Sixth Grade Science

CREDITS

Unless otherwise noted, the contents of this book are licensed under the Creative Commons Attribution NonCommercial ShareAlike license. Detailed information about the license is available online at http://creativecommons.org/licenses/by-nc-sa/3.0/legalcode. All definitions for vocabulary (identified in bold) are provided by dictionary.reference.com.

Prior to making this book publicly available, we have reviewed its contents extensively to determine the correct ownership of the material and obtain the appropriate licenses to make the material available. We will promptly remove any material that is determined to be infringing on the rights of others. If you believe that a portion of this book infringes another's copyright, contact Superintendent of Instruction.

If you do not include an electronic signature with your claim, you may be asked to send or fax a follow-up copy with a signature. To file the notification, you must be either the copyright owner of the work or an individual authorized to act on behalf of the copyright owner. Your notification must include:

1. Identification of the copyrighted work, or in the case of multiple works at the same location, a representative list of such works at that site.
2. Identification of the material that is claimed to be infringing or to be the subject of infringing activity. You must include sufficient information, such as a specific page number or other specific identification, for us to locate the material.
3. Information for us to be able to contact the claimant (eg., email, address, phone number).
4. A statement that the claimant believes that the use of the material has not been authorized by the copyright owner or an authorized agent.
5. A statement that the information in the notification is accurate and that the claimant is, or is authorized to act on behalf of, the copyright owner.

This book is adapted from the excellent materials created by the CK-12 Foundation (http://ck12.org) which are licensed under the Creative Commons Attribution NonCommercial ShareAlike license. We express our gratitude to the CK-12 Foundation for their pioneering work on secondary science textbooks, without which the current book would not be possible.

We would like to thank Utah's State Department of Education for providing a model for Broken Arrow Public Schools. We also thank the amazing Broken Arrow Public Schools' (BAPS) science teachers whose collaborative efforts made the book possible.

This textbook is aligned with Oklahoma Academic Standards (OAS), BAPS and SPS Sequence of Instruction for 6th grade. Thank you for your commitment to science education!

TABLE OF CONTENTS

Safety in Science Page 3

Chapter 1 Physical Sciences

1.0 An Introduction to Laboratory Equipment Page 4
1.1 Phases of Matter (MS-PS2-4) Page 14
1.2 Energy Takes Many Forms (MS-PS3-1and MS-PS3-2) Page 15
1.3 Magnetic Forces (MS-PS2-3 and MS-PS2-5) Page 20
1.4 Electrical Fields and Circuts (MS-PS2-3 and MS-PS2-5) Page 25
1.5 Temperature and Heat (MS-PS3-3 and MS-PS3-4) Page 30
1.6 Heat Transfer (MS-PS3-3) Page 36

Chapter 2 Life Sciences

2.0 An Introduction to Laboratory Equipment Page 40
2.1 The Cell (MS-LS1-1) Page 42
2.2 Cell Organelles and Function (MS-LS1-2) Page 46
2.3 Organization of Cells (MS-LS1-3) Page 49
2.4 Photosynthesis and Cellular Respiration (MS-LS1-6) Page 52
2.5 Food Webs and Nutrient Cycles (MS-LS2-3) Page 55
2.6 The Water Cycle (MS-ESS2-4) Page 60
2.7 Ecosystems and Populations (MS-LS2-1 and MS-LS2-4) Page 65
2.8 Interdependence of Organisms (MS-LS2-2) Page 68
2.9 Biodiversity and Ecosystem Services (MS-LS2-5) Page 71

Chapter 3 Earth Sciences

3.0 Human Use of Resources (MS-ESS3-3) Page 73
3.1 The Impact of Pollution (MS-ESS3-3) Page 78

Safety in Science

Research in science can be exciting, but it also has potential dangers. For example, the field scientist in this photo is collecting water samples from treatment ponds. There are many microorganisms in the water that could make him sick. The water and shore can also be strewn with dangerous objects such as sharp can lids and broken glass bottles that could cause severe injury. Whether in the field or in the lab, knowing how to stay safe in science is important.

Safety Symbols

Lab procedures and equipment may be labeled with safety symbols. These symbols warn of specific hazards, such as flames or broken glass. Learn the symbols so you will recognize the dangers. Then learn how to avoid them. Many common safety symbols are shown below.

Q: Do you know how you can avoid these hazards?

Following basic safety rules is another important way to stay safe in science. Safe practices help prevent accidents. Several lab safety rules are listed below. Different rules may apply when you work in the field. But in all cases, you should always follow your teacher's instructions.

Lab Safety Rules

- Wear long sleeves and shoes that completely cover your feet.
- If your hair is long, tie it back or cover it with a hair net.
- Protect your eyes, skin, and clothing by wearing safety goggles, an apron, and gloves.
- Use hot mitts to handle hot objects.
- Never work in the lab alone.
- Never engage in horseplay in the lab.
- Never eat or drink in the lab.
- Never do experiments without your teacher's approval.
- Use your hand to fan vapors toward your nose rather than smelling substances directly.
- Never point the open end of a test tube toward anyone—including yourself!
- Clean up any spills immediately.
- Dispose of lab wastes according to your teacher's instructions.
- Wash glassware and counters when you finish your work.
- Wash your hands with soap and water before leaving the lab.

In Case of Accident

Even when you follow the rules, accidents can happen. Immediately alert your teacher if an accident occurs. Report all accidents, whether or not you think they are serious.

1.0 An Introduction to Laboratory Equipment

Mass

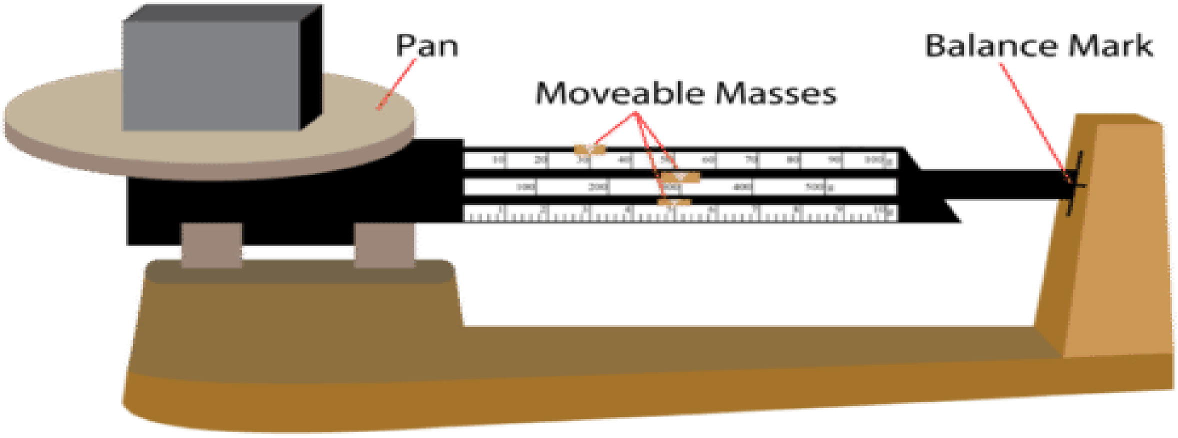
Mass is a measure of the amount of matter in a substance or an object. The basic SI unit for mass is the kilogram (kg), but smaller masses may be measured in grams (g). To measure mass, you would use a balance. In the lab, mass may be measured with a triple beam balance or an electronic balance, but the old-fashioned balance pictured below may give you a better idea of what mass is. If both sides of this balance were at the same level, it would mean that the fruit has the same mass as the iron object. As you can see, however, the fruit is at a higher level than the iron. This means that the fruit has less mass than the iron, that is, the fruit's mass is less than 1 kg.

Measuring Mass with a Triple Beam Balance

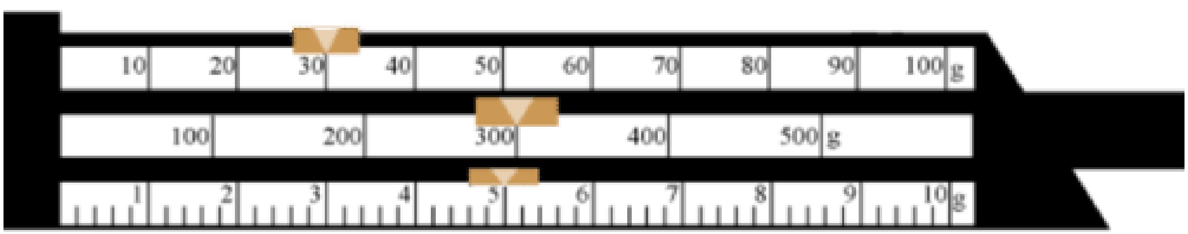
To use this type of balance, follow these steps:

1. Begin by calibrating the balance. Ensure the pan of the balance is clean and clear of any items. The balance arm should line up with the balance mark. If not turn the thumbscrew until the arm and balance mark are level.
2. Place the object to be measured on the pan at the left side of the balance.
3. Slide the movable masses to the right until the right end of the arm is level with the balance mark. Start by moving the larger masses and then fine tune the measurement by moving the smaller masses as needed.
4. Read the three scales to determine the values of the masses that were moved to the right. Their combined mass is equal to the mass of the object.

Triple Beam Tutorial: http://www.ohaus.com/en-us/tutorials/triple-beam



The figure below is an enlarged version of the scales of the triple beam balance in figure above. It allows you to read the scales. The middle scale, which measures the largest movable mass, reads 300 grams. This is followed by the top scale, which reads 30 grams. The bottom scale reads 5.1 grams. Therefore, the mass of the object in the pan is 335.1 grams (300 grams + 30 grams + 5.1 grams).



Volume

Volume is a measure of the amount of space that a substance or an object takes up. How the volume of matter is measured depends on its state. Volume can be measured for solids and liquids. The basic SI unit for volume of a solid is the cubic meter (m^3), but smaller volumes may be measured in cubic centimeters $(cm)^3$. The basic SI unit for volume of a liquid may be measured in liters (L) or milliliters (mL).

Type of Solid	Rectangular solid	Irregular solid	Liquid
Measurement Tool	Metric ruler	Graduated cylinder	Graduated cylinder
Unit of Measure	(cm^3)	mL	mL

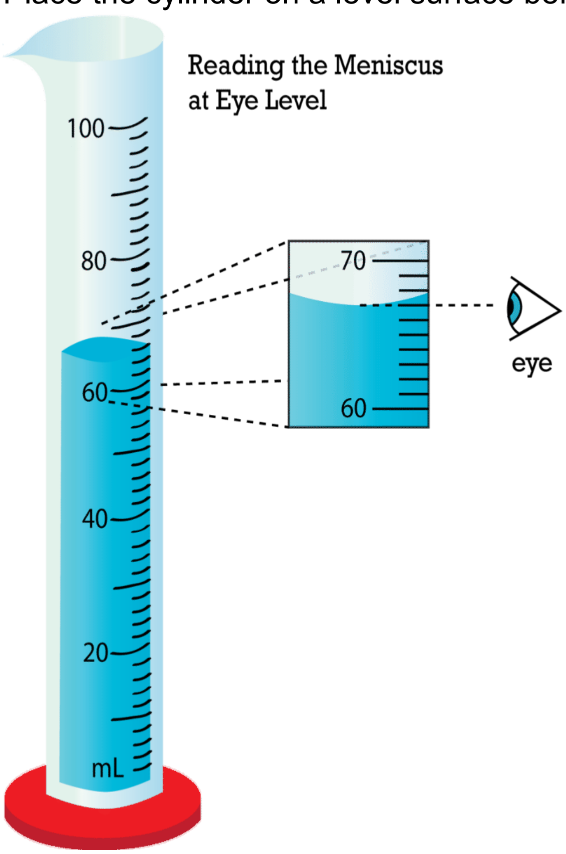
Method of Measuring

- The volume of a liquid is measured with a measuring container, such as a measuring cup or graduated cylinder.
- The volume of a gas depends on the volume of its container: gases expand to fill whatever space is available to them.
- The volume of a regularly shaped solid can be calculated from its dimensions. For example, the volume of a rectangular solid is the product of its length, width, and height. (LxWxH=Volume)
- The volume of an irregularly shaped solid can be measured by the displacement method. You can read below how this method works. For a video on the displacement method, go to this URL: https://www.youtube.com/watch?v=e0geXKxeTn4

Measuring Volume with a Graduated Cylinder

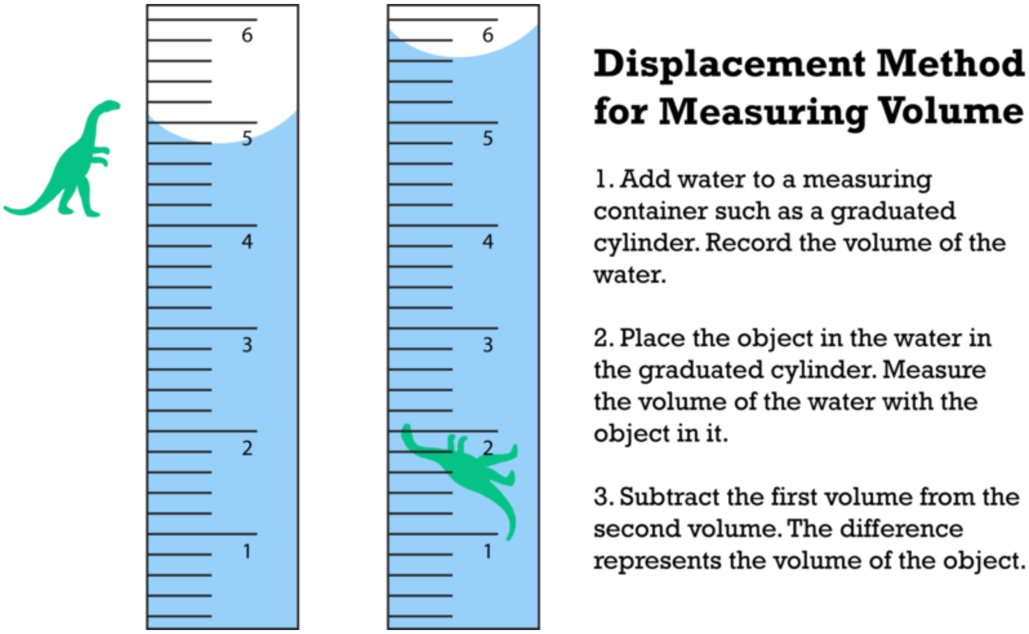
At home, you might measure the volume of a liquid with a measuring cup. In science, the volume of a liquid might be measured with a graduated cylinder, like the one sketched below. The cylinder in the picture has a scale in milliliters (mL), with a maximum volume of 100 mL. Follow these steps when using a graduated cylinder to measure the volume of a liquid:

1. Place the cylinder on a level surface before adding the liquid.



2. After adding the liquid, move so your eyes are at the same level as the top of the liquid in the cylinder.
3. Read the mark on the glass that is at the lowest point of the curved surface of the liquid. This is called the meniscus.

Q: How could you find the volume of air in an otherwise empty room?



Q: What is the irregular volume of the dinosaur in the diagram above?

right). All water molecules have the same ratio: two hydrogen to one oxygen.

Structure and Properties of Matter Assessment:

1. What is volume?

2. How can you measure the volume of an object that has an irregular shape? (DOK 2)

3. Compare the units of measurement for the volume of a liquid and volume of a solid object? (DOK 3)

4. Would you use a ruler or a graduated cylinder to measure the volume of the following items and why?
   a. Toy Car
   b. Tissue Box
   c. Iced Tea

Potential and Kinetic Energy Assessment
Essential Skill: Models can be used to represent systems and their interactions-such as inputs, processes, and outputs - and energy and matter flows within systems

1. Explain the definition of energy in your own words. (DOK1)

2. Which has more kinetic energy rolling down a hill: a bowling ball or a soccer ball? Explain your answer. (DOK2)

3. How can you make a bowling ball and soccer ball have the same gravitational potential energy? (DOK 3)

4. When a car burns the energy in gasoline, is the chemical energy destroyed? Explain your answer. (DOK 2)

5. According to the law of the conservation of energy, a kicked soccer ball will never lose its energy. However, it will eventually stop rolling. What happened to the energy? Create a diagram with labels or explain with words. (DOK 4)

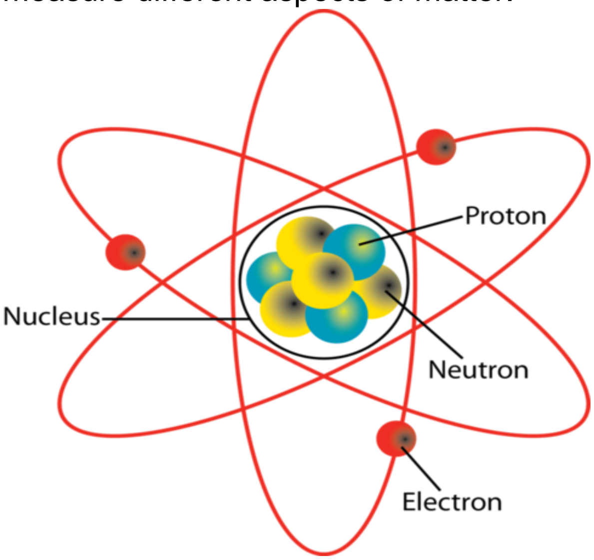
1.1 Properties and Phases of Matter

By the end of this reading...

MS-PS1-4 Students will develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

What's the Matter?

Matter is all the "stuff" that exists in the universe. Everything you can see and touch is made of matter, including you! The only things that aren't matter are forms of energy, such as light and sound. In science, matter is defined as anything that has mass and volume. Mass and volume measure different aspects of matter.



Properties of Matter

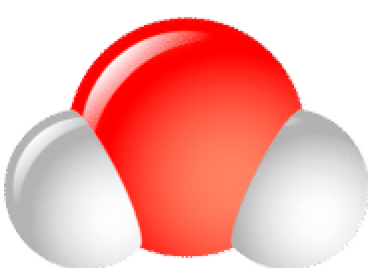
The basic unit of matter is an **atom** (figure below). At the center of an atom is its nucleus. Protons are positively charged particles in the nucleus. Also in the nucleus are neutrons with no electrical charge. Orbiting the nucleus are tiny electrons. **Electrons** are negatively charged particles. An atom with the same number of protons and electrons is electrically neutral. These atoms are always in motion.

The nucleus of an atom is made up of protons (blue) and neutrons (yellow). Electrons (red) orbit around the nucleus.

Elements, Molecules, and Compounds

A pure substance is called an **element** or **compound**. An element is a pure substance because all of the atoms are the same (example: Oxygen). All atoms of the same element have the same number of protons in their nucleus. Currently, 92 different elements are known to exist in nature, although additional elements have been formed in labs. All matter consists of one or more of these elements. Some elements are very common; others are relatively rare. Looking at the periodic table on the next page, the atomic number represents the number of protons in the nucleus of those atoms.

A **molecule** is the smallest unit of a chemical compound. A compound is a substance made of two or more elements (example: H_2O). The elements in a chemical compound are always present in a certain ratio.



Water is probably one of the simplest compounds that you know. A water **molecule** is made of two hydrogen atoms (the smaller, lighter atoms) and one oxygen atom (larger, darker atom) (figure

The Periodic Table of Elements

6 C CARBON 12

- 6 — **Atomic Number** = Number of Protons = Number of Electrons
- C — **Chemical Symbol**
- CARBON — **Chemical Name**
- 12 — **Atomic Weight** = Number of Protons + Number of Neutrons*

METALS

NON-METALS

1 H HYDROGEN 1																	2 He HELIUM 4
3 Li LITHIUM 7	4 Be BERYLLIUM 9											5 B BORON 11	6 C CARBON 12	7 N NITROGEN 14	8 O OXYGEN 16	9 F FLUORINE 19	10 Ne NEON 20
11 Na SODIUM 23	12 Mg MAGNESIUM 24											13 Al ALUMINUM 27	14 Si SILICON 28	15 P PHOSPHORUS 31	16 S SULFUR 32	17 Cl CHLORINE 35	18 Ar ARGON 40
19 K POTASSIUM 39	20 Ca CALCIUM 40	21 Sc SCANDIUM 45	22 Ti TITANIUM 48	23 V VANADIUM 51	24 Cr CHROMIUM 52	25 Mn MANGANESE 55	26 Fe IRON 56	27 Co COBALT 59	28 Ni NICKEL 59	29 Cu COPPER 64	30 Zn ZINC 65	31 Ga GALLIUM 70	32 Ge GERMANIUM 73	33 As ARSENIC 75	34 Se SELENIUM 79	35 Br BROMINE 80	36 Kr KRYPTON 84
37 Rb RUBIDIUM 85	38 Sr STRONTIUM 88	39 Y YTTRIUM 89	40 Zr ZIRCONIUM 91	41 Nb NIOBIUM 93	42 Mo MOLYBDENUM 96	43 Tc TECHNETIUM 98	44 Ru RUTHENIUM 101	45 Rh RHODIUM 103	46 Pd PALLADIUM 106	47 Ag SILVER 108	48 Cd CADMIUM 112	49 In INDIUM 115	50 Sn TIN 119	51 Sb ANTIMONY 122	52 Te TELLURIUM 128	53 I IODINE 127	54 Xe XENON 131
55 Cs CESIUM 133	56 Ba BARIUM 137		72 Hf HAFNIUM 178	73 Ta TANTALUM 181	74 W TUNGSTEN 184	75 Re RHENIUM 186	76 Os OSMIUM 190	77 Ir IRIDIUM 192	78 Pt PLATINUM 195	79 Au GOLD 197	80 Hg MERCURY 201	81 Tl THALLIUM 204	82 Pb LEAD 207	83 Bi BISMUTH 209	84 Po POLONIUM 209	85 At ASTATINE 210	86 Rn RADON 222
87 Fr FRANCIUM 223	88 Ra RADIUM 226		104 Rf RUTHERFORDIUM 267	105 Db DUBNIUM 270	106 Sg SEABORGIUM 271	107 Bh BOHRIUM 274	108 Hs HASSIUM 277	109 Mt MEITNERIUM 278	110 Ds DARMSTADTIUM 281	111 Rg ROENTGENIUM 281	112 Cn COPERNICIUM 285	113 Uut UNUNTRIUM 286	114 Uuq UNUNQUADIUM 289	115 Uup UNUNPENTIUM 289	116 Uuh UNUNHEXIUM 291	117 Uus UNUNSEPTIUM 294	118 Uuo UNUNOCTIUM 294

57 La LANTHANUM 139	58 Ce CERIUM 140	59 Pr PRASEODYMIUM 141	60 Nd NEODYMIUM 144	61 Pm PROMETHIUM 145	62 Sm SAMARIUM 150	63 Eu EUROPIUM 152	64 Gd GADOLINIUM 157	65 Tb TERBIUM 159	66 Dy DYSPROSIUM 163	67 Ho HOLMIUM 165	68 Er ERBIUM 167	69 Tm THULIUM 169	70 Yb YTTERBIUM 173	71 Lu LUTETIUM 175
89 Ac ACTINIUM 227	90 Th THORIUM 232	91 Pa PROTACTINIUM 231	92 U URANIUM 238	93 Np NEPTUNIUM 237	94 Pu PLUTONIUM 244	95 Am AMERICIUM 243	96 Cm CURIUM 247	97 Bk BERKELIUM 247	98 Cf CALIFORNIUM 251	99 Es EINSTEINIUM 252	100 Fm FERMIUM 257	101 Md MENDELEVIUM 258	102 No NOBELIUM 259	103 Lr LAWRENCIUM 262

KEY

- = **Solid** at room temperature
- = **Liquid** at room temperature
- = **Gas** at room temperature
- = **Radioactive**
- = **Artificially Made**

* The atomic weights listed on this Table of Elements have been rounded to the nearest whole number. As a result, this chart actually displays the **mass number** of a specific isotope for each element. An element's complete, unrounded atomic weight can be found on the It's Elemental web site: http://education.jlab.org/itselemental/index.html

http://education.jlab.org/

Last revised on April 16, 2010

Phases of Matter

Write down all that you know about the relationship between these images.

