# GENERAL SCIENCE POINTERS
BASIC CONCEPTS AND LAWS

# Science and Technology

## Science

- is a systematic study that is concerned with facts and principles, and methods that could be observed in our natural or physical and social environment. It comes from the Latin word 'scire' that means 'to know'.
- is both a body of knowledge and a process – away of thinking, a way of solving problems

## The Branches of Science

### THE PHYSICAL SCIENCES

- ***Physics*:** The study of matter and energy and the interactions between them. Physicists study such subjects as gravity, light, and time. Albert Einstein, a famous physicist, developed the Theory of Relativity.
- ***Chemistry*:** The science that deals with the composition, properties, reactions, and the structure of matter. The chemist Louis Pasteur, for example, discovered pasteurization, which is the process of heating liquids such as milk and orange juice to kill harmful germs.
- ***Astronomy*:** The study of the universe beyond the Earth's atmosphere.

### THE EARTH SCIENCES

- ***Geology:*** The science of the origin, history, and structure of the Earth, and the physical, chemical, and biological changes that it has experienced or is experiencing.
- ***Oceanography*:** The exploration and study of the ocean.
- **Paleontology:** The science of the forms of life that existed in prehistoric or geologic periods.
- ***Meteorology*:** The science that deals with the atmosphere and its phenomena, such as weather and climate.

### THE LIFE SCIENCES (BIOLOGY)

- ***Botany:*** The study of plants.
- ***Zoology:*** The science that covers animals and animal life.
- ***Genetics:*** The study of heredity.
- ***Medicine*****:** The science of diagnosing, treating, and preventing illness, disease, and injury.

## Scientific Method

is the logical method used by scientists to acquire knowledge that is used to explain different phenomena in nature. A thing observed by the senses is called a *phenomenon*; a scientifically tested observation is called a *fact*. The scientific method has six basic steps, namely:

***a. Identify and clearly state the problem*.** Questions arise from something observed as unusual; problem that is specific, measurable, and attainable is identified.

***b. Gather information pertinent to the problem*.** This is done by recalling past experiences concerning the problem, interviewing people who are knowledgeable of the problem, and researching in libraries and research centers.

***c. Formulate hypothesis.*** Based on information or data gathered, an **'educated guess'** can be made.

***d. Test the hypothesis*.** Carrying out experiments.

**Controlled experiment** - manipulating one of the conditions or factors that may affect the result of experiment.

1) **Trials** - number of times experiment is repeated.
2) **Controls** - factors that are kept constant throughout the experiment
3) **Variables** - factors that change during the experiment.

**Kinds:** 1. **Independent or experimental** - factors that are changed.

2. **Dependent** - factors that change as a result of changes in the independent variable.

**Presentation of Data**

**Tables** - easy to read, organized presentations.

**Graphs** - readily show patterns of data.

Kinds: 1. **Line** - proper to use when comparing two continuously changing variables.

2. **Bar** - appropriate to use when comparing a changing value with an unchanging value.

*e.* ***Draw a generalization or conclusion.***

**Conclusion** - a statement about the result of the experiment.

**Law** - a statement which describes what happens but does not explain the cause of the occurrence.

**Theory** - hypothesis that can be explained from observations.

*f.* ***Apply the principle (conclusion) to other situations.***

## Scientific Traits

Scientific knowledge may also be obtained through the use of models and ideas, or through serendipity or accidental discovery. In scientific study, .some standards or procedures must be observed. Scientists should always exhibit scientific attitudes like the following:

***a.*** ***Curiosity*** - keen observation of things and events in the surroundings.
*Galileo's intensive desire to study heavenly bodies drove him to use a telescope to study the moon, the planets, the sun, and the stars*
.

***b.*** ***Logic and system*** - use of step-by-step experimental method and keeping of accurate records.

*Gregor Mendel was successful in his study of hereditary traits because he used logical experimental methods and accurately recorded his observations.*

c. ***Open-mindedness*** - readiness or willingness to change or modify ideas or principles when necessary.
*Johannes Kepler changed his notion about the popular belief during his time that the planets moved along perfect circles to a more accurate information that these follow elliptical orbits.*

d. ***Intellectually honest*** - -acknowledging contribution of others to one's success.
I*saac Newton recognized the role of Galileo and others in his formulation the Laws of Motion.*

e. ***Hardwork and perseverance***
*Marie Curie and his husband Pierre had to work on several thousand kilograms of uranium ore to strain a tenth of a gram of pure uranium.*

f. ***Not opinionated*** – using hard evidences to prove ones theory.
*John Dalton used experimental evidences to support his atomic theory.*

g. ***Creativity and critical thinking***
*Albert Einstein did not just depend on established facts and accepted beliefs during his days. Rather, he used these to develop his own theory in different perspective.*

## Technology

is defined as the application of scientific knowledge to practical purposes. In short, it is an **applied science**. It is classified into three kinds, namely:

a. ***Machines*** - include tools, gadgets or devices that help us do our activities faster and better. They make life more pleasant to us to do certain things which we normally cannot do. *(e.g., airplane, internet, CT scan. and computers.)*

b. ***Products*** - materials produced or made through artificial or natural means. They make life more pleasant, more convenient, and more comfortable. *(e.g., steel, toothpaste, chemical fertilizers, and pesticides)*

c. ***Processes*** - include the ways of doing things. *(e.g., food Preservation, prawn culture and induced fruiting.)*

# Measurement

## International System (SI) of Measurement

Measurement is the process of comparing a quantity with a chosen standard. The **International System** (SI) is the system of units that scientists have agreed upon and is legally enforced in **almost all parts** of the world. There are seven basic quantities in this system:

| Quantity | Unit |
|---|---|
| Length | Meters (m) |
| Mass | Kilograms (kg) |
| Time | Seconds (s) |
| Electric current | Amperes (amp) |
| Temperature | Kelvin (K) |
| Amount of substance | Moles |
| Luminous intensity / light | Candelas |

Two factors affect the degree of measurements. They are (a.) *the ability to use the measuring instruments properly and (b.) the precision of the instrument.* The **unit factor method** is a systematic technique for solving numerical problems. The factors are derived from fixed relationships between quantities. The main purpose is to cancel units not desired using fixed relationships, leaving behind the unit desired. Units of a derived quantity like density may be inverted to be able to cancel the unit not desired.

## Metric Prefixes

**Metric prefixes** are pretty easy to understand and very handy for metric conversions. You don't have to know the nature of a unit to convert, for example, from *kilo-unit* to *mega-unit*. All metric prefixes are powers of 10.

| Prexis | Symbol | Factor |
|---|---|---|
| **giga** | **G** | $10^9$ = 1,000,000,000 |
| **mega** | **M** | $10^6$ = 1,000,000 |
| **kilo** | **k** | $10^3$ = 1,000 |
| hecto | h | $10^2$ = 100 |

| | | |
|---|---|---|
| deka | da | $10^1 = 10$ |
| **deci** | **d** | $10^{-1} = 0.1$ |
| **centi** | **c** | $10^{-2} = 0.01$ |
| **milli** | **m** | $10^{-3} = 0.001$ |
| **micro** | **µ** | $10^{-6} = 0.000,001$ |
| nano | n | $10^{-9} = 0.000,000,001$ |
| pico | p | $10^{-12} = 0,000,000,000,001$ |

Most people even in the countries where metric system is used only know the most important metric prefixes like 'kilo' and 'milli'. They are very handy for understanding metric conversions.

## Temperature

There are three temperature scales in use today, **Fahrenheit**, **Celsius** and **Kelvin**.
**Fahrenheit temperature** is a scale based on 32 for the freezing point of water and 212 for the boiling point of water, the interval between the two being divided into 180 parts. The conversion formula for a temperature that is expressed on the Celsius (C) scale to its Fahrenheit (F) representation is:
F = 9/5C + 32.

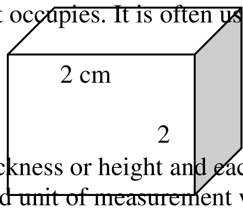
**Celsius temperature** scale also called centigrade temperature scale, is the scale based on 0 for the freezing point of water and 100 for the boiling point of water. Invented in 1742 by the Swedish astronomer Anders Celsius, it is sometimes called the centigrade scale because of the 100-degree interval between the defined points. The following formula can be used to convert a temperature from its representation on the Fahrenheit ( F) scale to the Celsius (C) value: C = 5/9(F - 32). The Celsius scale is in general use wherever metric units have become accepted, and it is used in scientific work everywhere.

