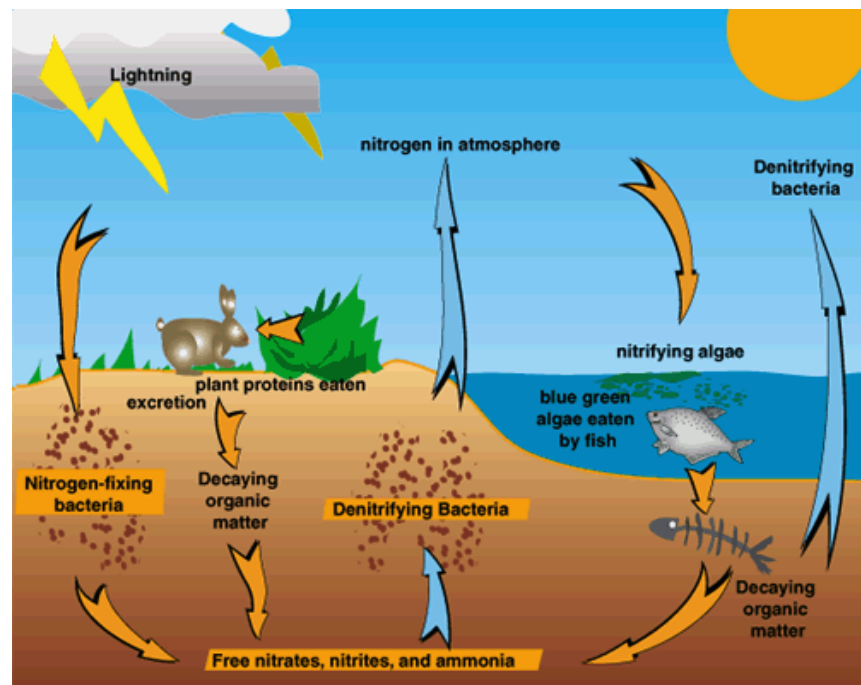


Earth Science Study Guide

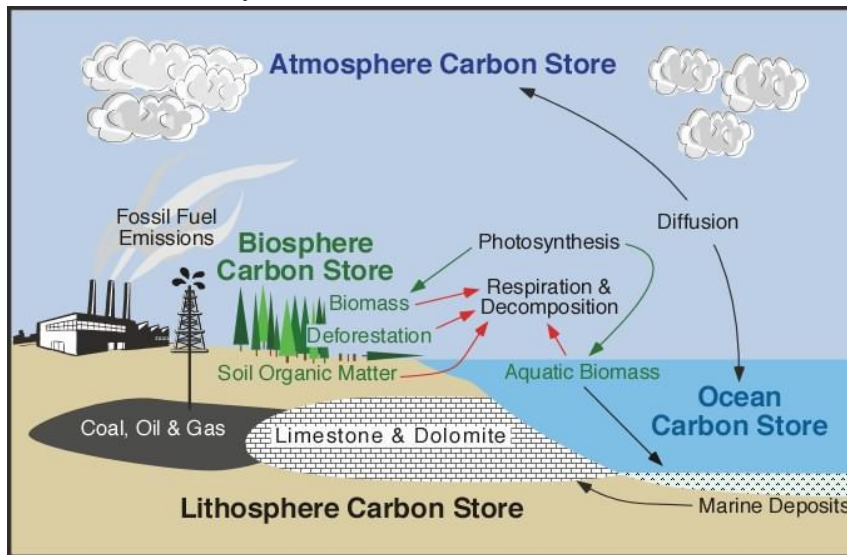
Earth:

- Formed 4.6 b.y.a
- 71% covered by water(global ocean)
- Oblate spheroid shape
 - Circumference pole to pole=40,007 km
 - Circumference equatorial= 40,074 km
- Earth's layers
 - Crust-thin, outermost layer (1% of mass)
 - Oceanic
 - Continental
 - Mohorovicic discontinuity: lower boundary of crust
 - Mantle
 - Layer under the crust (2/3 of Earth's mass)
 - Core
 - Made of iron and nickel (outer liquid, inner solid)
- Zones
 - Lithosphere
 - Asthenosphere
 - Mesosphere
- Magnetic field=magnetosphere
- Gravity
 - The larger the masses the greater the force
 - As the distance from earth's center increases, the weight decreases
- Energy
 - Ability to do work
 - Energy can be transferred by
 - Heat
 - Light
 - Vibrations
 - Electromagnetic waves
 - Transferred between systems but cannot be created nor destroyed
- Closed system
 - Energy, not matter is exchanged with surroundings
- Open system
 - Both energy and matter are exchanged with surroundings (earth is mainly an open system)
- Earth's 4 spheres
 - Atmosphere
 - Blanket of gases; 78% N, 21% O, 1% other gases (argon, CO₂, water vapor, and helium)
 - Hydrosphere
 - All of Earth's water, except in gaseous form
 - Covers 71% of Earth
 - 97% is salty ocean water

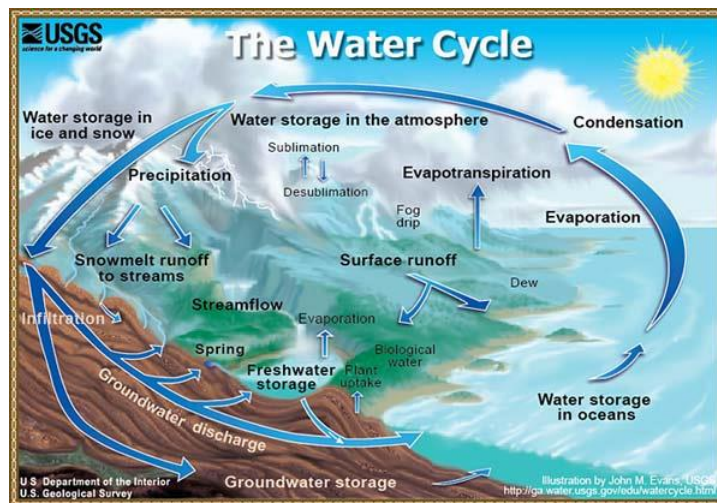
- 3% is fresh water
 - Lakes
 - Rivers
 - Streams
 - Frozen in glaciers
 - Polar ice sheets
 - Underground in soil and bedrock
 - Geosphere
 - Mostly solid part
 - All rocks and soil
 - Solid and molten interior of Earth
 - Biosphere
 - All forms of life in geosphere, hydrosphere, and atmosphere
 - Any organic matter that has not decomposed
 - Earth's Heat
 - Convection
 - Hot materials become less dense and rise and cooler materials sink
 - Radioactive atoms in Earth release heat
 - Retains heat from planet formation
 - Solar energy
 - External source, warms surface
 - Cycles
 - Group of processes in which matter and energy move through a series of reservoirs
 - Nitrogen cycle: nitrogen move from atmosphere to soil, from soil to plants and animals and back to air again



- Carbon cycle



- Water Cycle



Minerals

- A natural, usually inorganic solid that has a characteristic chemical composition, an orderly internal structure, and a characteristic set of physical properties
 - Is the substance inorganic?
 - Does the substance occur naturally?
 - Is the substance a solid in crystalline form?
 - Does the substance have a consistent chemical composition?
- 10 common rock forming minerals
 - Quartz
 - Orthoclase