<u>**States of matter**</u> are the different forms in which matter can exist. Look at the figure above. It represents water in three states: solid (ice), liquid (in the glass), and gas (water vapor in the air). In all three states, water is still water and the atoms are all moving. It has the same chemical makeup and the same chemical properties. That's because the state of matter is a physical property.

How do solids, liquids, and gases differ? Their properties are compared and described in the figure below. You can also watch the following video about the three states at this URL: **https://safeshare.tv/x/ss57f2c1304b70b**

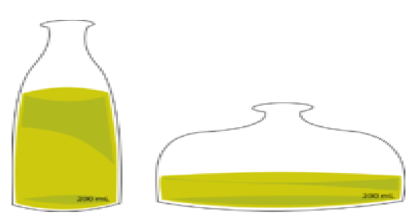
Phases of Matter Demonstration

Solids

Ice is an example of a **solid**. Compared with these other states of matter, solids have particles that are much more tightly packed together. The particles are held rigidly in place by all the other particles around them so they can't slip past one another or move apart. This gives solids a fixed shape and a fixed volume. Even though they seem to be sitting perfectly still, the atoms inside are still moving and have energy. The atoms in ice overall have less energy and move less than the atoms found in other states.

Liquids

Ocean water is an example of a **liquid**. The atoms of liquids are in close contact with each other but not as tightly packed as those in solids. The atoms can slip past one another and take the shape of their container. However, they cannot pull apart and spread out to take the volume of their container, as particles of a gas can. Water atoms that are in liquid form overall have more energy and move more than atoms in a solid state, but less than those in a gaseous state.



Gases

Water vapor is an example of a gas. A **gas** is matter that has neither a fixed volume nor a fixed shape. Instead, a gas takes both the volume and the shape of its container. It spreads out to take up all available space. The atoms move in random motion with little or no attraction to each other. Water vapor overall has more energy and moves more than atoms in either a solid or liquid.

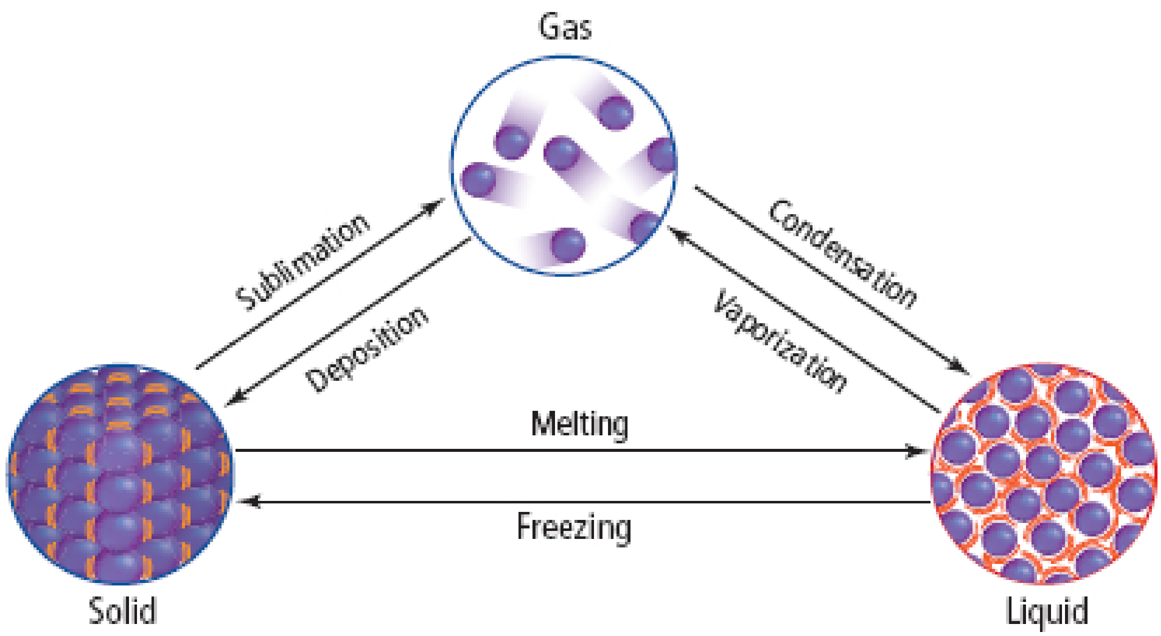
When you add air to a bicycle tire, you add it only through one tiny opening. But the air immediately spreads out to fill the whole tire.

Energy and Matter

Why do different states of matter have different properties? It's because of differences in energy that the atoms have. It is important to remember that energy is never created nor destroyed. Energy is transferred from one form to another.

Even atoms that are solid still move and have energy. As we add energy to the atoms in matter the atoms begin to move faster and can change to another state. One example of this would be to add heat to ice. Increasing the heat gives the atoms more energy so the atoms begin to move more and will become a liquid. The opposite is true, we can take away energy and this causes the atoms to move slower and can lead to a state change. This leads us to melting point, freezing point, and boiling point. Melting point is the temperature at which a solid melts to become a liquid; increasing the amount of energy. Freezing point is the temperature at which a liquid freezes to become a solid; decreasing the amount of energy. And boiling point/vaporization is the temperature at which a liquid heats up and becomes a gas (vapor); increasing the amount of energy.

Referring to the diagram below, condensation is the process of a gas changing into a liquid. Sublimation is the process of a solid changing into a gas. And deposition is the process of a gas changing into a solid.



Let’s look at how pressure and temperature affect matter with this virtual lab exercise:
http://phet.colorado.edu/en/simulation/states-of-matter

Structure and Properties of Matter Assessment

Essential Skill: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

1. What are three things that are NOT matter? (DOK 1)

2. Draw an atom and its particles. Be sure to label each particle. (DOK 1)

3. Draw a model of each state of matter - solid, liquid, and gas. Describe the motion of the particles in each state of matter. (DOK 2)

4. How can you change the shape of a liquid? (DOK 2)

5. How does a gas behave inside a closed container if the container’s size is decreased? (DOK 3)

6. Can an oxygen canister ever be half empty? Explain. (DOK 4)

1.2 Energy Takes Many Forms

By the end of this reading...

MS-PS3-1 The student will be able to construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

and

MS-PS3-2 The student will be able to develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Describe all the types of energy you come in contact with on a typical day.

What is Energy?

Energy is defined in science as the ability to move matter or change matter in some other way. Energy can also be defined as the ability to do work, which means using force to move an object over a distance. When work is done, energy is transferred from one object to another. **https://www.youtube.com/watch?v=pb6-DcMEYq4**

All energy falls into two groups: Potential energy and Kinetic energy

Q. What could these four photos possibly have in common? Can you guess what it is?

Kinetic Energy

Kinetic energy is the energy of moving matter. Anything that is moving has kinetic energy—from atoms in matter to stars in outer space. Things with kinetic energy can do work. For example, the spinning saw blade in the photo above is doing the work of cutting through a piece of metal.
The amount of kinetic energy in a moving object depends directly on:

- mass
- speed

An object with greater mass or greater speed has more kinetic energy.

Stored Energy is Potential Energy

This diver has just jumped up from the end of the diving board. After she dives down and is falling toward the water, she'll have kinetic energy, or the energy of moving matter. But even as she is momentarily stopped high above the water, she has energy. Do you know why?

The diver has energy because of her position high above the pool. The type of energy she has is called **potential energy**. Potential energy is energy that is stored in a person or object. Often, the person or object has potential energy because of its position or shape.

Q: ***What is it about the diver's position that gives her potential energy?***

Gravitational Potential Energy

Potential energy due to the position of an object above Earth's surface is called **gravitational potential energy**. Like the diver on the diving board, anything that is raised up above Earth's surface has the potential to fall because of gravity. You can see another example of people with gravitational potential energy in the pictures that follow.

Gravitational potential energy depends on:

- an object's weight and
- its height above the ground

Energy can change form but is never destroyed

Energy, or the ability to cause changes in matter, can exist in many different forms. Energy can also change from one form to another. Watching movies, eating hot popcorn, and many other activities depend on electrical energy. Most electrical energy comes from the burning of fossil fuels, which contain stored chemical energy. When fossil fuels are burned, the chemical energy changes to thermal energy and the thermal energy is then used to generate electrical energy. These are all examples of energy conversion. **Energy conversion** is the process in which one kind of energy changes into another kind. When energy changes in this way, the energy isn't used up or lost. The same amount of energy exists after the conversion as before. Energy conversion obeys the law of conservation of energy, which states that energy cannot be created or destroyed.

Investigate these concepts by clicking on this link:
https://phet.colorado.edu/sims/html/energy-skate-park-basics/latest/energy-skate-park-basics_en.ht

Forms of energy

There are many forms of energy, but they can all be put into two categories: Potential and Kinetic.

Potential Energy	Kinetic Energy
Potential energy is stored energy and the energy of position. There are several forms of potential energy.	**Kinetic energy** is the motion of waves, electrons, atoms, molecules, substances, and objects.
Chemical energy is energy stored in the bonds of atoms and molecules. Batteries, biomass, petroleum, natural gas, and coal are examples of stored chemical energy. Chemical energy is converted to thermal energy when we burn wood in a fireplace or burn gasoline in a car's engine. **Mechanical energy** is energy stored in objects by tension. Compressed springs and stretched rubber bands are examples of stored mechanical energy. **Nuclear energy** is energy stored in the nucleus of an atom—the energy that holds the nucleus together. Large amounts of energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms in a process called **fusion**. **Gravitational energy** is energy stored in an object's height. The higher and heavier the object, the more gravitational energy is stored. When you ride a bicycle down a steep hill and pick up speed, the gravitational energy is being converted to motion energy. Hydropower is another example of gravitational energy, where the dam *piles* up water from a river into a reservoir.	**Electromagnetic energy** is energy that travels in transverse waves. Electromagnetic energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of electromagnetic energy. Sunshine is electromagnetic energy, which provides the fuel and warmth that make life on earth possible. **Thermal energy**, or heat, is the vibration and movement of the atoms and molecules within substances. As an object is heated up, its atoms and molecules move and collide faster. Geothermal energy is the thermal energy in the earth. **Motion energy** is energy stored in the movement of objects. The faster they move; the more energy is stored. It takes energy to get an object moving, and energy is released when an object slows down. Wind is an example of motion energy. A dramatic example of motion is a car crash, when the car comes to a total stop and releases all its motion energy at once in an uncontrolled instant. **Sound** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate. The energy is transferred through the substance in a wave. Typically, the energy in sound is far less than other forms of energy. **Electrical energy** is delivered by tiny charged particles called electrons, typically moving through a wire. Lightning is an example of electrical energy in nature.

http://www.eia.gov/kids/energy.cfm?page=about_forms_of_energy-basics#top-container

Where is the energy in a roller coaster?

https://www.youtube.com/watch?v=Ehx1P4adv6I

Potential and Kinetic Energy Assessment

Essential Skill: Models can be used to represent systems and their interactions-such as inputs, processes, and outputs - and energy and matter flows within systems

1. Explain the definition of energy in your own words. (DOK1)

2. Which has more kinetic energy rolling down a hill: a bowling ball or a soccer ball? Explain your answer. (DOK2)

3. How can you make a bowling ball and soccer ball have the same gravitational potential energy? (DOK 3)

4. When a car burns the energy in gasoline, is the chemical energy destroyed? Explain your answer. (DOK 2)

5. According to the law of the conservation of energy, a kicked soccer ball will never lose its energy. However, it will eventually stop rolling. What happened to the energy? Create a diagram with labels or explain with words. (DOK 4)

1.3 Magnetic Forces

This reading supports...

MS-PS2-3: Students will ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

and

MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that field exist between objects exerting forces on each other even through the objects are not in contact.

How can this train move without touching the track?

The train in this photo is called a maglev train. The word *maglev* stands for “magnetic levitation.” Magnets push the train upward so it hovers, or levitates, above the track without actually touching it. This eliminates most of the friction acting against the train when it moves.

Other magnets pull the train forward along the track. Because of all the magnets, the train can go very fast. It can fly over the tracks at speeds up to 480 kilometers (300 miles) per hour! What are magnets and how do they exert such force? In this article, you’ll find out. You can also watch a video introduction to magnets at this URL: **https://www.youtube.com/watch?v=V-Gus-qIT74**

Magnetic Poles

A **magnet** is an object that attracts certain materials such as iron. You’re probably familiar with common bar magnets, like the one shown in the figure below. Like all magnets, this bar magnet has north and south magnetic poles. The red end of the magnet is the north pole and the blue end is the south pole. The poles are regions where the magnet is strongest. The poles are called north and south because they always line up with Earth’s north-south axis if the magnet is allowed to move freely. (Earth’s axis is the imaginary line around which the planet rotates.)

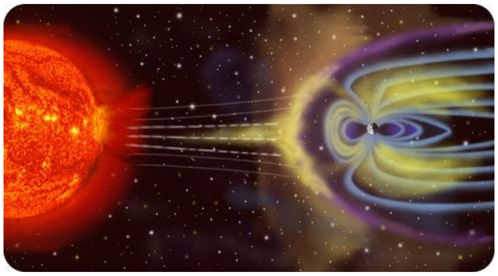
Q: ***What do you suppose would happen if you cut the bar magnet pictured in the figure to the side along the line between the north and south poles***

Magnetic Force and Magnetic Field

The force a magnet exerts on certain materials, including other magnets, is called **magnetic force**. The force is exerted over a distance and includes forces of attraction and repulsion. North and South poles of two magnets attract each other, while two north poles or two south poles repel each other. A magnet can exert force over a distance because the magnet is surrounded by a magnetic field. In the figure below, you can see the magnetic field surrounding a bar magnet. Tiny bits of iron, called iron filings, were placed under a sheet of glass. When the magnet was placed on the glass, it attracted the iron filings. The pattern of the iron filings shows the lines of force that make up the magnetic field of the magnet. The concentration of iron filings near the poles indicates that these areas exert the strongest force. You can also see how the magnetic field affects the compasses placed above the magnet.

When two magnets are brought close together, their **magnetic fields** interact. The lines of force of north and south poles attract each other whereas those of two north poles repel each other. The animations at the following URL show how magnetic field lines change as two or more magnets move in relation to each other. **http://www.coolmagnetman.com/magmotion.htm**

Electrically charged particles are everywhere. The sun sends forth an array of ionized particles into our solar system and into deep space, figure below. Some of the particles are trapped by the Earth's magnetic field and are responsible for interfering with electronic communication. Others initiate a chain of events culminating in the eerie and beautiful Aurora Borealis (the northern lights seen in high northern latitudes), figure below, and Aurora Australis (the southern lights seen in high southern latitudes).



Explore more:

- **http://www.windows2universe.org/physical_science/magnetism/earth_magnet_dipole_interactive.html**

- **http://www.ck12.org/physical-science/Electromagnetic-Devices-in-Physical-Science/enrichment/Simplest-Electric-Motor/**

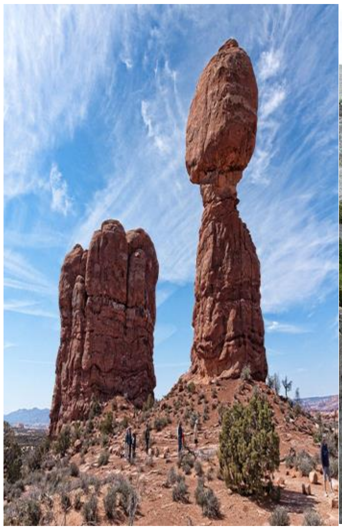
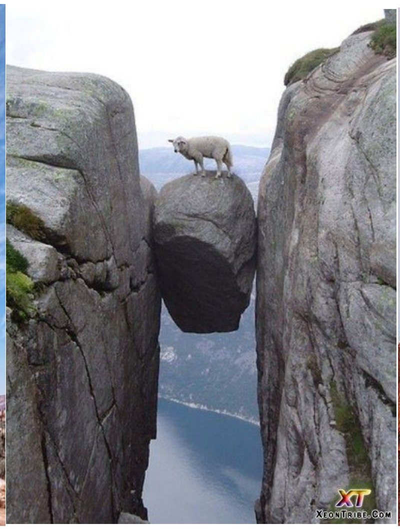
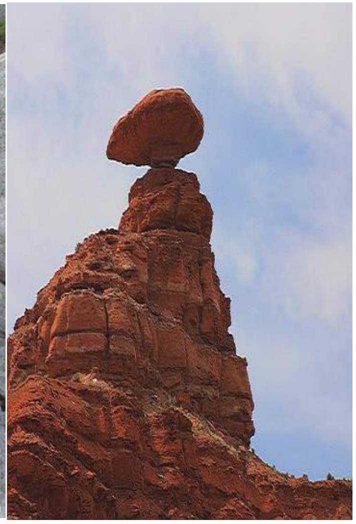
Magnetic Forces Assessment

Essential Skill: The transfer of energy can be tracked as energy flows through a natural system.

Essential Skill: Small changes in one part of a system might cause large changes in another part.

1. What is a magnet? (DOK 1)
2. Describe the magnetic poles of a bar magnet. (DOK 2)
3. Explain why a magnet can exert a force over a distance. (DOK 3)
4. Create a sketch of two bar magnets that are arranged so their magnetic fields attract each other. Label the magnetic poles and add arrows to represent lines of force between the two magnets. (DOK 4)

Gravitational Forces

May the force be with you!
What force is displayed here?
Do all objects on Earth exert this force?

Gravity has traditionally been defined as a force of attraction between two masses. According to this conception of gravity**,** anything that has mass, no matter how small, exerts gravity on other matter. The effect of gravity is that objects exert a pull on other objects. Unlike friction, which acts only between objects that are touching, gravity also acts between objects that are not touching. In fact, gravity can act over very long distances.

Earth's Gravity

You are already very familiar with Earth's gravity**.** It constantly pulls you toward the center of the planet. It prevents you and everything else on Earth from being flung out into space as the planet spins on its axis. It also pulls objects above the surface, from meteors to skydivers, down to the ground. Gravity between Earth and the moon and between Earth and artificial satellites keeps all these objects circling around Earth. Gravity also keeps Earth moving around the sun.

Gravity and Weight

Weight measures the force of gravity pulling on an object. Because weight measures force, the SI unit for weight is the newton (N). On Earth, a mass of 1 kilogram has a weight of about 10 newtons because of the pull of Earth's gravity. On the moon, which has less gravity, the same mass would weigh less. Weight is measured with a scale, like the spring scale in this figure. The scale measures the force with which gravity pulls an object downward.

Money hangs below this hand-held scale. It is pulled downwards by gravity. The scale measures the strength of that pull.

Find out your weight on other planets!   **http://www.exploratorium.edu/ronh/weight/**

Gravity Forces Assessment:

Essential Skill: Models can be used to represent systems and their interactions-such as inputs, processes, and outputs-and energy, matter, and information flows within systems.

1. What is the traditional definition of gravity? (DOK 1)

2. How is weight related to gravity? (DOK 2)

3. Explain how gravity would affect a satellite orbiting the earth. (DOK 3)

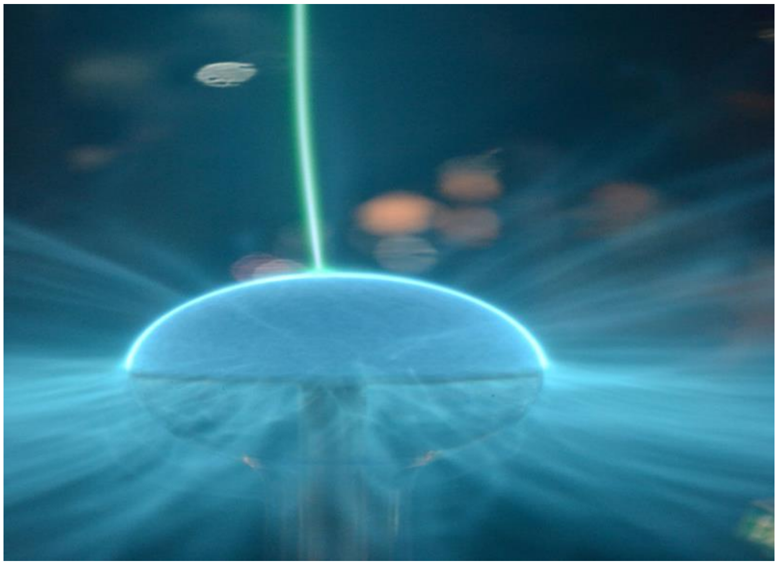
1.4 Electrical Fields and Circuits

This reading supports...