**Kelvin temperature** scale is the base unit of thermodynamic temperature measurement in the International System (SI) of measurement. It is defined as 1/ 273.16 of the triple point (equilibrium among the solid, liquid, and gaseous phases) of pure water. The Kelvin (symbol K without the degree sign) is also the fundamental unit of the Kelvin scale, an absolute temperature scale named for the British physicist William Thomson, Baron Kelvin. The Kelvin scale is related to the Celsius scale. The difference between the freezing and boiling points of water is 100 degrees in each, so that the Kelvin has the same magnitude as the degree Celsius. To convert Celsius to Kelvin: K = __°C + 273

## Volume

Volume refers to the amount of space that an object occupies. It is often used to signify more accurate measurements.

## VOLUME OF A REGULAR SOLID




A regular solid is one having length, width, and thickness or height and each can be measured in a single straight line. Tomeasure the volume, we use a standard unit of measurement which is the meter.

The volume of a regular solid is obtained by multiplying its length, width and thickness. The volume is expressed in cubic units ( ex. Cubic meter, cubic cm, etc)

## VOLUME OF A LIQUID

Liquid volume is also measured in cubic meters but the use of liter (L) is widely accepted. Graduated cylinder is used to measure the volume of liquid. In reading the measurement of the volume of clear liquid, read the lower meniscus. For colored liquids, read the upper meniscus.

Liquid Volume Equivalents
$1dm^3$ = 1liter (L)
1 $cm^3$ = a milliliter (mL)
1000 $cm^3$ = 1liter

**Application:**

2 cm

Calculate the volume of the block of wood.

Given :
L = 2 cm
W= 2 cm
T= 2 cm

Solution:
Volume = L x W x T
= 8 $cm^3$

## VOLUME OF AN IRREGULAR SOLID

An irregular solid is one where a dimension cannot be measured in a single straight line. The displacement method is used to determine the volume of irregular solids.

Displacement method used by Archimedes: Fill a container with water, put the object in the container and catch the overflow. Get the volume of the overflow)

**Application:**

A cylinder contains 25.9 mL of water. When a small rock is placed in it, the water rises to 34.7 mL. What is the volume of the rock?

Given:

$V_1$ = 25.9 mL
$V_2$ = 34.7 mL

Solution:

$V_{rock}$ = 34.7 mL – 25.9 mL
= 8.8 mL

## Density

**Density** is the mass of the object per unit volume. Substances differ in their densities. Each substance has a specific density.

All materials with a density les than 1 g./cc (density of water) will float on water, and all those with density greater than 1 g/cc will sink.

D= Mass / Volume (g/cc)

**Application:**

The volume of an object weighing 2.5 g is 1.4 cc. Will the object float or sink on water

Given : V = 1.4 cc
M= 2.5 g

Solution:
D = M/ V
= 2.5 g / 1.4 cc
= 1.79 g/cc

Answer: the object will sink since it is denser than water.
(Density of water = 1 g/cc)

## Force

- normally refers to the measurement of a push or a pull
- anything that changes the speed and direction of moving objects or that which causes a stationary object to start moving in a straight line

### MEASURING FORCE

Gravitational force is the pull that the earth exerts on all objects and is measured by the weight of an object. Some instruments for measuring weight are : the bathroom scale and the balance (or kilohan) you often see in the market.

### TYPES OF FORCES

***Gravitational force*** – downward force that the earth exerts on objects

a. Inertia – tendency of an object to remain at rest or maintain its motion unless disturbed by a force
b. Friction- resists / opposes the relative sliding movement of two surfaces in contact with one another.
c. Centripetal force – drive a thing inward toward a center or rotation. It keeps an object moving in a circular path.
d. Force of Gravity – that which is acting on an object which enables it to exert an equal and opposite force on its support.

***Nuclear Force***- the strongest known force which holds together the protons and neutrons in the nucleus of an atom.

***Electromagnetic Force***- binds electrons to the atomic nucleus, atoms in the molecules, ions in solid matter, and molecules into iquids and solids.

### MASS vs WEIGHT

Mass indicates the quantity of matter in a material object. It does not change, thus it a property that is constant. It is measured in a unit called kilogram. Weight on the other hand, is th measure of the pull of gravity on an object. On earth, it depends on the mass of the object and its distance from the venter of the earth. The greater the mass of an object, the greater is its weight. The closer is to the center of the earth, the greater is its weight. Weight is expressed in N unit. 100g = 1N.

## Work

In science, work is done only when the force applied to an object actually moves the object in the direction of the force. This is represented as:

WORK = force x displacement

Force- anything that causes motion or a change in motion
Displacement – the distance and direction through hich an object is moved

**CALCULATING THE AMOUNT OF WORK**

W = F x d
(Newton) ( meter)
= Newton-meter or joule

**Application:**

How much work do you do by pushing a sack of rice with a force of 50 N across a distance of 10 meters?

Given: F= 50 N
D = 10 m

Solution:
W = F x d
= 50 N x 10 m
= 500 Nm or 500 J

* note : 100 g = 1 N

## Machines

Machine is any mechanical device that we use yo help us do our work, or make our work easier

***Simple Machines*** – machines that have only one or two parts
***Compound Machines*** – machines that make use of or more simple machines

## SIMPLE MACHINES

a. ***Lever*** – any rigid body which is pivoted about a point called fulcrum (e.g. crowbar, hammer, pliers, nutcracker, tongs, table knife, baseball bat)
b. **Pulley**- a wheel with a grooved rim over which a rope passes.( as in flag pole)
c. ***Wheel and axle*** – consists of a wheel attached to an axle so that if you push on the wheel, the axle turns also ( e.g. doorknob, eggbeater, screw driver)
d. ***Inclined plane*** –a flat surface with one and higher than the other. The longer it is in relation to its height, the larger is its mechanical advantage (e.g. plank, ladder, winding road)
e. ***Wedge*** – an inclined plane with either one or two sloping sides. The smaller the angle of the wedge,the greater the mechanical advantage ( nail,scissors, chisel, knife)
f. ***Screw*** – spiral inclined planes.Works by transferring force exerted on the circumference of the screw (food grinder, metal screws)

## Energy

The term **energy** is derived from the Greek word, *energeial* (*en* meaning *in* and *ergon* , meaning *work*). Anything that is able to do work possess energy. Energy is the ability to do work or the ability to exert force on an object and make it move.

## FORMS OF ENERGY

a. ***Mechanical Energy***
- *kinetic energy* – energy possessed by an object or a body in motion
- *potential energy*- energy possessed by a body because of its position or state

b. ***Internal Energy or Thermal Energy*** – total energy coming from the attractive and repulsive forces of all the particles or molecules in a body
c. ***Heat Energy*** – energy which flows from one body to another due to a temperature difference between them, and the flow is always from the hotter to the colder body
d. ***Electrical Energy*** – electricity is the energy of electrons flowing through conductors, like copper wires and aluminum wires.
e. ***Chemical Energy*** – energy stored in matter due to forces of attraction and to the arrangement of subatomic particles in atoms and of atoms in the molecules of substances.
f. ***Radiant Energy*** – energy of the electromagnetic waves , radio waves, infrared rays, visible light, ultraviolet rays, x rays and gamma rays.
g**.** ***Nuclear Energy*** – energy released from nuclear fusion or fission of atomic nuclei of heavy element or light element.

## METHODS OF HEAT TRANSFER

***Conduction***

The molecules in a material are always moving. When one part of a material is heated, the molecules in that part move faster and collide with other molecules. As this goes on, heat is conducted from molecule to molecule until the heat is spread throughout the material. This is **conduction.** A *conductor* is the material through which heat passes easily. An *insulator* is a material that conducts heat poorly.

***Convection***

The movement of a gas or liquid brought about by temperature differences creates a convection current. Heat is transferred by Convection when a gas or liquid moves from one place to another.

***Radiation***

Heat transfer when heat is given of in all directions around them is radiation. The sun and other hot objects radiates energy.

**ENERGY RESOURCES**

**a. *Fossil Fuels***

1. Coal – being mined formed from trees and other vegetation buried in swamps crated by the encroaching sea
2. Petroleum - a liquid mixture of gaseous liquid and solid hydrocarbons.
3. Natural Gas- composed entirely of carbon and hydrogen. It is 50 to 94% methane and other hydrocarbons.
4.

***b. Hydroelectric Power***

Hydroelectric power pertains to the production of electricity by means of generators driven by water turbines.

***c. Geothermal Energy*** - Thermal energy inside the earth, energy of steam from beneath the earth's surface

***d. Wind Energy***- energy harnessed through the windmill

***e. Solar Energy***- energy from the sun, radiant energy. The visible light is harnessed to produce the electricity by means of so-called solar cells or photovoltaic cells, which generate eletricity when exposed to sunlight

# Earth

## Formation of the Earth

**BIG BANG**

In the beginning there is only a super-massive gaseous point in our empty universe. Instantaneously and randomly, enough energy is created to break the gravitational bond holding this massive body together, exploding the super-heated particles throughout space. In less than one millionth of a second, protons, neutrons, electrons, and their anti-particles begin to form.