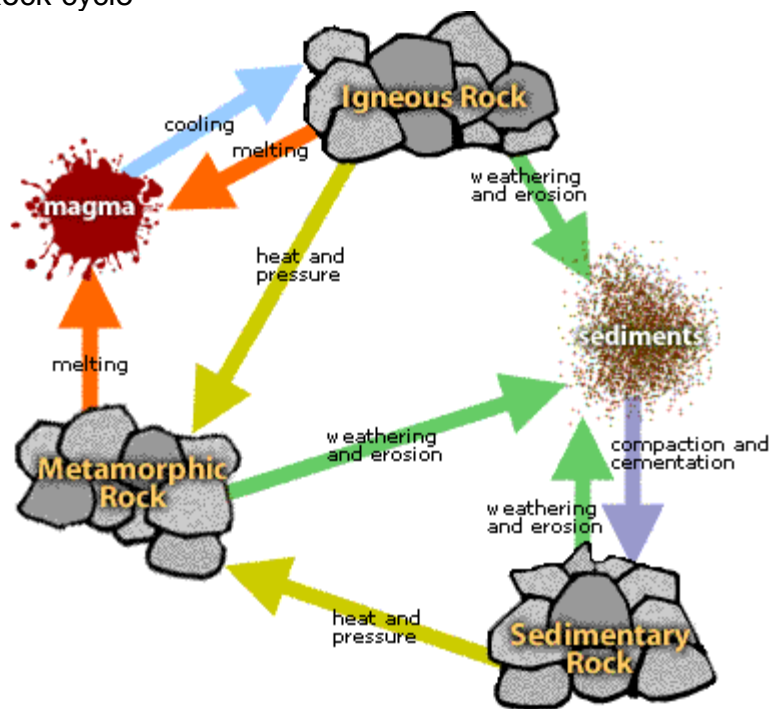
- Plagioclase
- Muscovite
- Biotite
- Calcite
- Ferromagnesian
- Dolomite
- Halite
- Gypsum
- Silicate minerals : make up 96% of earth's crust
 - Silicon-oxygen tetrahedron
 - Various structures of tetrahedrons
 - Isolated
 - Ring
 - Single-chain
 - Double-chain
 - Sheet
 - Framework
- Non-silicate minerals make up 4% of Earth's crust
 - Carbonates
 - Dolomite
 - Calcite
 - Halides
 - Halite
 - Fluorite
 - Native elements
 - Silver
 - Copper
 - Oxides
 - Corundum
 - Hematite
 - Sulfates
 - Gypsum
 - Anhydrite
 - Sulfides
 - Galena
 - Pyrite
- Crystalline structure
 - Specific geometric arrangement of atoms in a regular repeating pattern
- Physical properties of minerals
 - Color
 - Streak
 - Color of mineral in powdered form—when rubbed against an unglazed ceramic tile to test
 - Luster
 - Light that is reflected from a mineral's surface

- Metallic luster—if mineral reflects light as polished metal does
 - Non-metallic luster-all others
 - Glassy luster—transparent quartz
 - Waxy luster- appearance of candle wax
 - Pearly luster—mica minerals
 - Brilliant luster—diamonds
 - Dull/earthy luster—no shine
- Cleavage/fracture
 - Cleavage—tendency of a mineral to split along specific planes of weakness to form smooth flat surfaces
 - Fracture—break unevenly into pieces that have curved or irregular surfaces
 - Uneven/irregular
 - Splintery/fibrous
 - Conchoidal fractures
- Hardness
 - Moh's Hardness Scale
 - 1. Talc
 - 2. Gypsum
 - 3. Calcite
 - 4. Fluorite
 - 5. Apatite
 - 6. Feldspar
 - 7. Quartz
 - 8. Topaz
 - 9. Corundum
 - 10. Diamond
- Crystal shape
 - Isometric or cubic system: three axes of equal length intersect at 90 angles
 - Tetragonal system: three axes intersect at 90 angles. The two horizontal axes are of equal length. The vertical axis is longer or shorter than the horizontal axes
 - Monoclinic system: two of the three axes of unequal length intersect at 90 angles. The third axis is oblique to the others
 - Orthorhombic system: three axes of unequal length intersect at 90 angles
 - Hexagonal system: three horizontal axes of the same length intersect at 120 angles. The vertical axis is longer or shorter than the horizontal axes.
 - Triclinic system: three axes of unequal length are oblique to one another
- Density
 - Ratio of the mass of a substance to the volume of the substance

- Most earth's minerals have densities between 2 and 3 g/cm³
- Special properties of minerals
 - Fluorescence and Phosphorescence
 - Florescence: absorbs UV light and then produces visible light of various colors
 - Phosphorescence: continues to glow after UV light is turned off
 - Chatoyancy and Asterism
 - Chatoyancy: silky appearance in reflected light result of closely packed parallel fibers
 - Asterism: six-sided star shape appearance when a mineral reflects light
 - Double refraction
 - Light rays split into two parts to produce a double image
 - Magnetism
 - Radioactivity
 - Unstable nuclei decay over time into stable nuclei by releasing particles and energy-Pitchblende