MS-PS2-3: Students will ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

and

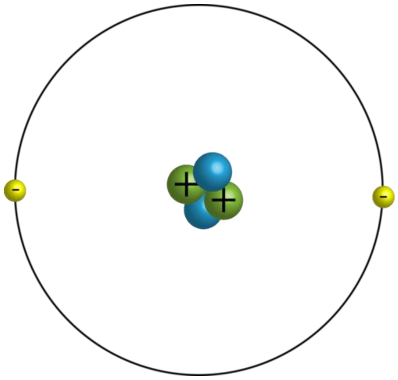
MS-PS2-5: Students will conduct an investigation and evaluate the experimental design to provide evidence that field exist between objects exerting forces on each other even through the objects are not in contact.



What is this?

This image is of a plasma ball at a science museum. It shows electricity flowing out of a charged ball. The electricity follows the lines of the electric field. What is an electric field? Read on to find out.

Electric Charge



Electric charge is a physical property of particles or objects that causes them to attract or repel each other without touching. All electric charge is based on the protons and electrons in atoms. A proton has a positive electric charge, and an electron has a negative electric charge. In the figure to the right, you can see positively charged protons (+) are located in the nucleus of the atom, while negatively charged electrons (-) move around the nucleus.

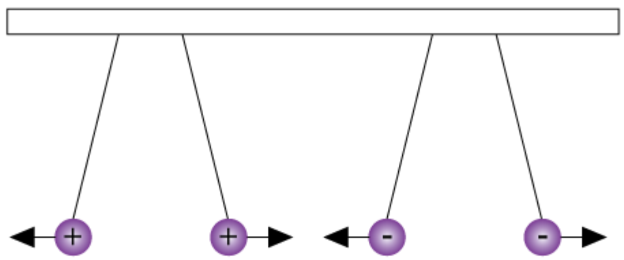
Properties of electric charge

- Interactions between charges
- Like charges repel
- Unlike charges attract
- Interaction decreases with increasing distance

Two types of electric charges: Positive and negative

Electric Force

When it comes to electric charges, opposites attract, so positive and negative particles attract each other. You can see this in the figure below . This attraction explains why negative electrons keep moving around the positive nucleus of the atom. Like charges, on the other hand, repel each other, so two positive or two negative charges push apart. This is also shown in the diagram. The attraction or repulsion between charged particles is called electric force. The strength of electric force depends on the amount of electric charge on the particles and the distance between them. Larger charges or shorter distances result in greater force.



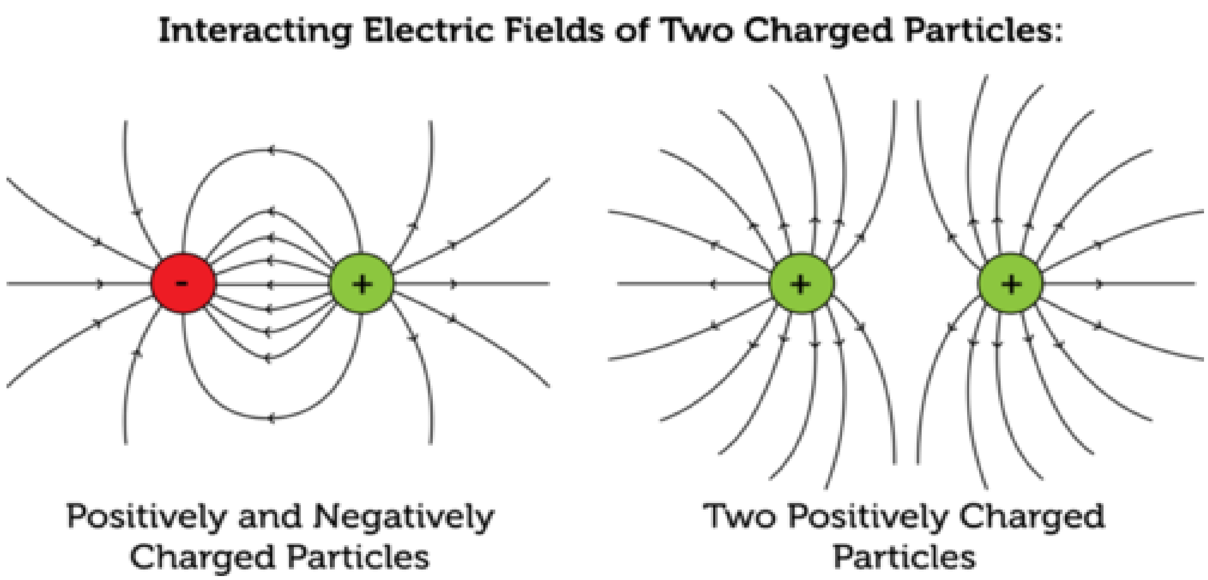
Q: ***You see two balloons that are sticking together. What are their possible charges?***

Electric Field

http://www.ck12.org/physics/Electric-Charge-and-Electric-Force/lecture/Van-de-Graaff-Generator/

When charged particles are close enough to exert force on each other, their **electric fields** interact. This is illustrated in the figure below. The lines of force bend together when particles with different charges attract each other. The lines bend apart when particles with like charges repel each other. At the following URL, play "Electric Field of Dreams" to experience interacting fields of two or more charged particles.

http://phet.colorado.edu/en/simulation/legacy/efield

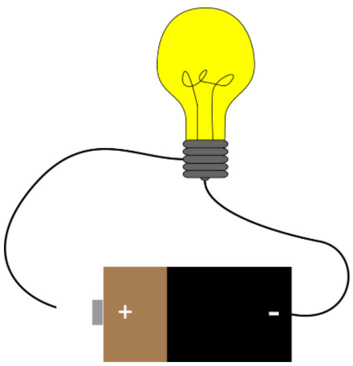


Q: ***Draw a diagram of what the lines of force look like around two negative particles.***

Explore More

Play electric field hockey at the following URL until you score at least one goal. Then write a brief paragraph describing what you did to score a goal. **https://phet.colorado.edu/en/simulation/electric-hockey**

Transfer of energy



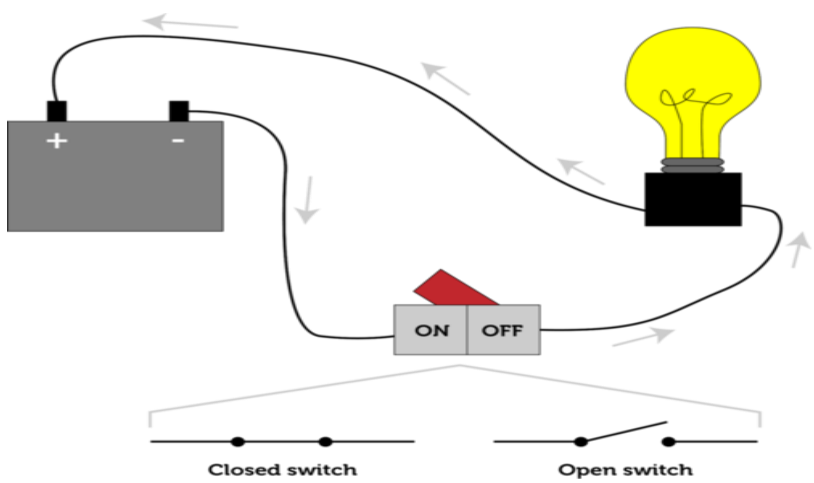
Q: Why does the light bulb need to be connected to both battery terminals?

Electric Circuit Basics

A closed loop through which current can flow is called an **electric circuit**. In homes in the U.S., most **electric circuits** have a voltage of 120 volts. The amount of current (amps) a circuit carries depends on the number and power of electrical devices connected to the circuit. Home circuits generally have a safe upper limit of about 20 or 30 amps.

Parts of an Electric Circuit

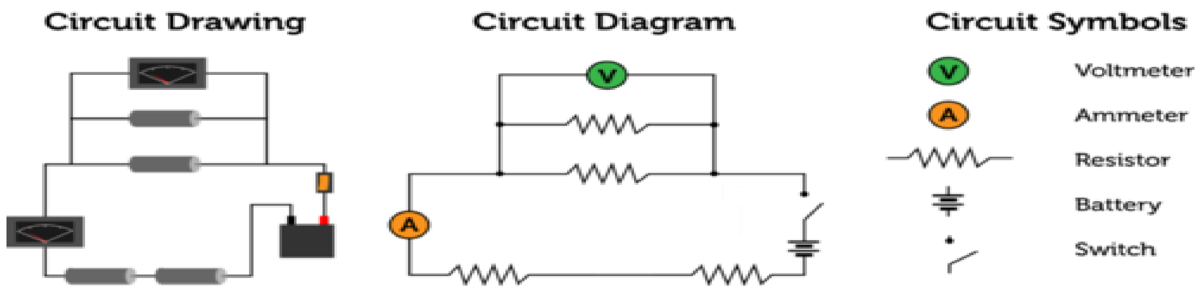
All **electric circuits** have at least two parts: a **voltage source** and a **conductor.** They may have other parts as well, such as light bulbs and switches, as in the simple circuit seen in the figure below.



- The **voltage source** of this simple circuit is a battery. In a home circuit, the source of voltage is an electric power plant, which may supply **electric current** to many homes and businesses in a community or even to many communities.
- The **conductor** in most circuits consists of one or more wires. The **conductor** must form a closed loop from the source of voltage and back again. In the figure above, the wires are connected to both terminals of the battery, so they form a closed loop.
- Most circuits have **electric device(s)** such as light bulbs that convert electrical energy to other forms of energy. In the case of a light bulb, electrical energy is converted to light and thermal energy.
- Many circuits have **switches** to control the flow of current. When the switch is turned on, the circuit is closed and current can flow through it. When the switch is turned off, the circuit is open and current cannot flow through it.

Circuit Diagrams

When a contractor builds a new home, she uses a set of plans called blueprints that show her how to build the house. The blueprints include circuit diagrams. The diagrams show how the wiring and other electrical components are to be installed in order to supply current to appliances, lights, and other electronic devices. You can see an example of a very simple circuit in the figure below . Different parts of the circuit are represented by standard circuit symbols. An ammeter measures the flow of current through the circuit, and a voltmeter measures the voltage. A resistor is any device that converts some of the electricity to other forms of energy. For example, a resistor might be a light bulb or doorbell.



The circuit diagram in the middle represents the circuit drawing on the left. On the right are some of the standard symbols used in circuit diagrams.

Q: ***Only one of the circuit symbols in the figure above must be included in every circuit. Which symbol is it?***

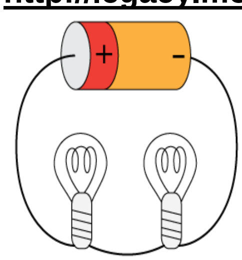
Series and Parallel Circuits

One Loop or Two?

An **electric circuit** consists of at least one closed loop through which **electric current** can flow. Every circuit has a **voltage source** such as a battery and a **conductor** such as metal wire. A circuit may have other parts as well, such as lights and switches. In addition, a circuit may consist of one loop or two loops.

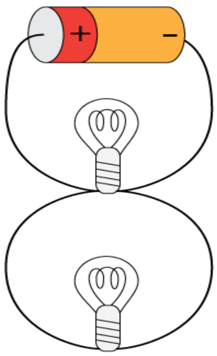
Series Circuit

A circuit that consists of one loop is called a series circuit . You can see a simple series circuit below. If a series circuit is interrupted at any point in its single loop, no current can flow through the circuit and no devices in the circuit will work. In the series circuit below, if one light bulb burns out, the other light bulb won't work because it won't receive any current. Series are commonly used in flashlights. You can see an animation of a series circuit at this URL:
http://legacy.mos.org/etf/elect.swf



Q: If one light bulb burns out in this series circuit, how can you tell which bulb it is?

Parallel Circuit



A circuit that has two loops is called a **parallel circuit.** A simple **parallel circuit** is sketched to the left. If one loop of a **parallel circuit** is interrupted, current can still flow through the other loop. In the **parallel circuit** to the left, if one light bulb burns out, the other light bulb will still work because current can bypass the burned-out bulb. The wiring in a house consists of **parallel circuits**.

Circuit Assessment

Essential Skill: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

1. What is an electric circuit? (DOK 1)

2. Which two parts must all electric circuits contain? (DOK 2)

3. Explain what would occur if the switch was replaced by a conductor? (DOK 2)

4) Compare and contrast series and parallel circuits. (DOK 2)

5) Sketch a simple circuit that includes a battery, switch, and light bulb. Then make a circuit diagram to represent your circuit, using standard circuit symbols. (DOK 3)

6) Create a sketch of a parallel circuit that contains 2 batteries and 3 light bulbs. (DOK 4)

1.5 Temperature, Thermal Energy and Heat

By the end of this reading...

PS3-3 The students will be able to apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

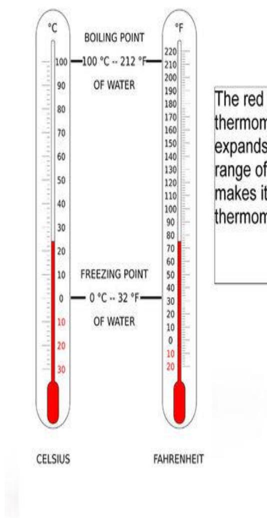
and

PS3-4 The students will be able to plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy.

This boy has a fever, and it makes him feel miserable. He feels achy and really tired. He also feels hot because his temperature is higher than normal. He has a thermometer in his mouth to measure his temperature.

What Is Temperature?

No doubt you already have a good idea of what temperature is. You might say that it's how warm or cool something feels. In physics, **temperature** is defined as the average kinetic energy of the particles of matter. When particles of matter move more quickly, they have more kinetic energy, so their temperature is higher. With a higher temperature, matter feels warmer. When particles move more slowly, they have less kinetic energy on average, so their temperature is lower. With a lower temperature, matter feels cooler.



The red liquid in the thermometer is alcohol. Alcohol expands uniformly over a wide range of temperatures. This makes it ideal for use in thermometers.

How a Thermometer Measures Temperature

Many thermometers measure **temperature** with a liquid that expands when it gets warmer and contracts when it gets cooler. Look at the common household thermometer pictured in the figure on the following page. The red liquid rises or falls in the glass tube as the temperature changes. Temperature is read off the scale at the height of the liquid in the tube. To learn more about measuring temperature, watch the animation "Measuring Temperature": **http://www.sciencehelpdesk.com/unit/science2/3**

Q: The red liquid in the thermometer is alcohol. Alcohol expands uniformly over a wide range of temperatures. This makes it ideal for use in thermometers. *Why does the liquid in the thermometer expand and contract when temperature changes?*

Temperature Scales

The thermometer pictured in the previous figure measures temperature on two different scales: Celsius (C) and Fahrenheit (F). Although some scientists use the Celsius scale, the SI scale for measuring temperature is the Kelvin scale. If you live in the U.S., you are probably most familiar with the Fahrenheit scale. The table below compares all three temperature scales. Each scale uses as reference points the freezing and boiling points of water. Notice that temperatures on the Kelvin scale are not given in degrees (°).

Scale	Freezing Point of Water	Boiling Point of Water
Kelvin	**273 K**	**373 K**
Celsius	**0 °C**	**100 °C**
Fahrenheit	**32 °F**	**212 °F**

What Is Thermal Energy?

Why does the air and sand of Death Valley feel so hot? It's because their particles are moving very rapidly. Anything that is moving has kinetic energy. Also, the faster it is moving, the more kinetic energy it has. The total kinetic energy of moving particles of matter is called **thermal energy**. It's not just hot things such as the air and sand of Death Valley that have thermal energy. All matter has thermal energy, even matter that feels cold. That's because the particles of all matter are in constant motion and have kinetic energy.

Thermal Energy, Temperature, and Mass

Thermal energy and temperature are closely related. Both reflect the kinetic energy of moving particles of matter. However, temperature is the *average* kinetic energy of particles of matter, whereas thermal energy is the *total* kinetic energy of particles of matter. Does this mean that matter with a lower temperature has less thermal energy than matter with a higher temperature? Not necessarily. Another factor also affects thermal energy. The other factor is mass.

Q: ***Look at the pot of soup and the tub of water in the figure below . Which do you think has greater thermal energy?***

The particles of soup have greater average kinetic energy (temperature) than the particles of water in the tub, explaining why the soup has a higher temperature. However, the mass of the water in the tub is much greater than the mass of the soup in the pot. This means that there are many more particles of water than soup. All those moving particles give the water in the tub greater total **kinetic energy**, even though their average **kinetic energy** is less. Therefore, the water in the tub has greater **thermal energy** than the soup. To compare the thermal energy of some other materials, go to the following URL and click on the interactive animation “Temperature and Thermal Energy.”

http://www.absorblearning.com/media/item.action?quick=ad

Q: ***Could a block of ice have more thermal energy than a pot of boiling water?***

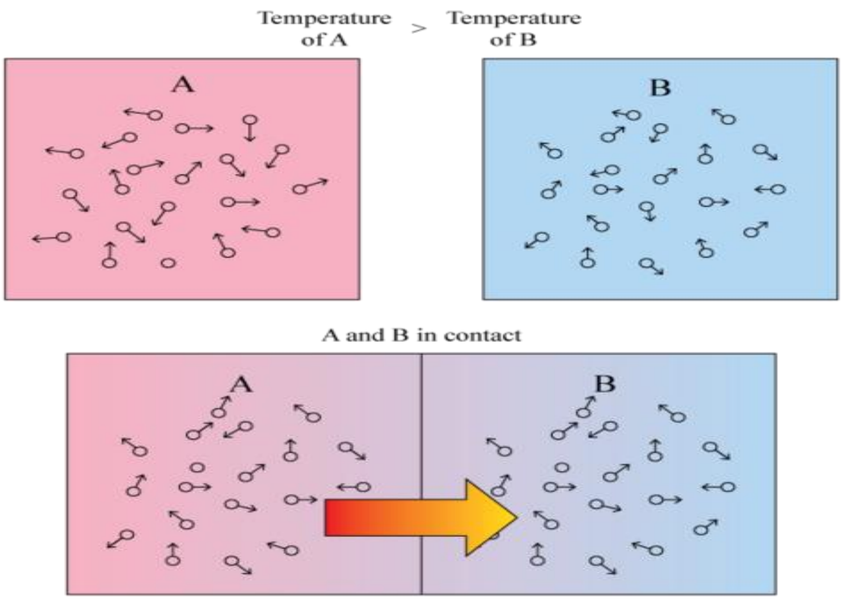
Explore More

Review thermal energy at the following URL, and then take the quiz at the end of the activity.

http://www.bbc.co.uk/schools/ks3bitesize/science/energy_electricity_forces/energy_transfer_storage/activity.shtml

What Is Heat?

Heat is the transfer of thermal energy between substances. Thermal energy is the kinetic energy of moving particles of matter, measured by their temperature. Thermal energy always moves from matter with greater thermal energy to matter with less thermal energy, so it moves from warmer to cooler substances. You can see this in the figure below. Faster-moving particles of the warmer substance bump into and transfer some of their energy to slower-moving particles of the cooler substance. Thermal energy is transferred in this way until both substances have the same thermal energy and temperature. For a visual **i**ntroduction to these concepts, watch the animation "Temperature vs. Heat" at this URL**:** **http://www.sciencehelpdesk.com/unit/science2/3**



Cooling Down by Heating Up

How do you cool down a glass of room-temperature cola? You probably add ice cubes to it. You might think that the ice cools down the cola, but in fact, it works the other way around. The warm cola heats up the ice. Thermal energy from the warm cola is transferred to the much colder ice, causing it to melt. The cola loses thermal energy in the process, so its temperature falls.

Temperature, Heat, and Thermal Energy Assessment

Essential Skill: The transfer of energy can be tracked as energy flows through a designed or natural system.

Essential Skill: Proportional relationships (e.g. speed as the ratio distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

1. What is temperature? (DOK1)

2. Explain how the amount of kinetic energy affects the temperature of matter. (DOK2)

3. What is thermal energy? (DOK1)

4. Compare and contrast thermal energy and temperature. (DOK2)

5. Explain how an object with a higher temperature can have less thermal energy than an object with a lower temperature. (DOK 3)

6. Explain how heat is different from temperature. (DOK 2)

7. Describe in your own words how thermal energy is transferred. (DOK 3

8. Create a diagram with labels to show how atoms move in hot soup versus how atoms move in cold milk. Labels in the diagram are required. (DOK 4)

1.6 Heat Transfers in Three Ways

By the end of this reading...

PS3-3 The students will be able to apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

Why do the cookies on the cookie sheets get hot in an oven?

Heat Transfer

In the previous section, we looked at how thermal energy gets transferred from matter with greater thermal energy to matter with lower thermal energy. For this section, we will look at how does that energy move from one place to another. Thermal energy can transfer in three ways: conduction, convection, and radiation.

What Is Conduction?

Conduction is the transfer of thermal energy between atoms of matter that are touching. Thermal energy is the total kinetic energy of moving atoms of matter, and the transfer of thermal energy is called heat, and thermal energy is always transferred from matter with a higher temperature to matter with a lower temperature. In the opening photo above, conduction occurs between atoms of metal in the cookie sheet and anything cooler that comes into contact with it—hopefully, not someone's bare hands!