As time moves on, particles begin to cool by giving off energy, which allows them to combine to create the first and most simple ion, hydrogen, as well as a few more massive atoms. More time passes; the atoms are becoming more abundant in the universe. They begin to pull together through atomic forces and the gravitational force. Gaseous bodies become more massive, attracting more atoms and becoming more massive. The gravitational force of these early bodies is so great that they collapse in on themselves, beginning fusion.

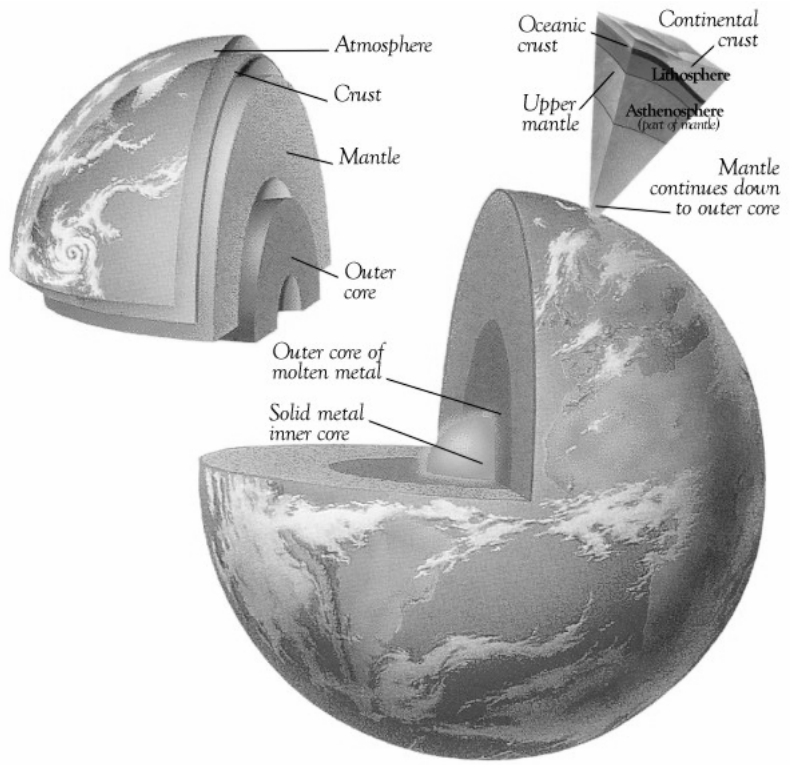
Hydrogen atoms combine, yielding larger atoms and enormous amounts of energy; enough energy to keep these stars from collapsing. Eventually, the fusion process has to end and the star will explode, sending out more massive atoms into the universe. Over time, these atoms collect and combine to create planets, smaller stars, asteroids, and numerous other solid bodies.

**FORMATION OF SOLAR SYSTEM**

As matter began to condense and stars began to form, one such star appeared where the Sun now appears within the Milky Way Galaxy. After igniting with fusion and burning its usable hydrogen and other larger elements, the star exploded, sending matter out in all directions. Once again, through gravitational forces, this matter eventually cooled and collected in a few key areas, forming the planets and the asteroid belt. The asteroid belt is simply an early form of the collection of matter that was not able to completely form a planet due to Jupiter's gravity. Some early planets may have collided with other early planets, creating larger planets, moons, or possibly space rocks. In the meantime, a smaller star began to form at the center of the previous explosion and our Sun started its fusion process again.

## Earth's Structure

The earth consists of several layers. The three main layers are the **core,** the **mantle** and the **crust.** The core is the inner part of the earth, the crust is the outer part and between them is the mantle. The earth is surrounded by the atmosphere. Till this moment it hasn't been possible to take a look inside the earth because the current technology doesn't allow it. Therefore all kinds of research had to be done to find which material the earth consists, what different layers there are and which influence those have (had) on the earth's surface. This research is called seismology.




**THE CORE** - The inner part of the earth is the core. This part of the earth is about 1,800 miles (2,900 km) below the earth's surface. The core is a dense ball of the elements iron and nickel. It is divided into two layers, the inner core and the outer core. The inner core - the center of earth - is solid and about 780 miles (1,250 km) thick. The outer core is so hot that the metal is always molten, but the inner core pressures are so great that it cannot melt, even though temperatures there reach 6700ºF (3700ºC). The outer core is about 1370 miles (2,200 km) thick. Because the earth rotates, the outer core spins around the inner core and that causes the earth's magnetism

**THE MANTLE -** The layer above the core is the mantle. It begins about 6 miles (10 km) below the oceanic crust and about 19 miles (30 km) below the continental crust (see The Crust). The mantle is to divide into the inner mantle and the outer mantle. It is about 1,800 miles (2,900 km) thick and makes up nearly 80 percent of the Earth's total volume.

**THE CRUST -** The crust lies above the mantle and is the earth's hard outer shell, the surface on which we are living. In relation with the other layers the crust is much thinner. It floats upon the softer, denser mantle. The crust is made up of solid material but these material is not everywhere the same. There is an Oceanic crust and a Continental crust. The first one is about 4-7 miles (6-11 km) thick and consists of heavy rocks, like basalt. The Continental crust is thicker than the Oceanic crust, about 19 miles (30 km) thick. It is mainly made up of light material, like granite.

## Plate Tectonics

The earth's crust consists of a number of moving pieces or plates that are always colliding or pulling apart. The Lithosphere consists of nine large plates and twelve smaller ones. The continents are imbedded in continental plates; the oceanic plates make up much of the sea floor. The study of Tectonic plates - called plate tectonics - helps to explain continental drift, the spreading of the sea floor, volcanic eruptions and how mountains are formed. The force that causes the movement of the tectonic plates may be the slow churning of the mantle beneath them. Mantle rock is constantly moved upwards to the surface by the high temperatures below and then sinks by cooling. This cycle takes millions of years.

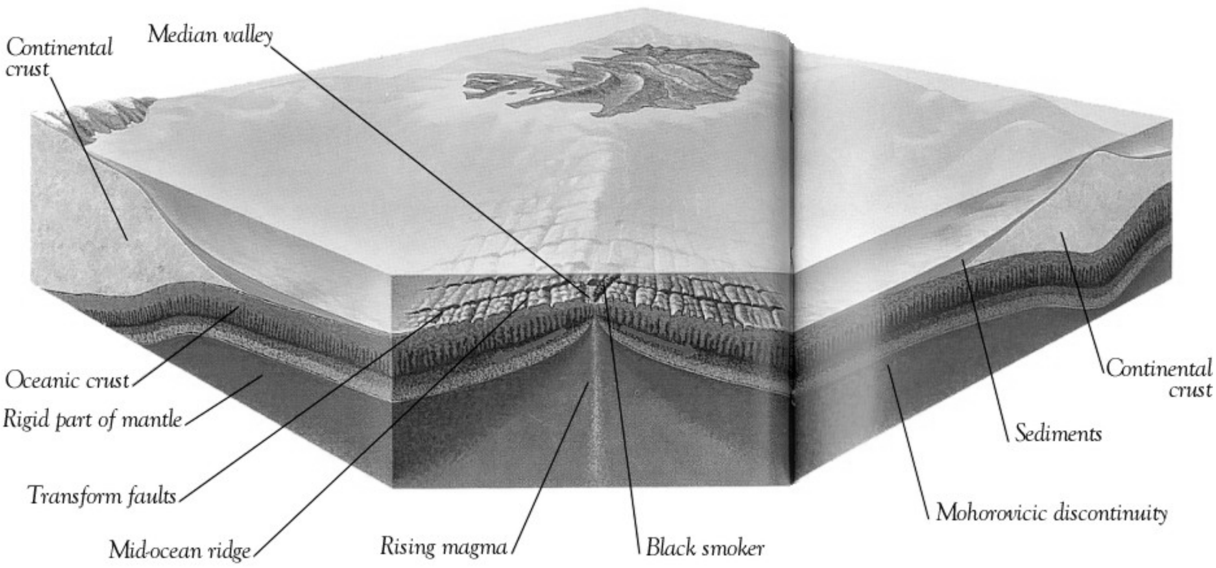
***Continental drift***
The drift of the plates across the surface of the earth has been going on over millions of years, which still changes the outward appearance of the earth. When you look at the map of the world, you see how well the east coast of North and South America fits into the west coast of Europe and Africa. Over millions of years these continents have slowly drifted apart. (continental drift).