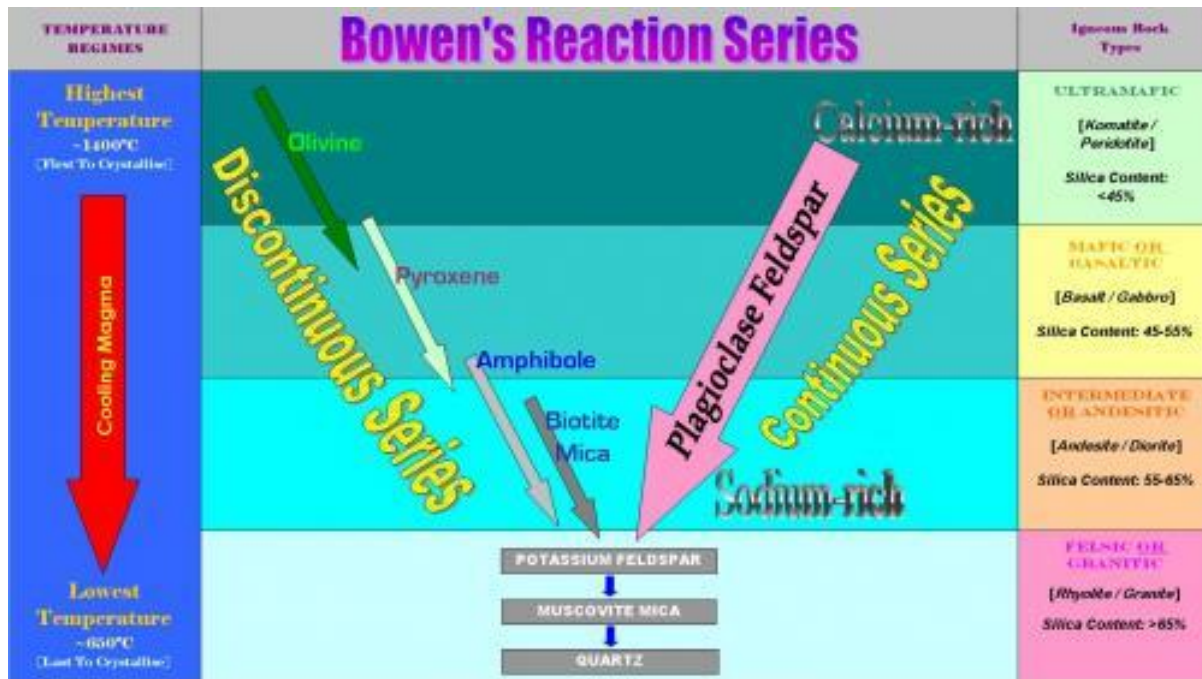
Rocks and Rock Cycle

- 3 types of rocks
 - Igneous
 - Sedimentary
 - Metamorphic
- Rock cycle



- Bowen's Reaction Series

- The simplified pattern that illustrates the order in which minerals crystallize from cooling magma according to their chemical composition and melting point



- Igneous Rocks
 - Forms when magma cools and hardens
 - Formation of magma depends on
 - Temperature
 - Pressure
 - Presence of fluids
 - Partial melting
 - Different minerals have different melting points; lower melting points melt first
 - Fractional crystallization
 - Minerals that have the highest freezing point melt first
 - This removes specific chemicals from the magma
 - Crystals that form early in the process are commonly the largest because they have the longest time to grow
 - Texture
 - Determined by the size of crystals in the rock—cooling rate of magma
 - Intrusive—formed by cooling beneath earth's surface
 - Extrusive—formed at Earth's surface
 - Coarse-grained: slow loss of heat allows minerals to form larger, well-developed crystals (granite)

- Fine-grained: igneous rock cools rapidly, large crystals are unable to form (basalt and rhyolite)
 - Other types: magma cools slowly at first then cools rapidly; large crystals inside smaller ones (porphyritic)
 - Highly viscous magma cools slowly; few crystals are able to grow; there is a small percentage of gas (obsidian has a glassy texture)—with more gas, bubbles form vesicular texture (pumice)
- Composition of igneous rocks
 - Felsic—magma contains a large proportion of silica; light in color includes plagioclase feldspar, feldspar, quartz, biotite mica, and muscovite mica
 - Common rocks formed are granite, rhyolite, obsidian, and pumice
 - Mafic—lower proportions of silica than felsic rock does and is rich in iron and magnesium; contains plagioclase feldspar and pyroxene minerals, and ferromagnesian minerals such as hornblende—olivine gives it dark color
 - Common rocks are basalt and gabbro
 - Intermediate—made of plagioclase feldspar, hornblende, pyroxene, and biotite mica; contain lower proportions of silica than felsic but higher than mafic
 - Rocks include diorite and andesite
- Intrusive rock structures
 - Batholiths: intrusive formations that spread over at least 100 km² when they are exposed on earth's surface; “deep rock”; form the cores of many mountain ranges
 - Stocks: similar to batholiths but cover less than 100km²
 - Laccoliths: when magma flows between rock layers and spreads upward, it sometimes pushes the overlying rock layers into a dome and the base of the intrusion is parallel to the rock layer beneath it; “lake of rock”
 - Sills: When magma flows between the layers of rock and hardens; lies parallel to the layers of rock that surround it, even if the layers are tilted; vary in thickness
 - Dike: magma forces through rock layers by following existing vertical fractures or by creating new ones and solidifies; cut across rock layers rather than lying parallel to the rock layers—common in areas of volcanic activity
- Extrusive rock structures
 - Volcano-vent through which magma, gases, and volcanic ash is expelled. When a volcanic eruption stops, the magma in the vent may cool to form rock; eventually the soft parts of the volcano are eroded by wind and water and the only hardest parts remain—central vent solidified is called a volcanic neck
 - Series of lava flows is a lava plateau
 - Tuffs-layer of volcanic ash and other solid particles

- Sedimentary Rock
 - Characteristics are determined by the source of sediment, the way the sediment was moved, and the conditions under which it was deposited
 - Compaction: process in which the sediment is squeezed and in which the size of the pore space between sediment grains is reduced by the weight and pressure of overlying layers
 - Cementation: process in which sediments are glued together by minerals that are deposited by water. As water moved through sediment, minerals precipitate from the water, surround the sediment grains, and form a cement that holds the fragments together
 - Three main classes of sedimentary rock
 - Chemical
 - Forms from minerals that were once dissolved in water; minerals left behind are called evaporates(salt flats)
 - Organic
 - Rock that forms from the remains of living things(coal and limestone)
 - Coal from plant remains that are buried before they decay and are then compacted into matter that is composed mostly of carbon
 - Marine organisms remove the chemical component of the minerals calcite and aragonite from sea water(Chalk)
 - Clastic
 - Rock fragments that are carried away from their source by water, wind or ice and left as deposits, they become compacted and cemented into solid rock
 - Classified by the size of the sediment they contain
 - Conglomerate: composed of rounded fragments that range in size from 2mm to boulders
 - Breccia: angular fragments with sharp edges
 - Sandstone: made of sand-sized grains that have been cemented together
 - Shale: clay sized particles that are cemented and compacted; flaky and in flat layers that will easily split apart
 - Characteristics of Clastic Sediments
 - Sorting: tendency of currents of air or water to separate sediments according to size
 - Can be well sorted, poorly sorted or somewhere in between
 - Well sorted—all roughly the same size
 - Poorly sorted—consist of many grains that are different sizes
 - Angularity
 - Particles that have moved long distances are rounded and smooth
 - When they first break from the rock they are sharp and uneven

- Sedimentary rock features
 - Depositional environment: the setting in which sediment is deposited
 - Rivers
 - Deltas
 - Beaches
 - Oceans
 - Stratification: layering of sedimentary rock; layers or beds vary in thickness depending on the length of time during which sediment is deposited and how much sediment is deposited; massive beds form when similar sediment is deposited for long periods of time or when a large amount of sediment is deposited at one time
 - Cross beds/ graded bedding: slanting layers are called cross-beds; when various sizes and kinds of materials are deposited within one layer, a type of stratification called graded bedding may occur
 - Ripple marks: caused by the action of wind or water on sand
 - Mud cracks: form when muddy deposits dry and shrink
 - Fossils and concretions: remains of plants and animals may be preserved in sedimentary rock (fossils); sometimes contain lumps of rock that have a composition that is different from that of the main rock body (concretions)
- Metamorphic rock
 - Process by which heat, pressure, or chemical processes change one type of rock to another
 - Formation of Metamorphic rocks
 - Heat, pressure and hot fluids cause some minerals to change into other minerals; they can also change in size or shape or may separate into parallel bands that give the rock a layered appearance
 - Hot fluids from magma may circulate through that rock and change the mineral composition of the rock by dissolving some materials and by adding others
 - Contact metamorphism
 - A change in the texture, structure, or chemical composition of a rock due to contact with magma
 - Only a small area of rock that surrounds the hot magma is changed by the magma's heat
 - Regional metamorphism
 - A change in the texture, structure, or chemical composition of a rock due to changes in temperature and pressure over a large area, generally as a result of tectonic forces
 - Most metamorphic rock forms as a result of regional metamorphism however, volcanism and movement of magma often accompany tectonic activity
 - Classification of Metamorphic rock