Pass It On... or Not

To understand how conduction works, you need to think about the atoms that make up matter. The atoms of all matter are in constant random motion, but the atoms of warmer matter have more energy and move more quickly than the atoms of cooler matter. When the atoms of warmer matter collide with atoms of cooler matter, they transfer some of their thermal energy to the cooler atom. From atom to atom, like dominoes falling, thermal energy moves through matter. Check out the animation "Conduction":

http://www.hk-phy.org/contextual/heat/hea/condu/conduction_e.html

Conduction is usually faster in certain solids and liquids than in gases. Materials that are good conductors of thermal energy are called **thermal conductors**. Metals are especially good thermal conductors because they have freely moving electrons that can transfer thermal energy quickly and easily.

The atoms of gases are relatively far apart, so they don’t bump into each other or into other things as often as the more closely spaced atoms of liquids or solids. Therefore, atoms of gases have fewer opportunities to transfer thermal energy. Materials that are poor thermal conductors are called **thermal insulators**. Other materials that are thermal insulators include plastic and wood. That’s why pot handles and cooking utensils are often made of these materials.

Examples of Conduction

The cookie sheet in the opening image transfers thermal energy to the cookies and helps them bake. There are many other common examples of conduction. The figure below shows a few situations in which thermal energy is transferred in this way.

Q: ***How is thermal energy transferred in each of the situations pictured in the figure <u>above</u>?***

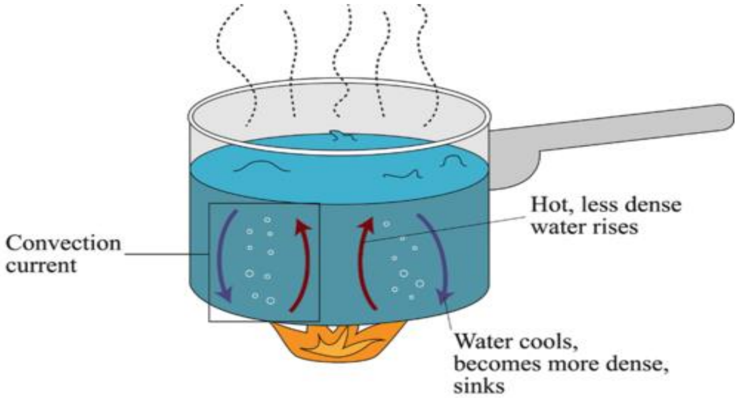
Convection

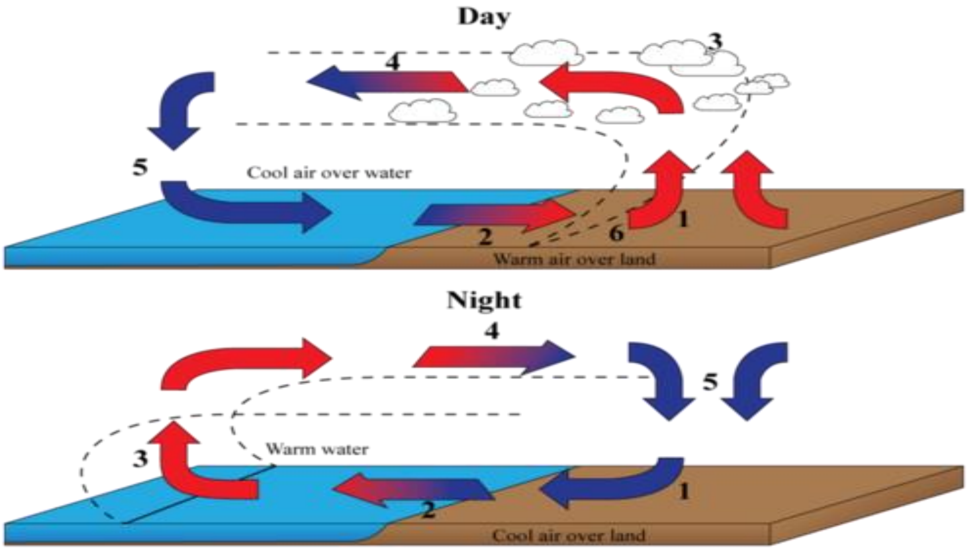
How does all the water in the pan get hot?

Heat Can Transfer by Convection

Convection is the transfer of thermal energy by atoms moving through a fluid (either a gas or a liquid). Thermal energy is the total kinetic energy of moving atoms of matter, and the transfer of thermal energy is called heat. Convection is one of three ways thermal energy can be transferred (the other ways are conduction and thermal radiation). Thermal energy is always transferred from matter with a higher temperature to matter with a lower temperature.

How Does Convection Occur?





This figure shows how convection occurs, using hot water in a pot as an example. When atoms in one area of a fluid (in this case, the water at the bottom of the pot) gain thermal energy, they move more quickly, have more collisions, and spread farther apart. This decreases the density of the atoms, so they rise up through the fluid. As they rise, they transfer their thermal energy to other atoms of the fluid and cool off in the process. With less energy, the atoms move more slowly, have fewer collisions, and move closer together. This increases their density, so they sink back down through the fluid. When they reach the bottom of the fluid, the cycle repeats. The result is a loop of moving atoms called a **convection current** . You can learn more about convection currents by watching the cartoon video called “Convection” at this

URL: **http://www.sciencehelpdesk.com/unit/science2/3**

Examples of Convection

Convection currents transfer thermal energy through many fluids, not just hot water in a pot. For example, convection currents transfer thermal energy through molten rock below Earth's surface, through water in the oceans, and through air in the atmosphere. Convection currents in the atmosphere create winds. You can see one way this happens in the figure below. The land heats up and cools off faster than the water because it has lower specific heat. Therefore, the land gets warmer during the day and cooler at night than the water does. During the day, warm air rises above the land and cool air from the water moves in to take its place. During the night, the opposite happens. Warm air rises above the water and cool air from the land moves out to take its place.

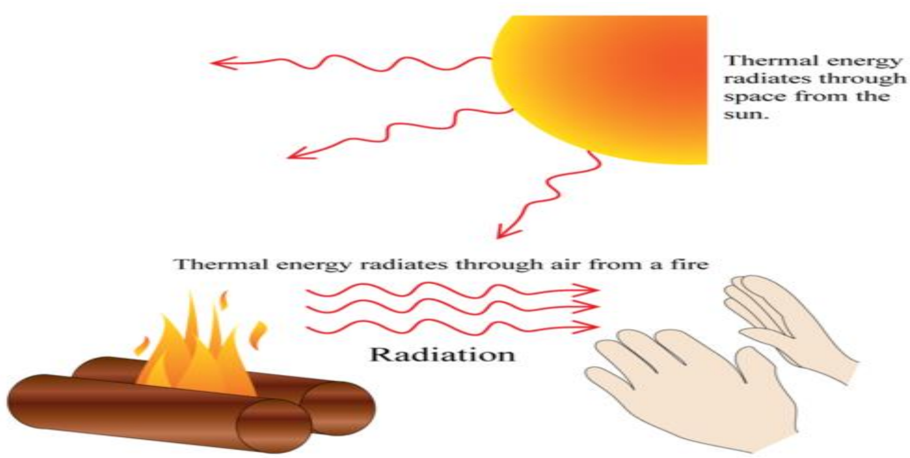
Q: During the day, in which direction is thermal energy of the air transferred? In which direction is it transferred during the night?

Radiation

How is warmth from the fire transferred to his hands?

Thermal Radiation

The bonfire from this image has a lot of thermal energy. Thermal energy is the total kinetic energy of moving atoms of matter, and the transfer of thermal energy is called heat. Thermal energy from the bonfire is transferred to the hands by thermal radiation. **Thermal radiation** is the transfer of thermal energy by waves that can travel through air or even through empty space, as shown in the figure below. When the waves of thermal energy reach objects, they transfer the energy to the objects, causing them to warm up. This is how the fire warms the hands of someone sitting near the bonfire. This is also how the sun's energy reaches Earth and heats its surface. Without the energy radiated from the sun, Earth would be too cold to support life as we know it.



Thermal radiation is one of three ways that thermal energy can be transferred. The other two ways are conduction and convection, both of which need matter to transfer energy. Radiation is the only way of transferring thermal energy that doesn't require matter. To learn more about thermal radiation, watch "Radiation" at the URL: **http://www.sciencehelpdesk.com/unit/science2/3**

Sources of Thermal Radiation

You might be surprised to learn that everything radiates thermal energy, not just really hot things such as the sun or a fire. For example, when it's cold outside, a heated home radiates some of its thermal energy into the outdoor environment. A home that is poorly insulated radiates more energy than a home that is well insulated. Special cameras can be used to detect radiated heat. In the figure below, you can see an image created by one of these cameras. The areas that are yellow are the areas where the greatest amount of thermal energy is radiating from the home. Even people radiate thermal energy. In fact, when a room is full of people, it may feel noticeably warmer because of all the thermal energy the people radiate!

Q: Where is thermal radiation radiating from the home in the picture?

Conduction Assessment

Essential Skill: The transfer of energy can be tracked as energy flows through a designed or natural system.

1. What is conduction? (DOK1)

2. Give three examples of conduction. (DOK1)
   What is a thermal conductor? Give an example. (DOK1)

3. A cold metal spoon is placed in a hot bowl of soup. What will happen to the temperature of the soup and the spoon? Why? (DOK 3)

4. Define thermal insulator. Describe a scenario in which thermal insulators are needed. (DOK 3)

Convection Assessment

1. What is convection? (DOK1)

2. Explain how the process of convection occurs and how convection currents form. (DOK2)

3. Looking at the figure to the right, add arrows representing convection currents by showing the thermal energy moving from the radiator to the rest of the room. Label areas of the room that are warm and cool. (DOK 3)

Radiation Assessment

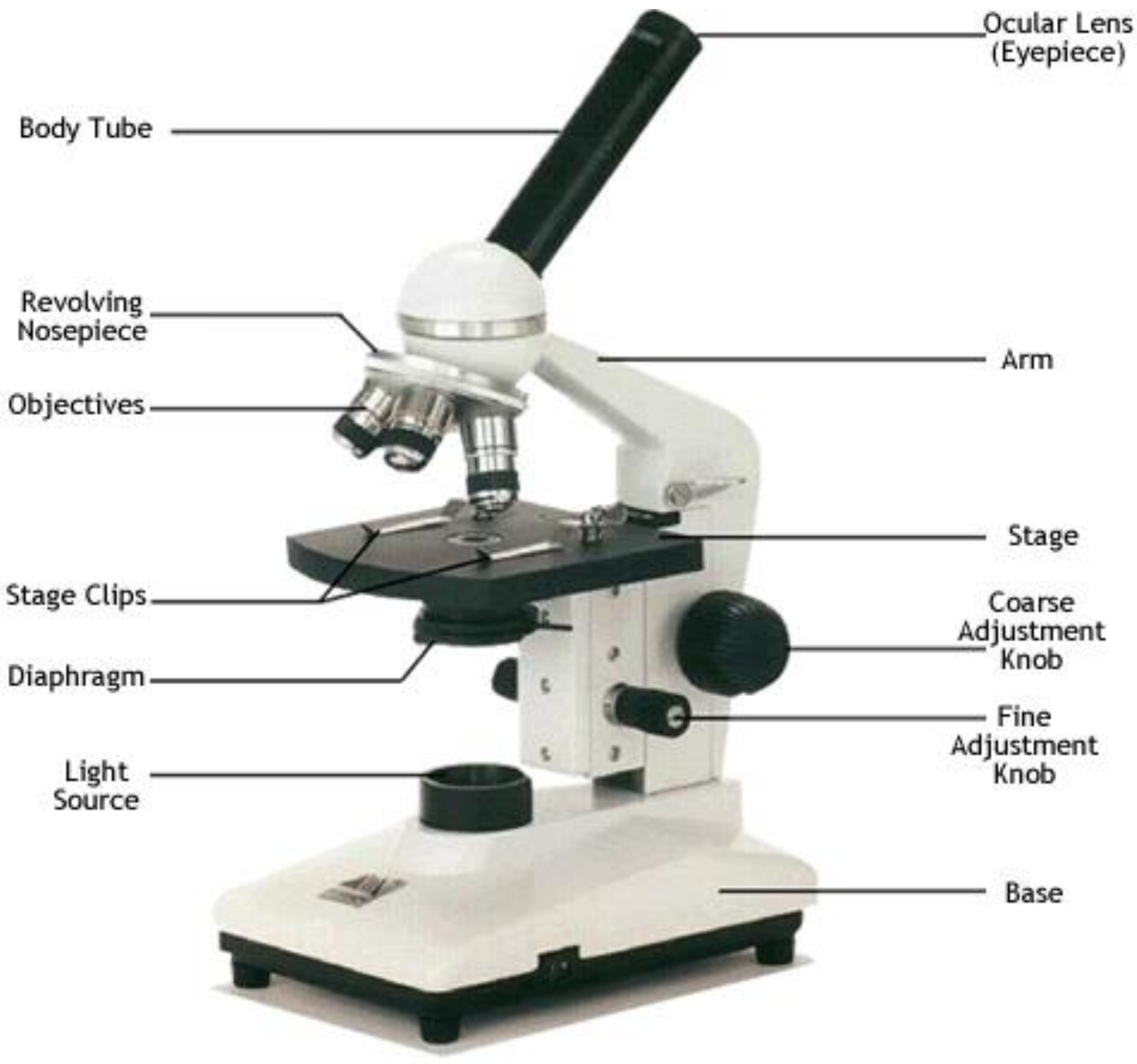
1. What is thermal radiation? (DOK1)

2. If you sit close to a campfire, the fire warms you. Describe how thermal energy is transferred from the fire to you. (DOK2)

3. Explain how radiation differs from conduction and convection. (DOK 3)

2.0 An Introduction to The Microscope

The microscope is a lab tool used for viewing very small objects, such as dust, minerals, and plant or animal cells. The microscope uses glass lenses to bend light to make objects appear larger than they really are. Below is a diagram of the microscope.



Parts of the Microscope

1. Body Tube - allows for the ocular lens and nosepiece to be at the correct distance apart
2. Revolving nosepiece - adjusts which objective lens is in place for use
3. Objectives (lenses) - contains three different magnifications (4x, 10x, 40x) to adjust how magnified a specimen may be
4. Stage clips - holds the slide/specimen in place
5. Diaphragm - rotates underneath the stage to adjust the amount of light that is passed through to the specimen
6. Light source - for most microscopes, this is a light bulb that shines light up through the stage to the specimen. However, some microscopes have a mirror that has to be adjusted by reflecting light from the environment.

7. Ocular lens / Eyepiece - contains a lens at 10x magnified; where you look to observe your specimen
8. Arm - holds the nosepiece, stage, and adjustments knobs in place and also attaches to the base
9. Stage - slides/specimens are placed here for viewing
10. Coarse adjustment knob - allows for quick and large changes in the height of the stage for focusing (brings stage closer to or farther away from the objective lens)
11. Fine adjustment knob - allows for small changes in the height of the stage for fine and clear focusing
12. Base - bottom of the microscope in which all other parts are connected for stability

Carrying a Microscope

Look at the picture to the right to understand the proper way to carry a microscope. Pay close attention to where he has placed each hand.

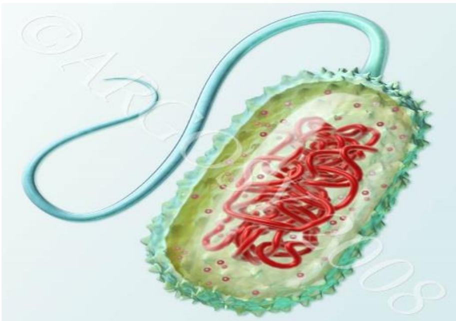
How is this student carrying the microscope?

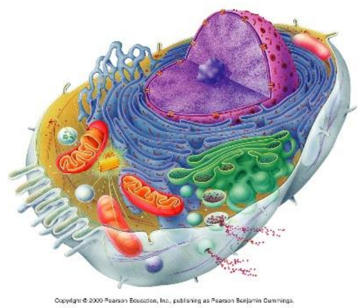
A

2.1 - The Cell

By the end of this reading...

MS-LS1-1: Students will be able to conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.





What similarities do you see in these two images? What differences do you see?

What is the smallest structure of life?

Cells make up all living things, including your own body. Not all cells look alike. Cells can differ in shape and size. The different shapes usually have different functions.

The Characteristics of Life

How do you define a living thing? What do mushrooms, daisies, cats, and bacteria have in common? All of these are living things, or **organisms**. It might seem hard to think of similarities among such different organisms, but they actually have many properties in common.

All living organisms have ALL of these properties:

1. Need energy to carry out life processes
2. Are composed of one or more cells
3. Respond to their environment
4. Grow and develop
5. Maintain a stable internal environment
6. Are able to reproduce

Watch this video that addresses a few misconceptions on what defines life.
Characteristics of Life https://www.youtube.com/watch?v=juxLuo-sH6M

Needs of Living Organisms

Each living organism has their own specific requirements for the following:

1. Materials: air
2. Energy: food and water
3. Living Space: habitat and proper temperature range

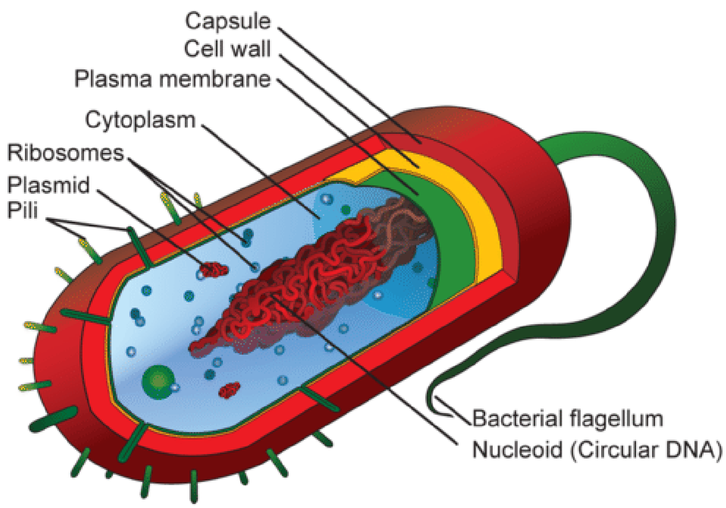
Introduction to Cells

A **cell** is the smallest structural and functional unit of an organism. Some organisms, like bacteria, consist of only one cell. Big organisms, like humans, consist of trillions of cells. There are many different types of cells. For example, in you there are blood cells and skin cells and bone cells and even bacteria. However, all cells - whether from bacteria, human, or any other organism - will be one of two general types. In fact, all cells other than bacteria will be one type, and bacterial cells will be the other. The classification depends on how the cell stores its DNA.

Two Types of Cells

There is a basic cell structure that is present in many, but not all, living cells: the nucleus. The **nucleus** of a cell is a structure that contains DNA. DNA is the basic coding system for all life's processes. Based on whether a cell has a nucleus will determine whether it is **prokaryotic** or **eukaryotic** cell. You can watch animations of both types of cells at the link below:

http://www.learnerstv.com/animation/animation.php?ani=162&cat=biology

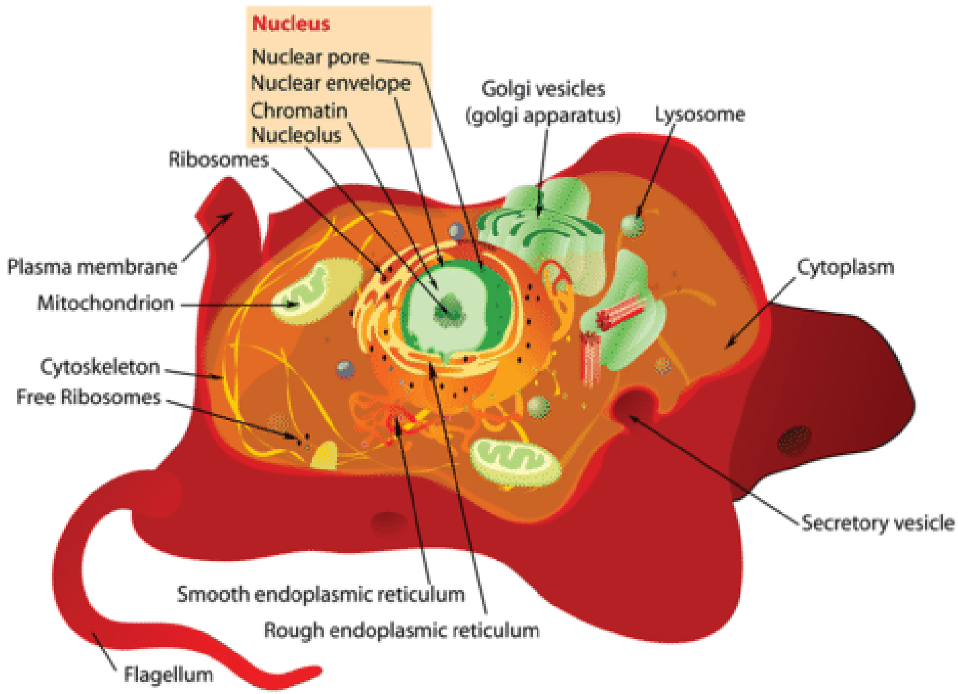


Prokaryotic Cells

Prokaryotic cells are cells without a nucleus. The DNA in prokaryotic cells floats throughout the cell rather than staying enclosed within a nucleus. Prokaryotic cells, like the one shown, are found in single-celled organisms. All prokaryotes are single-celled organisms. Bacteria and Archaea are the only prokaryotes. Organisms with prokaryotic cells are called prokaryotes. They were the first type of organisms to evolve and are still the most common organisms today.