***Diverging plates***
Where plates pull apart, hot molten rock (fluid magma) emerges as lava and so new matter is added to the plates. In this way new oceanic plates are formed. The place where this happens is known as a mid-ocean ridge. Mid-ocean ridges are rarely more than about 4,920 ft. (1,500 m) high, but they may snake along the ocean bed for thousands of miles. Beneath each of the world's great oceans there is a mid-ocean ridge. An example is the Mid-Atlantic Ridge in the Atlantic Ocean, which stretches from the North Pole to the South Pole. Mid-ocean ridges are areas of much volcanic and earthquake activity.

***Converging plates:***
In many places the huge plates of the earth's surface are slowly moving together with unimaginable force. Sometimes the edge of one plate is gradually destroyed by the force of collision, sometimes the impact simply crimps the plates' edges, thereby creating great mountain ranges.
When one tectonic plate bends beneath the other, it is called subduction. Most of the time this happens because a dense oceanic plate collides with a lighter continental plate. You can see this along the Pacific coast of South-America. The oceanic plate dips beneath into the Asthenosphere. Through the heat of the Asthenosphere the subducted plate melts. At the surface an ocean trench is created, followed by an arc of islands. In this area also volcanic activities and earthquakes occur.

***Seafloor Spreading***
Studies show that volcanic activity under the sea causes magma from beneath the earth's crust to rise to the surface, forming a very long ridge along the middle of the oceans that separate the large continents.

When continental plates collide, one of the plates splits up into two layers: a lower layer of dense mantle rock and an upper layer of lighter crystal rock. As the mantle layer subducts, the upper layer is peeled off and crumples up against the other plate, thus forming mountain ranges, like the Alps. These are called crumpled mountains.




**DIASTROPHISM** – the process which involves movements of the earth's crust such that a portion id pushed up, push down or forced sideways

- Folding – the process when the sideward forces acting on rocks deform the rocks into wavelike folds after tilting, bending of wrinkling.
- Faulting sliding or moving over of rock layers over one another along the break or fracture, may occur vertically or horizontally.

## Volcanoes

A Volcano is a gap in the earth where molten rock and other materials come to the earth's surface. Some volcanoes are just cracks in the earth's crusts. Others are weak places in the earth's crust, which occur on places where magma bubbles up through the crust and comes to the earth's surface. Magma is molten rock that occurs by partial melting of the crust and the mantle by high temperatures deep down in the ground. Once magma comes to the earth's surface it is called lava.

**ACTIVE AND NON-ACTIVE VOLCANOES**

There are volcanoes in different phases of activity: ***Active volcanoes***, which are likely to erupt at any moment, ***dormant volcanoes***, which lie dormant for centuries, but then erupt suddenly and violently, and ***extinct volcanoes***, ones no longer likely to erupt.

## TYPES OF VOLCANOES

The ordinary volcanoes can be divided in different types, relating to their forms:

| | |
|---|---|
| **The shield volcano:** | This is a broad, shallow volcanic cone, which arises because the running lava, which is fluid and hot, cools slowly. |
| **The dome volcano:** | This one has a steep, convex slope from thick, fast-cooling lava |
| **The ash-cinder volcano:** | Throws out - besides lava - much ash into the air. Through this the volcanic cone is built up from alternate layers of ash and cinder. |
| **The composite volcano:** | These are also built up from alternate layers of lava and ash but, besides its main crater, it has many little craters on its slope. |
| **The caldera volcano:** | An older volcano with a large crater which can be 62 miles(100km) wide. In this crater many little new craters are formed. |

# Earthquakes

An Earthquake is in fact the shaking of the ground caused by sudden movements in the earth's crust. The biggest earthquakes are set off by the movement of tectonic plates. Some plates slide past each other gently, but others can cause a heavy pressure on the rocks, so they finally crack and slide past each other. By this, vibrations or shock waves are caused, which go through the ground. It is these vibrations or seismic waves which cause an earthquake. The closer to the source of the earthquake (the focus or hypocenter), the more damage occurs. Earthquakes are classified according to the depth of the focus.

| | |
|---|---|
| **0-43 miles (0-70 km) below ground:** | **shallow earthquakes** |
| **43-186 miles (70-300 km) below ground:** | **intermediate earthquakes** |
| **deeper than 186 miles (300 km) below ground:** | **deep earthquakes** |

The closer the focus to the surface, the heavier the earthquake. The earthquake is always the most intense on the surface directly above the focus (Epicenter). In general big earthquakes begin with light vibrations (foreshocks). These are the initial fractures in the rocks. After the main shock, there may be minor aftershocks, most of the time for months. This occurs as the rocks settle down.

## Rocks

Rocks are classified in three types based on how they are formed.

a. ***Igneous rocks*** are formed when molten rock (magma) from within Earth cools and solidifies. There are two types: intrusive igneous rocks solidify beneath Earth's surface; *extrusive* igneous rocks solidify at the surface. Examples: Granite, basalt, obsidian
b. ***Sedimentary rocks*** are formed when sediment (bits of rock plus material such as shells and sand) gets packed together. They can take millions of years to form. Most rocks that you see on the ground are sedimentary. Examples: Limestone, sandstone, shale
c. ***Metamorphic rocks*** are sedimentary or igneous rocks that have been transformed by heat, pressure or both. Metamorphic rocks are usually formed deep within Earth, during a process such as mountain building. Examples: Schist, marble, slate

### THE ROCK CYCLE

The three major types of rocks, igneous, sedimentary, and metamorphic rocks are interrelated by a series of natural processes. **Igneous rocks** form from the cooling and crystallization of hot molten lava and magma. Igneous rocks undergo **weathering and erosion** to form sediments. **Sediments** are deposited and lithified by compaction and cementation to form **sedimentary rocks**. Sedimentary rock become buried by additional sedimentary deposition, and when they are deep within the Earth, they are subjected to **heat and pressure** which causes them to become **metamorphic rocks**. With further burial and heating, the metamorphic rocks begin to melt. Partially molten metamorphic rocks are known as migmatite. As **melting** proceeds with increasing temperatures and depths of burial, eventually the rock becomes molten and becomes **magma**, which cools and crystallizes to form **plutonic igneous rock**, or which is erupted onto the Earth's surface as lava, and cools and crystallizes to form **volcanic igneous rock**.

Further complications within the rock cycle include (1) weathering of sedimentary and metamorphic rocks (in addition to igneous rocks), and (2) metamorphism of igneous rocks and repeated metamorphism of metamorphic rocks.

**WEATHERING** – Breaking down of rocks brought about by either physial or chemical means giving rise to sediments or ther rock fragments

**Types of Weathering**

**A. Physical or mechanical weathering**

- **Frost wedging** - water expands when it freezes
- **Exfoliation or unloading** -
  - rock breaks off into leaves or sheets along joints which parallel the ground surface;
  - caused by expansion of rock due to uplift and erosion; removal of pressure of deep burial;
- **Thermal expansion** -
  - repeated daily heating and cooling of rock;
  - heat causes expansion; cooling causes contraction.
  - different minerals expand and contract at different rates causing stresses along mineral boundaries.

**B. Chemical weathering**

Rock reacts with water, gases and solutions (may be acidic); will add or remove elements from minerals.

- **Dissolution (or solution)** -
  - Several common minerals dissolve in water
    - halite
    - calcite
  - ***Limestone*** and ***marble*** contain calcite and are soluble in acidic water
  - Marble tombstones and carvings are particularly susceptible to chemical weathering by dissolution. Note that the urn and tops of ledges are heavily weathered, but the inscriptions are somewhat sheltered and remain legible.
  - Caves and caverns typically form in limestone
    - *speleothems* are cave formations
    - speleothems are made of calcite
    - form a rock called *travertine*
      - stala**c**tites - hang from **c**eiling
      - stala**g**mites - on the **g**round
  - **Karst topography** forms on limestone terrain and is characterized by:
    - caves/caverns,
    - sinkholes,
    - disappearing streams,
    - springs

- **Oxidation**
  - Oxygen combines with iron-bearing silicate minerals causing "rusting"
  - Iron oxides are produced . Iron oxides are red, orange, or brown in color
  - Mafic rocks such as basalt (which may contain olivine, pyroxene, or amphibole) weather by oxidation to an orange color
  - "Georgia Red Clay" derives its color from the oxidation of iron bearing minerals
- **Hydrolysis**

**C. Biological weathering**

Organisms can assist in breaking down rock into sediment or soil.

1. Roots of trees and other plants
2. Lichens, fungi, and other micro-organisms
3. Animals (including humans)

**EROSION**- the process by which rock fragments and sediments are carried along by such agents as wind and running water

**DEPOSITION-** the process by which rock fragments and sediments ae carried by agents of erosion are dropprd or deposited in other places.

**COMPACTING** – the process by which rock fragments and other materials that accumulated, usually at the bottom of a thick column of water, get cemented together and harden into rock

**METAMORPHISM** - a change in constitution of a rock brought about by pressure, heat and chemical action resulting in a more compact and highly crystalline condition of the rock.