- Minerals in the original rock help determine the mineral composition of the metamorphosed rock
- Have either foliated or non-foliated texture
- Foliated rocks:
 - Minerals are arranged in planes or bands
 - Can form either by extreme pressure causing the mineral crystals in the rock to realign or regrow to form parallel bands or as minerals have different compositions separate to produce a series of alternating dark and light bands
 - Include slate, schist, and gneiss
- Non-foliated rocks:
 - Rocks that do not have bands or aligned minerals
 - Original rock that is metamorphosed may contain grains of only one mineral or contains very small amounts of other minerals
 - The original rock may contain grains that are round or square
 - Quartzite

Resources and Energy

- Mineral resources can be either metals (gold, silver, aluminum) or non-metals (sulfur and quartz)
- Ores: a natural material whose concentration of economically valuable minerals is high enough for the material to be mined profitably
 - Chromium, nickel, and lead ores form from cooling magma
 - Lead, copper, and zinc ores form from contact metamorphism
 - Lode-mineral deposit within a rock formation
 - Ores can form from moving water
 - Placer deposit-deposit that contains a valuable mineral that has been concentrated by mechanical action
- Uses of Mineral Resources
 - Gemstones: mineral, rock or organic material that can be used as jewelry or an ornament when it is cut and polished

Metallic Minerals	Uses
Hematite and magnetite (iron)	Making steel
Galena(lead)	In car batteries; in solder
Gold, silver, and platinum	Electronics, and dental work; as objects such as coins, jewelry, eating utensils and bowls
Chalcopyrite (copper)	As wiring, in coins and jewelry, and building ornaments
Sphalerite (zinc)	Making brass and galvanized steel
Non-metallic minerals	Uses
Diamond (carbon)	Drill bits and saws (industrial grade) and in jewelry (gemstone quality)
Graphite	In pencils, paint, lubricants, and batteries

Calcite	In cement, as building stone
Halite (salt)	In food prep and preservation
Kaolinite (clay)	In ceramics, cement and bricks
Quartz (sand)	As glass
Sulfur	In gunpowder, medicines, and rubber
Gypsum	In plaster and wallboard

- Mining
 - Subsurface mining: many mineral deposits are located below earth's surface; they are mined by miners who work underground to recover mineral deposits
 - Surface mining: when mineral deposits are located close to earth's surface; overlaying rock material is stripped away to reveal the mineral deposits
 - Placer mining: mined by dredging; large buckets are attached to a floating barge; the buckets scoop up the sediments in front of the barge, dense minerals from placer deposits are separated from surrounding sediment the remaining sediment is released into the water
 - Undersea mining: nodules are lumps of minerals on the deep-ocean floor that contain iron, manganese, and nickel that could become economically important if they could be recovered efficiently
- Non-renewable energy
 - A resource that forms at a rate that is much slower than the rate at which it is consumed
 - Fossil fuels: non-renewable energy resource that formed from the remains of organism that lived long ago; examples include oil, coal, and natural gas; consist primarily of hydrocarbons
 - Coal: remains of plants that have undergone a complex process called carbonization (occurs when partially decomposed plant material is buried in swamp mud and becomes peat)
 - Peat: the partial decomposition of plant remains forms a brownish-black material called peat
 - Lignite: peat is buried by other sediment; as heat and pressure increase, peat becomes lignite-also called brown coal
 - Bituminous coal: increased temperature and pressure turn lignite into bituminous coal, which 80% carbon, bituminous coal is also called soft coal
 - Anthracite: under high temperature and pressure conditions, bituminous coal eventually becomes anthracite, which is the hardest form of coal
 - Petroleum-liquid hydrocarbons
 - Natural gas-hydrocarbons in gaseous form
 - Nuclear energy
 - Nuclear fission—the process by which the nucleus of a heavy atom splits into two or more fragments; the process releases neutrons and energy

- Advantage: no air pollution
 - Disadvantage: wastes must be stored for thousands of years-give off high doses of radiation that can destroy plant and animal cells and can cause harmful changes in the genetic material
 - Nuclear fusion—nuclei of hydrogen atoms combine to form larger nuclei of helium
- Renewable resources: a natural resource that can be replaced at the same rate at which the resource is consumed
 - Geothermal energy: energy produced by heat within the Earth
 - Solar energy: energy received by Earth from the sun in the form of radiation
 - Hydroelectric energy: electrical energy produced by flow of water
 - Energy from wind

Earth's History

- Uniformitarianism: a principle that geologic processes that occurred in the past can be explained by current geologic processes
- Relative age: the age of an object in relation to the ages of other objects
- Law of super-position: law that a sedimentary rock layer is older than the layers above it and younger than the layers below it if the layers are undisturbed
- Unconformities: break in the geologic record created when rock layers are eroded or when sediment is not deposited for a long period of time
- Law of cross-cutting relationships: principle that a fault or body of rock is younger than any other body of rock that it cuts through
- Absolute age dating
 - Absolute age: the numeric age of an object or event often stated in years, before the present, as established by an absolute dating process, such as radiometric dating
 - Rates of erosion
 - Rates of deposition
 - Varve count: a banded layer of sand and silt that is deposited annually in a lake especially near ice sheets or glaciers and that can be used to determine absolute age
 - Radiometric dating: a method of determining the absolute age of an object by comparing the relative percentages of a radioactive parent isotope and a stable daughter isotope
 - Half-life: the time required for half of a sample of a radioactive isotope to break down by radioactive decay to form a daughter isotope
 - Fossils
 - Mummification: wrapping body in carefully prepared strips of cloth
 - Amber: hardened tree sap in which insects are preserved
 - Tar seeps: under water (sticky); animals become preserved in tar
 - Freezing: low temperatures can preserve organisms in ice and snow

- Petrification: mineral solutions replace the original organic materials that were covered by layers of sediment with new materials
- Imprints: carbonized and preserved in sedimentary rock
- Molds & casts: leaving empty cavities and when mud fills it a cast forms
- Coprolites: fossilized dung or waste
- Gastroliths: stones in digestive systems of dinosaurs to help grind their food
- Geologic time scale
 - Eons: Hadean, Archean, Proterozoic, Phanerozoic
 - Eras: unit of geologic time that included two or more periods
 - Period: longer than epoch shorter than era
 - Epoch: longer than age but shorter than period

Cenozoic:age of mammals	Quaternary Tertiary
Mesozoic-pangea broke apart: mass extinction between cretaceous and tertiary	Cretaceous: t-rex and angiosperms Jurassic:lizard hipped and bird hipped dinosaurs Triassic: dinosaurs/cycads
Paleozoic(542mya-251mya)	Permian:mass extinction Carboniferous:major oil deposits;swamps Devonian:age of fishes Silurian: eurypterids-scorpion like sea creatures Ordovician:fish did not have jaws or teeth Cambrian: trilobites/brachiopods
Pre-cambrian (4.6 bya-542 mya)	88% of Earth's history ; stromatolites