Eukaryotic Cells

Eukaryotic cells are cells that contain a nucleus. A typical eukaryotic cell is shown in the figure below. Eukaryotic cells are usually larger than prokaryotic cells, and they are found mainly in multicellular organisms. Organisms with eukaryotic cells are called eukaryotes, and they range from fungi to people. Eukaryotic cells also contain other organelles besides the nucleus. An organelle is a structure that performs a specific job in the cell. Organelles allow eukaryotic cells to carry out more functions than prokaryotic cells can.



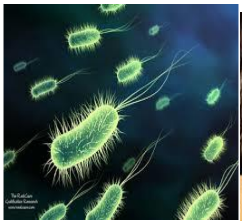
	Prokaryotic Cells	**Eukaryotic Cells**
Nucleus	No	Yes
DNA	Single circular piece of DNA	Multiple chromosomes
Membrane-Bound Organelles	No	Yes
Examples	Bacteria	Plants, animals, fungi

Cells are microscopic in size; therefore, we need tools to conduct our investigation and show that living things really are made of cells. Click on the following link to learn more about how to use a microscope: **http://safeshare.tv/v/bGBgABLEV4g** **(4:01)**

The Cell Assessment:

Essential Skill: Phenomena that can be observed at one scale may not be observable at another scale.

1. Which of these organisms is prokaryotic? Which is eukaryotic?

2. What is the smallest unit that can be said to be a living organism? (DOK 1)

3. List 3 of the characteristics of life. How many of the characteristics must be present in order for an organism to be considered alive? (DOK 1)

4. Choose an organism and explain how it will meet its three needs of life. (DOK2)

5. What are some differences and similarities between Eukaryotic organisms and Prokaryotic organisms? (DOK2)

6. What would be the advantage of having multiples cells compared to only having one cell? (DOK 3)

2.2 - Cell Organelles and Function

By the end of this reading...

MS-LS1-2: Students will be able to develop and use a model to describe the function of a cell as a whole and the ways parts of cells contribute to the function.

How is a cell like a city or a football team?

Eukaryotic Cells

Eukaryotic cells have many specific functions, so it can be said that a cell is like a factory. A factory has many machines and people, and each has a specific role. Just like a factory, the cell is made up of many different parts. Each part has a special role. The different parts of the cell are called **organelles**, which means "small organs." All organelles are found in eukaryotic cells. Prokaryotic cells are more simple than eukaryotic cells. Though prokaryotic cells still have many functions, they are not as specialized as eukaryotic cells. Thus, most organelles are NOT found in prokaryotic cells.

Follow the link for a catchy song about "Cell City." This is also a great study tool!
https://www.youtube.com/watch?v=u4ki28XLzOA (2:59)

Who guards your cells?

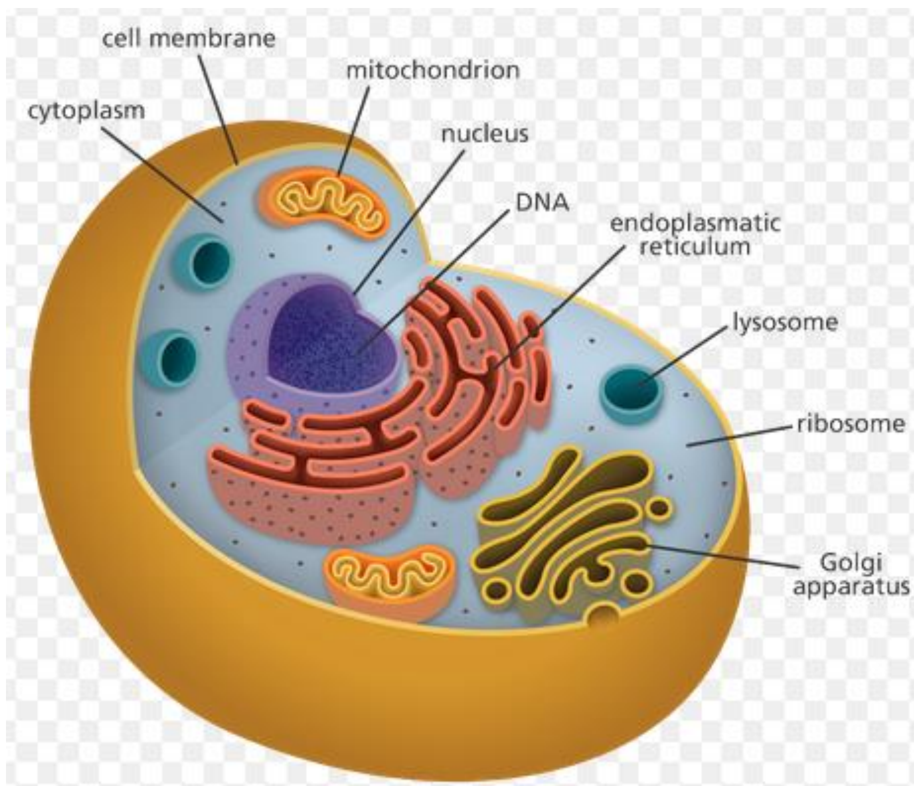
Not everything can make it into your cells. Your cells have a **cell membrane** that helps to guard your cells from unwanted intruders.

The function of the cell membrane is to control what goes in and out of the cell. Some particles (molecules) can go through the cell membrane but some cannot. The cell is therefore not completely passable. An open door is completely passable to anything that wants to enter or exit through the door. A screen is selective to what it allows to pass through. The cell membrane acts like a screen rather than an open door.

In addition to the **cell membrane** there are the other main organelles found in eukaryotic cells:

1. The **nucleus** of a cell is like a safe containing the factory's trade secrets. The nucleus contains the genetic material-the information about how to build thousands of proteins.
2. The **mitochondria** are the powerhouses of the cell; they provide the energy needed to power the cell. Cells that use a lot of energy, like muscle cells or brain cells, may have thousands of mitochondria.
3. **Lysosomes** are like the recycling trucks that carry waste away from the factory. Lysosomes have digestive enzymes that break down old molecules into parts that can be recycled.
4. In both eukaryotes and prokaryotes, **ribosomes** are the organelles where proteins are made. Ribosomes are like the machines in the factory that produce the factory's main product. Proteins are the main product of the cell.

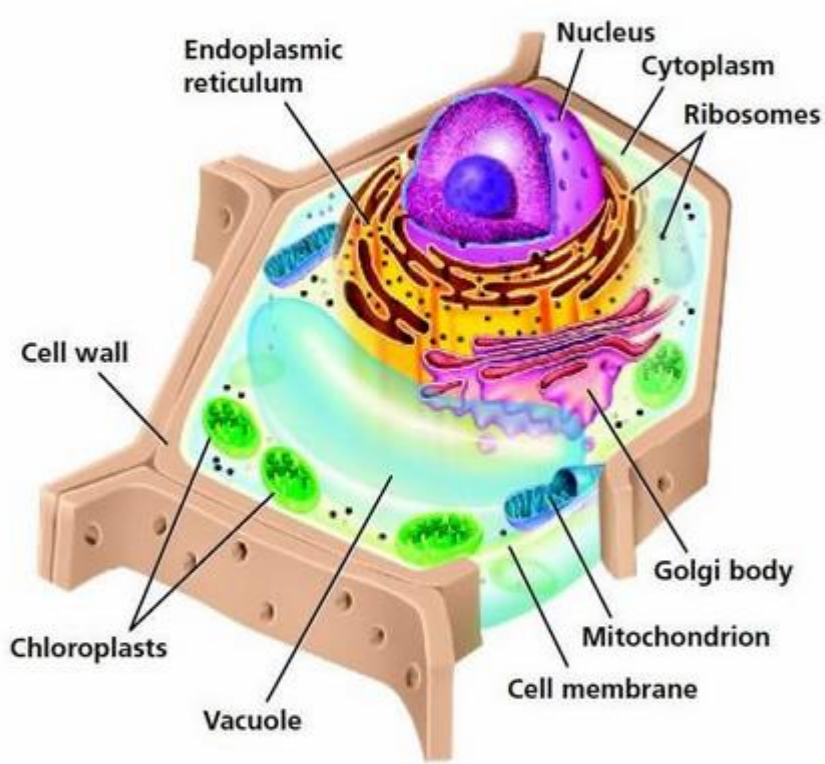
5. Some ribosomes can be found on folded membranes called the **endoplasmic reticulum** (ER), others float freely in the cell. If the ER is covered with ribosomes, it looks bumpy like sandpaper, and is called the rough endoplasmic reticulum. If the ER does not contain ribosomes, it is smooth and called the smooth endoplasmic reticulum. Many proteins are made on the ribosomes on the rough ER. Lipids are made in the smooth ER.
6. The **Golgi apparatus** (aka Golgi Body) works like a mail room. The Golgi apparatus receives proteins from the rough ER and puts "shipping addresses" on them. The Golgi then packages the proteins and sends them to the right place in the cell or to the cell membrane.
7. The **vacuoles** are like storage centers. Plant cells have larger vacuoles than animal cells. Plants store water and nutrients in their large central vacuoles.
8. All of the organelles are suspended in a gelatin-like substance called the **cytoplasm**. The cytoplasm provides protection and support, similar to the way packing peanuts, or bubble wrap, protect a fragile piece of mail.



Plants Only:

Plant cells have a large **central vacuole** that holds a mixture of water, nutrients, and wastes. A plant cell's vacuole can make up 90% of the cell's volume. In animal cells, vacuoles are much smaller.

9. Plant cells have a **cell wall** , while animal cells do not. The cell wall surrounds the cell membrane but does not keep substances from entering or leaving the cell. A cell wall gives the plant cell strength and shape.
10. Plants also have **chloroplasts** which are filled with **chlorophyll** and allow the plant to do photosynthesis.



Note: Lysosomes are in all eukaryotic cells but are not in this diagram.

Try out this fun game, CellCraft, and learn more about organelles.
http://www.biomanbio.com/GamesandLabs/Cellgames/cellcraft.html

Cell Organelles and Function Assessment

Essential Skill: Complex and microscopic structures and systems can be visualized, modeled and used to describe how their functions depend on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function.

1. What does the word "organelle" mean? (DOK 1)

2. What organelles does a plant cell have that an animal cell does not? (DOK 1)

3. The cell membrane is often referred to as the "gatekeeper" of the cell. Is this a good analogy? Why or why not? (DOK 3)

4. Could the Cell Wall be referred to as a gatekeeper? Why or why not? (DOK 3)

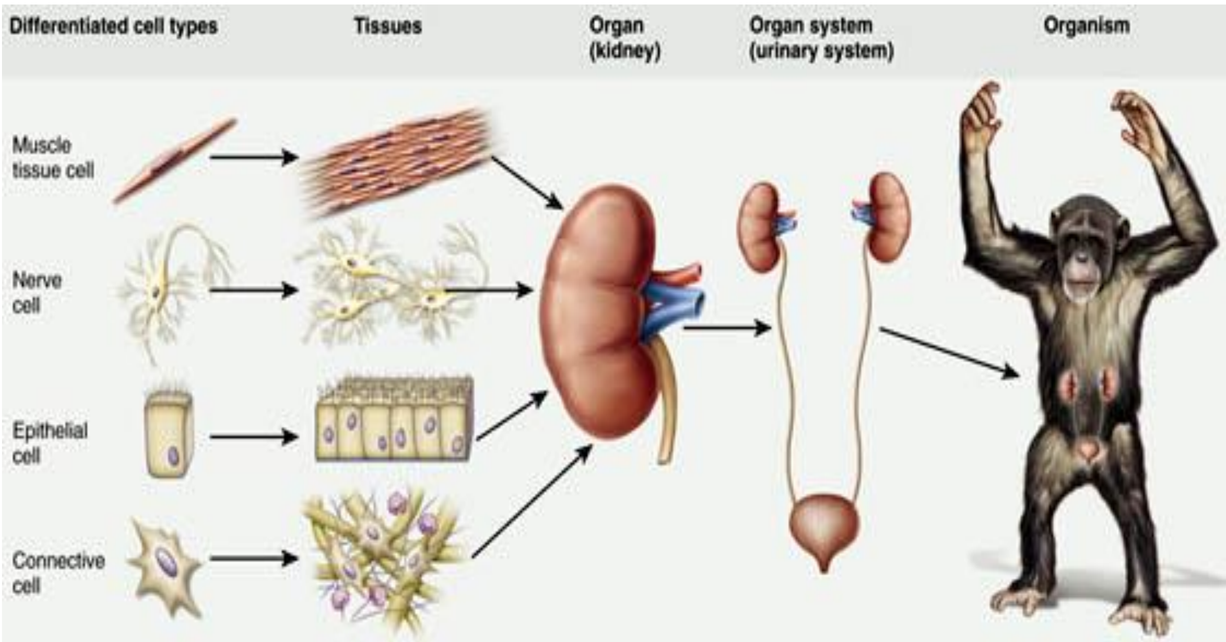
5. Which would have more mitochondria, a muscle cell or a skin cell? (DOK 4)

2.3 - Organization of Cells

By the end of this reading….

<u>MS-LS1-3</u>: Students will be able to use an argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Cells work together to form an organism. Can you think of another example where small parts work together to form a more complex system?

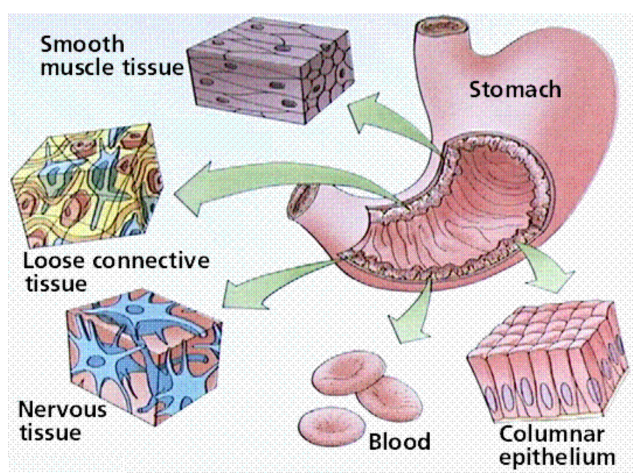


Do cells work together?

Cells do not work in isolation. To send orders from your brain to your legs, for example, signals pass through many nerve cells. These cells work together to perform a similar function. Just as muscle cells work together, bone cells and many other cells do as well. A group of similar cells that work together is known as a tissue.

Groups of Tissues Form Organs

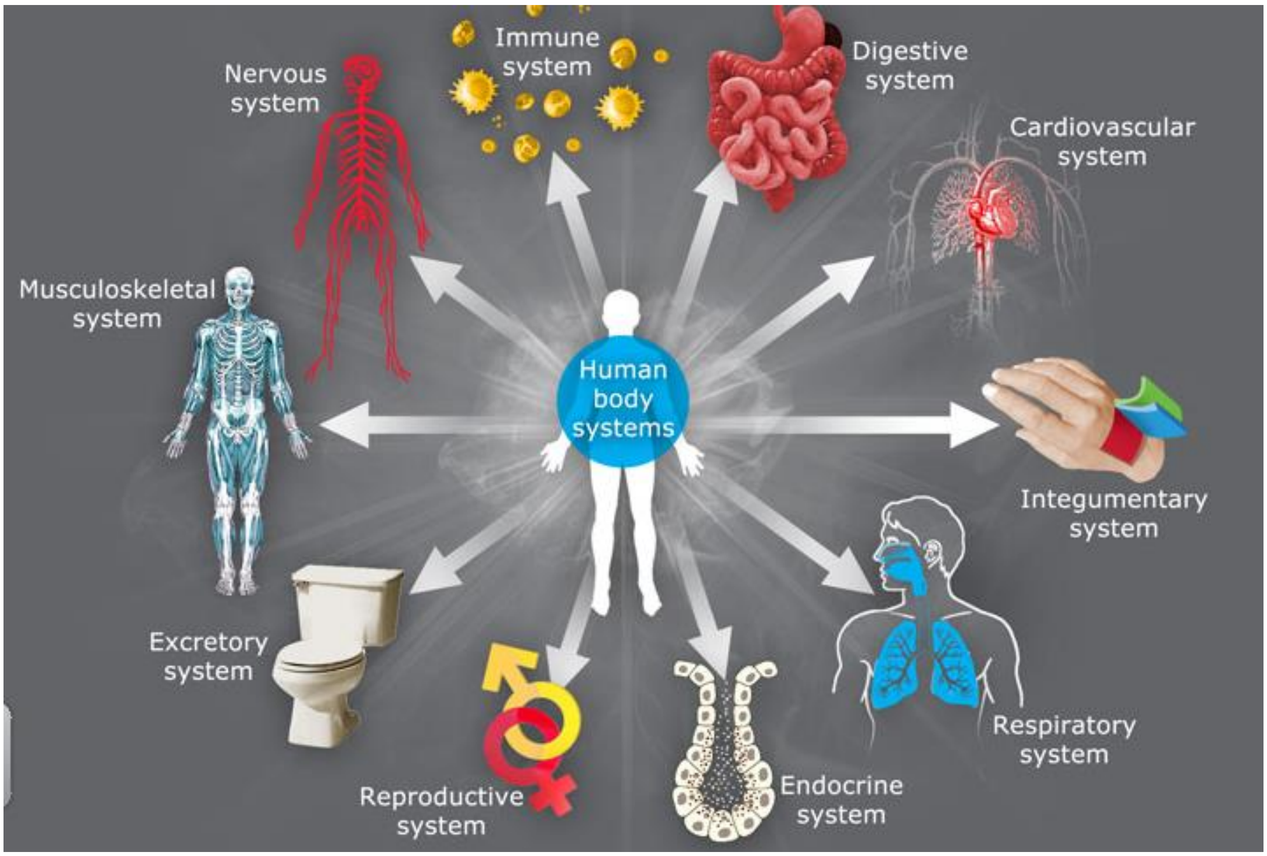
A single tissue alone cannot do all the jobs that are needed to keep you alive and healthy. Two or more tissues working together can do a lot more. An <u>**organ**</u> is a structure made of two or more tissues that work together. The stomach (see figure) is made up of several different tissues.



Groups of Organs Form Organ Systems

Your heart pumps blood around your body. But how does your heart get blood to and from every cell in your body? Your heart is connected to blood vessels such as veins and arteries. Organs that work together form an organ system. For example, when working together, your heart, blood, and blood vessels form your cardiovascular system**.**

Your organ systems do not work alone in your body. They must all be able to work together. For example, one of the most important functions of organ systems is to provide cells with oxygen and nutrients and to remove toxic waste products such as carbon dioxide. A number of organ systems, including the cardiovascular and respiratory systems, all work together to do this. See a diagram of all the major body systems below:



https://bdesai02.wordpress.com/2013/08/06/10-human-body-systems/

Organization of Cells Assessment

Essential Skill: *Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.*

1. List the 4 levels of organization of organisms. (DOK 1)
2. How are muscle cells different from muscle tissue? (DOK 2)
3. What would happen if your organ systems did not work together? Explain. (DOK 3)
4. Cells work together to form an organism. Can you think of another example where small parts work together to form a more complex system? Explain. (DOK 3)

Section 2.4 - Photosynthesis: Food for Cells

This reading supports that...

MS-LS1-6: Students will be able to construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

Cells can't go to the store for food. How do you think they obtain food for themselves?

What is Photosynthesis?

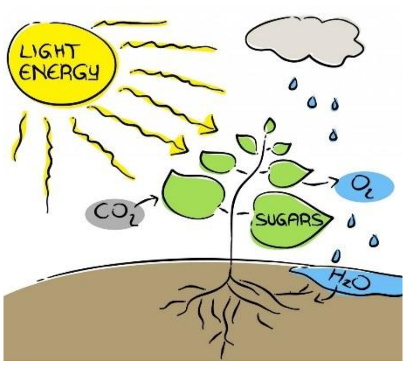
If a cell gets hungry, it cannot walk to a local restaurant and buy a slice of pizza. So, how does a cell get the food it needs to survive? Plants, algae, and some microorganisms are **producers**, which means they are able to make, or produce, their own food. They also produce the "food" for other organisms. Producers are the organisms that collect the energy from the sun and turn it into organic compounds. So once again, how does a cell get the food it needs to survive?

Photosynthesis is the process producers use to make their own "food". During photosynthesis, carbon dioxide and water combine with solar energy to create **glucose** (sugar), a carbohydrate ($C_6H_{12}O_6$), and oxygen. This glucose can be used immediately or stored for later use. Photosynthesis is a cycling process and plays a part in the flow of energy and matter into and out of organisms.

Photosynthesis Song (1:51): https://www.youtube.com/watch?v=C1_uez5WX1o

The process can be summarized as:

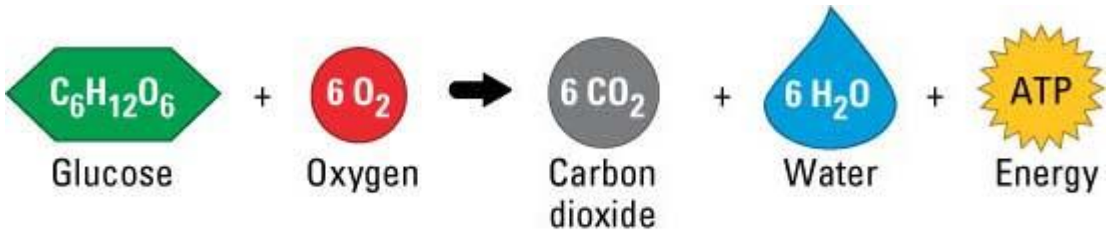
sunlight + carbon dioxide + water → glucose + oxygen



Actually, almost all organisms obtain their energy from photosynthetic organisms. For example, if a bird eats a caterpillar, then the bird gets the energy that the caterpillar got from the plants it ate. So the bird indirectly gets energy that began with the glucose formed through photosynthesis by the plant. Therefore, the process of photosynthesis is central to sustaining life on Earth. Only cells with chloroplasts can perform photosynthesis. Animal cells and fungal cells do not have chloroplasts and, therefore, cannot photosynthesize. That is why these organisms rely on other organisms to obtain their energy. These organisms are called **consumers.**

Cellular Respiration: Energy for Cells

Review the equation for photosynthesis. What do you notice about the equation for cellular respiration?