**MELTING**
**COOLING AND SOLIDIFYING**

## Minerals and Gems

***Minerals*** are solid, inorganic (not living) substances that are found in and on earth. Most are chemical compounds, which means they are made up of two or more elements. For example, the mineral sapphire is made up of aluminum and oxygen. A few minerals, such as gold, silver and copper, are made from a single element. Minerals are considered the building blocks of rocks. Rocks can be a combination of as many as six minerals.

Many minerals, such as gold and silver, are very valuable because they are beautiful and rare. Limestone, clay and quartz are other examples of minerals.

***Gems*** are minerals or pearls that have been cut and polished. They are used as ornaments, such as jewelry. ***Precious stones*** are the most valuable gems. They include diamonds, rubies and emeralds

# Atmosphere

## What is Atmosphere?

The earth is surrounded by all kind of gases. This layer is called the earth's Atmosphere. Without this atmosphere life on earth isn't possible. It gives us air, water, heat, and protects us against harmful rays of the sun and against meteorites.

This layer around the earth is a colorless, odorless, tasteless 'sea' of gases, water and fine dust. The atmosphere is made up of different layers with different qualities. It consists of 78 percent nitrogen, 21 percent oxygen, 0.93 percent argon, 0.03 percent carbon dioxide and 0.04 percent of other gases.

The Troposphere is the layer where the weather happens. Above this layer is the Stratosphere and in between them is the Ozone layer, that absorbs the sun's harmful ultraviolet rays. Above the Stratosphere is the Mesosphere, the Thermosphere including the Ionosphere - and the Exosphere. The atmosphere measures about 500 miles (800km).

## Layers of the Atmosphere

**THE TROPOSPHERE**

The Troposphere is the lowest layer of the atmosphere and measures about 7 miles(12 km). It contains over 75 percent of all the atmosphere's gases and vast quantities of water and dust. As the sun heats the ground, it keeps this thick mixture churning. The weather is caused by these churnings of the mass. The troposphere is normally warmest at ground level and cools higher up where it reaches its upper boundary (the tropopause). The tropopause varies in height. At the equator it is at 11.2 miles(8 km) high, at 50 N and 50 S, 5.6 miles(9 km) and at the poles 3.7 miles(6 km) high.

**STRATOSPHERE**

The Stratosphere extends from the tropopause up to its boundary (the Stratopause), 31 miles(50 km) above the Earth's surface. In this layer there is 19 percent of the atmosphere's gases and it contains little water vapour. Compared to the troposphere it is calm in this layer. The movements of the gases are slow. Within the stratosphere is the ozone layer, a band of ozone gas, that absorbs harmful ultraviolet rays of the sun. The higher you get in the atmosphere, the warmer the air gets. The temperature rises from -76 ºF(-60 ºC) at the bottom to a maximum of about 5 ºF(10 ºC) at the stratopause.

**MESOSPHERE**

The mesosphere is the next layer above the stratopause and extends to its upper boundary (the Mesopause), at 50 miles(80 km) above the ground. The gases in the mesosphere are too thin to absorb much of the sun's heat. Although the air is still thick enough to slow down meteorites hurtling into the atmosphere. They burn up, leaving fiery trails in the night sky. The temperatures in the mesosphere drop to -184 ºF(-120 ºC) at the mesopause.

**THERMOSPHERE**

The Thermosphere is the layer above the mesopause. The gases of the thermosphere are even thinner than those in the mesosphere, but they absorb ultraviolet light from the sun. Because of this, the temperatures rise to 3,600 ºF (2,000 ºC) at the top. This is at a height of 430 miles (700 km) of the earth's surface. In the thermosphere is a separate layer, the Ionosphere. This layer extends of 62 miles(100 km) to 190 miles(300 km) of the earth's surface.

### IONOSPHERE

The ionosphere is part of the thermosphere. It is made of electrically charged gas particles (ionised). The particles get this electric charge by ultraviolet rays of the sun. The ionosphere has the important quality of bouncing radio signals, transmitted from the earth. That's why places all over the world can be reached via radio.

### EXOSPHERE

The Exosphere is the outermost layer of the atmosphere and extends from 430 miles (700 km) to 500 miles (800 km) above the ground. In this layer gases get thinner and thinner and drift off into space.

## What influence does the Atmosphere have?

The atmosphere is of vital importance for life on earth. Without atmosphere life would be impossible. It gives us air to breathe and protects us from meteorites and ultraviolet rays from the sun. The atmosphere absorbs so much heat that temperatures on earth are such that life is possible. The weather, that exists by constant circulation of water to water vapor, to rain to water. This cycle causes, together with the differences in temperature and circulation of air (wind), erosion of the earth's surface. By erosion the outside of the earth changes through the years.

## Air

### AIR MOVEMENT

Warm air is less dense than cold air. Thus, warm air rises above cold air making the pressure below lower. The horizontal movement of air from high pressure area to lower pressure area produces wind.

### SEA BREEZES AND LAND BREEZES

When spending a day at the beach, a noticeable drop in temperature may occur during the early afternoon as a cool breeze begins to blow off of the water. This wind is known as the "sea breeze", which occurs in response to differences in temperature between a body of water and neighboring land.


Sea-breeze circulations most often occur on warm sunny days during the spring and summer when the temperature of the land is normally higher than the temperature of the water. During the early morning hours, the land and the water start out at roughly the same temperature. On a calm morning, a given pressure surface will be at the same height above both the land and water.

A few hours later, the sun's energy begins to warm the land more rapidly than the water. By later in the day, the temperatures of the land increases while the temperature of the water remains relatively constant. This occurs because water, especially large bodies of water like a lake or ocean, are able to absorb more energy than land without warming.

It is important to remember that the air is not heated directly from above by the sun. In fact, most of the incoming solar energy actually passes right through the atmosphere. However, as the land absorbs this energy, heat is radiated back into the atmosphere (from the earth), warming the overlying air. Some of this heat is transported to higher levels in the atmosphere through convection.

On the other hand, since the temperature of the water remains relatively constant throughout the day, the air over the water is not heated from below (as over land), resulting in lower air temperatures over the water.

On clear, calm evenings, temperature differences between a body of water and neighboring land produce a cool wind that blows offshore. This wind is called a "land breeze". Land breezes are strongest along the immediate coastline but weaken considerably further inland.


Land-breeze circulations can occur at any time of year, but are most common during the fall and winter seasons when water temperatures are still fairly warm and nights are cool.

On clear and calm evenings, the earth's surface cools by radiating (giving off) heat back into space, and this results in a cooling of the immediately overlying air.

Since the air over land cools more rapidly than the air over water, a temperature difference is established, with cooler air present over land and relatively warmer air located over water.

## AIR POLLUTION

When large amount of dust, soot, bacteria, and other harmful gases get into the air, air is being polluted. Today, the main sources of air pollution in the Philippines are : 1) industry and 2) transportation.

***Major Air Pollutants***

| Pollutant | Sources | Effects |
|---|---|---|
| **Ozone.** A gas that can be found in two places. Near the ground (the troposphere), it is a major part of smog. Higher in the air (the stratosphere), it helps block radiation from the sun. | Ozone is not created directly, but is formed when nitrogen oxides and volatile organic compounds mix in sunlight. That is why ozone is mostly found in the summer. Nitrogen oxides come from burning gasoline, coal, or other fossil fuels. There are many types of volatile organic compounds, and they come from sources ranging from factories to trees. | Ozone near the ground can cause a number of health problems. Ozone can lead to more frequent asthma attacks in people who have asthma and can cause sore throats, coughs, and breathing difficulty. It may even lead to premature death. Ozone can also hurt plants and crops. |
| **Carbon monoxide.** A gas that comes from the burning of fossil fuels, mostly in cars. It cannot be seen or smelled. | Carbon monoxide is released when engines burn fossil fuels. Emissions are higher when engines are not tuned properly, and when fuel is not completely burned. Cars emit a lot of the carbon monoxide found outdoors. Furnaces and heaters in the home can emit high concentrations of carbon monoxide, too, if they are not | Carbon monoxide makes it hard for body parts to get the oxygen they need to run correctly. Exposure to carbon monoxide makes people feel dizzy and tired and gives them headaches. Elderly people with heart disease are hospitalized more often when they are exposed to higher amounts |