Mountain Building

- Isostasy condition of gravitational and buoyant equilibrium between earth's lithosphere and asthenosphere
- Compression (push together)
- Tension (pull apart)
- Shear stress (distortion push and pull)
- Strain: any change in a rock's shape or volume caused by stress
- Fold: form of ductile strain in which rock layers bend, usually as a result of compression
- Anticline: rainbow shaped
- Syncline: u shaped
- Monocline: wave shaped
- Folded mountain: a mountain that forms when rock layers are squeezed together and uplifted
- Fault-block mountain-forms where faults break Earth's crust into large blocks and some blocks drop down relative to other blocks

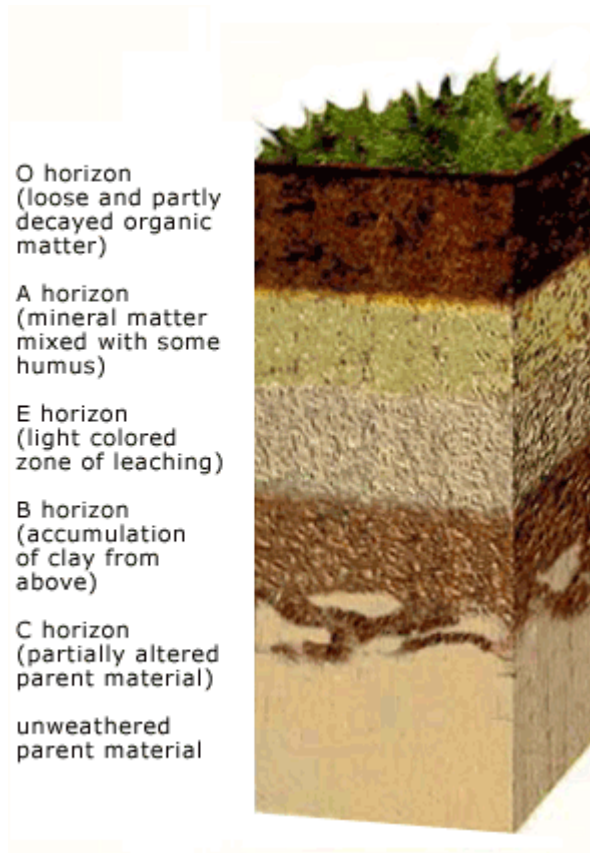
- Dome mountain: circular or elliptical almost symmetrical elevation or structure in which the stratified rock slopes downward gently from the central point of folding

Earthquakes

- Elastic rebound: sudden return of elastically deformed rock to its undeformed shape
- Focus: location within earth along a fault at which the first motion of an earthquake occurs
- Epicenter: point on Earth's surface directly above an Earthquakes starting point
- P wave: back and forth direction
- S Wave: side to side direction
- Shadow zone: area on earth's surface where no direct seismic waves from earthquakes are detected
- Acid precipitation: rain, sleet, snow that contains a high concentration of acids, often because of pollution in the atmosphere

Soil

- Horizon: horizontal layer of soil that can be distinguished from the layers above and below it
- Humus- dark, organic material formed in soil from the decayed remains of plants and animals



- Tropical soils: thick soil (laterites) contain iron and aluminum minerals that do not dissolve easily in water (A horizon is thin due to heavy rains and leaching)

- Temperate soils: pedalfer soil contains clay, quartz, and iron compounds; pedocal contains large amounts of calcium carbonate—very fertile and less acidic
- Desert and arctic soils: rainfall is minimal so soil is thin and consists mostly of regolith (evidence that soil in these areas forms mainly by mechanical weathering)
- Soil erosion
 - Sheet erosion: process by which water flows over a layer of soil and removes the topsoil
 - Gullying: furrows become large from plowing and water washes soil away and makes it even bigger
- Soil conservation
 - Contour plowing: soil is plowed in curved bands that follow the contour or shape of the land (prevents gullying)
 - Strip-cropping: crops are planted in alternating bands
 - Terracing: step like ridges that follow the contours of a sloped field
 - Crop-rotation: farmers plant one type of crop one year and a different type of crop the next year
- Mass movement: the movement of a large mass of sediment or a section of land down a slope
 - Rockfall: fall of rock from a steep cliff
 - Landslide: masses of loose rock combined with soil suddenly falling down a slope
 - Mudflow: rapid movement of a large amount of mud
 - Slump: large block of soil and rock becomes unstable and moves downhill in one piece; slides along the curved slope of the surface
 - Solifluction: the slow, down slope flow of soil saturated with water in areas surrounding glaciers at high elevations
 - Creep: slow downhill movement of weathered rock material

Water

- River system
 - Tributaries: a stream that flows into a lake or into a larger stream
 - Watershed: the area of land that is drained by a river system
 - Stream load: the materials other than the water that are carried by a stream
 - Discharge: the volume of water that flows within a given time
 - Gradient: the change in elevation over a given distance
 - Meander: one of the bends, twists, or curves in a low-gradient stream or river
 - Braided stream: a stream or river that is composed of multiple channels that divide and rejoin around sediment bars
 - Delta: a fan-shaped mass of rock material deposited at the mouth of a stream: for example, deltas form where streams flow into the ocean at the edge of a continent

- Alluvial fan: a fan-shaped mass of rock material deposited by a stream when the slope of the land decreases sharply; for example, alluvial fans form when streams flow from mountains to flat land
- Floodplain: an area along a river that forms from sediments deposited when the river overflows its banks
- Groundwater: the water beneath the earth's surface
 - Aquifer: a body of rock or sediment that stores groundwater and allows the flow of groundwater
 - Porosity: the percentage of the total volume of a rock or sediment that consists of open spaces
 - Permeability: the ability of a rock or sediment to let fluids pass through its open spaces, or pores
 - Zones of Aquifers
 - Zone of saturation
 - Water table: the upper surface of underground water; the upper boundary of the zone of saturation
 - Zone of aeration
 - Upper region
 - Well: hole that is dug to below the level of the water table and through which groundwater is brought to earth's surface
 - Spring: natural flow of groundwater to earth's surface in places where the ground surface dips below the water table
 - Artesian formation: a sloping layer of permeable rock sandwiched between two layers of impermeable rock and exposed at the surface
 - Karst topography: a type of irregular topography that is characterized by caverns, sinkholes, and underground drainage and that forms on limestone or other soluble rock

Glaciers

- Basal slip: the process that causes the ice at the base of a glacier to melt and the glacier to slide
 - Internal plastic flow: the process by which glaciers flow slowly as grains of ice deform under pressure and slide over each other
 - Cirque : a deep and steep bowl like depression produced by glacial erosion
 - Arête: a sharp, jagged ridge that forms between cirques
 - Horn: a sharp, pyramid-like peak that forms because of the erosion of cirques
 - Erratic: a large rock transported from a distant source by a glacier
 - Glacial drift: rock material carried and deposited by glaciers
 - Till: unsorted rock material that is deposited directly by a melting glacier
 - Moraine: landform that is made from unsorted sediments deposited by a glacier
 - Kettle: bowl-like depression in glacial drift deposit
 - Esker: long, winding ridge of gravel and coarse sand deposited by glacial melt water streams
-
- Milankovitch theory: the theory that cyclical changes in Earth's orbit and in the tilt of Earth's axis occur over thousands of years and cause climatic changes