Why do you need food?

The main reason you need to eat is to get energy. Food is your body's only supply of energy. However, this energy must be converted from the apple (or any other food you eat) into an energy source that your body can use. The process of getting energy from your food into a form that can be used by the cell is called cellular respiration.

What is Cellular Respiration?

How does the food you eat provide energy? When you need a quick boost of energy, you might reach for an apple or a candy bar. But cells do not "eat" apples or candy bars. These foods need to be broken down so that cells can use them. Through the process of **cellular respiration**, the energy in food is changed into energy that can be used by the body's cells. Initially, the sugars in the food you eat are digested into the simple sugar **glucose**. Recall that glucose is the sugar produced by the plant during photosynthesis. The glucose (or the substance made from many glucose molecules, such as starch) is then passed to the organism that eats the plant. This organism could be you, or it could be the organism that you eat. Either way, it is the glucose molecules that holds the energy.

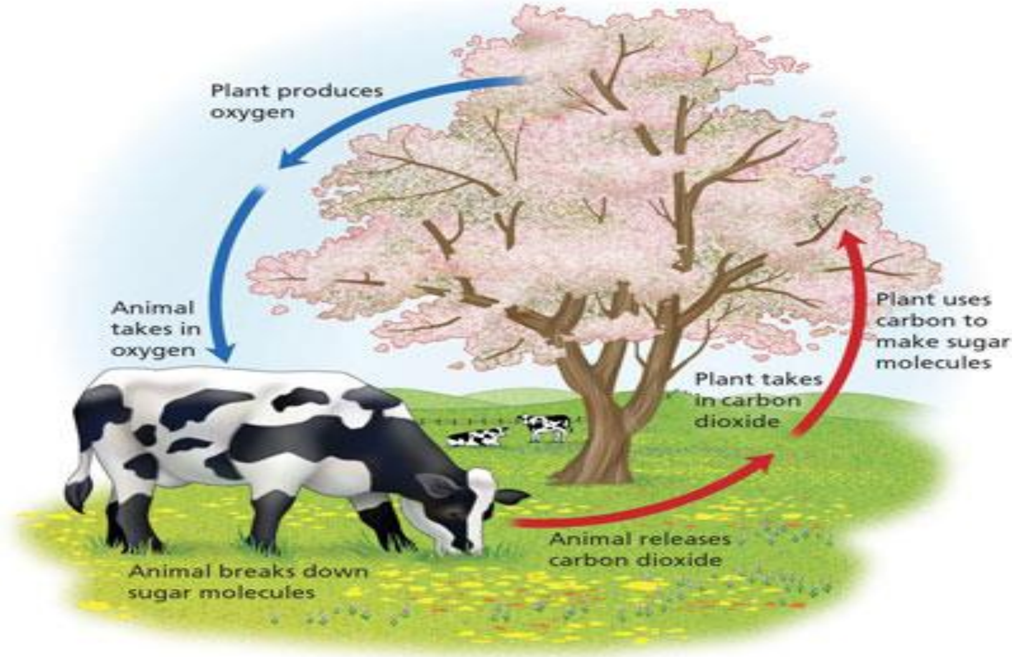
Try this virtual calorimetry lab to determine the energy content of different foods:
https://www.classzone.com/books/hs/ca/sc/bio_07/virtual_labs/virtualLabs.html

Connecting Cellular Respiration and Photosynthesis

Photosynthesis and cellular respiration are connected through an important relationship. This relationship enables life to survive as we know it. The products of one process (*the right side of the arrow)* are the reactants (*the left side of the arrow*) of the other. Notice that the flow of matter for **cellular respiration** is the direct opposite of photosynthesis.

(**reactants**) (**products**)

- **Cellular Respiration:** glucose + oxygen → carbon dioxide + water
- **Photosynthesis**: carbon dioxide + water → glucose + oxygen



<u>Photosynthesis and Cellular Respiration Assessment</u>

<u>Essential Skill:</u> Within a natural system, the transfer of energy of drives the motion and/or cycling of matter.

1. What do you call plants, algae and some microorganisms that make their own food? (DOK 1)

2. If a cloud covers the sun, what will happen to glucose production? Support your claim with reasoning from evidence. (DOK 2)

3. How is photosynthesis similar and different from cellular respiration? Use a Venn Diagram. (DOK 3)

4. Explain how the ***energy*** transfers from photosynthesis to cellular respiration. (DOK 3)

5. Draw a picture of an animal and plant. Label to show how the cycling of matter of photosynthesis flows into and out of organisms. (DOK 2)

2.5 - Food Webs and Nutrient Cycles

By the end of this reading...

MS-LS2-3: Students will be able to develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

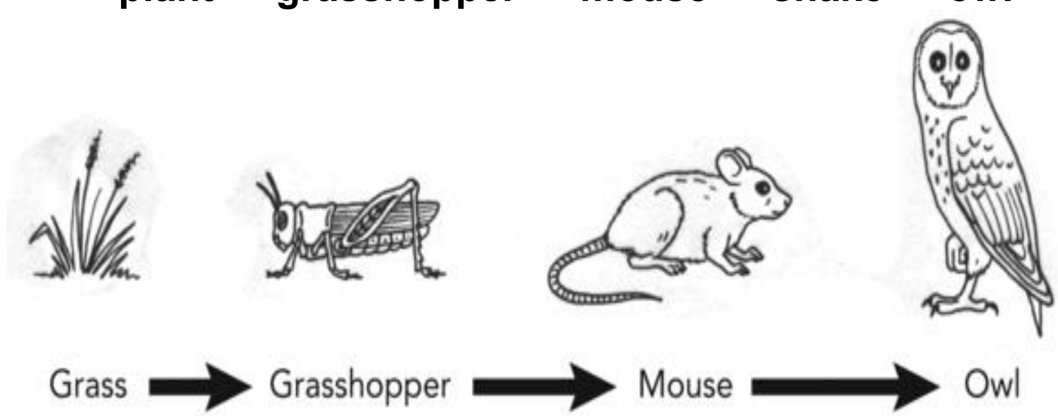

How do the grasshopper and the grass interact?

Grasshoppers don't just hop on the grass. They also eat the grass. Other organisms also eat the grass, and some animals even eat the grasshopper. These interactions can be visualized by drawing a food web, which will show all the feeding relationships in that ecosystem.

Food Chains and Webs

Energy must constantly flow through an ecosystem for the system to remain stable. What exactly does this mean? Essentially, it means that organisms must eat other organisms. Remember that all but a small amount of energy starts with the sun and then is transferred to producers through photosynthesis. Consumers who eat the producers then pass on energy to other consumers. **Food chains** show the eating patterns in an ecosystem. Food energy flows from one organism to another. Arrows are used to show the feeding relationship between the animals. The arrow points from the organism being eaten to the organism that eats it. For example, an arrow from a plant to a grasshopper shows that the grasshopper eats the leaves. Energy and nutrients are moving from the plant to the grasshopper. Remember it this way: ***'The arrow shows the energy flow.'*** Next, a mouse might prey on the grasshopper, a snake may eat the mouse, and then an owl might eat the snake. The food chain would be:

plant → grasshopper → mouse → snake → owl

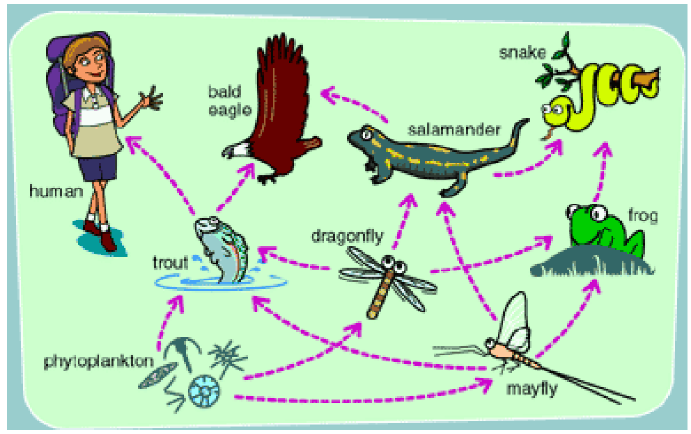


A food chain cannot continue to go on and on. For example, the food chain **could not** be:

plant → grasshopper → spider → frog → lizard → fox → hawk Food chains only have 4 or 5 total levels. Therefore, a chain has only 3 or 4 levels for energy transfer to consumers. Why do you think that is?

The **producers** are always at the beginning of the food chain, bringing energy into the ecosystem. Through photosynthesis, the producers create their own food in the form of glucose, but also create the food for the other organisms in the ecosystem. The **herbivores** come next, then the **carnivores**. When these **consumers** eat other organisms, they use the glucose in those organisms for energy. Could **decomposers** be added to the food chain? The following link may answer this question: **http://safeshare.tv/v/ss571fffc3d3915** (4:50)

Each organism can eat and be eaten by many different types of organisms, so simple food chains are rare in nature. Since most animals eat a variety of food, a food chain does not really give us enough information about an ecosystem. Ecologists often show the feeding relationships between animals as food webs. A **food web** is a better way of showing the feeding relationships between all of the organisms living in the community. A food web shows many more arrows, but still shows the flow of energy. A complete food web may show hundreds of different feeding relationships.



Watch the following video for more information related to food webs: **http://safeshare.tv/v/ss571fff61dfa5f (3:08)**

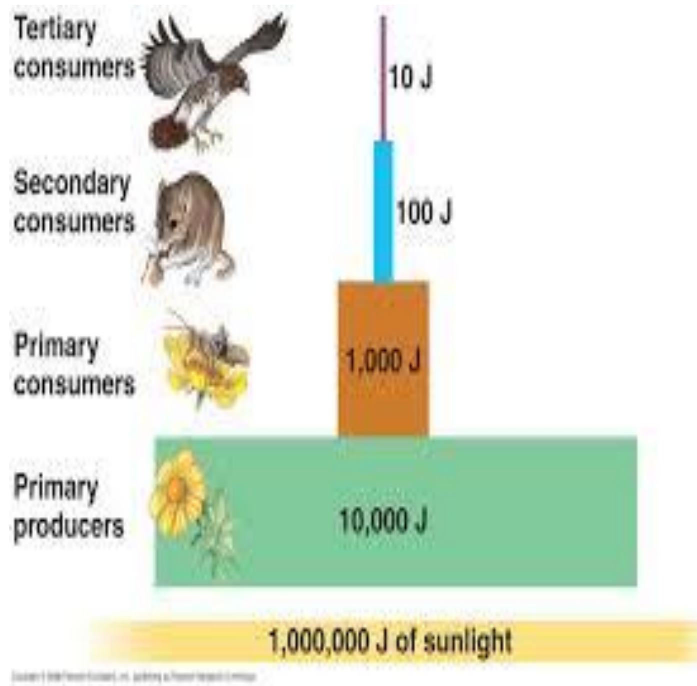
How much energy could be gained from the antelope?

If the cheetah is successful in capturing the antelope, it would gain some energy by eating it. But would the cheetah gain as much energy as the antelope has ever consumed? No, the antelope has used up some of the energy it has consumed for its own needs. The cheetah will only gain a fraction of the energy that the antelope has consumed throughout its lifetime.

Energy Pyramids

When an herbivore eats a plant, the **energy** in the plant tissues is used by the herbivore. But how much of the energy in the plant is transferred to the herbivore? Remember that plants are **producers**, bringing the energy into the ecosystem by converting sunlight into glucose. Does the plant use some of the energy for its own needs? Recall the energy is the ability to do work, and the plant has plenty of "work" to do with just growing and reproducing. So, of course, it needs and uses energy. After the plant uses the energy from glucose for its own needs, the excess energy is available to the organism that eats the plant.

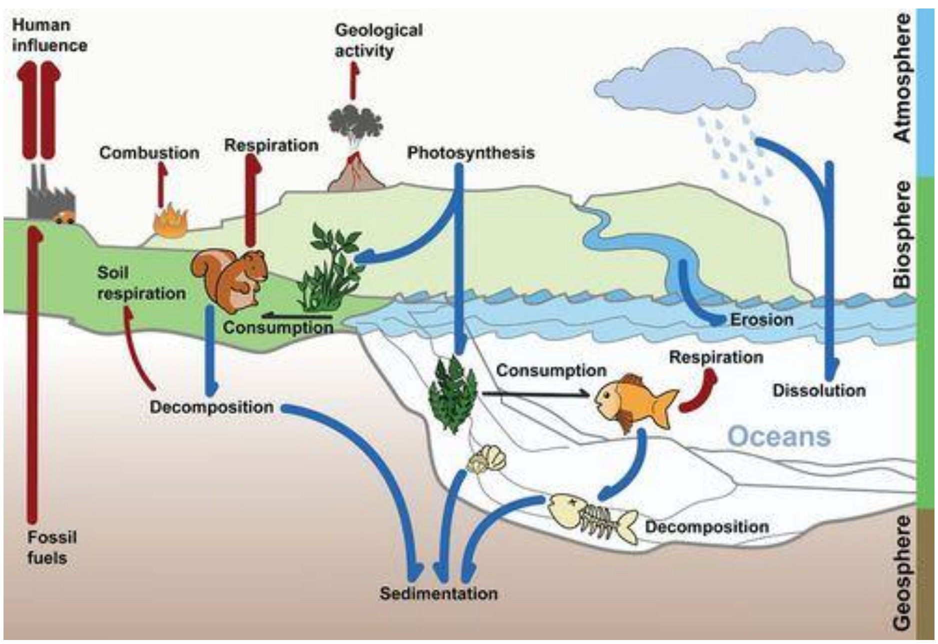
The herbivore uses the energy from the plant to power its own life processes and to build more body tissues. However, only about 10% of the total energy from the plant gets stored in the herbivore's body as extra body tissue. The rest of the energy is used by the herbivore and released as heat. The next consumer on the food chain that eats the herbivore will only store about 10% of the total energy from the herbivore in its own body. This means the carnivore will store only about 1% of the total energy that was originally in the plant. In other words, only about 10% of energy of one step in a food chain is stored in the next step in the food chain. The majority of the energy is used by the organism or released to the environment as heat.



Every time energy is transferred from one organism to another, there is a loss of energy. This loss of energy can be shown in an **energy pyramid**. Since there is energy loss at each step in a food chain, it takes many producers to support just a few carnivores in a community.

The Carbon Cycle

Carbon is one of the most common elements found in living organisms. Chains of carbon molecules form the backbones of many organic molecules, such as carbohydrates, proteins, and lipids. Carbon is constantly cycling between living organisms and the atmosphere (figure below). The cycling of carbon occurs through the **carbon cycle**.



Living organisms cannot make their own carbon, so how is carbon incorporated into living organisms? In the atmosphere, carbon is in the form of carbon dioxide gas (CO_2). Plants and other producers capture the carbon dioxide and convert it to glucose ($C_6H_{12}O_6$) through the process of photosynthesis. Then as animals eat plants or other animals, they gain the carbon from those organisms.

How does this carbon in living things end up back in the atmosphere? Well, we breathe out carbon dioxide. This carbon dioxide is generated through the process of cellular respiration, which has the reverse chemical reaction as photosynthesis. That means when our cells burn food (glucose) for energy, carbon dioxide is released. We, like all animals, exhale this carbon dioxide and return it back to the atmosphere. Also, carbon is released to the atmosphere as an organism dies and decomposes.

Cellular respiration and photosynthesis can be described as a cycle, as one uses carbon dioxide (and water) and makes oxygen (and glucose), and the other uses oxygen (and glucose) and makes carbon dioxide (and water).

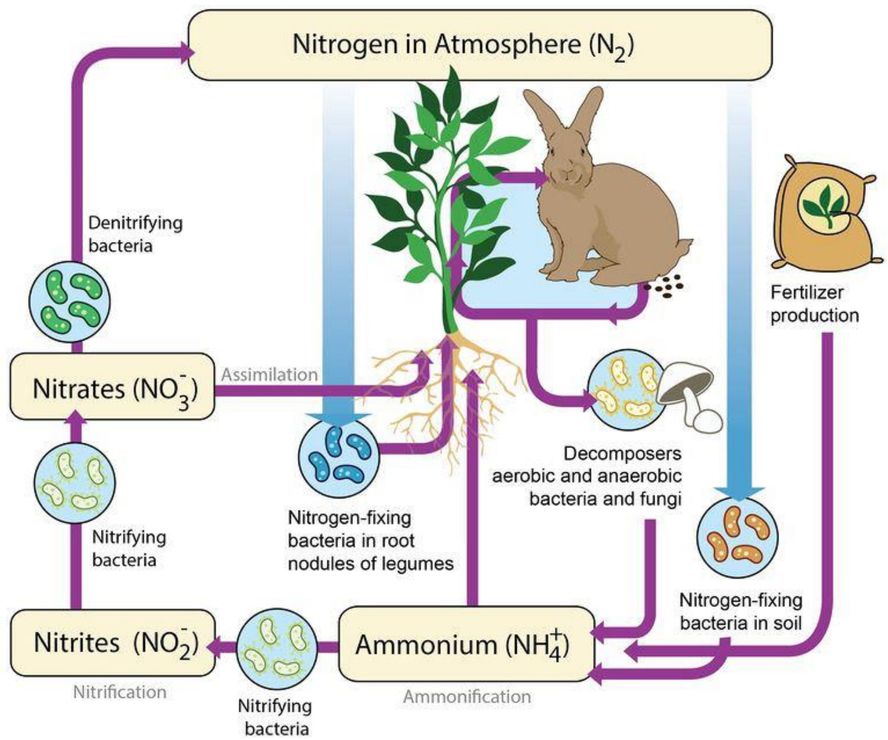
Formation of Fossil Fuels

Millions of years ago, there were so many dead plants and animals that they could not completely decompose before they were buried. They were covered over by soil or sand, tar or ice. These dead plants and animals are organic matter made out of cells full of carbon-containing organic compounds (carbohydrates, lipids, proteins and nucleic acids). What happened to all this carbon? When organic matter is under pressure for millions of years, it forms **fossil fuels.** Fossil fuels are coal, oil, and natural gas.

When humans dig up and use fossil fuels, we have an influence on the carbon cycle. This carbon is not recycled until it is used by humans. The burning of fossil fuels releases more carbon dioxide into the atmosphere than is used by photosynthesis. So, there is more carbon dioxide entering the atmosphere than is coming out of it.

The Nitrogen Cycle

Like carbon, nitrogen is also repeatedly recycled. This process is called the **nitrogen cycle**. Nitrogen is one of the most common elements in living organisms. It is important for creating both proteins and nucleic acids, like DNA. The air that we breathe is mostly nitrogen gas (N_2), but, unfortunately, animals and plants cannot use the nitrogen when it is a gas. In fact, plants often die from a lack of nitrogen even though they are surrounded by plenty of nitrogen gas. Nitrogen gas (N_2) has two nitrogen atoms connected by a very strong bond. Most plants and animals cannot use the nitrogen in nitrogen gas because they cannot break that bond.



In order for plants to make use of nitrogen, it must be transformed into molecules they can use. This can be accomplished several different ways.

- **Lightning**: When lightning strikes, nitrogen gas is transformed into nitrate (NO_3^-) in the atmosphere that plants can use.
- **Nitrogen fixation:** Special nitrogen-fixing bacteria can also transform nitrogen gas into useful forms. These bacteria live in the roots of plants in the pea family. They turn the nitrogen gas into ammonium (NH_4^+) through a process called ammonification. In water environments, bacteria in the water can also fix nitrogen gas into ammonium. Ammonium can be used by aquatic plants as a source of nitrogen.
- Nitrogen also is released to the environment by decaying organisms or decaying wastes. These wastes release nitrogen in the form of ammonium.

Ammonium in the soil can be turned into nitrate by a two-step process completed by two different types of bacteria. In the form of nitrate, nitrogen can be used by plants. It is then passed along to animals when they eat the plants.

Sending Nitrogen back to the Atmosphere

Turning nitrate back into nitrogen gas, the process of **denitrification**, happens through the work of denitrifying bacteria. These bacteria often live in swamps and lakes. They take in the nitrate and release it back to the atmosphere as nitrogen gas.

Just like the carbon cycle, human activities impact the nitrogen cycle. Some of these human activities include the burning of fossil fuels, which release nitrogen oxide gases into the atmosphere. Releasing nitrogen oxide back into the atmosphere may lead to problems like **acid rain** .

Carbon and Nitrogen are extremely important to the success of an ecosystem. To review each cycle, click on the following links:

- **Interactive Video on the Carbon Cycle**
- **Nitrogen Cycle (2:45)**

Food Webs and Nutrient Cycles Assessment

Essential Skill: The transfer of energy can be tracked as energy flows through a natural system.

1. How much energy is lost each time energy is passed to the next level of the food chain? (DOK 1)
2. What organisms are always at the beginning of a food chain? Why? (DOK 1)
3. What level of consumer are both a cow and a grasshopper? (DOK 2)
4. An ecosystem needs more producers than consumers. Why? (DOK 3)
5. Explain all the ways that organisms, alive and dead, contribute to the carbon cycle. (DOK 3)
6. Fossil Fuels: What are fossil fuels? How were they formed? Could we form more today? Explain. (DOK 2)
7. Should fossil fuels be used as an energy source today? Why or Why not? (DOK 4)
8. Explain how living organisms use nitrogen. (DOK 2)
9. What would be the result if all the pea plants died? Support your claim with reasoning from evidence. (DOK 3)

2.6 The Water Cycle

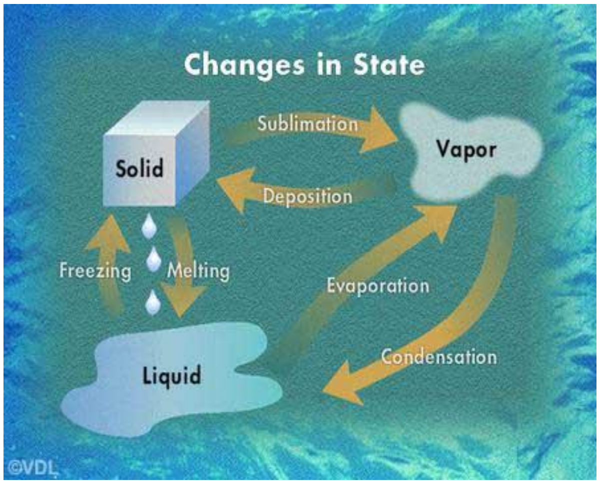
By the end of this reading...