| | | |
|---|---|---|
| | properly maintained. | of carbon monoxide. |
| **Nitrogen dioxide.** A reddish-brown gas that comes from the burning of fossil fuels. It has a strong smell at high levels. | Nitrogen dioxide mostly comes from power plants and cars. Nitrogen dioxide is formed in two ways—when nitrogen in the fuel is burned, or when nitrogen in the air reacts with oxygen at very high temperatures. Nitrogen dioxide can also react in the atmosphere to form ozone, acid rain, and particles. | High levels of nitrogen dioxide exposure can give people coughs and can make them feel short of breath. People who are exposed to nitrogen dioxide for a long time have a higher chance of getting respiratory infections. Nitrogen dioxide reacts in the atmosphere to form acid rain, which can harm plants and animals. |
| **Particulate matter.** Solid or liquid matter that is suspended in the air. To remain in the air, particles usually must be less than 0.1-mm wide and can be as small as 0.00005 mm. | Particulate matter can be divided into two types—coarse particles and fine particles. Coarse particles are formed from sources like road dust, sea spray, and construction. Fine particles are formed when fuel is burned in automobiles and power plants. | Particulate matter that is small enough can enter the lungs and cause health problems. Some of these problems include more frequent asthma attacks, respiratory problems, and premature death. |
| **Sulfur dioxide.** A corrosive gas that cannot be seen or smelled at low levels but can have a "rotten egg" smell at high levels. | Sulfur dioxide mostly comes from the burning of coal or oil in power plants. It also comes from factories that make chemicals, paper, or fuel. Like nitrogen dioxide, sulfur dioxide reacts in the atmosphere to form acid rain and particles. | Sulfur dioxide exposure can affect people who have asthma or emphysema by making it more difficult for them to breathe. It can also irritate people's eyes, noses, and throats. Sulfur dioxide can harm trees and crops, damage buildings, and make it harder for people to see long distances. |
| **Lead.** A blue-gray metal that is | Outside, lead comes from | High amounts of lead can |

| | | |
|---|---|---|
| very toxic and is found in a number of forms and locations. | cars in areas where unleaded gasoline is not used. Lead can also come from power plants and other industrial sources. Inside, lead paint is an important source of lead, especially in houses where paint is peeling. Lead in old pipes can also be a source of lead in drinking water. | be dangerous for small children and can lead to lower IQs and kidney problems. For adults, exposure to lead can increase the chance of having heart attacks or strokes. |
| **Toxic air pollutants.** A large number of chemicals that are known or suspected to cause cancer. Some important pollutants in this category include arsenic, asbestos, benzene, and dioxin. | Each toxic air pollutant comes from a slightly different source, but many are created in chemical plants or are emitted when fossil fuels are burned. Some toxic air pollutants, like asbestos and formaldehyde, can be found in building materials and can lead to indoor air problems. Many toxic air pollutants can also enter the food and water supply. | Toxic air pollutants can cause cancer. Some toxic air pollutants can also cause birth defects. Other effects depend on the pollutant, but can include skin and eye irritation and breathing problems. |
| **Stratospheric ozone depleters.** Chemicals that can destroy the ozone in the stratosphere. These chemicals include chlorofluorocarbons (CFCs), halons, and other compounds that include chlorine or bromine. | CFCs are used in air conditioners and refrigerators, since they work well as coolants. They can also be found in aerosol cans and fire extinguishers. Other stratospheric ozone depleters are used as solvents in industry. | If the ozone in the stratosphere is destroyed, people are exposed to more radiation from the sun (ultraviolet radiation). This can lead to skin cancer and eye problems. Higher ultraviolet radiation can also harm plants and animals. |

| | | |
|---|---|---|
| **Greenhouse gases.** Gases that stay in the air for a long time and warm up the planet by trapping sunlight. This is called the "greenhouse effect" because the gases act like the glass in a greenhouse. Some of the important greenhouse gases are carbon dioxide, methane, and nitrous oxide. | Carbon dioxide is the most important greenhouse gas. It comes from the burning of fossil fuels in cars, power plants, houses, and industry. Methane is released during the processing of fossil fuels, and also comes from natural sources like cows and rice paddies. Nitrous oxide comes from industrial sources and decaying plants. | The greenhouse effect can lead to changes in the climate of the planet. Some of these changes might include more temperature extremes, higher sea levels, changes in forest composition, and damage to land near the coast. Human health might be affected by diseases that are related to temperature or by damage to land and water. |

## Weather and Climate

**WEATHER**- describes the condition of the atmosphere in a particular time (cool and dry, humid, windy, rainy, or stormy)

**CLIMATE-** average weather in a region over a number of years or usually decades (tropical)

**CLOUDS** - little drops of water or ice hanging in the atmosphere. A **ceilometer** measures the height of clouds.

| Cloud Type | Descriptive Name | Description |
|---|---|---|
| Cirrus | Mare's tails | thin, feathery |
| Cirrocumulus | Mackerel sky | small patches of white |
| Cirrostratus | Bed sheet clouds | thin, white sheets |

| | | |
|---|---|---|
| Stratus | High fogs | low, gray blanket |
| Cumulus | Cauliflowers | flat-bottomed, white puffy |
| Cumulonimbus | Thunderheads | mountains of heavy, dark clouds |

## Winds

### WIND SYSTEMS

The major wind systems in the Philippines are

a. ***Northeast Trade Winds*** – from north, north east and east
b. ***Southwest Monsoon (habagat)*** – originates from Southeast Trade winds south of the equator
c. ***Northeast monsoon (amihan)-*** from east, south east

**CYCLONES** – low pressure areas in the tropics

a. ***tropical depresssion***- with wind speed of less than 63 kph
b. ***trpical storm*** – with wind speed of 63-118 kph
c. ***typhoon*** – with wind speed of more than 118 lph

## Thunderstorms

Thunderstorms **affect small areas** when compared with hurricanes and winter storms. The typical thunderstorm is **15 miles in diameter** and lasts an **average of 30 minutes.** Nearly 1,800 thunderstorms are happening at any moment around the world. That's **16 million a year!**

Despite their small size, all thunderstorms are **dangerous.** Every thunderstorm produces **lightning,** which kills more people each year than tornadoes. Strong **winds, hail, and tornadoes** are also dangers associated with some thunderstorms.

You can **estimate how many miles away a storm is** by counting the number of **seconds between the flash of lightning and the clap of thunder.** Divide the number of seconds by five to get the distance in miles. The lightning is seen before the thunder is heard because **light travels faster than sound**.

Thunderstorms **need three things:**

- **Moisture**—to form clouds and rain.
- **Unstable Air**—relatively warm air that can rise rapidly.
- **Lift**—fronts, sea breezes and mountains are capable of lifting air to help form thunderstorms.

## Lightning

The action of **rising and descending air within a thunderstorm** separates positive and negative charges. Water and ice particles also affect the distribution of electrical charge. Lightning results from the **buildup and discharge of electrical energy** between positively and negatively charged areas. Most lightning occurs within the cloud or between the cloud and ground.

The average flash of lightning **could turn on a 100-watt light bulb for more than 3 months.** The air near a lightning strike is **hotter than the surface of the sun!** The rapid heating and cooling of air near the lightning channel causes **a shock wave that results in thunder.**

**Your chances of being struck by lightning** are estimated to be 1 in 600,000 but those chances can be reduced by following safety rules. Most lightning deaths and injuries occur **when people are caught outdoors,** and most happen **in the summer.** Many fires in the western United States and Alaska are started by lightning. In the past 10 years, more than **15,000 fires have been started by lightning.**

## The Ozone Layer

Ozone is a molecule containing three oxygen atoms. It is blue in color and has a strong odor. Normal oxygen, which we breathe, has two oxygen atoms and is colorless and odorless. Ozone is much less common than normal oxygen. Out of each 10 million air molecules, about 2 million are normal oxygen, but only 3 are ozone.

However, even the small amount of ozone plays a key role in the atmosphere. The ozone layer absorbs a portion of the radiation from the sun, preventing it from reaching the planet's surface. Most importantly, it absorbs the portion of ultraviolet light called UVB. UVB has been linked to many harmful effects, including various types of skin cancer, cataracts, and harm to some crops, certain materials, and some forms of marine life.

At any given time, ozone molecules are constantly formed and destroyed in the stratosphere. The total amount, however, remains relatively stable. While ozone concentrations vary naturally with sunspots, the seasons, and latitude, these processes are well understood and predictable. Each natural reduction in ozone levels has been followed by a recovery. Recently, however, convincing scientific evidence has shown that the ozone shield is being depleted well beyond changes due to natural processes.

CFCs - are stable substances that only exposure to strong UV radiation breaks them down. When that happens, the CFC molecule releases atomic chlorine. One chlorine atom can destroy over 100,000 ozone molecules. The net effect is to destroy ozone faster than it is naturally created.

# Astronomy

## The Universe

How old is the universe? What is it made of? For the first time, scientists have clarity.