Oceans



Atmosphere

- Troposphere: lowest layer of the atmosphere, in which temperature drops at a constant rate as altitude increases; the part of the atmosphere where weather conditions exist
- Stratosphere: the layer of the atmosphere that lies between the troposphere and the mesosphere and in which temperature increases as altitude increases; contains the ozone layer
- Mesosphere: coldest layer of the atmosphere, between the stratosphere and the thermosphere, in which temperature decreases as altitude increases
- Thermosphere: the uppermost layer of the atmosphere, in which temperature increases as altitude increase; includes ionosphere

- Coriolis effect: the curving path of a moving object from an otherwise straight path due to earth's rotation
- Trade winds: prevailing winds that blow from east to west from 30 latitude to the equator in both hemispheres
- Westerlies: prevailing winds that blow from west to east between 30 and 60 latitude in both hemispheres
- Polar easterlies: prevailing winds that blow from east to west between 60 and 90 in both hemispheres
- Doldrums: most air movement is upward and surface winds are weak and variable

- Horse latitudes: subtropical high pressure zones
- Jet stream: narrow band of strong winds that blow in the upper troposphere
- Latent heat: heat energy that is absorbed or released by a substance during a phase change
- Sublimation: the process by which a solid changes directly into a gas
- Dew point: constant pressure and water vapor content, the temperature at which the rate of condensation equals the rate of evaporation
- Absolute humidity: the mass of water vapor per unit volume of air that contains the water vapor, usually expressed as grams of water vapor per cubic meter of air
- Relative humidity: the ratio of the amount of water vapor in the air to the amount of water vapor needed to reach saturation at a given temperature
- Cloud: collection of small water droplets or ice crystals suspended in the air, which forms when the air is cooled and condensation occurs
- Condensation nucleus: solid particle in the atmosphere that provided the surface on which water vapor condenses
- Adiabatic cooling: the process by which the temperature of an air mass decreases as the air mass rises and expands
- Advective cooling: the process by which the temperature of an air mass decreases as the air mass moves over a cold surface

Clouds

- Stratus cloud: gray cloud that has a flat, uniform base that commonly forms at very low altitudes
- Cumulus cloud: a low-level, billowy cloud that commonly has a top that resembles cotton balls and a dark bottom
- Cirrus cloud: a feathery cloud that is composed of ice crystals and that has the highest altitude of any cloud in the sky
- Fog: water vapor that has condensed very near the surface of earth because air close to the ground has cooled

Precipitation:





































































































- Coalescence: formation of a large droplet by the combination of smaller droplets
- Supercooling: condition in which a substance is cooled below its freezing point, condensation point, or sublimation point without going through a change of state

Fronts:

- Cold front: the front edge of a moving mass of cold air that pushes beneath a warmer air mass like a wedge
- Warm front: the front edge of advancing warm air mass that replaces colder air with warmer air
- Stationary front: a front of air masses that moves either very slowly or not at all
- Occluded front: a front that forms when a cold air mass overtakes a warm air mass and lifts the warm air mass off the ground and over another air mass
- Midlatitude cyclone: an area of low pressure that is characterized by roating wind that moves toward the rising air of the central low-pressure region
- Weather symbols

WEATHER SYMBOLS

Numbers indicate the weather code as used in synoptic weather reports (ww, present weather reported from a manned weather station, as defined in WMO Pub. No. 306-A).

00  Cloud development not observed/observable during past hour.	01  Clouds generally dissolving during past hour.	02  State of sky unchanged during past hour.	03  Clouds generally forming or developing during past hour.	04  Visibility reduced by smoke.	05  Haze.	06  Dust suspended in the air, but not raised by wind.	07  Dust or sand raised by wind.	08  Dust devils now or within past hour.	09  Duststorm or sandstorm not at station but within sight.
10  Mist.	11  Patches of shallow fog at station, not deeper than 2 m (10 m at sea).	12  Continuous shallow fog at station, not deeper than 2 m (10 m at sea).	13  Lightning visible, but no thunder heard.	14  Precipitation visible but not reaching ground at station.	15  Precipitation reaching the ground not at or near the station but at a distance.	16  Precipitation reaching the ground not at the station but nearby.	17  Thunder heard but no precipitation at the station.	18  Wind squall now or during the past hour.	19  Tornado, waterspout, or funnel cloud observed now or during past hour.
20  Recent drizzle (not freezing, not showers) during past hour.	21  Recent rain (not freezing, not showers) during past hour.	22  Recent snow (not showers) during past hour.	23  Recent rain and snow (not showers) during past hour.	24  Freezing drizzle or rain (not showers), not now but during past hour.	25  Rain showers, not now but during past hour.	26  Snow showers, not now but during past hour.	27  Hail or hail and rain, not now but during past hour.	28  Fog, not now but during past hour.	29  Thunderstorm, with or without precipitation, not now but during past hour.
30  Slight/moderate duststorm or sandstorm, decreased during hour.	31  Slight/moderate duststorm or sandstorm, no change during hour.	32  Slight/moderate duststorm or sandstorm, increased during hour.	33  Severe duststorm or sandstorm, which has decreased during hour.	34  Severe duststorm or sandstorm, no change during past hour.	35  Duststorm or sandstorm, severe, has increased during past hour.	36  Drifting snow, slight or moderate.	37  Drifting snow, heavy.	38  Blowing snow, slight or moderate.	39  Blowing snow, heavy.
40  Fog at a distance but not at station during past hour.	41  Patchy fog.	42  Fog, sky discernible, and has become thinner during past hour.	43  Fog, sky not discernible, and has become thinner during past hour.	44  Fog, sky discernible, no change during past hour.	45  Fog, sky not visible, no change during past hour.	46  Fog, sky visible, has begun or become thicker during past hour.	47  Fog, sky not visible, has begun or become thicker during past hour.	48  Freezing fog, sky visible.	49  Freezing fog, sky not visible.
50  Drizzle, light, intermittent, not freezing.	51  Drizzle, light, continuous, not freezing.	52  Drizzle, moderate, intermittent, not freezing.	53  Drizzle, moderate, continuous, not freezing.	54  Drizzle, heavy, intermittent, not freezing.	55  Drizzle, heavy, continuous, not freezing.	56  Freezing drizzle, light.	57  Freezing drizzle, moderate or heavy.	58  Drizzle and rain mixed, light.	59  Drizzle and rain mixed, moderate or heavy.
60  Rain, light, intermittent, not freezing.	61  Rain, light, continuous, not freezing.	62  Rain, moderate, intermittent, not freezing.	63  Rain, moderate, continuous, not freezing.	64  Rain, heavy, intermittent, not freezing.	65  Rain, heavy, continuous, not freezing.	66  Freezing rain, light.	67  Freezing rain, moderate or heavy.	68  Rain and snow mixed, light.	69  Rain and snow mixed, moderate or heavy.
70  Snow, light, intermittent.	71  Snow, light, continuous.	72  Snow, moderate, intermittent.	73  Snow, moderate, continuous.	74  Snow, heavy, intermittent.	75  Snow, heavy, continuous.	76  Ice needles, with or without fog.	77  Snow grains, with or without fog.	78  Snow crystals, with or without fog.	79  Ice pellets (sleet).
80  Rain showers, light.	81  Rain showers, moderate or heavy.	82  Rain showers, torrential.	83  Rain/snow showers mixed, light.	84  Rain/snow showers mixed, moderate or heavy.	85  Snow showers, light.	86  Snow showers, moderate or heavy.	87  Ice pellet showers, light.	88  Ice pellet showers, moderate or heavy.	89  Hail, light, not associated with thunder.
90  Hail, moderate or heavy, not associated with thunder.	91  Rain, light. Thunder heard during past hour but not now.	92  Rain, moderate or heavy. Thunder heard during past hour but not now.	93  Light snow or rain/snow mixed with hail. Thunder heard during past hour.	94  Moderate or heavy snow or rain/snow with hail. Thunder in past hour.	95  Thunderstorm, light or moderate. Rain or snow, but no hail.	96  Thunderstorm, light or moderate, with hail.	97  Thunderstorm, severe. Rain or snow, but no hail.	98  Thunderstorm, with duststorm or sandstorm.	99  Thunderstorm, severe, with hail.

