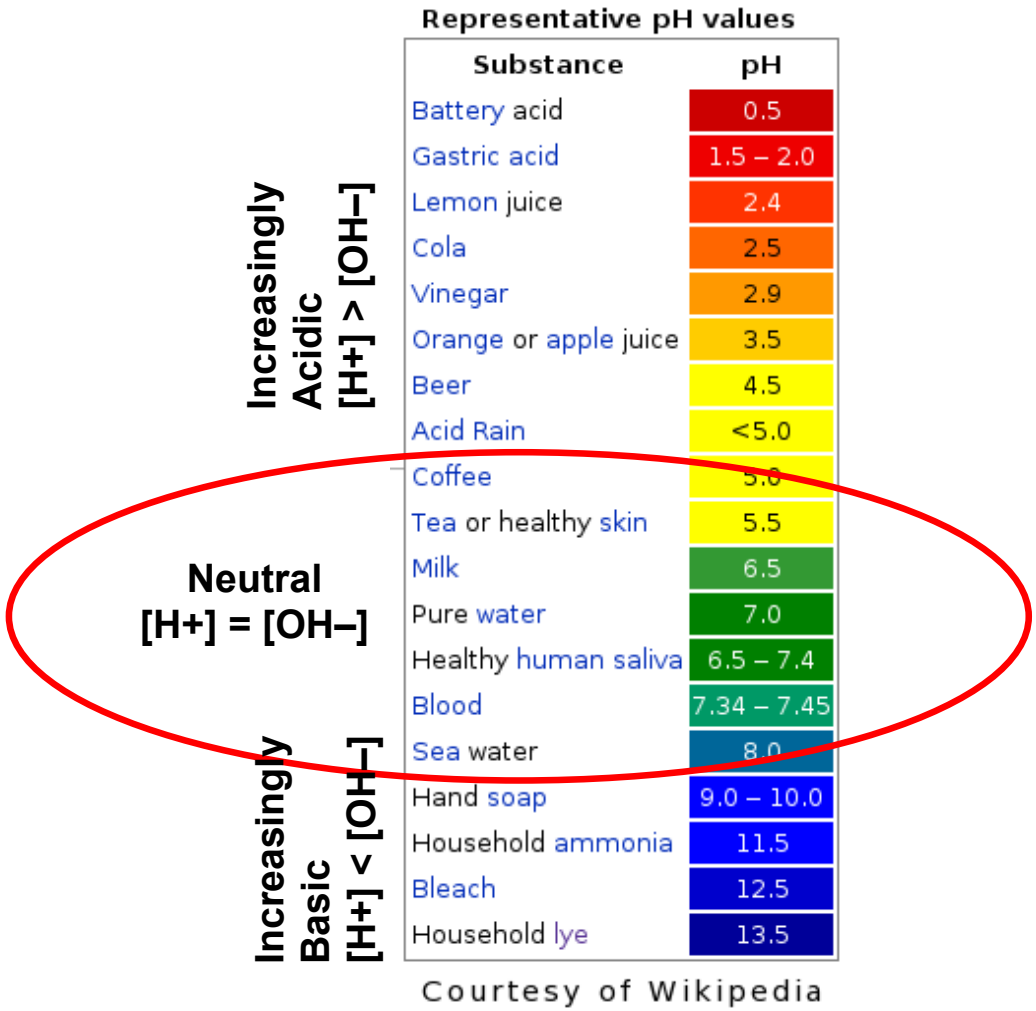
[H+] < [OH–]

The pH Scale

The pH of a solution is determined by the relative concentration of hydrogen ions.

Most biological solutions have pH values between 6-8.

Click Here to see a pH Simulation



24 The unequal sharing of electrons makes water a _____ molecule.

- A hypdrophobic
- B ionic
- C nonpolar
- D polar

25 Why is water a good solvent?

- A It expands upon freezing
- B It has a high specific heat
- C Water molecules are polar
- D Water molecules are ionic

26 Which of the following substances would have the highest concentration of H+ ions?

- A Soap
- B Human Blood
- C Coffee
- D Gastric Acid