- **13.7 billion years:** Age of the universe
- **200 million years:** Interval between the Big Bang and the appearance of the first stars
- **4%:** Proportion of the universe that is ordinary matter
- **23%:** Proportion that is dark matter
- **73%:** Proportion that is dark energy

**COLORS OF THE UNIVERSE**

***Blue Planets* -** Earth, Neptune, and Uranus are all blue because of gases in their atmosphere.

***Blue Stars* -** These are the hottest stars, with a surface temperature of more than 37,000°F.

***Yellow Stars* -** These are warm stars, such as the Sun. Their temperature is about 10,000°F.

***Red Stars*-** The coolest stars are red. Their surface temperature is less than 5,500°F.

***Red Shift* -** When light coming from a distant star is seen through a spectroscope (an instrument that separates light into its different colors); the light we receive continues to shift toward the red area of the spectrum, which is the least powerful. This means that, since the light is becoming weaker and weaker, the stars must be traveling away from us. This makes scientists believe that our universe is expanding.

***Red Spot* -** A swirling cloud on the planet Jupiter is a raging storm of gases, mainly red phosphorus.

## Space Glossary

***Galaxies*** are immense systems containing billions of stars. Astronomers have estimated that the universe could contain 40 to 50 billion galaxies. Galaxies have different shapes: some are spiral, others are elliptical, or oval-shaped, and some are irregular.

The ***Milky Way*** is our own galaxy. Just about all that you can see in the sky belongs to our galaxy—a system of roughly 200 billion stars. The Milky Way is a spiral-shaped galaxy about 100,000 light-years in diameter and about 10,000 light-years in thickness.

The ***solar system*** is made up of the Sun (*solar* means sun) at its center, the nine planets that orbit it, and the various satellites, asteroids, comets, and meteorites that are also controlled by the Sun's gravitational pull.

The ***Sun*** is the closest star to Earth and the center of our solar system. Every second, it converts 49 million tons (45 million metric tons) of matter into pure energy, which reaches us in the form of light. The Sun weighs more than 300,000 times as much as Earth and is 109 times larger.

***Sunspots*** appear as dark spots on the Sun, and are believed to be cooler than the rest of the Sun. They appear in 11-year cycles.

***Planet*** is the term used for a body in orbit around the Sun. The word comes from the Greek *planetes,* and means "wanderers." Our solar system has nine planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. An easy way to remember their names in the correct order is to keep in mind the following sentence: **M**y **V**ery **E**ducated **M**other **J**ust **S**erved **U**s **N**ine **P**ickles. The first letter of each word is the first letter of each planet. Since 1994, evidence has been found that planets also exist beyond our solar system. At least 10 planets existing in other solar systems have been discovered.

***Satellite (or moon)*** is the term for a body in orbit around a planet. As long as our own Moon was the only moon known, there was no need for a general term for the moons of planets. But when Galileo Galilei discovered the four main moons of the planet Jupiter, Johannes Kepler wrote Galileo a letter suggesting he call them "satellites" (from the Latin *satelles,* which means attendant). The word means the same thing as "moon."

***Orbit*** is the term for the path traveled by a body in space. It comes from the Latin *orbis,* which means circle. Some orbits are nearly circular, but the orbits of most planets are *ellipses*—shaped like ovals.

***Asteroids,*** also known as the minor planets, are small bodies orbiting the Sun that resemble planets. More than 5,000 asteroids have been discovered, and most are found between Mars and Jupiter. Usually having an irregular shape, asteroids—at least those discovered thus far—can range in size from 580 miles (940 km) in diameter, which is the size of the asteroid Ceres, to just 33 ft. (10 m) in diameter.

***Comets*** are made up of frozen dust and gases, and have been described as large, dirty snowballs with icy centers. They often travel on extremely elongated orbits around the Sun. Some comets have orbits that take just 10 years to circumnavigate while other comets have orbits that take hundreds of thousands of years to circulate. The tail of a comet, called a coma, forms when the comet comes within 100 million miles of the Sun. It is then affected by the solar wind (hydrogen and helium that travel away from the Sun at high speeds), which causes a tail of dust and gases to form behind the comet.

**Meteors** are fragments of comets, planets, moons, or asteroids that have broken off. It is estimated that a billion meteors enter our atmosphere every day. Contact with our atmosphere causes most to disintegrate before reaching Earth. Those that do not disintegrate completely but fall to Earth are called meteorites.

***Stars*** are composed of intensely hot gasses, deriving their energy from nuclear reactions going on in their interiors. Our Sun is the nearest star. Stars are very large — some are even bigger than planets. Our Sun has a diameter of 865,400 miles—making it a comparatively small star.

***White dwarfs*** occur when a star runs out of energy and shuts down. The force of gravity at its center pulls the mass of the star in on itself, forcing it to collapse. It resembles the glowing cinders of a fire that has died down. It is called a white dwarf because it emits a white glow.

***Brown Dwarfs*** are also called failed stars. They lack enough energy to be true stars but are also too massive and hot to be planets.

*A* ***supernova*** is an extremely large exploding star. Just before the star dies, it releases huge amounts of energy, briefly becoming millions of times brighter than it was. Then it immediately shrinks.

***Neutron stars*** are formed after a supernova explodes and shrinks. The shrunken form of the star becomes incredibly dense and compact as gravity pulls all of its matter inward. It becomes so compressed that a million tons of its matter would hardly fill a thimble. This density crushes together the electrons and protons that make up its atoms, turning them into neutrons.

***Pulsars*** are believed to be rapidly spinning neutron stars that give off bursts of radio waves at regular intervals. Pulsar is a shortened version of Puls[ating st]ar.

***Quasars*** (quas[istell]ar objects) are believed to be the most remote objects in the universe. Despite their small size they produce tremendous amounts of light and microwave radiation: not much bigger than Earth's solar system, they pour out 100 to 1,000 times as much light as an entire galaxy containing a hundred billion stars.

A ***black hole*** is created by the total gravitational collapse of a massive star or group of stars. It is the final phase of some stars, in which gravity sucks the star in on itself—it *implodes* rather than *explodes*. This makes it so dense that not even light can escape its gravitational field.

A ***nebula*** is a giant glowing cloud thought to be made up of dust and gas. Nebulae were thought to have been galaxies that appeared as a blur because they were so far away, but as more powerful telescopes were created, they showed that nebulae were not clumps of stars but in fact a hazy cloud of gasses. A nebula is illuminated by bright stars nearby. More than 300 nebulae have been named.

## The Solar System

**THE SUN**

The diameter of **our closest star,** the Sun, is 1,392,000 kilometers. The Sun is thought to be **4.6 billion years old.** The Sun is a medium–size star known as **a yellow dwarf.** It is a star in the **Milky Way galaxy** and the temperature in its core is estimated to be over **15,000,000 degrees Celsius.**

In the Sun's core, **hydrogen is being fused** to form helium. The **energy created by this process radiates** up to the visible boundary of the Sun and then **off into space.** It radiates into space in the form of **heat and light.**

Because the Sun is **so massive,** it exerts a **powerful gravitational pull** on everything in our solar system. It is because of the Sun's gravitational pull that **Earth orbits the Sun** in the manner that it does.

The Sun has several layers: **the core, the radiation zone, the convection zone,** and **the photosphere** (which is the surface of the Sun). In addition, there are two layers of gas above the photosphere called **the chromosphere** and **the corona.**

Events that occur on the Sun include sunspots, solar flares, solar wind, and solar prominences. **Sunspots** are **magnetic storms** on the photosphere that appear as dark areas. Sunspots regularly appear and disappear in eleven-year cycles. **Solar flares** are spectacular discharges of **magnetic energy** from the corona. These discharges send streams of protons and electrons outward into space. Solar flares can interrupt the communications network here on Earth. **Solar winds** are the result of **gas expansion** in the corona. This expansion leads to ion formation. These ions are hurled outward from the corona at over 500 kilometers per second. **Solar prominences** are **storms of gas** which erupt from the surface in the form of columns which either shoot outward into space or twist and loop back to the Sun's surface.

The Sun gives off many kinds of radiation other than light and heat. It also emits **radio waves, ultraviolet rays,** and **X-rays.** The Earth's atmosphere protects us from the harmful effects of the ultraviolet rays and the X-rays.

The Sun does rotate, but because it is a large gaseous sphere, not all parts rotate at the same speed. This is known as a **differential rotation.**

**Corona** - The very hot outermost layer of a star's atmosphere. Our Sun's corona can only be seen during a total solar eclipse.
**Solar Flares -** A magnetic storm on the Sun's surface which shows up as a sudden increase in brightness.
**Solar Prominences** - Gases trapped at the edge of the Sun which appear to shoot outward from the Sun's surface.
**Solar wind** - A continuous stream of charged particles which are released from the Sun and hurled outward into space at speeds up to 800 kilometers per second. Solar winds are very prominent after solar flare activity.
**Sunspot** - A magnetic storm on the Sun's surface which appears as a dark area. A sunspot is approximately 1500 degrees Celsius cooler than its surrounding material. The number of sunspots we see on the Sun at any given time appears to cycle every 11 years.