Space

- Astronomy: the scientific study of the universe
- Cosmology: the study of the origin, properties, processes, and evolution of the universe
- 14 billion years ago—big bang
- Galaxy: a collection of stars, dust, and gas bound together by gravity
- Astronomical unit: the average distance between the earth and the sun; approximately 150 million km (AU)
- Telescopes: instrument that collects electromagnetic radiation from the sky and concentrates it for better observation
 - Refracting telescope: telescope that uses a set of lenses to gather and focus light from distant objects
 - Reflecting telescope: telescope that uses curved mirror to gather and focus light from distant objects
- Revolution: the motion of a body that travels around another body in space; one complete trip along an orbit
- Perihelion: the point in the orbit of a planet at which the planet is closest to the sun
- Aphelion: the point in the orbit of a planet at which the planet is farthest from the sun
- Equinox: the moment when the sun appears to cross the celestial equator
 - Autumnal equinox: occurs September 22 or 23 beginning of fall in northern hemisphere
 - Vernal equinox: occurs March 21 or 22 beginning of spring in northern hemisphere
- Solstice: point at which the sun is as far north or as far south of the equator as possible
 - Summer solstice: June 21 or 22 northern hemisphere has the most hours of daylight
 - Winter solstice: December 21 or 22; beginning of winter in northern hemisphere; fewest daylight hours
- Solar nebula: rotating cloud of gas and dust from which the sun and planets formed; also any nebula from which stars and exoplanets may form
- Planetesimal: small body from which a planet originated in the early stages of development of the solar system
 - Formation of the inner planets: four protoplanets became Mercury, Venus, Earth and Mars; large percentages of heavy elements, such as iron and nickel; smaller rockier and denser than the outer planets
 - Formation of the outer planets: four other protoplanets became Jupiter, Saturn, Uranus and Neptune; formed in the colder regions of the solar nebula; gas giants
 - Pluto-first dwarf planet: ice ball
- Aristotle proposed an Earth centered (geocentric) model of the solar system
- Claudius Ptolemy proposed the planets moved in small circles around the earth (epicycles)

- Nicolaus Copernicus proposed a heliocentric (sun centered) model of the solar system
- Kepler's laws
 - Law of Ellipses: each planet orbits the sun in a path called an ellipse, not a circle
 - Eccentricity: the degree of elongation of elliptical orbit
 - Law of equal areas: describes the speed at which objects travel at different points in their orbits
 - Law of periods: describes the relationship between the average distance of a planet from the sun and the orbital period of the planet
 - Orbital period: the time required for a body to complete a single orbit
- Terrestrial planet: one of the highly dense planets nearest to the sun; Mercury, Venus, Mars, and Earth
- Gas giants: a planet that has a deep massive atmosphere, such as Jupiter, Saturn, Uranus or Neptune
- Kuiper Belt: a region of the solar system that starts just beyond the orbit of Neptune and that contains dwarf planets and other small bodies made mostly of ice

Moon

- Satellite: natural or artificial body that revolves around a larger celestial body
- Moon: celestial body that revolves around a body that is larger in mass; a natural satellite
- Lunar surface (luna)
 - Lighter areas are rough highlands that are composed of rocks called anorthosites
 - Darker areas are smooth, reflect less light and are called maria (mare); basalt
 - Crater: bowl-shaped depression that forms on the surface of an object when a falling body strikes the object's surface or when an explosion occurs
 - Rilles: long deep channels that run through the maria
 - Ridge: long narrow elevations
 - Regolith: layer of dust and rock
- Interior of moon
 - Seismographs have recorded numerous weak moonquakes
 - Crust
 - One side that always faces earth = near side; other is far side
 - Near side=60 km thick; far side=100km thick
 - Mantle and core
 - Mantle is made of rock that is rich in silica, magnesium and iron
 - Small iron core that has a radius of less than 700 km
 - Almost no magnetic field
- Formation of the moon

- Giant impact hypothesis: large object collided with Earth more than 4 billion years ago; Mars sized body struck earth early in the history of the solar system; most of the ejected materials came from earth's silica rich mantle rather than from the earth's dense metallic core
- Differentiation of the lunar interior: lunar surface was covered by an ocean of molten rock; over time the dense materials moved toward the center of the moon and formed the small core
- Meteorite bombardment: outer surface cooled to form a thick solid crust over the molten interior; debris left over from the formation of the solar system struck the solid surface and produced craters and regolith
- Movement of moon
 - Apogee: the orbit of a satellite, the point at which the satellite is farthest from earth
 - Perigee: the point at which the satellite is closest to earth
 - Lunar rotation: spins slowly and completes one rotation only once during each orbit around the earth; orbits earth in about 27.3 days
- Eclipses: event in which the shadow of one celestial body falls on another
 - Solar eclipse: the passing of the moon between Earth and the sun; during a solar eclipse, the shadow of the moon falls on earth
 - Total: sun's light is completely blocked by the moon; umbra falls on the area of earth that lies directly in line with the moon and the sun
 - Partial: penumbra falls on the area that immediately surrounds the umbra
 - Lunar eclipse: passing of the moon through Earth's shadow at full moon
 - Frequency: may have as many as 7 eclipses a year; total eclipses are rare
- Phases of the moon:
 - Waxing phases: when the size of the lighted part of the moon is increasing
 - Waxing crescent: sliver of the moon is visible
 - First quarter: when the waxing moon becomes a semi-circle
 - Waxing gibbous: when the lighted part of the moon's near side is larger than a semi-circle and still increasing in size
 - Full moon: the entire moon is illuminated by the light of the sun
 - Waning phases: after the full moon, the moon appears to decrease in size
 - Waning gibbous: larger than semi-circle but smaller than a full moon
 - Last quarter: semi-circle
 - Waning crescent: one sliver of the moon as it is disappearing is visible
 - New moon: no moon is visible in the sky
 - Period from one new moon to the next is 29.5 days
- Galilean moon: any one of the four largest satellites of Jupiter—Io, Europa, Ganymede, and Callisto—discovered by Galileo in 1610
- Asteroids: small, rocky object that orbits the sun; most asteroids are located in a band between the orbits of Mars and Jupiter