MS-ESS2-4: Students will develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Why is there water on the outside of this cold beverage

Where does water come from, and where does it go?

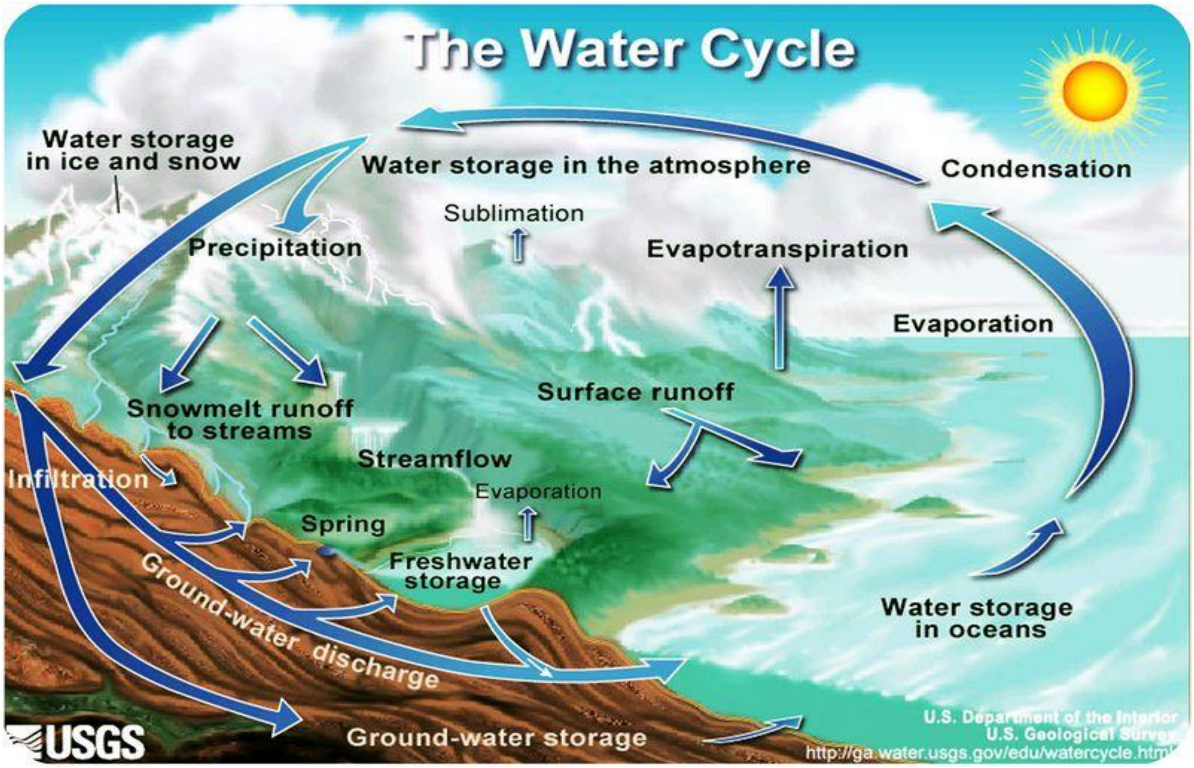
Because of the unique properties of water, water molecules can cycle through almost anywhere on Earth. The water molecule found in your glass of water today could have erupted from a volcano early in Earth's history. In the intervening years, the molecule probably spent time in a glacier or far below the ground. The molecule may have been high up in the atmosphere and may be deep in the belly of a dinosaur. As the water is recycled through the water cycle, it passes through all three states of matter.



The Water Cycle

The movement of water around Earth's surface is the **hydrological (water) cycle** (figure below). Water inhabits reservoirs within the cycle, such as ponds, oceans, or the atmosphere. The molecules move between these reservoirs by certain processes, including **condensation** and **precipitation**. The following section looks at the **reservoirs** and the processes that move water between them.

NASA Water Cycle: https://www.youtube.com/watch?v=0_c0ZzZfC8c (1:23)



Because it is a cycle, the water cycle has no beginning and no end.

What powers the water cycle?

The Sun provides the energy that powers the water cycle. The sun directly impacts the water cycle by heating water and turning water into water vapor. This is known as **evaporation**.

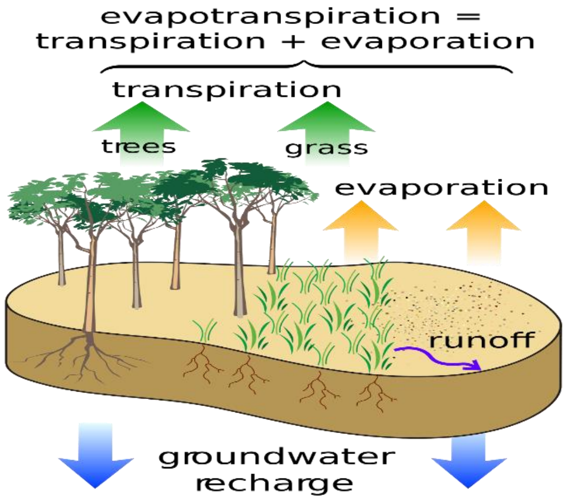
Another factor that impacts the water cycle is gravity. While in the atmosphere, gravity pulls on the water molecules, forcing them to fall to the earth's surface. Once on the surface, gravity works to pull the water to the lowest point such as a river, lakes, streams, groundwater, and oceans.

Evaporation (liquid to vapor)

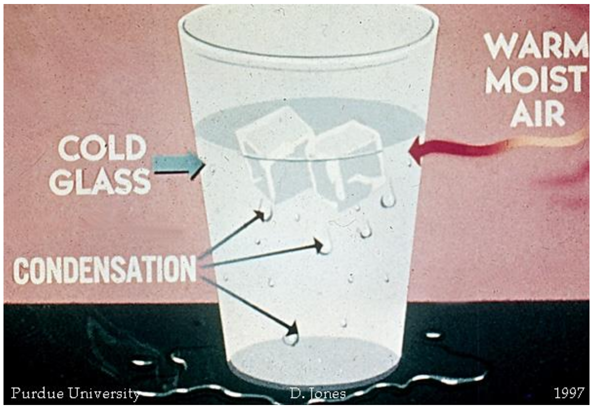
As the sun heats up water in oceans, streams and lakes the water molecules begin to rise into the atmosphere.

Transpiration (liquid to vapor)

Plants are involved in evaporation as well. Plants take up water from the soil and release large amounts of water vapor into the air through their leaves, a process known as **transpiration**.

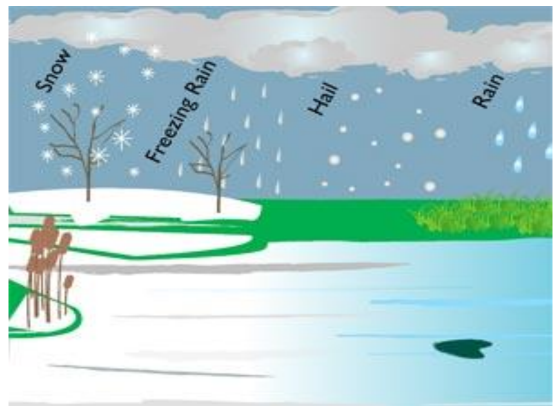


Condensation (vapor to liquid)



As water vapor moves into the atmosphere it remains there until it undergoes **condensation** to become tiny droplets of liquid. The droplets gather and form clouds, which are blown about the globe by winds.

Precipitation (vapor to liquid or liquid to solid)

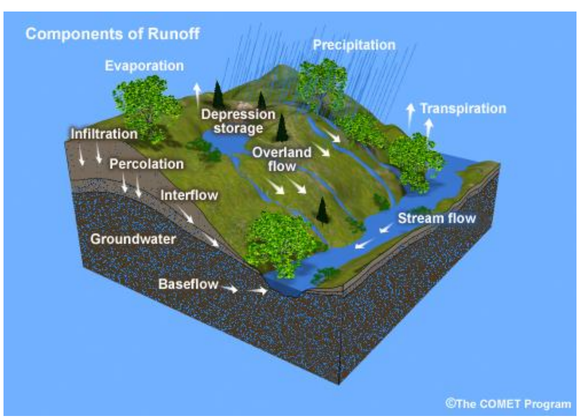


As the water droplets in the clouds collide and collect, they fall from the sky as precipitation. **Precipitation** can be rain (liquid), sleet, hail, or snow (solids). Sometimes precipitation falls back into the ocean and sometimes it falls onto the land surface.

Sublimation (solid to vapor)

Precipitation that lands as snow and ice may go directly back into the air by **sublimation**. Although you probably have not seen water vapor undergoing sublimation from a glacier, you may have seen dry ice sublimating into gas**.**
Watch dry ice sublimate: https://www.youtube.com/watch?v=JoH7sdCaa4g (1:25)

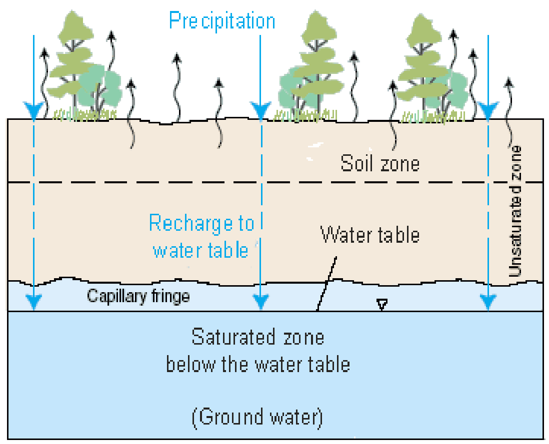
Run Off



When precipitation lands on the earth's surface and travels over the landscape it is known as **run off**. This water runs into rivers, lakes, streams, and the oceans. As it moves across the landscape, water can pick up mineral deposits.

Infiltration

From precipitation and runoff, water may seep through dirt and rock below the soil and then through pores **infiltrating** the ground to go into Earth's groundwater system.



Storage

The majority of water ends up in some form of storage. Water molecules in storage can remain there for thousands of years. Major forms of storage include:

- Oceans, Streams, and Lakes
- Glaciers and Snow Melt
- Ground water

Oceans, Streams, and Lakes

A water droplet falling as rain could also become part of the oceans, streams, or lakes. Most of the Earth's water is stored in this manner. This storage can be very short (especially at the surface) or last for hundreds to thousands of years. As water evaporates it leaves behind the mineral deposits gained during run off. This is why the oceans contain so much salt.

Glaciers and Snow Melt

Water that falls as snow may sit on a mountain for several months. Snow may become part of the ice in a glacier, where it may remain for hundreds or thousands of years. Snow and ice may also slowly melt over time to become liquid water, which provides a steady flow of fresh water to streams, rivers, and lakes below.

Groundwater

A significant amount of water infiltrates into the ground. Despite soil and rock, groundwater enters **aquifers** that may store fresh water for centuries. Alternatively, the water may come to the surface through springs or find its way back to the oceans.

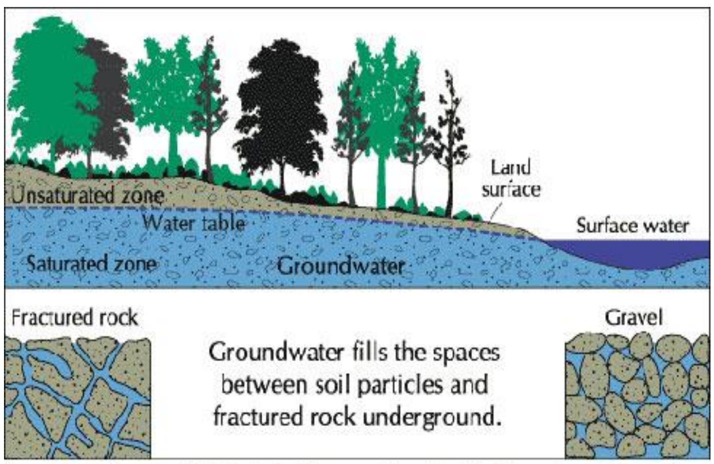


Image compliments of US Geological Survey, adapted by The Groundwater Foundation.

Earth is the Water Planet:
https://www.youtube.com/watch?v=8NwS86wtmIM

Roles of Water Assessment

Essential Skill: *Within a natural and designed system, the transfer of energy drives the motion and/or cycling of matter*.

1. What state(s) of matter changes are happening during the different phases of the water cycle? (DOK1)
   a. Evaporation
   b. Condensation
   c. Precipitation
   d. Transpiration
   e. Sublimation

2. A water molecule needs energy in order to change its state of matter. Where does the energy come from? (DOK1)

3. Draw a picture that shows the direction of thermal energy movement in the system when a piece of ice is melting. Describe what is happening to the distance between the water molecules during this process. (DOK 2)
4. Make an illustrative model of the water cycle. Include labeled arrows to show the flow of water molecules through these processes: Evaporation, Condensation, Precipitation, Transpiration, Sublimation. (DOK 2)

5. What would happen to the water cycle if the pull of Earth's gravity doubled? Explain your claim using evidence. (DOK3)

6. Design an experiment to increase the rate of complementary processes of the water cycle.(DOK 4)

Section 2.7 - Ecosystems and Populations

By the end of this reading...

MS-LS2-4: Students will be able to construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

and

MS-LS2-1: Students will be able to analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

What nonliving things are essential for life?

Living organisms cannot exist without the nonliving aspects of the environment. For example: air, water, and sunlight are all nonliving, but are essential to living organisms. Both nonliving and living things make up an ecosystem.

What is an Ecosystem?

An **ecosystem** consists of all the nonliving factors and living organisms interacting in the same **habitat**. **Biotic factors** are the living organism in an ecosystem. The biotic factors of an ecosystem include all the **populations** in a habitat, such as all the species of plants, animals, and fungi, as well as all the microorganisms. The nonliving factors are called **abiotic factors**. Abiotic factors include temperature, water, soil, and air. **Ecology** is the study of ecosystems. Ecologists are scientists who study how living organisms interact with each other and with the nonliving part of their environment.

Watch this video to learn the different components that make up an ecosystem:
https://www.youtube.com/watch?v=EdKhQVHc3Ao

What is a Population

A **population** is a group of organisms of the same species, all living in the same area and interacting with each other. Since they live together in one area, members of the same species reproduce together. Ecologists who study populations determine how healthy or stable the populations are. They also study how the individuals of a species interact with each other and how populations interact with the environment.

Population Growth

What does population growth mean? You can probably guess that it means the number of individuals in a population is increasing. The **population growth rate** tells you how quickly a population is increasing or decreasing. What determines the population growth rate for a particular population?

If the birth rate is larger than the death rate, than the population grows. If the death rate is larger than the birth rate, the population size will decrease. If the birth and death rates are equal, then the population size will not change.

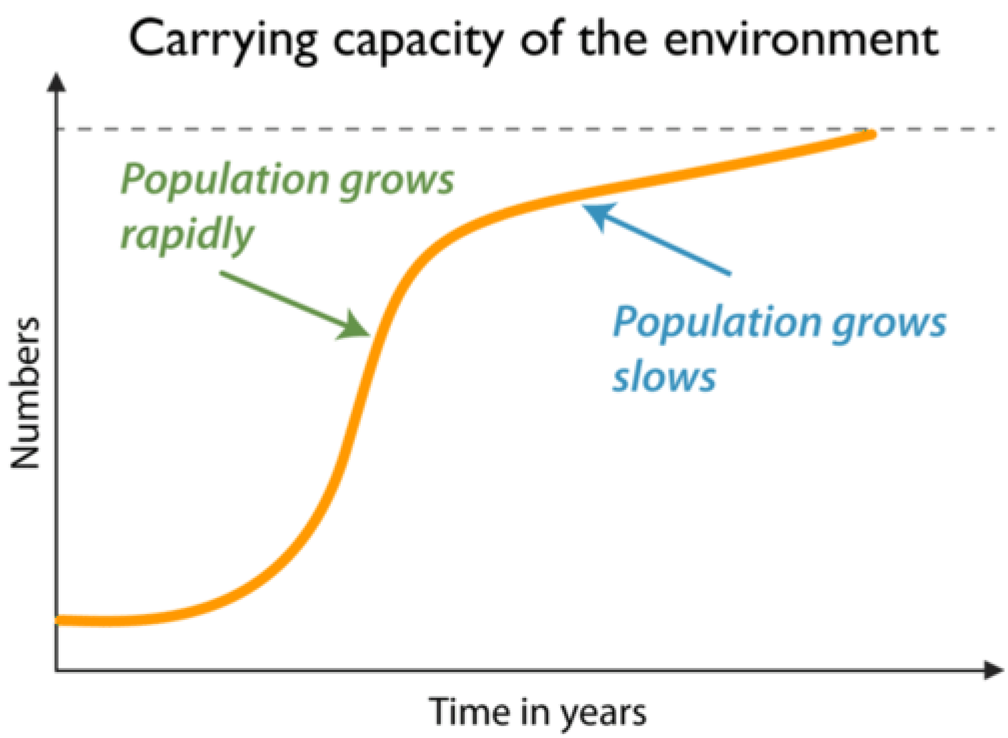
Factors that affect population growth are:

1. Age of organisms at first reproduction
2. How often an organism reproduces
3. The number of offspring of an organism
4. The presence or absence of parental care
5. How long an organism is able to reproduce
6. The death rate of offspring

For an ecosystem to be stable, populations in that system must be healthy, and that usually means reproducing as much as their environment allows.

Limiting Factors to Population Growth

For a population to be healthy, factors such as food, nutrients, water and space, must be available. What happens when there are not resources to support the population? **Limiting factors** are resources or other factors in the environment that can lower the population growth rate. Limiting factors include a low food supply, lack of space, light, water, nutrients or minerals, oxygen, the ability of an ecosystem to recycle nutrients and/or waste, disease and/or parasites, temperature, space, and predation. Limiting factors can lower birth rates, increase death rates, or lead to emigration. The **carrying capacity** is the maximum population size that can be supported in a particular area without destroying the habitat. Limiting factors determine the carrying capacity of a population. When a population gets close to the carrying capacity, it usually grows more slowly (see graph). When the population reaches the carrying capacity, it stops growing.



Explore this simulation to gain a better understanding on how the Avril Gulf tuna are affected by limiting factors such as predators, food, disease, and pollution.
http://sepuplhs.org/high/sgi/teachers/fishery_sim.html

Ecosystems and Populations Assessment

Essential Skill: Small changes in one part of a system might cause large changes in another part.

Essential Skill: Cause and effect relationships may be used to predict phenomena in natural or designed system

1. What two things must a habitat have to be considered an ecosystem? (DOK 1)
2. List the four main abiotic factors. (DOK 1)
3. Can you explain why exceeding the carrying capacity of a population would damage an ecosystem? (DOK 2)
4. Can you predict the outcome of an ecosystem that is experiencing low rainfall and limited space? Explain your answer. (DOK 3)

Section 2.8 - Interdependence of Organisms

By the end of this reading...

MS-LS2-2: Students will construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.



Competition

Recall that **ecology** is the study of how living organisms interact with each other and with their environment. But how do organisms *interact* with each other? Organisms interact with each other through various mechanisms, one of which is competition. Competition occurs when organisms strive for limited resources. Competition can be for food, water, light, or space.

Predation

Predation is another mechanism in which species interact with each other. Predation is when a predator organism feeds on another living organism or organisms, known as **prey**. **Predator-prey relationships** are essential to maintaining the balance of organisms in an ecosystem. Examples of predator-prey relationships include the lion and zebra, the bear and fish, and the fox and rabbit.

There are different types of predation, including:

- true predation
- grazing


Watch this video on predator-prey relationships: **https://www.youtube.com/watch?v=E5nfVsZcjDc**

Try these simulations that show how organisms interact with one another:

The Habitable Planet - How Plants, Herbivores, Omnivores, and Carnivores Affect One Another: **http://www.learner.org/courses/envsci/interactives/ecology/**

Lions, Antelopes, and Grass Growth - **http://gwydir.demon.co.uk/jo/games/lion/index.htm**

Symbiosis

Symbiosis describes a close and long-term relationship between different species. At least one species will benefit in a symbiotic relationship. These relationships are often necessary for the survival of one or both organisms. There are three types of symbiotic relationships: mutualism, commensalism, and parasitism.

- **Mutualism** is a symbiotic relationship in which both species benefit.
- **Commensalism** is a symbiotic relationship in which one species benefits while the other is not affected.
- **Parasitism** is a symbiotic relationship in which the parasitic species benefits while the host species is harmed.

An example of a **mutualistic relationship** is between herbivores (plant-eaters) and the bacteria that live in their intestines. The bacteria get a place to live. Meanwhile, the bacteria help the herbivore digest food. Both species benefit, so this is a mutualistic relationship. The clownfish and the sea anemones also have a mutualistic relationship. The clownfish protects the anemone from anemone-eating fish, and the stinging tentacles of the anemone protect the clownfish from predators.

Commensal relationships may involve an organism using another for transportation or housing. For example, spiders build their webs on trees. The spider gets to live in the tree, but the tree is unaffected. Other commensal relationships exist between cattle egrets and livestock. Cattle egrets are mostly found in meadows and grasslands are always seen near cattle, horses and other livestock. These birds feed on the insects that come out of the field due to the movement of the animals. They even eat ticks, fleas, and other insects off the back of animals.