## THE PLANETS

There are nine planets in our solar system including Earth. So far, no life as we know it exists on any planet other than our own.

***Mercury***

Mercury, the planet closest to the Sun, has almost no atmosphere, and its dusty surface of craters resembles the Moon. The planet was named for the Roman god Mercury, a winged messenger, and it travels around the Sun faster than any other planet. Mercury is difficult to see from Earth—in fact, the famous astronomer Nicolaus Copernicus, for all his years of research and observation, never once was able to see Mercury.

***Venus***

Venus is often called Earth's twin because the two planets are close in size, but that's the only similarity. The thick clouds that cover Venus create a greenhouse effect that keeps it sizzling at 864°F. Venus, named after the Roman goddess of love and beauty, is also known as the “morning star” and “evening star” since it is visible at these times to the unaided eye. Venus appears as a bright, white disk from Earth.

***Earth***

Earth is not perfectly round; it bulges at the equator and is flatter at the poles. From space the planet looks blue with white swirls, created by water and clouds.

- **Size:** Four planets in our solar system are larger and four are smaller than Earth
- **Diameter:** 7,926.2 miles (12,756 km)
- **Surface:** Earth is made up of water (70%), air, and solid ground. It appears to be the only planet with water
- **Atmosphere:** Nitrogen (78%), oxygen (21%), other gases
- **Rotation of its axis:** 23 hours, 56 minutes, 4 seconds
- **Rotation around the Sun:** 365.2 days
- **Mean Distance from Sun:** 92.9 million miles (149.6 million km)
- **Satellites:** 1
- **Rings:** 0

***Mars***

Because of its blood-red color (which comes from iron-rich dust), this planet was named for Mars, the Roman god of war. Mars is the fourth planet from the Sun, situated between Earth and Jupiter. Three-quarters red, Mars also has dark blotches on it and white areas at the poles—these are white polar ice caps.

***Jupiter***

*A belt of asteroids (fragments of rock and iron) between Mars and Jupiter separate the four inner planets from the five outer planets.*

Jupiter, the largest planet in our solar system, was named for the most important Roman god because of its size. About 1,300 Earths would fit into it. Viewed through a large telescope, Jupiter is stunningly colorful—it is a disk covered with bands of blue, brown, pink, red, orange, and yellow. Its most distinguishing feature is "the Great Red Spot," an intense windstorm larger in size than Earth, which has continued for centuries without any signs of dying down. It has 63 moons and 4 rings.

***Saturn***

Saturn, the second-largest planet, has majestic rings surrounding it. Named for the Roman god of farming, Saturn was the farthest planet known by the ancients. Saturn's seven rings are flat and lie inside one another. They are made of billions of ice particles. It has 31 moons and about 1000 rings.

***Uranus***

Uranus is a greenish-blue planet, twice as far from the Sun as its neighbor Saturn. Uranus wasn't discovered until 1781. Its discoverer, William Herschel, named it Georgium Sidus (the Georgian star) after the English king, George III. Later its name was changed to Uranus, after an ancient Greek sky god, since all the other planets had been named after Roman and Greek gods. It has 27 moons and 11 rings.

***Neptune***

Neptune, named for an ancient Roman sea god, is a stormy blue planet about 30 times farther from the Sun than Earth. Neptune was discovered when astronomers realized that something was exerting a gravitational pull on Uranus, and that it was possible that an unknown planet might be responsible. Through mathematical calculations, astronomers determined there was indeed an undiscovered planet out in space—a year before it was actually seen for the first time through a telescope (in 1846). It has 13 satellites and 4 rings.

***Pluto***

Pluto, named after the Roman and Greek god of the underworld, is the coldest, smallest, and outermost planet in our solar system. Pluto and its moon, Charon, are called "double planets" because Charon is so large it seems less of a moon than another planet. Pluto was predicted to exist in 1905 and discovered in 1930. It is the only planet that has not yet been studied closely by a space probe. During each revolution around the sun, Pluto passes inside Neptune's orbit for 20 years, making Neptune the outermost planet for that time. Pluto passed inside Neptune's orbit in 1979 and remained there until 1999.

## THE MOONS

**Earth's Moon** is a small ball of gray rock revolving 239,000 miles around Earth. It is just one of many in the solar system. The Moon has no air and no water. It is about one-fourth as large as Earth.

The Moon travels around Earth in **an oval orbit** at **36,800 kilometers per hour.** The Moon **does not have an atmosphere,** so temperatures range from -184 degrees Celsius during its night to 214 degrees Celsius during its day except at the poles where the temperature is a constant -96 degrees Celsius.

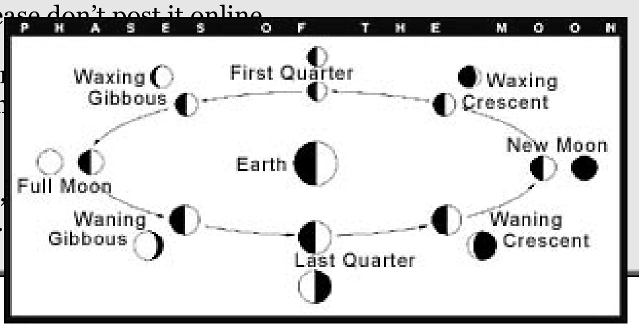
The Moon is actually **a little lopsided** due to the lunar crust being thicker on one side than the other. When you look at the Moon, you will see **dark and light areas.** The dark areas are young plains called maria and are composed of basalt. The basalt flowed in and flooded the area created by a huge impact with an asteroid or comet. The light areas are the highlands, which are mountains that were uplifted as a result of impacts. The lunar surface is covered by **a fine-grained soil called "regolith"** which results from the constant bombardment of the lunar rocks by small meteorites.

Scientists theorize that **the Moon was the result of a collision** between Earth and an object the size of Mars. One theory states that the debris from the impact was hurtled into space where, due to gravity, it combined. This resulted in the formation of the Moon.

The **gravitational pull** of the Moon on the Earth affects the **ocean tides** on Earth. The closer the Moon







is to Earth, the greater the effect. The time between high tides is about 12 hours and 25 minutes.

"**Full Moon** and **No Moon** describe two phases of the Moon as it orbits Earth. When the Moon is between the Sun and the Earth, its sunlit side is turned away from the Earth and we say there is no Moon. When the Earth is between the Sun and Moon, we can see the entire sunlit side of the Moon and call it a full Moon.

**The Far Side of the Moon** is always facing away from Earth because of the force of gravity. So when we look at the Moon, we always see the same side.

**The moons of Jupiter:** Jupiter has 63 moons. 45 of these moons were discovered between 2000 and 2003. Astronomers believe that the moon count of Jupiter could go as high as 100. The newer moons were named after members of the god Jupiter's (Zeus to the Greeks) entourage, among them : Themisto, Iocaste, Harpalyke, Praxidike, Taygete, Chaldene, Kalyke, Callirrhoe, Megaclite, Isonoe, and Erinome.

**The moons of Saturn:** Saturn has 31 moons. 12 of them were discovered in late 2000 and another one was announced in 2003. The older moons were named after figures in Greek mythology (Pan, Atlas, Pandora, Calypso, etc.). The newer moons of Saturn were named after Norse (Ymir, Thrym, Skadi, Suttung, Mundilfari), Celtic (Tarvos, Albiorix), and Inuit (Paaliaq, Siarnaq, Kiviuq, Ijiraq) legends.

**The moons of Uranus:** Uranus has 27 moons. Astronomers detected five of them between 1787 and 1948. The space probe *Voyager* discovered 10 more in 1985 and 1986. The names of these moons are the names of characters from plays by Shakespeare. They are: Oberon, Titania, Umbriel, Ariel, Miranda, Puck, Portia, Juliet, Cressida, Rosalind, Belinda, Desdemona, Cordelia, Ophelia, and Bianca. Miranda, with its deep scars and jumbled surface is one of the strangest objects in the solar system. It seems to have been shattered by a collision, then pulled back together by gravity! In 1997, two more moons were discovered, Caliban and Sycorax—also characters from Shakespeare. 1999 brought Stephano, Prospero, and Setebos. A satellite discovered in 2001 was dubbed Trinculo.

**The moons of Neptune:** Neptune has 13 moons, with Triton the largest. It is covered with a frosty crust, where active volcanoes shoot crystals of nitrogen that look like geysers. The surface temperature of Triton is –390°F, making it the coldest object in the solar system. Five new Neptunian moons were discovered in 2002 and 2003.