- Comet: small body of rock, ice and cosmic dust that follows an elliptical orbit around the sun and that gives off gas and dust in the form of a tail as it passes close to the sun
- Oort cloud: spherical region that surrounds the solar system, that extends from the Kuiper Belt to almost halfway to the nearest star, and that contains billions of comets
- Meteoroid: a relatively small, rocky body that travels through space
- Meteor: bright streak of light that results when a meteoroid burns up in the Earth's atmosphere

Sun

- Protons emit positrons
- Interior
 - Core: 15,000,000 degrees Celsius; made entirely of ionized gas
 - Radiative zone: surrounds the core; the temperature ranges from 2,000,000 to 7,000,000 degrees Celsius; energy moves outward in the form of electromagnetic waves or radiation
 - Convective zone: temperatures are about 2,000,000 degrees Celsius. Energy produced in the core moves through this zone by convection
- Atmosphere: uppermost region of solar gases
 - Photosphere: the visible surface of the sun; 6,000 degrees Celsius; much of the energy given off from the photosphere is in the form of visible light
 - The chromospheres: the thin layer of the sun that is just above the photosphere and that glows a reddish color during eclipses
- Outer parts:
 - Corona: the outermost layer of the sun's atmosphere; huge region of gas above 1,000,000 degrees Celsius
- Solar activity: not all locations on the sun rotate at the same speed. Places close to the equator on the surface of the sun take 25.3 earth days to rotate once. Points near the poles take 33 days to rotate once. On average the sun rotates once every 27 days
- Sunspots: dark area of the photosphere of the sun that is cooler than the surrounding areas and that has a strong magnetic field
- Solar ejections: events in which the sun emits atomic particles
 - Prominence: loop of relatively cool, incandescent gas that extends above the photosphere
 - Solar flare: an explosive release of energy that comes from the sun and that is associated with magnetic disturbances on the sun's surface
 - Coronal mass ejections: a part of coronal gas that is thrown into space from the sun—creates a disturbance in the Earth's magnetic field and can cause blackouts (geomagnetic storms)
- Auroras: colored light produced by charged particles from the solar wind and from the magnetosphere that react with and excite the oxygen and nitrogen of earth's upper atmosphere; usually seen in the sky near earth's magnetic poles
 - Aurora borealis—northern lights
 - Aurora australis—southern lights

Stars, Galaxies, and the Universe

- Star: large celestial body that is composed of gas and that emits light—ball of gasses that gives off a tremendous amount of electromagnetic energy—energy comes from nuclear fusion
- Spectrograph—devices that separate light into different colors or wavelengths
 - Emission: bright line
 - Absorption: dark line
 - Continuous
 - A stars dark-line spectrum reveals the star's composition and temperature
- Composition of stars: hydrogen/helium
- Temperature:

Color	Surface Temp $^{\circ}\text{C}$	Example
Blue	Above 30000	10 lacertae
Blue-white	10,000-30,000	Rigel, Spica
White	7,500-10,000	Vega, Sirius
Yellow-white	6,000-7,500	Canopus, Procyon
Yellow	5000-6000	Sun, Capella
Orange	3,500-5000	Arcturus, Aldebaran
Red	Less than 3500	Betelgeuse, Antares

- Dwarf stars: same size as earth
- Sun is medium sized (1,390,000km)
- Giant starts much larger than the sun
- Visible stars appear to shift slightly to the west every night
- Circumpolar stars: never pass below the horizon in either their nightly or their annual movements
- Actual motion: rotate on the axis; revolve around another star; move either away or toward our solar system
 - Doppler effect: an observed change in the frequency of a wave when the source or observer is moving
 - Blue shift: star moving toward earth
 - Red shift: star moving away from earth
- Distance:
 - Light year: distance that light travels in one year 300,000 km/s
 - Parallax: an apparent shift in the position of an object when viewed from different locations
- Stellar brightness
 - Apparent magnitude: brightness of a star as seen from earth
 - Absolute magnitude: brightness that a star would have at a distance of 32.6 light-years from earth
- Luminosity: total amount of energy they give off each second
- Main sequence: the location on the H-R diagram where most stars lie; it has a diagonal pattern from the lower right to the upper left
- Star formation:
 - Nebula: large cloud of gas and dust in interstellar space; a region in space where stars are born

- Consists of 70% hydrogen, 28% helium and 2% heavier elements
 - Protostars: gravity makes these dense regions more compact and any spin in the region has is greatly amplified; begins to flatten into a disk that has a central concentration of matter
 - Plasma: hot ionized gas that consists of an equal number of free moving positive ions and electrons
 - Onset of nuclear fusion marks the birth of a star
 - Equilibrium makes a star stable in size; main sequence star maintains a stable size as long as the star has an ample supply of hydrogen to fuse into helium
- Main sequence stage:
 - Second and longest stage in the life of a star; energy continues to be generated in the core of the star as hydrogen fuses into helium—releases enormous amounts of energy
- Third stage: almost all of the hydrogen atoms within its core have fused into helium atoms, star contracts under the force of its own gravity which increases temperature in the core; as helium core becomes hotter, it transfers energy into a thin shell of hydrogen surrounding the core; causes hydrogen fusion to continue in the shell of the gas—on going fusion of hydrogen radiates energy outward, which causes the outer shell of the star to expand greatly
 - Giant stars: a star's shell of gasses grows cooler as it expands; glow with reddish color
 - Supergiants: often at least 100 times larger than the sun
- With energy no longer available the star enters its final stages
 - Planetary nebulas: cloud of gas that forms around a sunlike star that is dying
 - White dwarfs: small, hot, dim star that is the leftover center of an old star—shine for billions of years for they cool off completely; becomes a black dwarf when it no longer gives off light
 - Nova: star that suddenly becomes brighter
 - Supernova: star that has such a tremendous explosion that it blows itself apart
 - Neutron star: a star that has collapsed under gravity to the point that the electrons and protons have smashed together to form neutrons
 - Pulsars: rapidly spinning neutron star that emits pulses of radio and optical energy
 - Black hole: object so massive and dense that even light cannot escape its gravity
- Constellations: one of 88 regions into which the sky has been divided in order to describe the locations of celestial objects; a group of stars organized in a recognizable pattern
- Galaxy: collection of stars, dust, and gas bound together by gravity
 - Spiral
 - Elliptical
 - Irregular

- Quasar: quasi-stellar radio source: a very luminous object that produces energy at a high rate

Big Bang Theory

- Theory that all matter and energy in the universe was compressed into an extremely small volume that 13 to 15 billion years ago exploded and began expanding in all directions
- Cosmic background radiation: radiation uniformly detected from every direction in space; considered a remnant of the big bang
- Dark energy: rate of expansion seems to be accelerating