Parasites may live either inside or on the surface of their host. An example of a parasite is a hookworm. Hookworms are roundworms that affect the small intestine and lungs of a host organism. They live inside of humans and cause them pain. However, the hookworms must live inside of a host in order to survive. Parasites may even kill the host they live on, but then they also kill themselves, so this is rare. Parasites are found in animals, plants, and fungi.

Watch this video on the different types of symbiotic relationships:
https://www.youtube.com/watch?v=zSmL2F1t81Q

Interdependence of Organisms Assessment

Essential Skill: Patterns can be used to identify cause and effect relationships.

1. How would you describe the relationship between a lion and an antelope? (DOK 1)
2. Can you explain how a host is affected by a parasite? (DOK 2)
3. How is the predator-prey relationship different from a parasitic relationship? (DOK 3)
4. How are mutualism and commensalism alike? How are they different? (DOK 2)

Section 2.9 - Biodiversity and Ecosystem

By the end of this reading...

MS-LS2-5: Students will be able to evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Biodiversity

How many species exist? We don't really know for sure. But all those species together, from the smallest bacteria, the most bizarre fungi, the prettiest plant, and the biggest mammal, compile the diversity of life, or biodiversity.

https://www.youtube.com/watch?v=7tgNamjTRkk

https://www.youtube.com/watch?v=aqtdaIkxnQo

What Is Biodiversity?

Biodiversity refers to the variety of life and its processes, including the variety of living organisms, the genetic differences among them, and the communities and ecosystems in which they occur. Scientists have identified about 1.9 million species alive today. Scientists are still discovering new species. Thus, they do not know for sure how many species really exist today. Most estimates range from 5 to 30 million species.

Extinction is a threat to biodiversity. Does it matter if we are losing thousands of species each year? The answer is yes. It matters even if we consider not only the direct benefits to humans, but also the benefits to the ecosystems. The health and survival of ecosystems is related to that ecosystem's biodiversity.

Ecosystem Services

Biodiversity is important for healthy ecosystems. It generally increases ecosystem productivity and stability. It helps ensure that at least some species will survive environmental change. Biodiversity also provides many other ecosystem services. For example:

- Plants and algae maintain Earth’s atmosphere. They add oxygen to the air and remove carbon dioxide when they undertake photosynthesis.
- Plants help protect the soil. Their roots grip the soil and keep it from washing or blowing away. When plants die, their organic matter improves the soil as it decomposes.
- Microorganisms purify water in rivers and lakes. They also decompose organic matter and return nutrients to the soil. Certain bacteria fix nitrogen and make it available to plants.
- Predator species such as birds and spiders control insect pests. They reduce the need for chemical pesticides, which are expensive and may be harmful to human beings and other organisms.
- Animals pollinate flowering plants. Many crop plants depend on pollination by wild animals.

Biodiversity and Ecosystem Services Assessment

Essential Skill: Small changes in one part of a system might cause large changes in another part.

1. Consider the two parts of the word "Bio" and "Diversity." What does biodiversity mean to you? (DOK 1)
2. Explain how a high biodiversity increases the health of an ecosystem. (DOK 3)
3. Bees are very important to pollinate flowers. If the bees died out due to disease, describe at least two ways the ecosystem would be affected. Be sure to support your claim with reasoning from evidence. (DOK 3)

3.0 Human Use of Resources

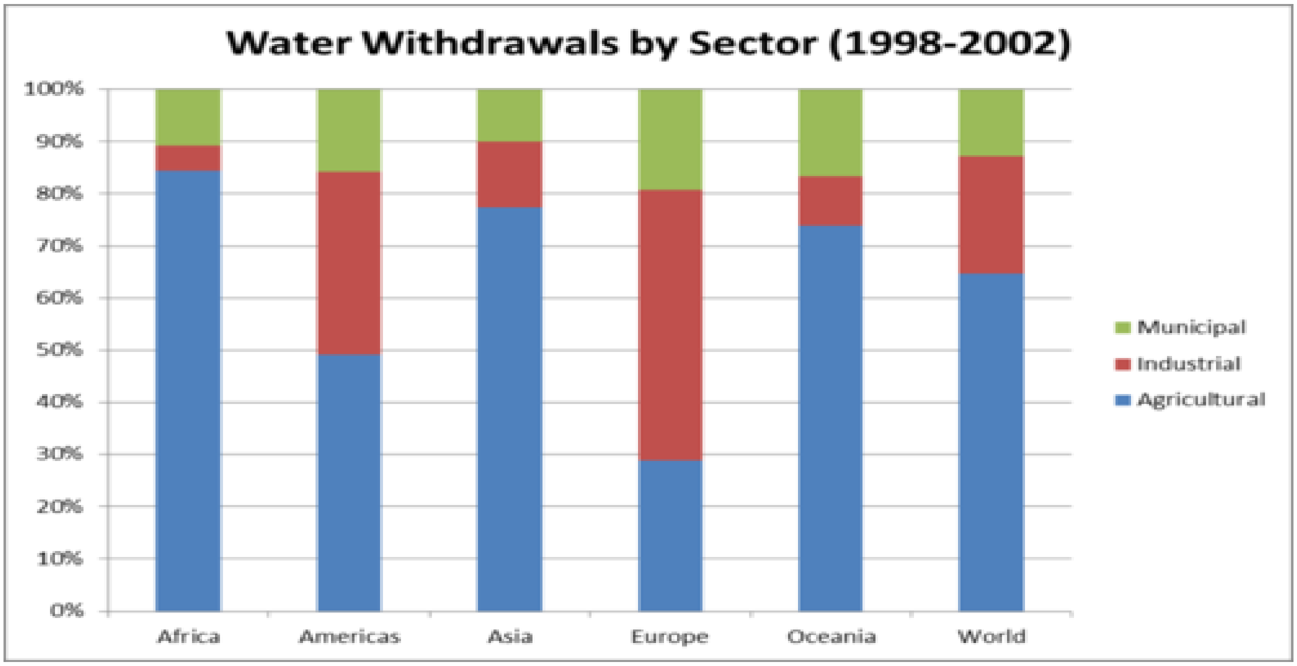
This reading supports that...
MS-ESS3-3 Students will apply scientific principles to design a method for monitoring and minimizing human impact on the environment.

Too many people?

In October 2011, the human population passed 7 billion people. What problems could result if the human population continues its rapid rise? One issue is that overpopulation makes many environmental issues more serious. More people on the planet means more food and water is needed and more pollution is generated.

Is there a carrying capacity for the human population?

Water Use



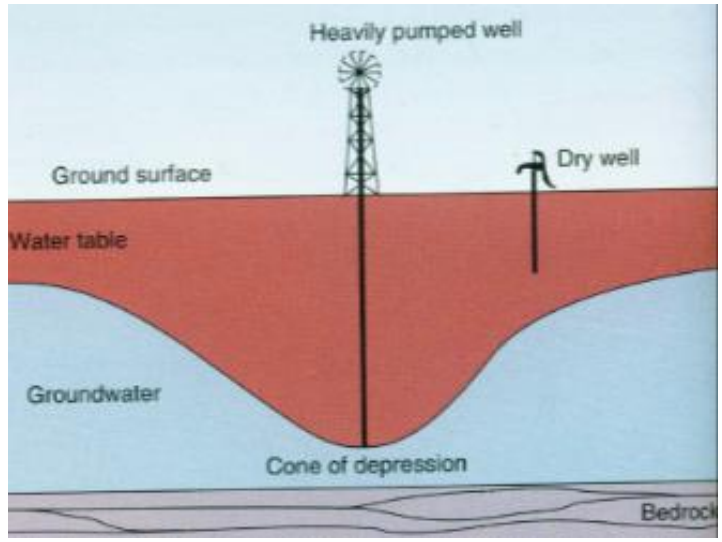
One basic need of every human is water. Besides drinking and washing, people need water for agriculture, industry, household uses, transportation and recreation. Water used for home, industrial, and agricultural purposes in different regions. Globally more than two-thirds of water is for agriculture.

In order to control and use the water, humans have altered the environment. Some examples include:

- **Wells**
- **Dams**
- **Levees**

Wells:

In order to tap into underground aquifers people drill into the **water table** and deliver the water to the surface. This method reduces the amount of water in the ground for plant use and can alter the flow of underground water. The figure to the right shows how a well affects the groundwater in a given area.



(http://academic.evergreen.edu/g/grossmaz/wormka/

Dams:

Dams provide two major benefits to people. They provide an area to store water, which reduces the fluctuation in water level and possible flooding. Dams also raise the level of water, which can be diverted to provide hydroelectric power. Despite these benefits, there are some environmental impacts. Fish migrations can be blocked, not allowing fish to native spawning grounds. Dams also trap sediments that normally would flow and replenish downstream ecosystems. The lakes created by dams also alter the water's temperature, oxygen concentration, and chemical composition which can lead to more non-native and invasive species. Below is an image of a dam in Altus, Oklahoma.

Altus Dam http://soundwaves.usgs.gov/2013/10/pubs2.html

Click the link below to watch a video and understand how the Elwha Dam impacted the native fish populations.

Dam Removal: http://bcove.me/yct9gb9t

Levees:

Levees are structures designed to prevent flooding. These structures are used in and around rivers to provide protection for homes in areas that would typically flood. Despite these benefits there are some ecological concerns. Levees can cut off the river from its floodplain, reduce the recharge of aquifers, and reduce the amount of sediments in the area around the river by not allowing overbank flooding. Unfortunately, levees have also given people a false sense of security. Many floodplain areas have been developed. If a levee fails, the damage can be more catastrophic. An example of this is the flood that occurred in New Orleans in 2005, as seen in image below.
image:http://www.kingcounty.gov/environment/wlr/sections-programs/river-floodplain-section/capital-projects/cedar-rapids.aspx

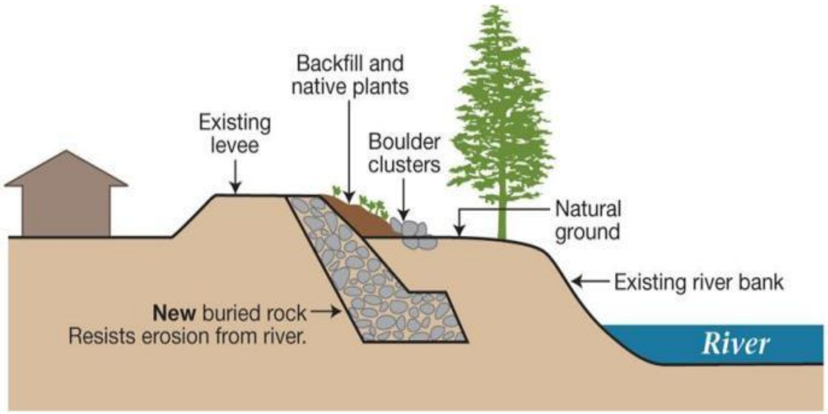


Image: http://commons.trincoll.edu/edreform/2012/05/was-hurricane-katrina-good-for-the-education-of-students-in-new-orleans/

Monitoring Water

Scientists have developed several methods to monitor water levels. This allows governments and agencies the information needed to ensure there is enough water for people and the local ecosystems. One example is a stream gauge. Read about stream gauges here:
https://water.usgs.gov/edu/measureflow.html

Land use

As the human population grows there is a greater need for space and resources. This has led to more economic development and habitat destruction.
Watch this video Arizona Sprawl:
https://www.youtube.com/watch?v=rCYYf3igZuM

Habitat Destruction

From a human point of view, a habitat is where you live, go to school, and go to have fun. Your habitat can be altered, and you can easily adapt. Most people live in a few different places and go to a number of different schools throughout their life. But a plant or animal may not be able to adapt to a changed habitat. A **habitat** is the natural home or environment of an organism. Humans often destroy the habitats of other organisms. Habitat destruction can cause the extinction of species. Once a species is extinct, it can never recover. Some ways humans cause habitat destruction are by clearing land and by introducing non-native species of plants and animals.

Land Loss

Clearing land for agriculture and development is a major cause of habitat destruction. Within the past 100 years, the amount of total land used for agriculture has almost doubled and land used for grazing cattle has more than doubled. Agriculture alone has cost the United States half of its wetlands (figure left) and almost all of its tallgrass prairies. Native prairie ecosystems, with their thick fertile soils, deep-rooted grasses, diversity of colorful flowers, burrowing prairie dogs, and herds of bison and other animals, have virtually disappeared.

Slash-and-Burn Agriculture

Other habitats that are being rapidly destroyed are forests, especially tropical rainforests. The largest cause of deforestation today is **slash-and-burn agriculture**. This means that when people want to turn a forest into a farm, they cut down all of the trees and then burn the remainder of the forest. This technique is used by over 200 million people in tropical forests throughout the world.

As a consequence of slash-and-burn global agriculture, nutrients are quickly lost from the soil. This often results in people abandoning the land within a few years. Then the topsoil erodes and desertification can follow. **Desertification** turns forest into a desert, where it is difficult for plants to grow. Half of the Earth’s mature tropical forests are gone. At current rates of deforestation, all tropical forests will be gone by the year 2090.

Non-Native Species

One of the main causes of extinction is introduction of exotic species into an environment. These exotic and new species can also be called **invasive species** or **non-native species**. These non-native species, being new to an area, may not have natural predators in the new habitat, which allows their populations to easily adapt and grow. Invasive species out-compete the native species for resources. Sometimes invasive species are so successful at living in a certain habitat that the native species go extinct.

Recently, cargo ships have transported zebra mussels, spiny water fleas, and ruffe (a freshwater fish) into the Great Lakes. These invasive species are better at hunting for food. They have caused some of the native species to go extinct.

Invasive species can disrupt food chains, carry disease, prey on native species directly, and outcompete native species for limited resources, like food. All of these effects can lead to extinction of the native species.

Watch this news report on Oklahoma Zebra Mussels:
https://www.youtube.com/watch?v=rdSls_Y-UPY

Human Uses and Resources Assessment

Essential Skill: *Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.*

1. Describe your local habitat? (DOK 1)

2. What are three ways in which humans have altered the environment to control and use water (DOK 1)

3. Can you explain how dams affect aquatic ecosystems? (DOK 2)

4. Design a mini poster (8 ½ x11 paper) that talks about the dangers of zebra mussels and what people can do to prevent their spread. (DOK 3)

3.1 The Impact of Pollution

By the end of this reading...

MS-ESS3-3 Students will apply scientific principles to design a method for monitoring and minimizing human impact on the environment.

Pollution

Q: Did you ever see a sky without contrails?

In the three days after the terrorist attacks on September 11, 2001, jet airplanes did not fly over the United States. Without the gases from jet contrails blocking sunlight, air temperature increased 1°C (1.8°F) across the United States. This is just one of the effects air pollution has on the environment. In this section, we will focus on how **pollution** affects the air, water, and soil.

Air Pollutants

All air pollutants cause some damage to living creatures and the environment. Different types of pollutants cause different types of harm.

Particulates

Particulates reduce visibility. In the western United States, people can now ordinarily see only about 100 to 150 kilometers (60- 90 miles), which is one-half to two-thirds the natural (pre-pollution) range on a clear day. In the East, people can only see about 40 to 60 kilometers (25-35 miles), which is one-fifth the distance they could see without any air pollution (see this figure showing smog in New York City).

Particulates reduce the amount of sunshine that reaches the ground, which may reduce photosynthesis. Since particulates form the nucleus for raindrops, snowflakes, or other forms of precipitation, precipitation may increase when particulates are high. An increase in particulates in the air seems to increase the number of raindrops, but often decreases their size.

By reducing sunshine, particulates can also alter air temperature as mentioned above. Imagine how much all of the sources of particulates combine to reduce temperatures.

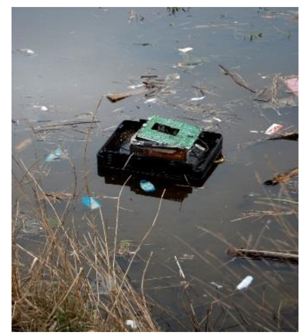
Ozone

Ozone is gas that occurs in the earth's upper and lower atmosphere. The lower atmospheric gas contains pollutants from the burning of fossil fuels to create ground level ozone. This can cause plant damage. Since ozone effects add up over time, plants that live a long time show the most damage. Some species of trees appear to be the most susceptible. If a forest contains ozone-sensitive trees, they may die out and be replaced by species that are not as easily harmed. This can change an

entire ecosystem, because animals and plants may not be able to survive without the habitats created by the native trees.

Some crop plants show ozone damage (see leaf figure). When exposed to ozone, spinach leaves become spotted. Soybeans and other crops have reduced productivity. In developing nations, where getting every last bit of food energy out of the agricultural system is critical, any loss is keenly felt.

Oxides



Oxides are another type of air pollutant released during the burning of fossil fuels. An example of this is Nitrogen Oxide, NO_2, which is a toxic, orange-brown colored gas that gives air a distinctive orange color and an unpleasant odor. Nitrogen and sulfur-oxides in the atmosphere create acids that fall as acid rain.

Lichens get a lot of their nutrients from the air so they may be good indicators of changes in the atmosphere, such as increased nitrogen.

Lichens point to pollution in this audio: http://science.kqed.org/quest/audio/lichen-point-to-pollution/Water Pollution

Surface Water Pollution

Water pollution may come from one source. For example, chemicals from a factory may empty into a stream. Or, water pollution may come from more than one source. For example, chemicals may rain from the air into that same stream. It is much more difficult to control pollution from more than one source.

In the developed nations, there are three main sources of water pollution:

1. Agriculture
2. Industry
3. Municipal, or community

Agriculture

Chemicals that are applied to farm fields include fertilizers and pesticides. Excess chemicals can be picked up by rainwater. The chemicals can then end up in streams, ponds, lakes, or the ocean. Dissolved fertilizer causes tremendous numbers of water plants and algae to grow. This can lead to **dead zones** where nothing can live in lakes or the coastal oceans.

Waste from livestock can also pollute water. The waste contains **pathogens** that can cause diseases. Many farms in the U.S. have thousands of animals. These farms produce millions of gallons of waste. The waste is stored in huge lagoons, like the one pictured below (figure **to** left). Many leaks from these lagoons have occurred.

This is a pond of hog manure. Check out the vehicles at the bottom of the picture for scale.

Industry

Factories and power plants may pollute water with harmful substances.

- Many industries produce toxic chemicals
- Nuclear power plants produce radioactive wastes
- Oil tanks and pipelines can leak

Oil spills are hard to clean up and kill a lot of wildlife.

Municipal

"Municipal" refers to the community. Households and businesses in a community can pollute the water supply. Municipal pollution comes from sewage, storm drains, septic tanks, boats, and runoff from yards. For example:

- People apply chemicals to their lawns. The excess can run off into surface waters.
- People may dispose of harmful substances incorrectly. For example, motor oil must not be drained into a storm sewer.
- Municipal sewage treatment plants dump treated wastewater into rivers or lakes. But the wastewater may not be treated for everything, or it may not be treated enough.

Soil Pollution

We think of a landfill as being somehow separate from the environment, but in this photo seagulls are scavenging in an open landfill along the Hudson River.

Trash that will eventually be taken to a landfill.

Why it Matters

When the soil becomes contaminated there are several effects on the ecosystem:

- Rain water washes over the contaminants and can wash them into bodies of water, or the water can carry the contaminants into underground aquifers.
- Plants in the area soak up contaminants that can affect their growth.
- Animals, including humans, that dig in the soil or eat the contaminated plants absorb these toxins in their skin.

SciShow, The Smelly, Oozy, Sometimes Explode-y Science of Garbage:
http://www.youtube.com/watch?v=x4x8HsAhp8U

Love Canal and Superfund

The story of Love Canal, New York, begins in the 1950s, when a local chemical company placed hazardous wastes in 55-gallon steel drums and buried them. Love Canal was an abandoned waterway near Niagara Falls and was thought to be a safe site for hazardous waste disposal because the ground was fairly **impermeable**. After burial, the company covered the containers with soil and sold the land to the local school system for $1. The company warned the school district that the site had been used for toxic waste disposal.

Soon a school, a playground, and 100 homes were built on the site. The impermeable ground was breached when sewer systems were dug into the rock layer. Over time, the steel drums rusted and the chemicals were released into the ground. In the 1960s people began to notice bad odors. Children developed burns after playing in the soil, and they were often sick. In 1977, a swamp created by heavy rains was found to contain 82 toxic chemicals, including 11 suspected cancer-causing chemicals.

A Love Canal resident, Lois Gibbs, organized a group of citizens called the Love Canal Homeowners Association to try to find out what was causing the problems (See opening image). When they discovered that toxic chemicals were buried beneath their homes and school, they demanded that the government take action to clean up the area and remove the chemicals.

Superfund Act

In 1978, people were relocated to safe areas. The problem of Love Canal was instrumental in the passage of the Superfund Act in 1980. This law requires companies to be responsible for hazardous chemicals that they put into the environment and to pay to clean up polluted sites, which can often cost hundreds of millions of dollars. Love Canal became a Superfund site in 1983 and as a result, several measures were taken to secure the toxic wastes. The land was capped so that water could not reach the waste, debris was cleaned from the nearby area, and contaminated soils were removed.

Pitcher Oklahoma: https://www.youtube.com/watch?v=ChpmuHk3A3U

Explore More

Human Impacts on Earth Systems: www.youtube.com/watch?v=lrxZ_UqQKyI
Renewable Energy: www.youtube.com/watch?v=0KhDUz13kBc

The Impact of Pollution Assessment

Essential Skill: *Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.*

1. What are the three ways surface water becomes contaminated? (DOK 1)

2. Describe how particulates can affect plants. (DOK 2)

3. Water pollutants affect agriculture, industry, municipal and soil. Write about how if your water source in your community became polluted, how it would affect your everyday life. (DOK 4)